Table 2. Micro nutrient composition of less familiar leaves

Local name	Iron, mg%	Calcium, mg%	β-carotene, μg%	Ascorbic acid, mg%	Oxalic acid, mg%
Lunakia	13.2±0.4	103.0±2.0	2258±9.0	29.0±3.0	426.0±0.2
Kanejara	2.6±0.7	205.0±4.0	5902±4.0	68.7±1.2	132.5±1.2
Bogana	6.4±0.9	223.0±4.0	5325±5.0	18.7±0.9	1012.0±2.0
Dandi chandloi	1.4±0.3	118.0±2.0	5982±3.0	31.2±0.6	130.0±3.0
Cheel bathua	4.2±0.3	150.0±4.0	1735±6.0	35.0±2.0	496.0±4.0
Cow pea leaves	18.2±0.4	250.0±3.0	6022±3.0	5.2±0.5	360.0±3.0
Drumstick leaves	0.8±0.3	430.0±4.0	6700±4.0	190.0±3.0	101.2±3.9
Phuwad	9.2±0.5	76.0±3.0	6203±3.0	21.8±2.1	56.2±1.2
Hatda	32.0±0.2	51.0±3.0	2328±3.0	26.1±2.4	135.0±4.0

Mean±SD

excellent sources of β-carotene and if their use is promoted, these can serve a great task of eradicating vitamin A deficiency. The contents ranged from a minimum value of 1735 μg% in *cheel bhatua* to as high as 6700 μg% in drumstick leaves. The results are in tune with the β-carotene content of less familiar leaves of Bihar as reported by Rao and Vijay (2002). Less familiar leaves, when studied for their ascorbic acid content were found to be low to moderate sources furnishing 5.2 to 68.7 mg%. However, drumstick leaves need a special mention for it was an excellent source of vitamin C, the content being 190 mg%.

Oxalic acid is a non-nutrient factor and its higher content is not desirable as it impairs calcium absorption by forming insoluble calcium oxalate. Besides, it may also contribute to oxaluria, thus increasing the risk of urolithiasis. *Bogana* leaves contained higher amount of oxalic acid (1012 mg%). All other leaves were having low to moderate contents (Table 2).

Findings of the present study led us to conclude that the less familiar leaves namely, *hatda*, cowpea leaves and *phuwad* have comparable or even superior nutritional quality to that of commonly consumed greens like cabbage, spinach and fenugreek leaves. Hence, their utilization must be propogated to ensure nutrition security especially the critical micronutrients like iron and β-carotene.

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SHORT COMMUNICATION *J Food Sci Technol, 2005, 42(5), 448-450*

Studies on starch gelatinisation pattern in rice (*Oryza sativa* L.)

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The structure, size and shape of fractionated starch granules of rice (*Oryza sativa* L.) variety 'Pusa Basmati' were studied before and after cooking. Starch granules sizes have been categorized as small (2.0-5.5 μm), medium (5.6-8.5 μm) and large (>8.6 μm). Cooking was done for 10, 20, 30 and 40 min. At 10 min cooking, starch grains started swelling and maximum swelling was at 20 min cooking. At 30 min cooking, large granules disintegrated totally followed by medium and small granules and started forming clumps. At the end of 40 min cooking, complete gelatinization occurred. The percent expansion of small, medium and large starch granules was 77, 135.29 and 152.53, respectively.

Keywords: Rice, *Oryza sativa*, 'Pusa Basmati', Cooking, Starch, Gelatinisation, Structure

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The major molecular constituents of starch are amylose and amylopectin. Amylopectin molecule is 100 times larger than the amylose molecule (Banks et al 1972, Banks and Greenwood 1975). The proportions of both molecules depend on the source of starch. As far as the rice starch is concerned, the granules are the smallest of all known starch granules.

Gelatinisation is the thermal disordering of crystalline structures in native starch granules which includes related events such as swelling of granules and leaching of soluble polysaccharides (Atwell et al 1988). The proposed definition by them was the collapse of molecular orders within the starch granules manifested by irreversible changes in properties such as granular swelling, native crystalline melting, loss of birefringence, and starch solubilization. Tester and Morrison (1990) have reported that swelling is a property of the amylopectin in normal cereal starches and amylose and lipids actively inhibit swelling.

The objective of this work was to understand the swelling behaviour and gelatinisation pattern of starch in 'Pusa Basmati' rice by observing changes in size and shape of starch granules at different intervals of cooking.

The grains of variety 'Pusa Basmati' were procured from ICAR Research Complex, Old Goa, Goa. After dehulling by hand, caryopses were subjected to gradual cooking from 10 to 30 min in excess of distilled water at 100°C. After cooling, the endosperm was teased to separate starch granules. Further, they were stained with potassium iodide, mounted on a clean slide and observed under light microscope and photographed in bright-field mode using Nikon E-800 microscope. The preparation and fractionation of starch granules was done following the method of Takeda et al (1998) and Tang et al (2000). The isolated small, medium and large starch granules were measured before and after cooking.

Table 1 shows different sizes and % expansion of starch granules observed in 'Pusa Basmati'. The isolated starch granules were broadly classified into three types based on the size: 2.0-5.5 µm as small, 5.6-8.5 µm as medium and >8.6 µm as large. The minimum size measured was 2.9 µm and the maximum was 11.60 µm. In the small size granules, the maximum expansion of granules took place between 10 and 20 min of cooking and between 20 and 30 min of cooking it showed least swelling. The medium and large size starch granules also followed the same trend. In case of large size starch granules no swelling was recorded between 20 and 30 min of cooking. The total % expansion was maximum in large sized granules followed by medium and small sized granules.

The structure, shape and size of starch granules in 'Pusa Basmati' before (Fig. 1.1) and after cooking are shown in Fig. 1.2-1.6. At 10 min of cooking, the starch grain starts swelling (Fig. 1.2) and maximum swelling was observed at 20 min (Fig. 1.3). At 30 min cooking, the large granules disintegrated totally followed by medium and small granules and started

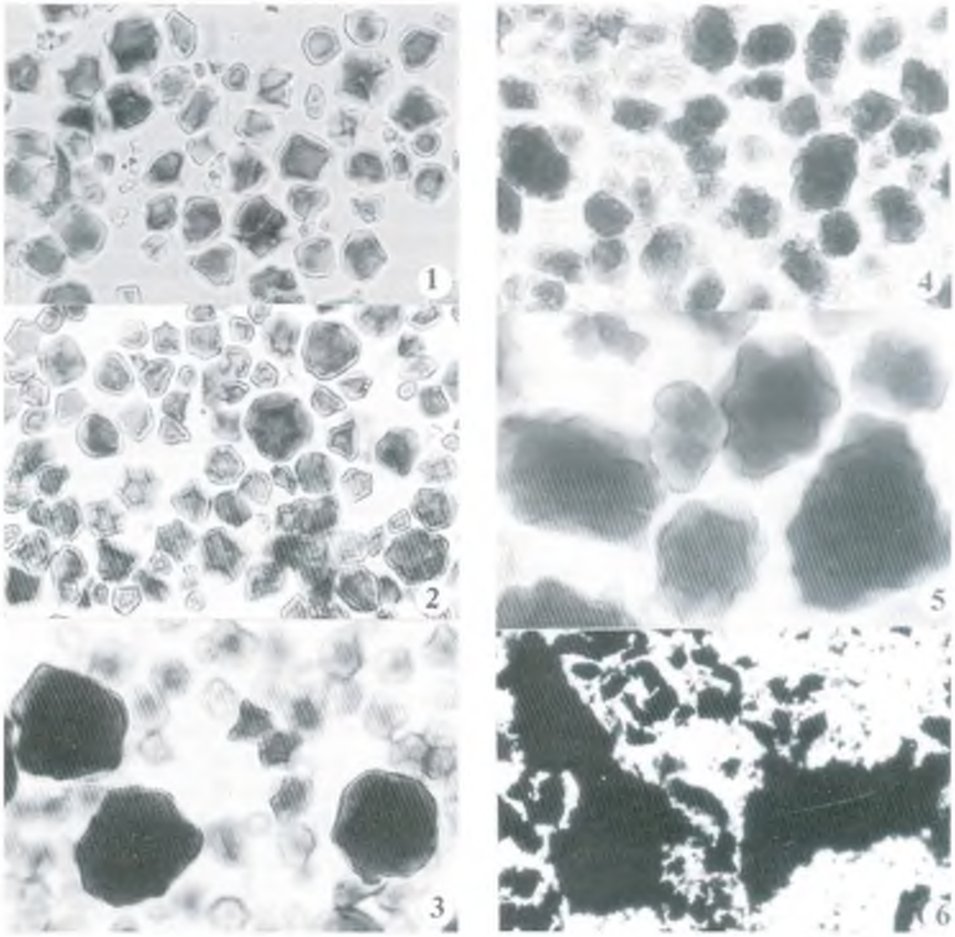

Fig. 1. Uncooked and cooked starch granules from variety 'Pusa Basmati' and stained with pottassium iodide.
1. Uncooked starch (small, medium and large) × 1500; 2. Starch (swelling) 10 min after cooking × 1500; 3. Starch (expanded) 20 min after cooking × 1500; 4. Starch (clumps) 30 min after cooking × 600; 5. Closer view of 4. × 1500; 6. Starch (gelatinized) 40 min after cooking × 60.

Table 1. Size of starch granules in variety 'Pusa Basmati' before and after cooking

Type	Size, µm	Swelling (µm) of starch after cooking for			Expansion (%) after cooking for			Total expansion, %
		10 min	20 min	30 min	0-10 min	11-20 min	21-30 min	
Small	2.0-5.5	5.67	9.38	9.50	5.98	65.43	1.28	77.57
Medium	5.6-8.5	9.54	13.76	20.00	12.24	44.23	45.35	135.29
Large	>8.6	15.55	37.88	37.88	3.67	143.60	0.00	152.53

forming clumps (Fig. 1.4 and 1.5). At the end of 40 min cooking, complete gelatinization occurred (Fig. 1.6).

Ramarathnam and Kulkarni (1985) recorded the elongation ratio of 1.89 and volume expansion ratio as 3.81 in 'Pusa Basmati'. Other varieties like 'Basmati 370' and 'Haryana Basmati-1' showed the comparable values. Tang et al (2000) observed that the gelatinization property of the starch granule was mainly controlled by structure of starch rather than their size. Tester and Morrison (1992) reported that in barley starch the swelling property is only of amylopectin, which took place at 70 and 80°C. The present study revealed that small, medium, and large starch granules showed specific percentages of expansion, this may be due to the presence of different proportion of amylose and amylopectin in each type.

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SHORT COMMUNICATION *J Food Sci Technol, 2005, 42(5), 450-452*

Development of an energy efficient laboratory model parboiling unit

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An electronically controlled laboratory-parboiling unit (capacity 8-10 kg) was developed to integrate soaking and steaming. The paddy was soaked and the required time-temperature combination was set by an electronic programmer. After preset time of soaking, hot water was drained into steaming unit for a pre-programmed time. The heat energy in the hot water drained from soaking chamber was utilized for steam production thereby saving energy. The net energy saving was 11.6%. Cost of operation was brought down by 21.7%. The parboiling unit gave satisfactory performance when tested for various paddy varieties and hybrids.

Keywords: Paddy, Soaking, Steaming, Electronic control, Parboiling, Energy

Rice is the staple food for more than 65% of Indian population and is a source of livelihood for about 100 million rural households. The country ranks first in area and second in production of rice in the world. Increasing productivity and sustained production of rice are critical for food and nutritional security. Our per capita income is increasing fast and growth rate currently is about 3%.

More than 50% of paddy produced in India is parboiled. Parboiling is one of the most widespread food processing industries of the world (Bhattacharya 1985, 1990, Pillaiyar 1988). The basic steps involved in the parboiling process are soaking, steaming, and drying of paddy (Shukla and Khan 1989). Traditional parboiling process involves soaking paddy overnight or longer in water at ambient temperature followed by boiling or steaming paddy at 100°C to gelatinize the starch, while grain expands until hull's lemma and palea start to separate (Pillaiyar et al 1994). The parboiled paddy is then cooled and dried (in sun or using mechanical dryer) before storage or milling.

Conservation of energy is of prime concern all over the world. Most of the parboiling methods are capital and energy intensive and are mostly not suited for village and small-scale operations. Approximately 2,49,000 kcal of heat is required to parboil a ton of paddy using modern methods. A major portion of this energy is consumed during steaming and subsequent drying operations (Ali and Ojha 1976, Wimberly 1983, Shukla and Khan 1989).

Most of the small-scale industries carry out all the three operations of soaking, steaming and drying separately, thereby consuming enormous amount of energy. If two operations can be combined, it would save a lot of energy (Varadharaju and Sreenarayanan 2002).

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