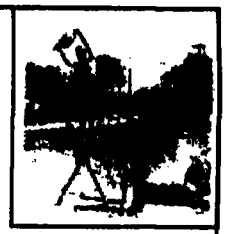
NUTRITIONAL QUALITY OF RICE



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Rice is described as the ancient staple of the Asian world with its origin somewhere in the Southeast Asia. The first records of cultivation of rice dates back to 5,000 years in China. Rice feeds more than half the population of the world and is the staple in the Sri Lankan diet. Annual per capita consumption of rice in Sri Lanka is around 100 kg. In the plant Kingdom, rice is classified under the genus *Oriza*. Within this genus there are twenty other species along with rice. Of these species *Oriza sativa* is the main cultivated rice species. Seeds (paddy) of plants of about 12,000 varieties of rice are maintained in the research stations all over the world for studies on their growth characteristics, quality and nutritional properties. These varieties are grouped under three sub-species; Indica (made of slender and somewhat flat grains), Japonia (short, round and smaller grains) and Javanica (broad thick grains). The rice used commonly in Sri Lanka is of the type Indica, which is the common subspecies in the tropical regions. Japonica is cultivated in more temperate regions and Javanica is more common in tropical islands like Indonesia. Within each of the three subspecies, the rise kernels appear in two common characteristic forms. One form contains the kernels, which are opaque and chalky with a waxy or glutinous appearance. They become sticky on cooking. Transparent, non-sticky, vitreous kernels characterize the other form.

Composition

The composition of the rice kernels is influenced by both varietal (genetic) factors and the environmental factors. However, the nutritional properties of rice could be examined taking into consideration the mean composition of the kernels. The protective seed coat in the rice grain consists mainly of silica and possesses no nutritional value. The outer coating of the rice grain is described as the bran, and may exist as a brown layer or a white layer. The bran consists of two components. The outer layer within the bran is made of the chemical constituents lignin and hemicellulose which are of low nutritional value and is generally accounted as fibre. Inner to this is the aleurone layer, which is rich in many nutrients including B vitamins - thiamin, niacin, riboflavin and pyridoxine - and the minerals calcium and iron. It also contains relatively high proportions of proteins (15%) and fats (15%) compared to the innermost parts of the kernel. The extent to which these outer layers are retained at milling is vital in retention of the nutritional qualities of rice. The germ located in one end of the rice kernel is also rich in nutrients and easily removed during milling.

The inner part of the rice kernel is made almost totally of carbohydrates of highly digestible nature. Of the carbohydrates 85-90% consists of starch along with about 2% pentosans and 1% sugar. The predominant sugar is sucrose with traces of glucose and fructose. Rice starch contains two major chemical constituents amylose and amylopectin, which governs much of the sensory and cooking characteristics of rice. In most types of rice the amylose content varies commonly from 12-35% of the total starch. The non-sticky types of rice preferred by Sri Lankans contain 25-30% amylose. In contrast to this, almost total absence or less than 6% of amylose characterizes the sticky rice; their amylopectin content is high. The amylose content in rice is also reported to be sensitive to variations of ambient temperature, with temperatures above 29C causing a decrease in the amylose content. Some of the different cooking quality characteristics associated with the rice from the Kalmunai-Ampara area, compared to the rice from the other less warm areas in the country, may probably be reflections of the temperature differences to a recognizable extent. In contrast to the Japonica and Javanica, the rice of the Indica subspecies show wide range of amylose content and gelanitization properties resulting in variations in

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sensory characteristics of cooked rice from country to country. High amylose rice is preferred in India and Sri Lanka, whereas Japan and South Korea prefer the low amylose rice. The Filipinos, Indonesians, Thais and the Malaysians prefer the intermediate amylose rice. The amylose content also has bearings on the resistance of the raw rice (paddy) to insects and the equilibration of the moisture content in rice with the relative humidity of the atmosphere during storage. The amylose content contributes much to stability of rice in addition to cooking characteristics.

The protein content of rice varies between 6 to 13% with an average of 8%. The main protein in the rice is oryzenin, which is described as an alkali soluble protein. It also contains small amounts of albumin (water-soluble), globulin (salt soluble) and prolamin (alcohol soluble) proteins. The proteins are concentrated in the outer layers of the rice kernel and they decrease towards the centre.

A major proportion of fats present in rice is removed during milling with the bran and polish leaving behind less than 1% in the polished rice. The bran consists of 10-20% of the fats. The stale flavour developed in rice during storage is mostly due to oxidation of the fats.

The mean calorie content in polished rice is around 350 keal per 100 gram. The vitamins present in the rice include thiamin, riboflavin, niacin, pyridoxine, pantothenic acid, folic acid, insoitol, choline and biotin. The vitamins are concentrated in the germ and the aleurone layer of bran. The major minerals present in rice are calcium and iron. However, the contribution of these two minerals to daily dietary requirement through rice are negligible. The phosphorus in rice is bound mostly to phytin.

Processing

Processing of rice in Sri Lanka is done in two ways. The paddy is either milled raw or after parboiling. The rice milled in the raw form contains a nutty flavour, which is preferred by some. This type of rice is consumed mostly in the Southern region of the country and to a lesser extent in Badulla and Bandarawela areas. The type of machinery used in Sri Lanka causes heavy breakage of the kernels in milling of raw rice. Thus the food regulations in Sri Lanka governing the quality of rice allows upto 45% broken kernels in the market product to allow for the milling difficulties, although it indicates a recognizable loss of quality of rice. The corresponding value for broken kernels in parboiled rice is only 25%. More than 70% of the Sri Lankans prefer the parboiled rice having an odour and flavour different from the raw (kekulu) rice. The individuals who are used to consumption of one of these two types of processed rice, raw or parboiled, appear to feel that the sensory characteristics of what each person prefers is of higher acceptability.

Parboiling of rice impart many important characteristics to the kernel. Parboiling brings about gelatinization of the starch in the kernels hardening them and cementing any cracks already present in the grains. Thus the kernels become more resistant to insects and pests giving superior storage characteristics. Soaking of paddy prior to parboiling brings about migration of nutritionally important constituents, the vitamins and minerals in the outer tissues of rice grain to the inner tissues. The inward migration helps in retention of the nutrients to greater extent within the kernel during milling thus improving the nutritional quality. Parboiled rice on milling removes only 4% as outer layer as against 7% in milling of raw rice under processing conditions in Sri Lanka, thus giving an advantage in retention of valuable nutrients. Parboiling however, introduces a few undesirable characteristics such as removal of natural antioxidants, making the rice more susceptible to rancidity during storage. It also increases cooking time.

Conventionally paddy is soaked in water overnight prior to parboiling and is next boiled in water for 2-3 hours. The reuse of water for soaking of paddy tend to allow heavy bacterial growth on the water, imparting unacceptable flavours and odours to rice kernels reducing their quality and nutritional value. Changing of soaking water every 10 hours is recommended to avoid the nutrient losses associated with bacterial growth. The high moisture absorption by the kernels during parboiling makes rice more susceptible to growth of molds during storage, if effective drying is not carried out. Boiling in water is sometimes inadequate to bring about nutritionally desirable changes completely. Boiling water tend to dissolve away some of the B vitamins and minerals and also may result in partly gelatinized starch imparting poor milling qualities. Greater nutrient retention and much improved cooking quality of rice is achieved by steaming for 30 minutes, instead of boiling in water for 2-3 hours. Parboiling carried out under more scientifically controlled conditions impart a light colour and mild flavour to rice increasing palatability. It is thus important from a nutritional point of view to provide incentives where necessary for the rice processing industry to move into parboiling using steam instead of boiling in water.

Quality Standards

Strict adherence to quality standards is a must in maintaining the nutritional quality in rice. The standards

stipulated at commercial purchase of paddy in Sri Lanka are as follows:

Moisture	less than 15%
Extraneous matter	less than 1%
Immature seeds	less than 9%
Varietal mixture	less than 10%
Discoloured or damaged seeds	absent

Preparation

The cooking characteristics of rice depend heavily on the properties of the kernels. In general the long grain types cook to a dry fluffy product and become hardened when stored cold after cooking. Sri Lankans prefers them. The short grain types tend to be more cohesive and moist. They carry a high tendency to get spoiled more readily on storage after cooking.

Rice is generally prepared for consumption by boiling in water for cooking. The rinsing or washing of rice prior to cooking for cleaning depletes the water-soluble B vitamins seriously. The washing removes the already low content of thiamin, riboflavin and niacin removing upto 50% of them. Use of excess water for cooking and discarding the water after cooking removes further 25% of the vitamins. Thus the provision of clean and well-packed rice which could be cooked without washing would provide an effective means of retaining the nutritional quality of rice. Use of the correct minimum quantity of water for cooking is a must from a nutritional point of view. The quality of cooking water also plays a role in retaining the vitamins. Hard water found mostly in lime stone containing soils is alkaline in nature. Such water causes more than 60% loss of available thiamin rice.

Although baking and frying of rice is possible, is not practiced much in the rice consuming countries. Baking is carried out in special occasions such as in preparation of *Kanji*. a liquid preparation given for sick who needs easily digestible foods. Frying is done to improve the sensory characteristics of rice for special occasions and functions.

Nutritional significance

Rice is looked upon mainly as the source of calories in the Sri Lankan diet. The average per capita consumption of about 300 g rice, provides about 1050 keal per day, meeting 45% of the per capita calorie requirements. The same amount of rice provides 45% of the per capita protein requirements. However, considering the fact that the amino acid balance in the rice proteins is limited by inadequacy of the sulphur containing amino acids, especially lysine, the diet plans should be aimed to meet this inadequacy by combining rice with lycine rich legumes. In spite of the limitation arising from the lysine content, rice possesses the highest biological value among the cereals. Other cereals are much poor sources of lysine. Rice also exhibits the highest true protein digestibility among the cereals. The high digestibility is associated with the low fibre and tannin contents in rice.

Rice, like other cereals, is devoid of vitamins A, D, and C. Vitamin B12 is also apparently absent. The nutritional value of rice with respect to vitamins and minerals is determined to a great extent by the their losses associated with processing and cooking. Due to losses in other B group vitamins during milling-rice meet only about 15% of the thiamin needs, 8% riboflavin needs and 35% niacin needs in the Sri Lankan diet. Although iron and calcium are present in higher quantities in rice than other minerals, they contribute only about 3% and 10% of the daily dietary needs and thus do not make a significant contribution to nutrition. Thus the need to supplement the diet of the Sri Lankans with adequate milk, or fortification of rice with calcium is desirable. Although the total phosphorus content in rice is adequate to meet bulk of the needs, the availability of phosphorus is rather low. This is due to the binding of phosphorous to phytin in rice. The calcium-to-phosphorus ratio in rice is highly desirable being 1:10, however, this ratio reflects the inadequacy of calcium in rice from the point of view of human nutrition.

Retention of nutrients during milling of rice needs greater attention by the industry. Change of the milling conditions to use shellers containing rubber rollers to polish the rice, instead of currently used steel hullers will help much in retaining nutritional quality of rice. Sophistification of milling conditions will help in retaining more nutrients with the kernel while removing the fibre to desirable levels. Processes to recover the vitamins, minerals and 12-14% protein in the bran with a view to incorporate them back into the kernels or rice flour needs examination.

Rice is generally considered a non-allergenic food, although occasional allergic symptoms are reported from among the wheat consumers. The rice flour and rice bran thus forms an important ingredient in the preparation of baby foods. The absence of any strong and dominating flavours in rice leave room to incorporate other more attractive flavours to rice based processed foods increasing the palatability.

The low salt, low fat and low protein nature of the cooked rice makes it a more suitable food for the sick.

Recipes based on rice are popular among the consumers suffering from the diseases of affluence, such as high blood pressure, heat ailments and vascular disease. The high recommendation of *rice kanji* in the traditional medicine indicates the recognition of this character from early times.

The milled rice containing less than 1% fibre is easily digestible. Rice polishing contains about 2.5 % fibre, which may cause digestion difficulties in certain individuals. The bran, which contains about 11% fibre, could be used as an additive to processed foods for improving their nutritional quality.

The post-harvest losses of upto 30% noted in Sri Lanka also signify the quality losses in addition to the loss of quantities. Harvest of the crop prior to maturity permits continued activity of the enzymes depleting the valuable nutrients due to fermentation and deterioration. The high moisture at these early stages of maturity as well as improper drying at storage permits the growth of molds on rice. Occurrence of 'black grain' which keep on increasing with storage time is an obvious problem arising due to growth of a mold in the local rice. Some of the molds are known to produce a variety of toxic compounds including the cancer causing compounds, the aflatoxins. The proper post-harvest management of rice is thus a necessity in preventing the development of anti-nutritional factors during storage and marketing. The threshing of paddy add various extraneous matter carrying anti-nutritional components into the grains when animal and tractors are used. The use of threshers will protect quality of rice.

Fortification

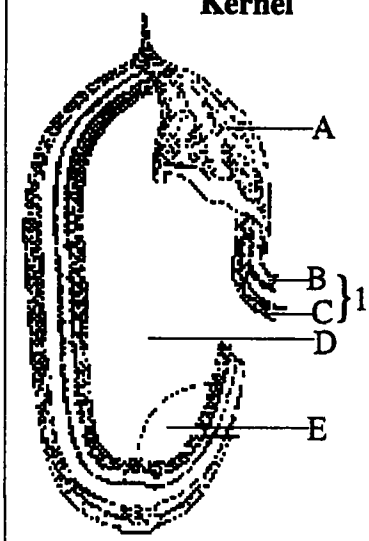
Fortification of rice to meet the nutritional inadequacies is practiced in many parts of the world. Calcium is made to incorporate into rice by adding calcium to water during parboiling. Other nutrients such as iron and the B vitamins are incorporated using various technologies commercially. Rice being the staple in the Sri Lankan diet could be used as a vehicle in providing much needed nutrients through enrichment and fortification.

Future Needs

The rice breeding programmes in Sri Lanka carried out during the last few decades had been aimed mainly in increasing the yields and imparting resistance to attack by pests with a view to achieve self sufficiency in rice production. Having achieved 85% self sufficiency in production, with 20-30% post-harvest losses, it is logical to look into means of reducing the losses through improved technology than to expand on production. Breeding plans undertaken currently envisage incorporation of resistant characteristics in rice to pests and submerged conditions. Local gene pool office is being examined with a view to incorporate these characteristics to future breeds of rice. The future rice breeding programs need to address towards improving sensory, nutritional and keeping characteristics of rice. With the global and regional trade agreements liberalizing the movement of foods, the market competition would naturally favour quality rice. If Sri Lanka is to possess the competitive edge in rice marketing, even locally, the quality need to be improved. From a nutritional point of view an increased protein content could do much to alleviation of malnutrition.

The emphasis on modern biotechnological research should be aimed at increasing the protein content in rice to meet the nutritional needs of the population. If the protein content could be doubled that would meet much needed proteins in the diet without resorting to expansion of more expensive animal protein resources. As one of the major nutritional inadequacies of rice is due to the low content of the amino acid lysine, attempts also need to make to work towards lysine rich proteins in rice.

Composition of the Rice Kernel



A - Sead Coat
B - Aleurone Layer
C - Pericap
1 - Bran
D - Kernal
E - Germ

Rice breeding also needs to be carried out with a view for development of rice flours of high quality by increasing gluten content. Gluten provides the dough characteristics needed in using rice flour more effectively as a bakery product without mixing with wheat flour. Rice rich in gluten is needed for improved product development based on the traditional recipes. Only such products would survive in the market competition in the next century.