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Role of Local Germplasm and Induced Mutations in the Improvement of the Protein Content in Rice

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Summary. Ninety local cultivars and 124 induced grain shape mutants were screened for their protein content and the distribution of protein in their endosperm. The protein content varied widely from 4.2 to 12.1% in the local varieties and from 5.5 to 13.7% in the mutants. Some high protein lines like 'Chinnavadlu', 'Budumavadlu', etc. with more than 10.0% protein were identified. Protein distribution studies have shown that several mutants, such as IR-8-FG-28, IR-8-FG-33, etc., have a deeper distribution of protein bodies and some local cultivars, like 'Kakathya' and 'Muchulu', have a relatively more uniform distribution of protein in the endosperm. The protein content at different milling levels revealed that at 12% milling the percentage retention of protein varied from about 79 to 96% irrespective of the percentage of protein, suggesting that the distribution of protein, in addition to the protein content, plays an important role in nutritive value *of rice*.

Key words: Local germplasm – Induced Mutations – Protein content – Endosperm protein distribution

Introduction

Rice is an important cereal which accounts for nearly 30% of the world food intake and plays a vital role as a major source of protein (Chase 1969). In Asia rice contributes to nearly 80% of the total protein and calorie intake (Juliano 1972). Though rice is the principal source of protein, one of the major limitations is its low protein content, which averages about 7.0 to 8.0%. Several high yielding varieties have been released in recent years but most of them are beset with one or more drawbacks with regard to grain quality in general and protein content in particular. Attempts have therefore been made to improve the grain quality, especially the protein content, by the utilisation of local germplasm. The International Rice Research Institute, Philippines, surveyed 7,760 varieties of rice from the World germplasm for different characteristics, including the protein content, for subsequent use in rice improvement programmes (IRRI 1973). About 300 of the 4,830 varieties collected from North-East India, were screened for their protein content, which ranged from 6.0 to 14.0% (Sharma et al. 1971).

In the present study, about 90 local varieties and 124 induced mutants were screened for their crude protein content and the distribution of protein in the endosperm. The local cultivars and induced mutants exhibited wide variations for protein content, ranging from 4.2 to 13.7%. Some of the cultivars exhibited better protein distribution in the endosperm, suggesting that these cultivars may be utilized in breeding programmes.

Materials and Methods

Ninety varieties, which included local and a few improved cultivars, were collected from three districts of Andhra Pradesh, viz. Warangal, Karimnagar and Adilabad, and about 124 grain shape mutants, recovered from the cultivars 'Tellahamsa' (TH), 'Early-basangi' (EB), 'Yerragaluvadlu' (YV), 'Pottibasangi' (PB), 'Bangaruteegalu' (BT) and 'HR-5' after treatment with 0.5% ethyl methane sulphonate, were used in the present study (Reddy 1977). These varieties and mutants were grown under uniform field conditions and screened for protein by the conventional micro-kjeldahl method using the conversion factor 5.95. About 103 local cultivars and 38 induced mutants, including the ninety local cultivars, were screened for the distribution of protein in the endosperm. Five grains from the middle portion of the panicles of each of the varieties were softened in 10% glycerine for about 48 hours and hand-sectioned transversely as uniformly as possible with a fine razor blade. The sections were then stained with 0.1% bromophenol blue whereby the protein bodies were stained intense blue. The excess stain was then washed out with distilled water and examined microscopically. The distribution of protein bodies in the endosperm was screened on the basis of the intensity of staining in the different regions of the endosperm

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(Vilawan and Siddiq 1973). Besides these, ten cultivars were also milled in a mini-miller at four different levels of milling i.e., 3%, 6%, 9% and 12%. The residual kernels at each level of milling were analysed for their crude protein content in order to study the distribution of protein in the endosperm.

Results and Discussion

Protein content is an important characteristic which determines the grain quality in rice. Though rice is an important source of protein, contributing to nearly a third of the total protein intake of the world population, it has a serious drawback due to its low protein content. Protein content is known to exhibit wide variability both between and within cultivars. Amongst 7,760 varieties screened by the International Rice Research Institute, Philippines, the protein content varied from about 5.0 to 17.0% (Beachell et al. 1972). The protein content in certain Indian varieties was also found to vary considerably from 6.0 to 14.0% (Sharma et al. 1971).

The protein content in the ninety varieties screened in the present study ranged from 4.2 to 12.1% with a majority of the varieties on the low protein side (Fig. 1). Fifty-six varieties ranged in protein content from 6.1 to 8.0%. Four varieties 'Chinnavadlu' (12.1%), 'Budumavadlu' (11.1%), 'Peddavadlu' (10.5%) and 'Vagai' (10.3%) had high protein contents of more than 10%. Other varieties with fairly high protein contents, ranging between 9.0% and 10.0% were 'Kumkumabantulu', 'HR-47', 'Manela', 'Muchavadlu', 'Pottimolukalu', 'Yerragaluvadlu', 'Gottelu-1', and 'Tellakattera'. Some of these high protein cultivars, such as 'Yerragaluvadlu', 'Manela' and 'HR-47', were also found to have fine grains though in general the correlation between protein content and grain dimensions in these varieties was observed to be insignificant. It can therefore be concluded that even though nutritionally superior grains cannot be selected on the basis of the grain dimensions it is still possible to identify varieties with high protein content and desirable grain shape.

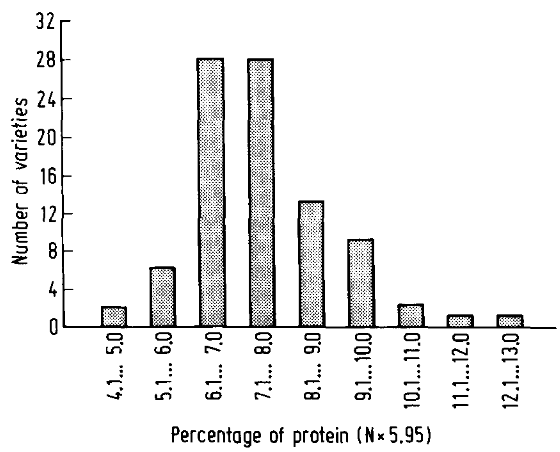

Fig. 1. Protein content in local varieties

Table 1. Range of grain dimensions and protein content in induced mutants

Sl. no. Varieties	No. of mutants	Length (mm)	Breath (mm)	Length/breadth	Protein content (%)
1. HR-5					
Control		6.17	2.11	2.95	9.9
Mutants	28	3.8-6.52	1.5-2.52	1.55-3.38	7.5-13.7
2. Earlybasangi					
Control		5.09	2.23	2.53	10.8
Mutants	12	5.1-5.37	2.03-2.28	2.24-2.38	6.2-12.5
3. Pottibasangi					
Control		5.37	2.04	2.24	10.0
Mutants	16	5.27-6.29	2.11-2.43	2.18-2.93	6.4-10.2
4. Yerragaluvadlu					
Control		6.36	2.04	3.12	9.3
Mutants	13	5.83-6.32	1.90-2.15	2.74-3.12	7.2-11.3
5. Bangaruteegalu					
Control		5.5	1.79	3.27	9.4
Mutants	11	4.69-6.2	1.66-2.25	2.44-3.40	7.7-12.0
6. Tellahamsa					
Control		6.39	2.05	3.1	9.1
Mutants	44	5.18-6.75	1.77-2.32	2.14-3.61	5.5-11.9

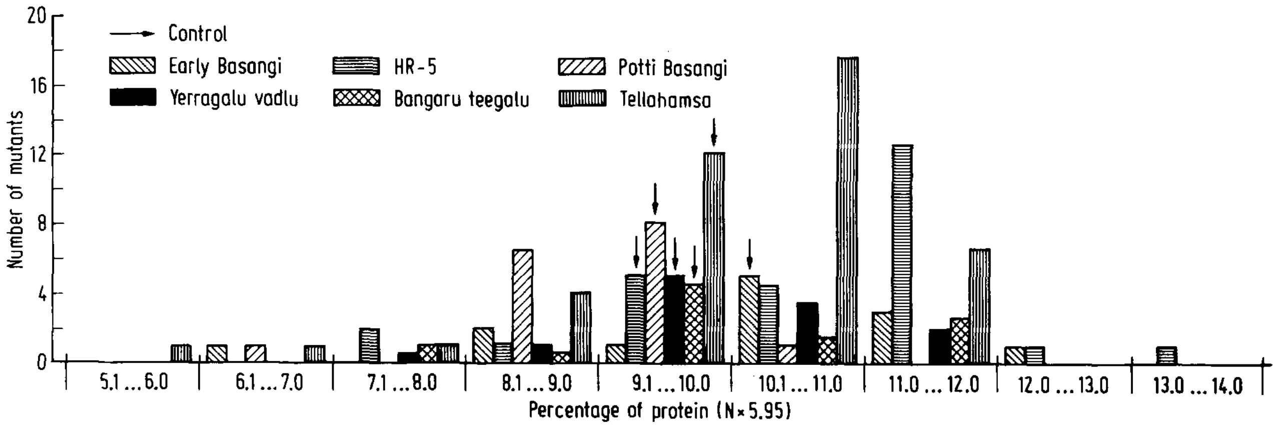

Fig. 2. Protein content in induced mutants.

Table 2. Crude protein content in certain varieties at different milling levels

Sl. no.	Variety	Whole grain	Level of milling			
			3%	6%	9%	12%
1.	Muchulu	7.6	7.4[a] 97.4[b]	8.0 105.0	7.2 94.7	6.4 84.2
2.	Ulliguttulu	6.8	6.5 95.6	6.5 95.6	6.5 95.6	6.2 91.5
3.	Mashuri	8.6	8.2 95.3	8.1 94.2	7.7 89.5	7.2 83.7
4.	Kalinga-2	10.1	9.1 90.1	9.0 89.1	8.6 85.1	8.6 85.1
5.	Chinnakichidi	7.6	7.11 93.4	6.9 90.8	6.9 90.8	6.9 90.8
6.	HR-47	9.4	9.0 95.0	9.3 98.9	8.8 93.6	8.9 94.7
7.	IR-8	8.1	8.02 99.1	7.7 94.5	7.8 96.4	7.6 93.2
8.	IR-8-FG-19	8.7	7.8 89.7	7.2 82.8	6.7 77.0	6.9 79.3
9.	IR-8-FG-26	11.7	11.5 98.3	11.4 97.4	11.4 97.4	11.3 96.4
10.	IR-8-FG-24	8.6	8.1 94.2	8.4 97.7	8.2 95.3	8.1 94.2

[a] Actual percentage of protein
[b] Percentage of whole grain

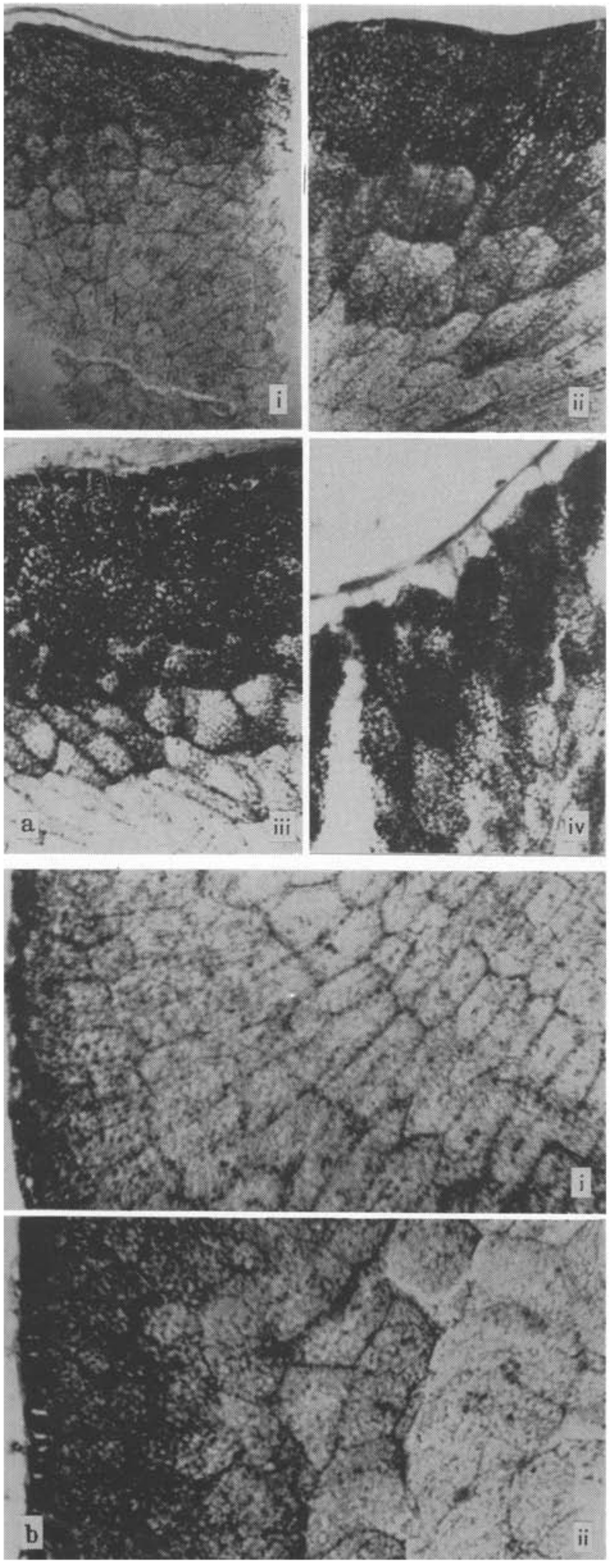

Fig. 3a and b. Endosperm sections showing. a Deeper distribution of protein bodies. (i) IR-8-Control (ii) IR-8-FG-28 (iii) IR-8-FG-33 (iv) IR-8-RG b Uniform distribution of protein bodies. (i) Kakathya (ii) Muchulu

In the induced mutants the protein content ranged from 5.5 to 13.7% (Fig. 2), and most of the mutants had a fairly high protein content ranging between 9.1% and 11.0% (Table 1). Though the protein content in the local varieties varied considerably only 13 cultivars had more than 9.0% protein in contrast to the induced mutants where the majority exhibited a high protein content of more than 10%.

The highest variability, ranging from 5.5 to 11.9%, was induced in 'Tellahamsa' followed by a 6.2 to 12.3% variability in 'Earlybasangi'. It was least in 'Pottibasangi' mutants (Table 1). Nearly 70 of the 124 mutants had higher protein content (> 10.0%) and 17 mutants had lower protein content (< 8.0%) compared to their respective controls, thus suggesting that mutations for protein are polydirectional in nature and a great frequency of mutants exhibit high protein content. These studies further suggest that high protein mutants can be recovered with an increase in the protein content to an extent of 38% more than the control, as observed in HR-5-3 (13.7%). Several high protein mutants also had desirable fine grains thus indicating the usefulness of induced variability in the improvement of the protein content and grain shape. These superior mutants have great potential in developing high protein and agronomically superior cultivars.

The protein in rice generally occurs as small discrete particles of 1 to 4μ diameter and is mostly concentrated in the outer layers of the endosperm. The low protein content, which is a serious problem in rice, is further aggravated by its partial loss with milling. At 10 to 20% milling the loss in protein ranged from 11.0 to 26.0% of the total protein though with an increase in the protein content, the loss of protein on milling was observed to be less (Cagampang et al. 1966). Thus, any improvement in the distribution of the protein in the endosperm whereby milling losses could be minimized would be of great advantage. A study of the distribution patterns in local and other varieties revealed considerable differences, though in general there were more protein bodies in the aleurone and outer layers of the endosperm than in the inner layers. Twenty-five varieties had a slightly better distribution of protein in the endosperm (Fig. 3a). Seven varieties, 'Kakathya', 'Muchulu', 'Beetavadlu', 'Gavirivagulu', 'Jaya', 'Gottelu-2' and 'IET-10-89', had relatively a more uniform distribution of protein (Fig. 3b). However, no consistent relationship was observed between the protein content and protein distribution pattern. Some of the varieties like 'Bangaruteegalu', 'Palasannalu', 'Kakathya', 'IET-10-89', 'Gottelu-2' and 'Jaya' had a comparatively superior distribution of protein though the protein content was low.

The analysis of the crude protein content at different milling levels in the ten varieties indicated that at 12% level of milling the percentage retention of protein in the endosperm varied from 79.3 to 96.4% (Table 2) and it was further observed that the percentage retention of protein was not related to the protein content since both high protein ('IR-8-FG-26', 'HR-47') and low protein cultivars ('Ulliguttulu', 'Chinnakichidi') had a high percentage retention of protein whereas, varieties like 'IR-8-FG-19' and 'Mashuri' had lost considerable protein at similar levels of milling. These observations suggest that it is preferable to have varieties with a moderate reduction in the protein bodies rather than those cultivars with a drastic reduction from the outer to the inner layers of the endosperm, as also observed in earlier studies (Chu et al. 1973). The identification of varieties with minimal losses of protein is desirable since the retention of protein on milling varies from about 80 to 90%.

These observations clearly suggest that the criteria for breeding varieties with superior nutritive quality should not be based only on increasing the protein content in the cultivars but also in developing varieties with better protein distribution patterns in the endosperm and subsequently a higher percentage retention of protein on milling. Thus, some of the high protein cultivars like 'Chinnavadlu' and 'Peddavadlu', identified in the present study, in addition to those with better protein distribution like 'Kakathya', 'Muchulu', 'IR-8-FG-28', IR-8-FG-26', etc., and varieties with a slower rate of protein reduction on milling can be successfully utilized in breeding programmes to improve the nutritive value of rice.

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