NUTRITIONAL CHARACTERISATION OF INDIGENOUS RICE VARIETIES IN THANE DISTRICT

A Project Thesis

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In Partial Fulfilment

of the Requirements for the Award of the Degree

of

5 Years Integrated M. Sc. Biotechnology

By

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May 2010

CERTIFICATE OF GUIDE

This is to certify that the dissertation titled "*Nutritional Characterisation of Indigenous Rice Varieties in Thane District*", is a bona-fide piece of research work done by *Mr. Yatin RS Diwakar* under my guidance and completed to my satisfaction, in partial fulfilment of the requirements for the degree of 5 years Integrated Master of Sciences in Biotechnology (Institute of Bioinformatics and Biotechnology, University of Pune) at BAIF-MITTRA.

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CERTIFICATE OF DIRECTOR, IBB

This is to certify that the dissertation titled "*Nutritional Characterisation of Indigenous Rice Varieties in Thane District*", is a bona-fide piece of research work done by *Mr. Yatin RS Diwakar* under the guidance of Mr. Sanjay Patil, BAIF-MITTRA in partial fulfilment of the requirements for the degree of 5 years Integrated Master of Sciences in Biotechnology from the Institute of Bioinformatics and Biotechnology, University of Pune.

Professor B A Chopade
Director,
Institute of Bioinformatics and Biotechnology
University of Pune

DEDICATION

To *India*,

My country with bountiful biodiversity.

To the *Tribal people*,

Who are treasures of Traditional knowledge and resources.

To the *Farmers*,

Who feed us all.

and,

To my *Parents*.

ACKNOWLEDGEMENTS

This thesis is not an individual's effort. This research, done by first identifying the need, happened due to aid of many people. I thank them all, while naming a few.

First, i thank my guide, Mr. Sanjay Patil. This work was born when i met him, thanks to Nirman. I want to thank BAIF-MITTRA for starting and making required budgetary allocations for this study along with the ongoing paddy conservation activities.

Most of the work was done at Central Research Station (CRS), BAIF Uralikanchan under Dr. P Nisal, head of Animal Nutrition section and Mrs. Surekha N Kale, Junior Research Officer. Also, a mention should be given to the other staff of CRS (especially Kantilal) who helped me everywhere. I was fortunate to receive guidance from Dr J Desale and Dr. A L Joshi.

A part of the project was done at iBB with valuable technical and material inputs from Mr Saugoto Das, a PhD student under Prof. B A Chopade. In this period, Ms. Sharvari Gaidhani offered a lot of help and guidance.

A special thanks to Mr Mavanji Pawar, a farmer from village Chowk in Jawhar, Thane, for his constant efforts with my guide for conservation of the paddy varieties. Without him, this study would not have been for want of enough samples.

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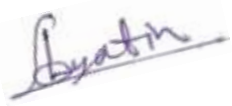
I want to thank RANWA for honouring me with their first ever Naturalist Scholarship in '*Biodiversity Conservation and Characterisation*' for the year 2010 and inspiring me by giving me recognition.



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ABSTRACT

KEYWORDS

Rice, Paddy, BAIF, Jawhar, indigenous varieties, nutrition, analytical measurements, proximate analysis, biodiversity conservation, cooking parameters

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HYV

CBM

BAIF

MITTRA

GATRC

CHAPTER 1: INTRODUCTION

RICE

Across the world, Rice (*Oryza sativa* L.) is the second most important staple food crop after wheat.(Steenson & Sathe, 1995) It is grown in over 100 countries, consumed regularly by over two billion people and the primary source of protein for millions (Thompson & Thompson, 2009). It is a staple food for Asian, Latin American, Caribbean and African population. About 90% of rice is produced and consumed in Asia, where it is more than just a staple food. India is a major producer and consumer of rice and a hot spot of rice biodiversity.

India is a major producer and consumer of rice and a hot spot of its biodiversity. Rice satisfies basic food demand of our 60% population. In the interior blocks across India, a large number of farmers still cultivate traditional varieties which have been grown in the area for centuries. The varieties are selected based on the land type, viz., lowland, highland, upland etc. Socio-economic, cultural needs, eating quality, feed value were some of the other considerations during selection of this indigenous biodiversity.

GREEN REVOLUTION AND ITS EFFECT ON RICE BIODIVERSITY

But since the Green revolution, the number of cultivated local varieties has been drastically reduced in major rice cultivating regions. The diversity has survived in the regions where this revolution didn't reach, especially in the backward districts and tribal belts (Mazoyer & Roudart, 2006). During the first three decades of the revolution, up to the late 80's, no inroads were made in the remote regions, but in the last twenty years, this has changed with increased approach roads and communication media.

It has been noticed that as a fall out of this revolution, requirement of chemical inputs has increased, water holding capacity of the soil has decreased, nutritious value of the food has decreased, and soil fertility is decreasing rapidly. These facts haven't been missed by the farmers who have come to realise that the hybrid varieties require more water and external inputs, which may not be as good as they are claimed to be, when a cost-benefit analysis is considered. Also, germplasm conservation has been accepted as the need of the hour and seed material for propagation is required. The hybrid seeds have to be procured from the market, unlike the local seeds, which can be cultivated in one's field.

PRESENT STATUS OF RICE BIODIVERSITY IN MAHARASHTRA

In the interior blocks of Maharashtra, mostly in the Western Ghats, in the remote regions populated by tribal people, a good biodiversity of various cultivars still exists. As this region has heavy rainfall, a good number of rice cultivars are also found in the region, especially rich zones being Jawhar, Junnar-Ambegaon, Velhe-Mulshi area. From this area, it has been possible to collect over a hundred different rice cultivars (Patil, 2010). These varieties vary with respect to land type, rainfall requirements, maturation period, straw length, hull and husk colours, aroma, taste, cooking qualities etc and have been thus selected over the centuries for their specific traits.

One such area is Thane district's tribal belt around Jawhar and Wada. Farmers in this region still cultivate a large number of land races or cultivars of rice, suitable to the local conditions, adapted to the water availability and land variations encountered there. Also, many of these varieties are touted to have different medicinal properties and are used in home remedies. The varieties differ markedly with respect to shape, size, taste, growth period, nutritional value and make up an important part of rice biodiversity and gene pool. These landraces haven't been previously documented and studied carefully, a major reason behind decline in their cultivation as compared to hybrids and other HYVs. The reason HYVs are now replacing is local landraces is their excessive promotion backed by scientific research, the likes of which have never been carried out for the indigenous varieties. When considered from genetic richness and biodiversity conservation aspect for further breeding programs, it becomes necessary to conserve this biodiversity.

NEED OF CONSERVATION AND REVIVAL

In today's times, when good, timely and predictable rainfall is rare due to global warming and climate change, it becomes very necessary to have a staple crop which can adapt to the changing conditions. For a good population of Maharashtra, this means rice, along with sorghum and wheat. The currently promoted hybrid lines in rice, which are touted as high yielding varieties are also input intensive. These need high amounts of fertilisers, insecticides and water and can't give guaranteed yield if the same aren't made available. This means that under the changing climate conditions, the hybrids are not sustainable. Also, these hybrids are susceptible to many common pests prevalent in the humid Indian conditions as their parentage includes exotic lines. There are also problems associated with fertility of the seeds and farmers are becoming increasingly dependent on

seed companies for the same. In case of a monopoly, the seed providers can charge extravagant sums and this raises the serious issue of seed security.

Another aspect is food and nutritional security. While going in for higher yields and non-lodging varieties the crop duration has increased and the fodder value gone down. This has serious impact for the availability of food for the farmers themselves in case of a bad or delayed harvest.

TRIBAL AREA IN THANE DISTRICT

Thane is one of the northern districts of the *Konkan* region in the state of Maharashtra. It includes part of the *Western Ghats* region which is considered to be a biodiversity "hot spot". The area is host to an amazing diversity of rice and other food plants. The typical lateritic soils are poor, and agriculture is largely rainfed (only 5 to 7% of the Konkan region is irrigated) Thane district has a fairly large tribal population. The tribal people in this area have traditionally cultivated over 300 diverse rice varieties with specific attributes such as hunger satiation, instant energy provision during peak workloads and for medicinal use. This wonderful diversity of rice has formed the basis of a nutritious and secure diet for the tribal population. Jawhar Taluk is at the heart of this tribal belt and a focus of this study.

FIGURE 1.1: MAP OF THANE DISTRICT

Jawhar is a hilly area situated between 19° 43' and 20° 5' N and 72° 55' and 73° 20' E. The average rainfall of area exceeds 3000 mm. Its height above sea-level is – and is thus considered a hill station in Thane. The climate of the region is variable. The entire region is situated in the Sahyadri ranges and thus the land is hilly, with steep slopes in many areas. The soil in the region is red soil, with a poor water holding capacity, thus though there is high rainfall in monsoon season, perennial water availability is a major hurdle to development of the region.

The per capita land holding is meagre in the area. Due to rainfed agriculture and poverty, people migrate to nearby regions during the January to May period every year. The major cereals in the area are paddy, finger millet, sorghum. Paddy is the staple crop of the region, though the productivity has been declining in recent year as is soil fertility.

This is partially due to a shift to chemical farming of rice varieties not suitable to the land and climate of the region.

FOCUS ON NUTRITIONAL ASPECTS OF PROMISING RICE LANDRACES

Of the over three hundred varieties which were extant in this region until recently, only a hundred could be collected as the others aren't under cultivation any more. At the same time, of these too, only a few were still cultivated on a large scale by the farmers. The others were planted for home use and for their religious significance. Through interviewing of the tribals and cross referencing, it was found that most of these varieties are nutritionally important for the tribals. For example, some rices were said to be useful during convalescence; others for lactating mothers; still others for fracture healing or for post-delivery weakness.

The very early varieties are important food source during the late monsoon months, when the main harvest isn't ready yet and last year's stocks are finished. The late varieties which can withstand prolonged dry spells are important for annual food security. Thus, it is necessary to conserve and characterise all these and to bring them again to the markets so that the tribals get an increased income source through these and speciality rices while addressing nutrition security issue of the greater population.

The nutritional analysis serves the purpose of identifying the special traits and supports the claims by the locals. The comparative nature is necessary to establish status of the traditional varieties when compared to widely cultivated and eaten hybrid varieties.

METHODOLOGY – SAMPLE COLLECTION IN BAIF GERMPLASM PROGRAMME

BAIF started its work on indigenous rice varieties in the tribal parts of Thane district on a pilot scale. It initiated a survey under the CBM-South Asia, India programme from January 2009 to September 2009. The scope of its work was to understand occurrence of indigenous rice genetic resources, characterise them on the basis of food security, yield, pest & disease resistance, fragrance and try to understand peoples' perceptions for the continued cultivation of such varieties. Efforts were also made to know the traditional cultivation practices associated with such varieties.

For the past few years, attempt has been made by Mr. Sanjay Patil to collect, document and conserve this diversity. Over hundred rice cultivars have been collected from local farmers, along with a documentation of the cultivation parameters, maturity

period, disease resistance and special properties reported by them; cross-checked and confirmed by other farmers, especially the village elders. Since last year, *in situ* conservation of the rice varieties and establishment of seed-bank has been started, by cultivating these rices in pots, small plots and fields.

It was realised that to make farmers to cultivate these varieties, guarantee food security, combating climate-change and gain economic benefits, first their superiority to the hybrid varieties must be demonstrated. Then, to add economic value, the claims about special properties, end use and nutritional properties must be validated. For this, as first step the samples have been collected, then in the second step, grown in test fields and now in third step, analytical measurements and nutritional analysis will be done, so that in the fourth step, we can approach the local farmers to convince them accept these varieties once again and also create market opportunities for the same, all the while conserving and spreading rice biodiversity and maintaining an *in situ* participatory gene bank.

This year, all varieties have been planted in the three ways described above, with more farmers participating. Also, this year, plots were chosen depending on the soil type and water availability requirements of each, recorded last year. The plot experiments have been carried out in triplicates, as the monsoon this year seemed unreliable, so that at least one of the sites survives and enough seed is produced for future cultivation. The plot experiments are being continued for purity of the varieties. Here, it may be noted that rice is a self pollinating crop and thus different varieties can be cropped close to each other.

At this stage it is necessary to take analytical measurements of all the growth parameters for proper documentation and acceptance by the scientific community. Also, the special traits observed can be utilised commercially by promoting different varieties for special purposes: different rices have end use as daily cooking, papad making, fragrant rice, puffed rice etc; for medicinal uses such as anti-diabetic, treatment for anaemia, for lactating mothers, for convalescent patients etc; for disease resistances, s.a. leaf blight, midge, spots etc; additional nutritive values as high protein content, pigments, vitamins, higher mineral contents, low glycemic index and so on. All these properties need validation before promotion. Some of these are being considered in this study.

CHAPTER 2: OBJECTIVES OF PROJECT

All the varieties under analysis have been selected by farmers for cultivation immediately or preferred for their special traits and there are some claims about their nutritive values. Thus, it became important to analyse them and check the claims in scientifically acceptable manners. At the end of this study, a basic nutritional analysis of the economically and medicinally important indigenous rices from Thane district will be in hand. This information can be used to increase the acceptability and market value of these varieties. This will also serve as a heuristic study for any future, in-depth studies. Also, if this analysis is found useful and if time and resources permit, a similar screening and characterisation of all the varieties can be carried out in the future.

From analysis of all the data collected, a few varieties can be selected and promoted for cultivation. Simultaneously, pure seeds of these varieties can be collected and selective breeding for yield and trait improvement can be carried out for the future to make these economically competitive to the hybrid varieties, without any need of cross breeding. All this information and technology will be handed back to the tribal people so that they can earn a sustainable livelihood. Except for the in lab nutritional analyses, all work is and will be done in the fields of the farmers, so that they can learn seed selection and maintenance of seed purity through participative seed selection, maintain local seed banks at village levels, follow organic paddy cultivation on the lines of SRI and market the produce. It is expected that this study and its follow ups lay down a replicable pattern for any future analytical, biochemical, nutritional and medicinal characterisation of land races, in the same fashion as the germplasm conservation work of these very rice varieties has formulated.

CHAPTER 3: MATERIALS AND METHODS

This chapter gives a short description of the methods that were adopted for the characterisation of the rice varieties. The parameters studied can be clubbed into two parts,

- Analytical parameters and
- Chemical parameters.

Here is a list of all the parameters studied as a part of this project.

I. Analytical parameters

1. Panicle Characteristics

   Size, Shape, Branching and Awns

2. Grain characteristics

   Dimensions, Colours, Phenol reaction and weight

II. Nutritional or Chemical parameters

3. Proximate principles analysis
   a. Dry matter
   b. Crude Protein
   c. Crude Fat
   d. Carbohydrate
   e. Fibre
   f. Ash and Silica
4. Macronutrients

   Calcium and Phosphorous

5. Micronutrients
   a. Iron, Copper, Manganese, Magnesium, Cobalt and Zinc
6. Pigment nature
7. Cooking parameters
   a. Alkali spreading value
   b. Gelatinisation temperature
   c. Aroma

ANALYTICAL TESTS

The analytical characteristics have been identified and reported in the form described in the Guidelines published by the Government of India under the Plant variety protection guidelines for rice (PPVFRA, 2007).

These guidelines are applicable to all varieties, hybrids, parental lines of rice. These parameters are being recorded for future registration of these threatened indigenous varieties. The coding system and characteristics recording has been done in accordance to the same. Here is a list of the analytical characteristics of the rice grains, recorded in this project:

TABLE 3.I: ANALYTICAL AND MORPHOLOGICAL CHARACTERISTICS

C. No	Characteristics	States	Note	Stage of Observation	Type of Assessment
33	Panicle : length of main axis	Very short(<16 cm)	1	Dough development(spikelets becomes hard) to ripening(terminal spikelets ripened)	MS
		Short(16-20 cm)	3		
		Medium(21-25 cm)	5		
		Long(26-30 cm)	7		
		Very long(>30 cm)	9		
35	Panicle :Curvature of main axis	Straight	1	Ripening (terminal spikelets ripened)	VS
		Semi-straight	3		
		Deflexed	5		
		Dropping	7		
38	Lemma and Palea colour	Straw	1	Dough development(spikelets becomes hard) to ripening(terminal spikelets ripened)	VG
		Gold and gold	1		
		Furrows on straw background	2		
		Brown spots on straw	3		
		Brown furrows on straw	4		
		Brown (tawny)	5		
		Reddish to light purple	6		
		Purple spots	7		
		Furrows on straw	8		
		Purple black	9		
39	Panicle awns	Absent	1	ripening(terminal spikelets ripened)	VG
		Present	9		
40	Panicle : awn colour (Late observation)	Yellowish white	1	Ripening(terminal spikelets ripened)	VS
		Yellowish brown	2		
		Brown	3		
		Reddish brown	4		
		Light red	5		
		Red	6		
		Light purple	7		
		Purple	8		
		Black	9		

41	Panicle :length of longest awn	Very short	1	Ripening(terminal spikelets ripened)	VG-MS
		Short	3		
		Medium	5		
		Long	7		
		Very long	9		
43	Panicle- Presence of secondary branching	Absent	1	Ripening	VG
		Present	9		
44	Panicle :secondary branching	Weak	1	Ripening(terminal spikelets ripened)	VG
		Strong	2		
		Clustered	3		
45	Panicle :Attitude of branches	Erect	1	Ripening(terminal spikelets ripened)	VG
		Erect to semi-erect	3		
		Semi-erect	5		
		Semi-erect to spreading	7		
		Spreading	9		
46	Panicle : exertion	Partly exerted	3	Ripening(terminal spikelets ripened)	VG
		Mostly exerted	5		
		Well exerted	7		
47	Time maturity(Days)/crop period	Very early(<100 days)	1	Ripening(terminal spikelets ripened)	VG
		Early(101-120 days)	3		
		Medium(121-140 days)	5		
		Late (141-160days)	7		
		Very late (>160 days)	9		
50	Grain: weight of 1000 fully developed grains	Very low(<15 gms)	1	Caryopsis hard(can be no longer be dented by thumb nail and over 90 % spikelets ripened	MG
		Low(15-20 gms)	3		
		Medium(21-25 gms)	5		
		High(26-30 gms)	7		
		Very high(>30 gms)	9		
51	Grain: length	Very short(<6.0 mm)	1	Caryopsis hard(can be no longer be dented by thumb nail and over 90 % spikelets ripened	MS
		Short(6.1-8.5 mm)	3		
		Medium(8.6-10.5 mm)	5		
		Long(10.6-12.5 mm)	7		
		Very long(>12.5 mm)	9		
52	Grain: width	Very narrow(<2.0 mm)	1	Caryopsis hard(can be no longer be dented by thumb nail and over 90 % spikelets ripened	MS
		Narrow(<2.1-2.5 mm)	3		
		Medium(2.6-3.0 mm)	5		
		Broad(3.1-3.5 mm)	7		
		Very broad(>3.5 mm)	9		
53	Phenol Reaction	Absent	1	After harvesting	VG
		Present	9		
54	Decorticated grain : length	Short	1	Caryopsis hard(can be no longer be dented by thumb nail and over 90 % spikelets ripened	MS
		Medium	3		
		Long	5		
		Long for basmati type	7		
		Extra long	9		
55	Decorticated grain : width	Narrow(<2.0 mm)	3	Caryopsis hard(can be no longer be dented by thumb nail and over 90 % spikelets ripened	MS
		Medium(2.0-2.5 mm)	5		
		Broad(>2.5 mm)	7		

56	Decorticated grain: shape (in lateral view)	Short slender	1	Caryopsis hard(can be no longer be dented by thumb nail and over 90 % spikelets ripened	MS
		Short bold	2		
		Medium slender	3		
		Long bold	4		
		Long slender	5		
		Long slender(for basmati)	5		
		Extra long slender	6		
57	Decorticated grain : colour	White	1	Caryopsis hard(can be no longer be dented by thumb nail and over 90 % spikelets ripened	VS
		Light brown	2		
		Variegated brown	3		
		Dark brown	4		
		Light red	5		
		Red	6		
		Variegated purple	7		
		Purple	8		
		Dark purple	9		
61A	Alkali Spreading Value	Kernel not affected	1	After harvesting	MG
		Kernel swollen	2		
		Kernel swollen, collar incomplete and narrow	3		
		4. Kernel swollen, collar complete and wide	4		
		Kernel split or segmented, collar complete	5		
		Kernel dispersed, merging with collar	6		
		All kernel dispersed and intermingled	7		
61B	Gelatinisation Temperature	Low	1	After harvesting	MG
		Medium	3		
		High, medium	5		
		High	7		
62	Decorticated grain-Aroma	Absent	1	Caryopsis hard and over 90 % spikelets ripened	MG
		Present	9		

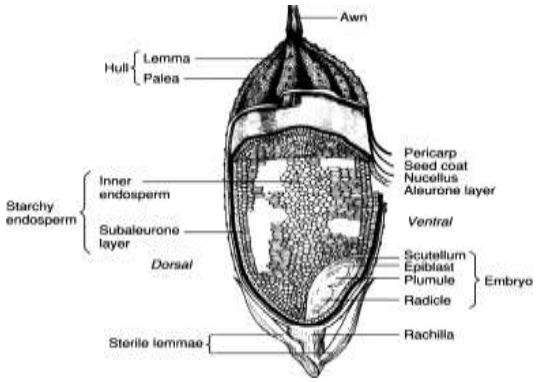

FIGURE 3.2: RICE GRAIN STRUCTURE

All the length parameters were studied on a micrometer (Mitutoyo,0–25 mm, 0.01 mm) while the longer lengths were taken using a measuring tape. For the weights, electronic balance (Cantech CB - 330) at IBB, Pune was used. Panicles and grains were collected in this harvest season. Wherever decorticated grains were used, de-husking was done using a mortar and pestle or with hands and unbroken grains were used.

The following experiments define the procedures for the other characterstics.

Phenol reaction of lemma

Grains were soaked in 1.5 % aqueous phenol solution for 24 hours in test tubes, drained and air-dried. Hull colour was then recorded unstained and stained (T.T & Bardenas, 1965). Presence of phenol reaction means change in the colour of the hull of the rice grain.

Gelatinization temperature

This was estimated through alkali spreading and clearing test (Little, Hilder, & Dawson, 1958) Duplicate sets of whole milled grains were spaced evenly in transparent plastic box containing 1.7 % KOH. The dishes were kept at 27- 30°C for 23 hours undisturbed in an incubator. The spreading of kernels noted on a 7 point scale was expressed as average two. Scoring is done as mentioned in Table 3.I.

Aroma

15 ml of water was added to 5g of rice sample in a tube, soaked for 10 minutes. Then it was cooked in the water bath for 15 minutes and cooled. After cooling it was kept it in the refrigerator for 20 minutes. Then it was opened and the contents were smelled. The samples possessing the scent, as one could easily feel, produce a sharp and readily recognizable aroma. (Singh, Singh, & Khush, 2000)

SS : Strongly Scented
MS : Mild Scented
NS : Non Scented

NUTRITIONAL TESTS

This section contains proximate analysis, a general characterisation analysis of any food material to give a fair idea of the nutrient contents of the varieties. Also, some important macro and micro minerals were also estimated.

PROXIMATE ANALYSIS

a. Dry matter percentage

Dry matter is one of the parameters of proximate analysis. This is estimated as the moisture content between samples can vary and all further experiments are done using this weight or dry samples obtained in this. After estimating dry matter content, sample is ground finely for further analysis.

Principle:

Dry matter is calculated by weighing after drying to a constant weight in an oven at high temperatures. The samples are initially dried by normal procedures, weighed and then dried in the oven. The difference in weight is also an indicator of moisture content.

Apparatus:

Tray – Aluminium / enamel coated

Balance – digital, calibrated

Oven – 70-80 °C for 12 h

Procedure:

Weigh the tray (W), Tray + sample (W1) and Tray + dried sample (W2)

Dry matter % = (W2-W) ×100/ (W1-W)

b. Crude Protein estimation by Macro Kjeldahl method

Kjeldahl method is the most reliable method for protein estimation; protein content is determined by first determining nitrogen content and multiplying the percent nitrogen by the suitable factor (**5.95** for rice). This factor is a reflection of the average nitrogen content in rice proteins.

Principle:

The nitrogen is determined by digesting the sample in conc. sulphuric acid at high temperature with catalyst to convert it into ammonium sulphate. On steam distillation

with NAOH, this yields ammonia which is collected in boric acid. Ammonium borate formed is titrated with standard hydrochloric acid.

Apparatus:

1. Macro Kjeldahl digestion unit
2. Macro Kjeldahl distillation unit
3. Digestion tubes/ flasks
4. Measuring cylinders
5. Volumetric flasks

Reagents:

1. Sulphuric acid, SP. Gr. 1.84, Nitrogen free
2. Digestion Mixture – 10 g K_2SO_4 and 1 g $CuSO_4$ (9:1, wt by wt)
3. Sodium Hydroxide Solution – Dissolve 450 g NaOH in 1000 ml distilled water.
4. Standard Hydrochloric acid solution – 0.02 N.
5. Alternatively, dissolve 200 g Boric acid, 0.05 g Bromocresol green and 0.035 g methyl red in 5 litre of water

Procedure:

1. Take 0.5 g of ground sample + 5 g Digestion mixture + 20 ml conc. H_2SO_4 in Kjeldahl flask.
2. Heat below BP till frothing stops. Boil at 350 °C for about 2 h till the solution becomes clear.
3. Transfer the clear digested solution into distillation apparatus, quantitatively, using about 50 ml water.
4. Add sodium hydroxide to make it alkaline – add slowly, to form a layer beneath the acid.
5. In a conical flask, take 20 ml boric acid solution and place it beneath the condenser with delivery tip immersed
6. Steam distillate the digest – green colour is formed in the conical flask.
7. Carry out titration with HCl. (R1 ml)
8. Run a blank control. (B1 ml)

% N = (R1 – B1) × N (HCl) × 14 × 100 / mg sample

% protein = % N ×Factor (= **5.95** for rice)

c. Ether Extract / Crude Oil content

Ether Extract contains not only the oils, fats but also other substances such as pigments which are soluble in non-polar solvents. In rice, waxy character is an important desirability criterion.

Principle:

The oil is extracted by the non-polar, in this case hexane by repeated extraction procedure. This is then dried and weighed to give % oil content of the sample.

Apparatus:

1. Soxhlet Extraction assembly
2. Whatman Filter paper
3. Non absorbent cotton
4. Volumetric flasks
5. Distillation unit, heating mantle.
6. Oven

Reagents:

1. Hexane

Procedure

1. Fold the filter paper into a packet to hold the material (0.5 – 1 g)
2. Put this into the extractor of the Soxhlet apparatus with some cotton at the bottom. A piece is put at top to allow even dripping of solvent.
3. Add organic solvent, two and half times the capacity of the extractor, extract for 6-7 h, collect solvent in a flask, W.
4. Distil or oven-dry the solvent, to remove all solvent and moisture.
5. Weigh, W1

Ether extract % = (W1 - W)×100 / Mass of sample

d. Estimation of Crude Fibre:

Crude fibre is mainly cellulose and lignin (97%) plus minerals. This is an important dietary parameter, as it adds to the roughage value. Also, this parameter defines the smoothness and ease of eating. In speciality rices lower fibre content is also favoured.

Principle:

It is estimated by treating the sample first with acid and subsequently with alkali. Oxidative hydrolytic degradation of the native cellulose and lignin occur. The residue obtained after final filtration is weighed, incinerated, cooled and weighed again. The loss in weight gives crude fibre content.

Apparatus:

1. Extracting apparatus
2. Hot plate
3. Oven
4. Muffle Furnace
5. Beakers
6. Dessicator
7. Filtering Device
8. Filtering cloth (muslin, so solid should pass through)

Reagents:

1. Sulphuric acid solution (0.225 N) containing 1.25 g H_2SO_4 per 100 ml. Or 25 ml of 10% H_2SO_4 concentrated and 175 ml H_2O.
2. Sodium Hydroxide solution (0.313 N) similar to above, free from Na_2CO_3.
3. Ethyl alcohol
4. Petroleum ether

Procedure:

1. Take 0.5 g sample in a beaker. To remove fat, extract with petroleum ether. This can be bypassed if sample has less than 1 % fat content.
2. Add 200 ml boiling H_2SO_4 solution, immediately connect digestion flask to condenser and heat. (Contents of flask must come to boiling within a minute and boiling should continue for 30 min minimum. Rotate to wet sample thoroughly)
3. Filter through muslin cloth and give hot water wash till washings are not acidic (can be tested with $BaCl_2$)
4. Boil with 200 ml NaOH solution. Connect to reflux condenser, boil for 30 min. Rotate till sample is wetted.
5. Remove flask and filter. Wash the residue with boiling water and transfer to crucible.

6. Keep sample overnight for drying. Take wet weight W1
7. Dry at 600 °C in Muffle Furnace for 3 hours.
8. Take weight of the ash, W2.

Crude fibre % = (W1 –W2) ×100 / Sample weight

e. Ash and Silica content:

The residue of incineration at 600°C is called crude ash. When this is boiled with strong acid and incinerated again, the residue gives the silica content.

Apparatus:

1. Crucible
2. Muffle furnace
3. Hot plate
4. Whatman filter paper
5. Beakers

Reagents:

1. 5 ml Concentrated HCl + 5 drops concentrated HNO_3
2. Distilled water

Procedure:

1. Take 0.5 g sample in a silica crucible
2. Incinerate in a muffle furnace at 600°C for 3 h.

Weight of crucible, W1

Weight of crucible + sample, W2

Weight of crucible + ash, W3

% Ash = (W3-W1) × 100 / (W2-W1)

3. Add acid mixture to the ash
4. Boil on a hot plate; add water in between to reduce fumes.
5. Filter the residue using a Whatman filter paper No. 1 or 42
6. Put the filter paper into a crucible.
7. Again, incinerate in muffle furnace at 600°C till no traces of the paper remain.
8. Weigh the crucible with residue, W4

% silica = (W3-W4) × 100 / (W2 – W1)

MINERAL ANALYSIS

Food grains are a major source of minerals. In areas where staple food is rice, it becomes necessary that it should be rich in minerals to satisfy the body's needs. The minerals, Calcium and Phosphorous are important in the total metabolic processed of each cell in the body and are considered amongst macronutrients ass they are generally found in higher concentration. Other minerals referred to as micronutrients, as they are found in much lower concentrations are important in the total metabolic processed of each cell in the body as they act as cofactors of many enzymes and chelating agents in many proteins.

Principle:

For macronutrient analysis, the sample is first incinerated, boiled in acid and the filtrate is tested using atomic absorption spectroscopy.

Apparatus:

1. Fume hood
2. Hot plate or micro digestion bench
3. Micro digestion flask
4. Glass funnel

Reagents:

1. Digestion acid – 1 part perchloric acid (60-62%) to 4 parts nitric acid (69-71%)
2. Standard solutions of minerals

Procedure:

1. Weigh a gram of sample into a Kjeldahl digestion flask, add 20 ml digestion acid. Keep overnight.
2. Increase temperature of digestion bench to 180° to 200°C.
3. Dissolve completely, evaporate all acid.
4. Cool, filter; make up volume to 50 ml.
5. Using AAS, create a graph of concentration versus absorption for the mineral being studied.
6. Find concentration of mineral in sample.
7. Calculate amount in the sample, express it as amount per 100g or ppm.

COOKING PARAMETERS

The three cooking parameters have been already referred to in the analytical measurements table, as they are part of the same guidelines.

SECONDARY METABOLITES

The test for pigments, including carotenoids extraction and Polyphenols was initially planned as an attempt to deduce the nature of the pigments of the red rices. But it was realised that not enough literature survey was done and this also needs standardisation of few protocols and standards for cross comparison. Instead, simple extraction was done to deduce basic hydrophobic – hydrophilic nature of the pigments.

For extraction, quick carotenoids estimation protocol (Schaub, Beyer, Islam, & Rocheford, 2004)was adopted in which pigments are separated into a water-ethanol (hydrophilic) phase or petroleum ether – diethyl ether (hydrophobic) phase. This is a crude estimate of the nature of the pigment.

Materials

Grinding mill, 15 ml Falcon tubes, water bath, TLC Plates, TLC Tank, calibration filter, centrifuge, photometer

Chemicals

Diethyl ether, petroleum benzene (40-60C-fraction), Ethanol, Ascorbic Acid, water

Methods

1. Grind seeds to a very fine powder.
2. Weigh 0.5 g to a 15ml blue cap plastic tube (Falcon tube).
3. Add 6ml ethanol to every sample and mix the sample by vortexing. Add Ascorbic acid as an antioxidant.
4. Incubate the samples at 85°C in a water bath for 6 minutes; mix the sample after 3 minutes by vortexing for 10 seconds. (Make sure that the cap is not tightly closed during heating; close tightly when vortexing)
5. Add 120 µl KOH (1g/ml H_2O, prepare fresh daily) and vortex thoroughly for 20 seconds.
6. Saponification: Incubate the samples for 5 minutes at 85°C, vortex for 10 seconds and incubate another 5 minutes at 85°C.
7. Cool down samples on ice. Add 4ml H_2O.
8. Add 3ml PE: DE (2+1, v/v).

9. Mix sample by shaking or vortexing and centrifuge for 10 minutes at 1400 x g. A phase separation will be visible.
10. Transfer upper phase to a fresh tube.
11. Repeat step 8 to 10 another 2 times. Combine the organic epiphases in the new tubes introduced in 10.
12. Visually inspect whether the extract is coloured or the lower phase.
13. A yellow coloured extract denotes presence of carotenoids pigments while a transparent hydrophobic extract rules them out. Dark coloured aqueous ethanol extracts point to presence of some hydrophilic pigments which might be anthocyanins.

LABS

The entire nutritional analysis was done at the Animal Nutrition lab, CRS - BAIF, Uralikanchan. The cooking parameters and secondary metabolites were estimated at iBB, Pune. The other readings were either taken at Jawhar or at a suitable workbench in Pune. The materials required for nutritional analysis were available in the Animal Nutrition lab; such tests are routinely carried out there for feed samples. The chemicals required for the other tests are regular lab chemicals, available in the stores at iBB, and were procured from the labs there.

CHAPTER 4: RESULTS AND DISCUSSIONS

During this entire study, 17 different rice varieties were studied in all. Of these, 12 were indigenous threatened rice cultivars cultivated at test centres in Jawhar, Thane District, one was from Dahisar region, one from Gujarat and three standards varieties were used for controls. These were Ratna and Suvarna, both grown widely in the test region. The third was packaged Kohinoor Basmati rice brought from a local grocery market in Pune. Due to IPR issues, the varieties have been referred to by their land race coding numbers.

TABLE 4.II: LIST OF VARIETIES UNDER STUDY

Sr. No	LRC No	Accession Code	Property	Land Type	Crop Period
1	3	MSLA_JWR			Very early
2	6	SAG_WDA			
3	8	DNGI_W_JWR			Very early
4	14	KLKDI_VKRD	Red		
5	15	DNGI_R_JWR	Red		Very early
6	41	SRTKLM_WDA			Early
7	49	RJGDA_JWR			Very early
8	50	SDDGRI_JWR			Medium
9	67	KASBI_JWR			Medium
10	72	MHDIL_KJT	Red		Very early
11	79	BGLY_JWR			Medium
12	80	MASR_JWR			Medium
13	C_1	RTNA_JWR	Ratna		
14	C_2	SVRNA_JWR	Suvarna		
15	131	RATT_Dhisr	Red		
16	G_1	Gujrat_brown	Red		Very Early
17	B_1	BSMTI_K	Basmati		

The analytical characteristics were studied for the first 12 varieties. For other varieties, since the samples weren't procured from the fields personally, panicles weren't collected and for controls Suvarna and Basmati, rice grains were procured, ruling out study of grain characteristics. Nutritional analysis and cooking parameters were studied for all the 17 varieties. Pigment analysis was done for the red rices only with suitable standards.

FIGURE 4.3: LRC 3, MSLA_JWR

FIGURE 4.4: LRC 6, SAG_WDA

FIGURE 4.5: LRC 8, DNGI_W_JWR

FIGURE 4.6: LRC 14, KLKDI_VKRD

FIGURE 4.7: LRC 15, DNGI_R_JWR

FIGURE 4.8: LRC 41, SRTKLM_WDA

FIGURE 4.9: LRC 49, RJGDA_JWR

FIGURE 4.10: LRC 50, SDDGRI_JWR

FIGURE 4.11: LRC 67, KASBI_JWR

FIGURE 4.12: LRC 72, MHDIL_KJT

FIGURE 4.13: LRC 79, BGLY_JWR

FIGURE 4.14: LRC 80, MASR_JWR AND C_1, RTNA_JWR

FIGURE 4.15: LRC 131, RATT_DHISR AND G_1, GUJRAT_BROWN

ANALYTICAL PARAMETERS

TABLE 4.III: ANALYTICAL PARAMETERS, PANICLE

	Panicle			Awns			Panicle Secondary Branching				
	33	**35**	**38**	**39**	**40**	**41**	**43**	**44**	**45**	**46**	**49**
Acc code	**Length**	**Curvature**	**Lemma colour**	**Awns**	**Colour**	**Length**	**Branching**	**Type**	**Attitude**	**Exertion**	**Sterile lemma colour**
3	Medium	Semi-straight	Reddish to light Purple	Absent	NA	NA	Present	Weak	Semi-erect	Well Exerted	Straw
6	Very long	Dropping	Purple spots/ furrows on Straw	Present	Black	Medium	Present	Clustered	Spreading	Well Exerted	Gold
8	Long	Dropping	Brown furrows on Straw	Present	Yellow-White	Short	Present	Clustered	Spreading	Well Exerted	Straw
14	Medium	Semi-straight	Black	Absent	NA	NA	Present	Weak	Semi-erect	Mostly exerted	Purple
15	Very long	Dropping	Brown (tawny)	Absent	NA	NA	Present	Clustered	Semi-erect to spreading	Well Exerted	Straw
41	Very long	Dropping	Gold and Gold furrows on Straw	Absent	NA	NA	Present	Clustered	Spreading	Mostly exerted	Straw
49	Medium	Deflexed	Gold and Gold furrows on Straw	Absent	NA	NA	Present	Clustered	Spreading	Well Exerted	Straw
50	Long	Dropping	Straw	Absent	NA	NA	Present	Clustered	Semi-erect to spreading	Mostly exerted	Straw
67	Very long	Dropping	Gold and Gold furrows on Straw	Absent	NA	NA	Present	Clustered	Semi-erect	Mostly exerted	Gold
72	Medium	Straight	Brown furrows on Straw	Absent	NA	NA	Present	Weak	Erect to Semi-erect	Mostly exerted	Straw
79	Very long	Dropping	Gold and Gold furrows on Straw	Absent	NA	NA	Present	Weak	Spreading	Well Exerted	Straw
80			Gold and Gold furrows on Straw	Absent	NA	NA					Straw
C_1			Gold and Gold furrows on Straw	Absent	NA	NA					Straw
C_2											
131			Brown Spots on Straw	Present	Yellow-brown	Short					Straw
G_1			Gold and Gold furrows on Straw	Present	Yellow-brown	Medium					Straw
B_1											

The panicles for LRC C_1, C_2, 131, G_1 and B_1 weren't available. These characteristics are important for on-field differentiating between cultivars of rice.

TABLE 4.IV: ANALYTICAL PARAMETERS, GRAIN

	Grain				Decorticated Grain			
	50	**51**	**52**	**53**	**54**	**55**	**56**	**57**
Acc code	**Weight (1000 grains)**	**Length**	**Width**	**Phenol Reaction**	**Length**	**Width**	**Shape**	**Colour**
3	Low	Short	Medium	Present	Medium	Medium	Short Bold	White
6	Very High	Medium	Very broad	Present	Long	Broad	Long Slender	White
8	Medium	Medium	Medium	Present	Long	Medium	Long Slender	White
14				Present				
15				Present				Red
41	very low	Short	Narrow	Present	Medium	Narrow	Short slender	White
49	Low	Medium	Narrow	Present	Long	Medium	Long Slender	White
50	Very High	Medium	Broad	Absent	Long	Broad	Long Slender	White
67	Very High	Long	Medium	Present	Long	Broad	Extra long slender	White
72	High	Medium	Broad	Present	Long	Broad	Long Slender	Dark Brown
79	Very low	Short	Narrow	Absent	Medium	Medium	Short Bold	White
80	Low	Long	Medium	Absent	Long	Medium	Long Slender	Light Brown
C_1	Medium	Long	Narrow	Present	Long	Medium	Long Slender	Light Brown
C_2								White
131	Medium	Medium	Broad	Absent	Long	Broad	Long Slender	Red
G_1	High	Medium	Broad	Present	Medium	Broad	Short Bold	Dark Brown
B_1								

For the numerical values of these parameters, please refer to Appendix 1(Table IX: Numerical Values of Analytical Parameters).

This data characterises the varieties with respect to the grains. These characteristics are desirable from cooking point of view. The shape size and colour of the grains are few of the parameters which determine the end use and price of the rice. Some varieties have a high weight and this is important when considering yields. The red and brown coloured rices are generically referred to as red rices. These are the colour of the seed coats. When sold in market, during polishing, the seed coat is removed (the rice bran) and this leads to the loss of various secondary metabolites like pigments and vitamins present in the seed coat. The coloured rices are reported to have anthocyanins and polyphenols. Please refer to Secondary metabolites section of results.

NUTRITIONAL PARAMETERS

Nutritional tests which give an overall idea of the nutritive value of the rices were performed. In these, estimation of various parameters was done. As this is the first such test being done on these varieties, after interpreting the results of this screening, if necessary, specific assays can be done.

While a balanced diet consists of all the nutrients, viz., carbohydrates, protein, oils and fats, mineral and vitamins in a right proportion as per the need of the body. Cereals are good protein and energy sources but diets based on cereal and pulses are deficient in one or the other nutrition (Johari, Singh, Srivastava, Gupta, & Lodha, 2000). Protein-calorie malnutrition is a wide spread problem in the developing countries. The indigenous agricultural and cultural practises followed in these regions have recently been trodden down by one-point agenda of higher yields using hybrids which were not always nutritionally superior to the locally cultivated low yielding varieties. So, to focus on nutritional security, this analysis is important.

For these tests, two varieties, cultivated widely in the region were taken as controls and packaged Basmati obtained from local grocery store was the third variety used for comparison. The standard values were taken from Encyclopedia of Food Sciences and Nutrition (Juliano, 2003) and (Oelke & Boedicker, 1991)

TABLE 4.V: REPORTED VALUES

Parameter	Value	units
Dry Matter	86	%
Crude Protein	7.1 - 8.3	%
Crude Fat	1.6 - 2.8	%
Fibre	0.6 - 1.0	%
Ash	1.0 - 1.5	%
Calcium	0.01 - 0.05	%
Phosphorus	0.22	%
Magnesium	0.12	%
Copper	4 – 7	ppm
Iron	10 – 17	ppm
Zinc	24	ppm

The obtained values have been compared to these standards and controls used. In most parameters, higher is better but in parameters like Fibre, a lower fibre content might be more desirable for speciality rice varieties. These values are for as reported for Brown rice.

TABLE 4.VI: PROXIMATE ANALYSIS

LRC No	83	84.00	85	86	87	88
	DM	CPr	CF	F	A	Si
	%	%	%	%	%	%
3	90	9.31	2.85	0.89	0.71	0.07
6	90.76	6.69	2.48	0.85	1.15	0.2
8	95.54	8.22	3.26	0.87	0.66	0.02
14	92.22	6.59	2.13	0.77	0.9	0.27
15	93.05	7.68	2.58	0.69	1.13	0.2
41	92.41	6.64	1.97	0.52	0.73	0.25
49	90.17	6.96	2.39	0.17	0.7	0.16
50	87.33	7.43	2.63	0.06	1.08	0.36
67	91.62	6.85	1.49	0.77	0.76	0.25
72	90.3	7.54	1.09	1.43	1.26	0.41
79	95.64	5.80	3.17	0.72	0.9	0.09
80	91.35	5.36	2.31	1.15	0.85	---
C_1	91.78	6.25	2.13	0.11	1.03	0.31
C_2	88.88	7.70	1.42	0.3	1.09	0.21
131	89.69	7.79	3.54	0.23	1.45	0.2
G_1	92.36	9.75	3.27	0.65	1.45	0.085
B_1	96.96	9.57	1.93	0.77	0.46	0.02

TABLE 4.VII: MINERAL ANALYSIS

LRC No	89	90	91	92	93	94	95	96
	Ca	P	Mg	Cu	Fe	Zn	Mn	Co
	%	%	%	ppm	ppm	ppm	ppm	ppm
3	0.12	0.16	---	---	---	---	---	---
6	0.1	0.14	0.112	2.7	87	34.4	b.l.	b.l.
8	0.12	0.08	0.07	1.39	40	51.1	b.l.	b.l.
14	0.14	0.18	0.1	1.1	49	41.5	b.l.	b.l.
15	0.13	0.1	0.08	1.38	46	62.2	b.l.	b.l.
41	0.11	0.19	---	---	---	---	---	---
49	0.16	0.24	0.105	2.47	134	34.6	b.l.	b.l.
50	0.11	0.14	0.117	3.18	101	83.9	b.l.	b.l.
67	0.11	0.15	0.11	3.1	75	56	b.l.	b.l.
72	0.13	0.23	0.123	2.29	72	38.5	b.l.	b.l.
79	0.16	0.11	0.09	1.42	54	53.1	b.l.	b.l.
80	0.1	0.12	---	---	---	---	---	---
C_1	0.1	0.11	0.121	2.43	230	60.72	b.l.	b.l.
C_2	0.1	0.15	0.12	1.1	77	32.2	b.l.	b.l.
131	0.12	0.18	0.14	1.1	71	41.1	b.l.	b.l.
G_1	0.17	0.2	0.15	0.7	83	93.3	b.l.	b.l.
B_1	0.1	0.09	0.06	0.9	59	47	b.l.	b.l.

b.l. = below detection limit of instrument

To further stress on the differences and compare them visually, following graphs have been plotted. The bold lines across the graphs represent the reported values or their ranges, the bars coloured blue are the test varieties, red ones are the red rices amongst the test varieties, green bars represent the controls.

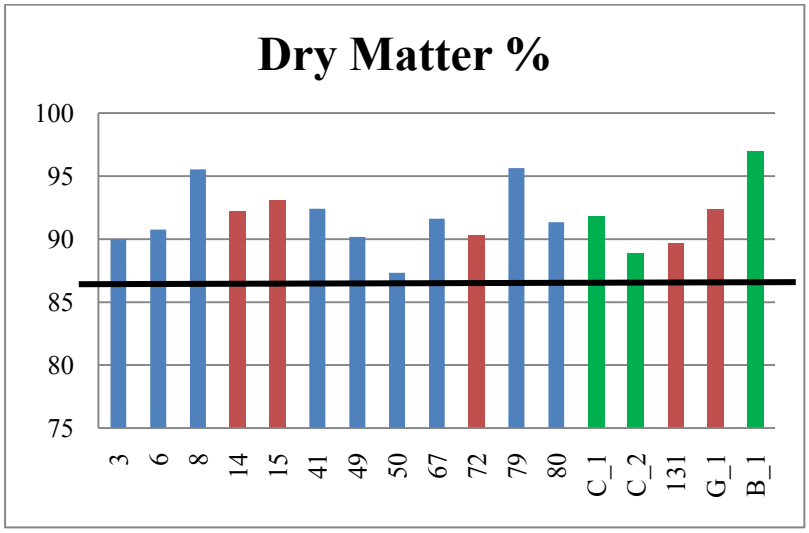

FIGURE 4.16: DRY MATTER PERCENTAGE

As can be seen, most samples have much less moisture than typical samples brought to the laboratory, but this is due to better drying and storage of the samples in the time between harvesting and storage. Ideal storage requires no more than 12 % of moisture in grains.

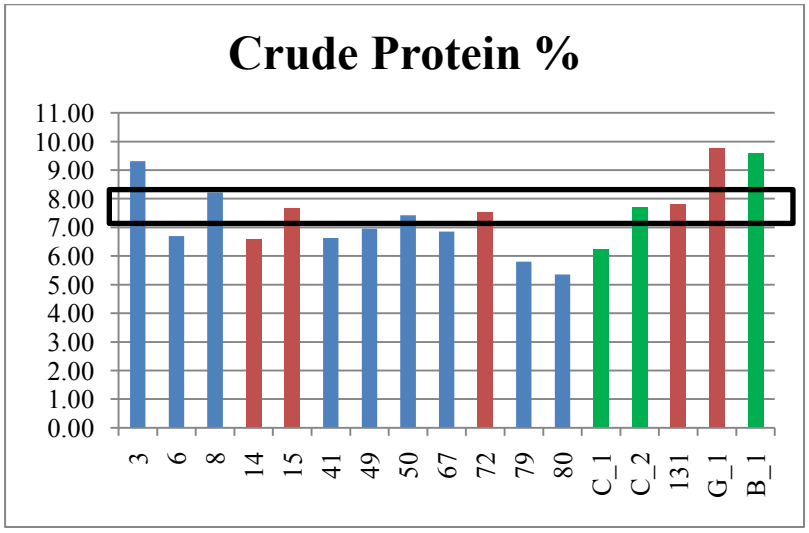

FIGURE 4.17: CRUDE PROTEIN CONTENT

Crude protein is just an estimate from total nitrogen that was present in the sample. The conversion factor of 5.95 for converting nitrogen to protein was used as has been reported in earlier studies on a local rice variety in south India (Deepa, Singh, &

Naidu, 2008). This has also been reported as the standard conversion factor for rice in ICAR publication (Johari, Singh, Srivastava, Gupta, & Lodha, 2000).

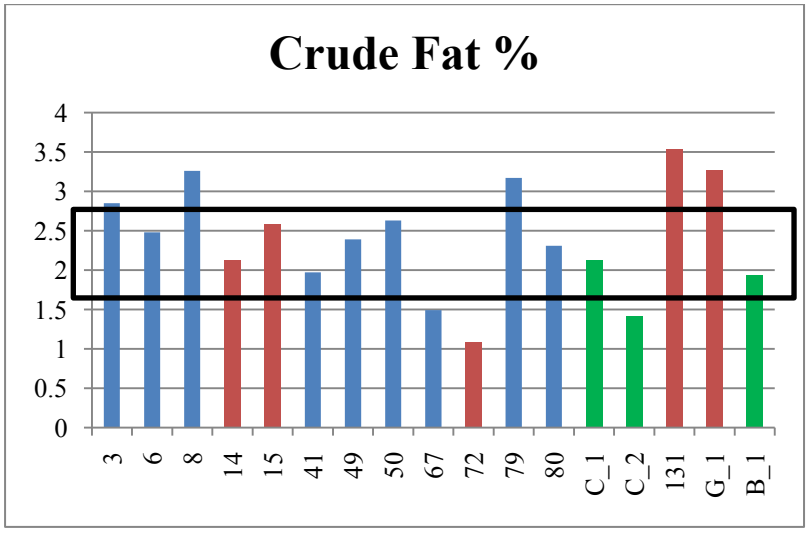

FIGURE 4.18: CRUDE FAT CONTENT

Crude fat content or ether extract is the sum total of all hydrophobic compounds in the grains. It can be seen that LRC 131, G_1, 79 and 8 are exceptionally higher in their oil content. Initially it was postulated that this might be due to leaching of the pigments in the red rices, but as was seen later the pigments are water soluble in nature. So, it is indeed the fat content of these varieties that is higher.

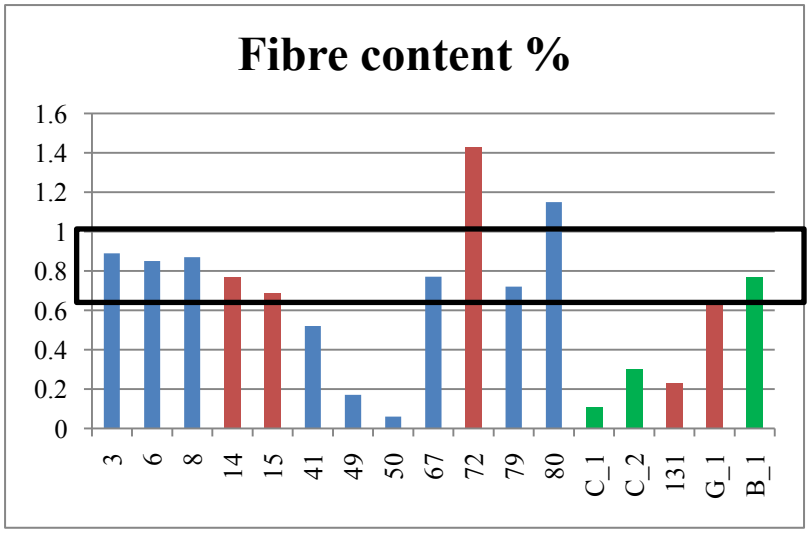

FIGURE 4.19: FIBRE CONTENT

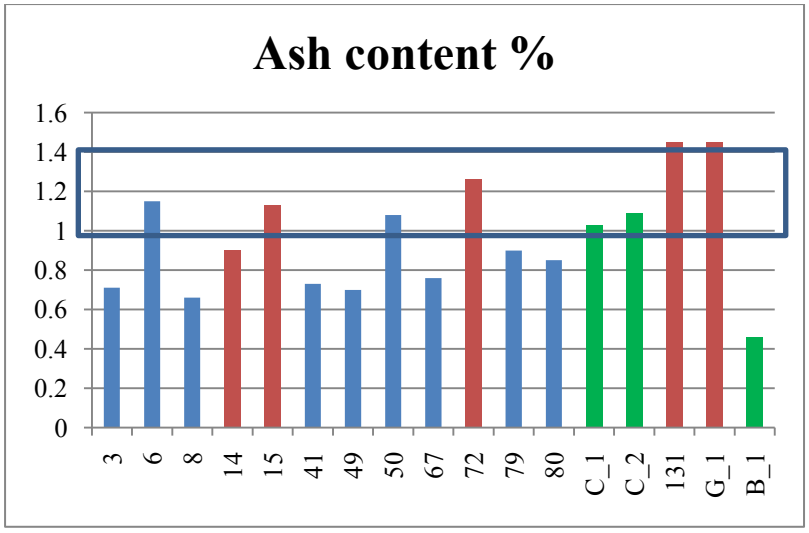

FIGURE 4.20: ASH CONTENT

This assumes significance from nutritional point of view as higher protein and fat content means higher energy content. Contrast this to the controls and it can be seen that most of the native varieties are indeed better than hybrids when it comes to the energy gained from eating the same amount of rice, a thing also noticed by elders in village communities. Especially, with respect to Sorghum this has been claimed by many farmers and village families. May be there is a need to re-evaluate the agricultural policy from higher yield to better nutrition.

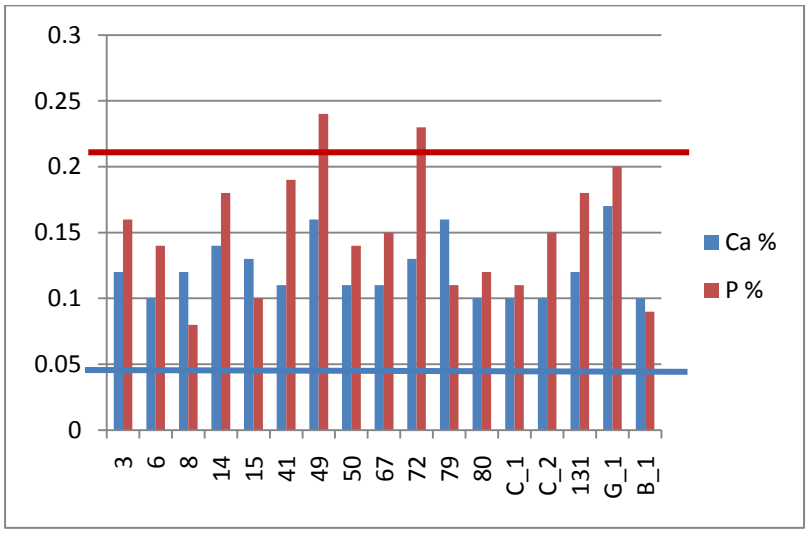

FIGURE 4.21: MACRONUTRIENT CONTENT

The average calcium concentration of the local varieties is more than that of controls and reported standard, though phosphorus is low.

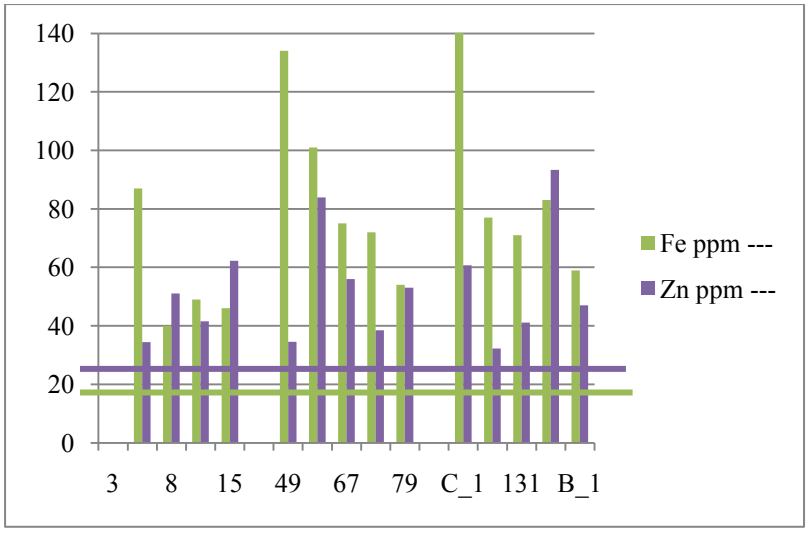

FIGURE 4.22: MICRONUTRIENTS

As can be seen, all these varieties are richer than the international recorded values for most micronutrients. One reason might be the nature of the soil of Jawhar (though this doesn't apply to Basmati rice) or the cultivation practises followed in this experiment. But to speak any further on this, more trials are needed in the coming seasons.

PIGMENT NATURE

In the red rice varieties, through literature survey, it was postulated that anthocyanins will be the major pigments present. Also, since these were water miscible and it was claimed that they are also antioxidants, polyphenols were to be checked. Also, carotenoids were being checked by wishful thinking, as screening for carotenoids in such rices has never been done.

Since this was the first screening, instead of estimating the pigment and determining their structure, importance was given to deduce the type. After performing extraction as detailed for carotenoids, it was noticed that no colouration was picked up by the hydrophobic phase, but all was retained in the alcohol – water phase, where the anthocyanins are reported to partition. This happened with all the five red rice varieties that were tested, while with corn that was used as a positive control for carotenoids, the hydrophobic phase picked up a clear yellow tint. So, it can be said that the red colouration is due to Anthocyanins with some antioxidant activity, but this will need to be further proved conclusively by performing standard purification and estimation assays with reference samples for comparison.

COOKING PARAMETERS

These parameters are necessary as the rice being a major food crop with wide diversity is chosen by the customers for its taste, aroma and cooking quality.

So, a few parameters were studied as outlined in the DUS guidelines (PPVFRA, 2007) and the results are tabulated here.

TABLE 4.VIII: COOKING PARAMETERS

LRC No	61A	61B	62
	ASV	**GT**	**DGA**
3	Kernel swollen	High	Present
6	Kernel swollen	High	Present
8	Kernel not affected	High	Absent
14	Kernel not affected	High	Absent
15	Kernel not affected	High	Absent
41	Kernel not affected	High	Present
49	Kernel not affected	High	Present
50	Kernel swollen	High	Present
67	Kernel swollen	High	Present
72	Kernel swollen	High	Absent
79	Kernel swollen	High	Present
80	Kernel swollen	High	Present
C_1	Kernel not affected	High	Absent
C_2	Kernel swollen	High	Absent
131	Kernel not affected	High	Absent
G_1	Kernel swollen	High	Absent
B_1	Kernel split or segmented, collar complete	Medium	Present

The first parameter is just a chemical mean to estimate the second parameter, gelatinisation temperature, an indicator of the cooking time required and as compared to the controls, it can be said that most varieties have an average cooking time. Another observation that was made during this experiment was that only four rices were very sticky after cooking, these being LRC 15, 50, 72 and 80. Thus, all other rices can be

accepted by housewives who are already used to the hybrid rices. Of these four rices, two, LRC 50 and 72 have been claimed to be good for porridges.

The third parameter, cooked rice aroma, is an important characteristic when market value of the rice variety is decided. It is a desired characteristic and along with other nutritional data, can be used to get a higher selling price.

Most of the data generated through lab analysis in this section is seconded by experiences of tribals and farmers in the Jawhar region from where these varieties have been collected. So, in truth, this study just documents their observation using a scientifically acceptable protocol.

CHAPTER 5: CONCLUSIONS

The major objective of this project, to establish a database of nutritive and analytical characteristic of some important indigenous rice varieties from Thane district has been achieved. Also, a few of the claims by the local people, with respect to medicinal properties of these varieties are now seconded by initial chemical analysis. For example, varieties numbered LRC 72, LRC 49 and LRC 14 are said to be good for recovery from weakness and it was found that these are rich in calcium and phosphorous.

Similarly, a few varieties were found to be high in protein content as has been depicted in graph above. So, now that the protein and fat rich varieties can be identified, in future breeding and selection, these varieties can be selected to improve these traits. Aromatic rices have been established through test standard protocol. In future, work can be done for identification of the aromatic molecule, the genes responsible etc.

This chemical analysis will also help in better marketing of these varieties. Now, in the fat rich varieties, if fatty acid profiling is done, it can be further promoted as a healthy food if important fatty acids are detected. Similarly for protein rich varieties, if they are found to be rich in essential amino acids, they can be promoted as health foods and substitute for health tonics. This data can also be used to establish the superiority of the brown rices, i.e., rice with bran with respect to polished rices.

Similarly, there is a want of more work on these varieties at a genetic and molecular level in near future to identify the specific desired trait loci and molecules responsible for the same. This will help in selective breeding and improvement of the same varieties.

Another follow up will be testing of the soil, straw and grain nutrient contents together to estimate the uptake and assimilation of various nutrients into different plant tissues. This is especially necessary in view of the above range data for iron and high variability in other nutrients.

The scope of this work, though limited, the methodologies can be extended to characterisation and conservation of all indigenous germplasms, including rice, wheat, pulses, sorghum, millets, and vegetables. This type of work in the lab should go hand in hand with field based experimentation and conservation activities to fairly estimate the nutritive value of the food materials and also to open new avenues for marketing into national and international markets. This is important for the nutritional security, a need

much greater than food security today. Further, if cultivated organically, these nutritive varieties can be promoted as real health food.

At the end, i would like to comment on the very reasons this project, from the conservation to nutritional analysis has been started. In the current age of climate change and seed companies' monopolisation, there is an urgent need to conserve whatever little germplasms that are still protected in the pockets around this country. Today, research institutes are after genetically modifying the crops to get traits that they don't even know might exist naturally in the same plant. Examples are BT Brinjal, salt tolerant rices, pigmented rices, iron rich food varieties and so on. So, the real need is to scientifically catalogue and conserve the existing diversity and traits of interest and try through socially more acceptable means of breeding to increase the expression of the phenotypes. Like, is it really necessary to spend millions of dollars and decades to develop a transgenic crop which is not acceptable in half the world? Doesn't it make more sense, than to make one super-crop, which if fails will lead to famines, try to provide a balanced diet? Is there really a need to provide Vitamin A through a GM rice variety because rice is the staple crop when efforts can be made to elevate poor people and provide them another crop, say some vegetables? At question is the direction of research and development followed today, under the influence of western capitalist seed companies which is blindly followed by the authorities in developing countries under some pressure or the other.

To bring about conservation of the indigenous food crops to improve and protect agriculture and farmers' condition in the backward nations, research, conservation, advocacy, activism, constructive work, forward and backward market linkages, social acceptance and a lot more will need to be done simultaneously. This thesis is one step in the research field of this matter.

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APPENDIX

APPENDIX 1

TABLE IX: NUMERICAL VALUES OF ANALYTICAL PARAMETERS

	33	**50**	**51**	**52**	**54**	**55**	**56**	**57**	**47**
	m(cm)	m (g)	m (cm)	M (cm)	m (cm)	m(cm)	v	v	
LRC No.	length	weight (1000grains)	length	width	length	width	shape	colour	Crop period
3	20.4	15.57	7.04	2.53	4.93	2.29	Short Bold	White	81
6	31.6	31.69	9.87	3.69	7.24	2.96	Long Slender	White	
8	29.6	24.33	8.79	2.92	6.35	2.50	Long Slender	White	78
14	21.7								
15	30.6							Red	78
41	32.6	12.17	7.59	2.05	5.43	1.79	Short slender	White	100
49	24.2	18.15	9.18	2.38	6.25	2.09	Long Slender	White	90
50	28.6	30.87	8.95	3.34	6.35	2.74	Long Slender	White	130
67	36.7	30.36	10.86	2.88	7.82	2.56	Extra long slender	White	123
72	23.7	27.61	10.25	3.33	6.35	2.84	Long Slender	Dark Brown	84
79	31.6	14.50	6.56	2.50	4.72	2.14	Short Bold	White	135
80		18.60						Light Brown	120
C_1		20.25	10.77	2.36	6.24	2.11	Long Slender	Light Brown	
C_2								White	
131		22.42	9.13	3.26	6.15	2.69	Long Slender	Red	
G_1		26.15	8.63	3.28	5.91	2.74	Short Bold	Dark Brown	60
B_1									