9 Quality Characteristics of Indian Wheat

S. Nagarajan

After rice, wheat is the most important cereal in India. It is grown in cooler regions of India during the mild winter months of November to mid-April. Nearly 26 million hectares (mio ha) are sown with wheat. Of this, 24.5 mio ha are sown with spring bread wheat or *Triticum aestivum*, nearly 1.5 mio ha go under durum (*T. durum*); Khapli or *T. dicoccum* covers less than 50,000 ha, and a few fields of *T. monococcum* have been reported from Rajasthan. India's annual wheat production has been around 72 mio tons for the last few years, with minor variations between years. This puts India in second position among the wheat producing countries, with approx. 12 % of the world's wheat production. But India is also the second largest wheat consumer after China, with a quickly growing demand.

The diverse growing environments are used to produce wheat grain with different quality attributes, so India is able to meet both domestic and international consumer needs.

Abbreviations

NHZ = *Northern Hill Zone*
NWPZ = *North West Plain Zone*
NEPZ = *North East Plain Zone*
CZ = *Central Zone*
PZ = *Peninsular Zone*
SHZ = *Southern Hill Zone*
HLW = *hectolitre weight (kg/100 L)*
AWRC = *alkaline water retention capacity*
HMW = *high molecular weight (gluten)*
AICWIP = *All India Coordinated Wheat Improvement Project*
CGIAR = *Consultative Group on International Agricultural Research*
CIMMYT = *International Maize and Wheat Improvement Center (Centro Internacional de Mejoramiento de Maíz y Trigo)*

9.1 India's Wheat Growing Zones

Wheat is the most important winter cereal grown during the non-monsoon months, and it is less vulnerable to yield fluctuation than other crops. On the contrary: production of the monsoon-season rice crop is dependent on good rainfall distribution. In order to have a reliable and robust food security system it is essential to have an adequate quantity of wheat.

The wheat-growing parts of India differ considerably in respect of soil type, temperature and moisture regime and are divided into six mega environments (Fig. 28): Northern Hill Zone (NHZ), North West Plain Zone (NWPZ), North East Plain Zone (NEPZ), Central Zone (CZ), Peninsular Zone (PZ) and Southern Hill Zone (SHZ). The NHZ has approximately 1.2 mio ha under wheat, which is grown at various elevations; on slopes it is un-irrigated, whereas irrigation is feasible where rivers flow.

The NWPZ is the fertile, canal and tube irrigated (› 90%) tract of the Gangetic plain, with alluvial soil and a very low gradient. Here, wheat occupies more than 9.0 mio ha. For several days the minimum temperature remains around 5 °C. In NWPZ wheat matures in 140 days, tillers well with more grains per spike and therefore has a very high yield. The limitations are the occurrence of karnal bunt (*Tellesia indica*) disease and grain shrivelling due to a sudden increase in the maximum temperatures around grain filling time.

The NEPZ has a network of rivers and drains, with high humidity, high soil pH and irregular topography with unreliable irrigation services. The wheat season is foggy for several days, and dew condensation on the leaves promotes severe leaf blight (*Dreschlera* spp.) and brown rust (*Puccinia triticiana*). Wheat matures here in 125 days and may be affected by pre-harvest summer showers. The more than 9.0 mio

ha under wheat in this zone falls into several cropping sequences resulting from the irregular topology, the low-lying area near rivers causes staggered wheat sowing.

The CZ and PZ are predominantly highland areas with deep black soil, and in these tracts wheat is grown over 5.0 mio ha and 1.0 mio ha, respectively. Here wheat is cultivated under retreating soil moisture conditions and at best, in some areas, farmers are able to provide two irrigations. Wheat crops mature in 100 to 110 days and are continuously exposed to high temperatures (Fig. 29). As a consequence there is poor tillering, and the number of grains per spike is less, so per hectare produc-

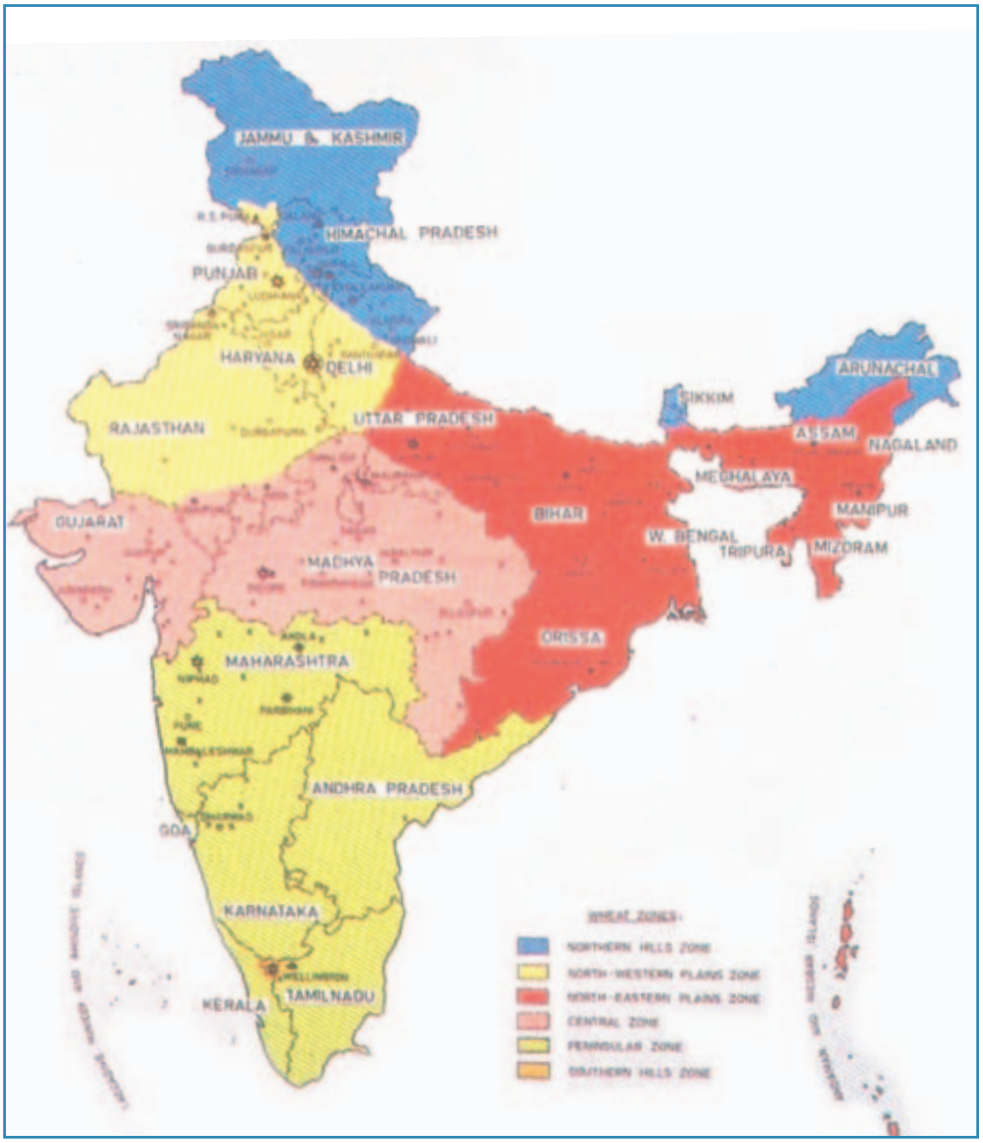

Fig. 28: Wheat growing zones. (The boundaries of India as shown in this map are neither accurate nor authentic.)

tivity is only around two tons. The low yields are compensated for by the high quality of the grain. In the SHZ only a few hundred hectares are under wheat, and these hills are the main source of inoculum against stem (*P. graminis tritici*) and leaf rust (*P. triticiana*) for PZ and CZ. Hence, the development of rust-resistant varieties is an important strategy for reducing crop loss in PZ and CZ.

9.2 Wheat Varieties

In the last forty years more than 200 wheat varieties have been released for cultivation in the six mega wheat growing environments. Most of the wheat varieties released for cultivation are for irrigated, high-fertility, timely-sown conditions or for the late-sown situation. Rain fed crop growth conditions may account for 12% of the net area sown to wheat, and all Khapli is grown as a rain fed crop. The seed replacement ratio in wheat is very poor and mostly it is farmers' retained seed that is exchanged horizontally between farmers.

Although breeders produce seed for more than sixty wheat varieties each year, a maximum of fifteen varieties accounts for 80% of the crop, and of these one or two cultivars cover 30% of the area.

9.2.1 Grain Quality

The physical aspects of grain quality include external features, foreign matter presence, plant debris damage due to saprophytes, grain diseases, stored grain pest damage and seed damage due to post-harvest operations.

Fig. 29: "Tropicalized wheat". IARI variety HW 3070 is grown in Tamil Nadu, close to the equator. Note coconut and wheat growing in the same ecosystem.

9.2.2 Physical Purity

The manual harvesting and threshing of wheat practised earlier used to continue for two months after the harvest. But the situation changed dramatically in the 1970*s*, when farmers mechanized their operations with tractor power. Following this, the local manufacture of threshing machines started. Threshing and winnowing operations are now completed quickly by mechanical means. In NWPZ nearly 60% of the wheat area is harvested by combines on a custom hiring basis, whereas in the NEPZ and the PZ there is less use of combines. The combine contractor roves over the wheat growing continuum of the NWPZ and facilitates the harvesting process. The combine is generally not well kept, and is only cleaned from time to time. It also carries a substantial amount of seed from one field to another, thus promoting grain admixture. In the combine-harvested fields there is a large percentage of broken grain because of poor maintenance of the machine or over-drying of the standing crop. Plant debris, weed seed and foreign matter are also abundant in combine-harvested fields, and if the farmer does not fine-clean his harvest it is difficult to market the produce.

There are more shrunken and broken kernels in the freshly harvested grain lots of Punjab, Haryana and the Plains of Uttaranchal, and to some extent in Uttar Pradesh where combine harvesting is common practice. In states like

Yet another meaning of "rain fed": harvested wheat lying in a pool of rain water (2001)

Uttar Pradesh, Haryana and the Plains of Uttaranchal many varieties are grown, and the admixture of grains from different classes happens frequently. Foreign matter content is very high in the grain harvest from Madhya Pradesh, and the percentage of damaged kernels is distinctly high in the freshly harvested grain samples from Punjab. In general the samples from NWPZ, which is the largest grain surplus producing area, have low physical purity and fall into grade II or III. Fig. 30 summarizes the physical purity of wheat samples from different states in 2004.

9.2.3 Other Physical Features Relevant to Milling

Physical characteristics such as hectolitre weight, thousand grain weight, grain hardness and texture are important for the grain trade. The wheat grain samples from Punjab have a hectolitre weight (HLW) of approximately 78 (kg/100 L), a thousand grain weight of about 37 g and a sedimentation value of < 40. The low temperature during the initial plant growth stages promotes the number of grains per spikelet. The accelerated ripening due to sudden terminal heat often results in small grain of uneven seed size. There are varietal differences in seed size and thousand grain weight, and the large-seeded genotypes rarely produce more than 3 or 4 grains per spikelet. The wheat kernel from NEPZ is generally large with more than 10% seed moisture, and has a sedimentation value above 40. The grains from PZ and CZ are hard and lustrous, with > 80 HLW and yield around 70% flour recovery.

Based on physical parameters and purity, Indian wheat has been grouped into five different grades in accordance with the international grading system. The durum wheat grain is generally large and hard with a higher hectolitre value. The CZ grain samples of bread wheat often have > 10% durum grain as an admixture. Millers do not like such material, since it impairs the quality of the flour. Most of the fresh grain arrivals from the farm need a first round of cleaning before they are graded, dried and sent to the silo for storage. This cleaning causes a 2.3 to 24.0% loss, depending on the grain grade (Gupta *et al.*, 2002) and thus reduces the profit margin of the trader and the cultivator.

9.2.4 Micronutrient Status of the Grain

The micronutrient level of the grain is important. If it is low, it becomes necessary to supplement the flour with zinc, iron, etc. Such fortification raises the cost of the product, and to some extent this issue of micronutrient enrichment of the grain can be addressed through plant breeding. The micronutrient content of Indian wheat varies considerably. For example, C 306, C 591, K 68, UP 262 and WH 712 have

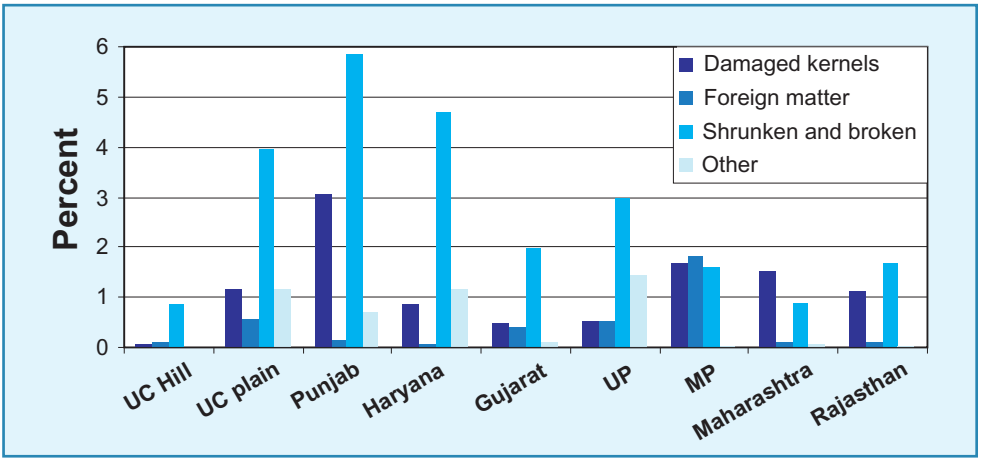

Fig. 30: Physical purity of freshly harvested wheat samples from different states of India (data from AICWIP report, 2004).

higher Zn, Fe and Cu levels than the recently most popular varieties such as HD 2329 and PBW 343 (Tab. 43). The micronutrient content in the first group of varieties and their excellent *chapatti*-making quality make them ideal grain types, and so they generally fetch a premium price in the market. The well-funded global programme "Harvest Plus" of the CGIAR (Consultative Group on International Agricultural Research) addresses the issue of micronutrient enhancement. Many national programmes are also targeted towards accumulating the micronutrient-enriching genes in high yielding wheat.

The information available indicates that it is possible to combine good micronutrient levels with high yield as in the case of WH 712 and with a good gluten score, sedimentation value and *chapatti*-making attributes (*chapatti* is flat, non-fermented Indian bread).

9.3 Cereal Chemistry

The grain protein content varies considerably, depending on whether the harvest is from well irrigated highly fertilized fields or from rain fed, low yielding fields to which less fertilizer has been applied. The warm wheat growing areas generally have a higher grain protein content than the cool NHZ. The hill wheat with low protein and a high spread factor is suitable for the biscuit industry. PZ wheat is good for crackers and cookies, as it has a high protein content and strong gluten. High molecular weight (HMW) gluten in Indian wheat varies with the variety. A frequency of 2+12 for Glu-D is usual in › 70 of the Indian varieties and the rest have a 5+10 band. Similarly, the most common Glu-A is band 2* in › 60% of the genotypes and the rest have either band 1 or N (nil). Glu-B is very diverse, and an almost equal number of varieties have either 7+9 or 7+8 or 17+18. The presence of band 7 or only band 20 is found in a few odd wheat varieties. In the CIMMYT material, In the CIMMYT material, Pena (1995) observed that a maximum number of lines contain 2* as Glu-A, 7+9 for Glu-B and 5+10 for Glu-D. The distribution pattern of the CIMMYT material of 1994 is at variance with the Indian material sampled during 2002 despite the fact that the Indian national wheat improvement programme uses the CIMMYT lines extensively in its breeding programme. This mixture of the HMW gluten combinations present in Indian varieties is used for making various value-added end products.

Tab. 43: Micronutrient, sedimentation-value and HMW data for Indian wheat

Variety	Fe mg/kg	Zn mg/kg	Cu mg/kg	Sedi[a]	HMW bands	Remarks
C306	77.0	80.0	36.5	53	N+20; 2+12	Released in 1965 for CZ
C591	41.0	49.0	31.0	38	N+20; 2+12	Pre-partition Punjab variety, NWPZ
NP4	41.0	107.0	7.6	58	2; 17+18; 5+10	Land race[11] released in 1909 for Bihar, NEPZ
K68	61.0	57.0	32.3	70	2; 17+18; 5+10	Tall improved wheat of NEPZ, released in 1965
UP 262	52.0	95.0	30.6	60	2; 7+8; 2+12	High yielding semi-dwarf wheat for NEPZ
HI 977	31.0	67.0	16.8	65	2; 17+18; 5+10	Semi-dwarf high yielding variety of CZ
HI 1077	37.0	78.0	30.0	71	2; 17+18; 2+12	Semi-dwarf high yielding variety of CZ
WH 712	85.0	105.0	23.2	64	2; 17+18; 5+10	High yielding semi-dwarf variety of Haryana, NWPZ
PBW 343	44.0	53.0	7.7	36	1; 7+9; 5+10	High yielding semi-dwarf of NWPZ & NEPZ
HD 2329	44.0	49.0	9.1	46	2; 7+9; 2+12	High yielding semi-dwarf of NWPZ

[a] *Sedimentation value*

[11] *"Land race" is a population maintained by the farmers; it has not been bred scientifically. A "variety" comes out of planned crossing programmes.*

9.4 Dough Properties of Indian Wheat

The contribution of gliadin and glutenins to gluten strength and extensibility can be inferred from protein content, sedimentation value, dough strength and dough extensibility, the crumb and the loaf volume of the bread. The dough properties or rheological information are of importance in value addition and product development. If the Alveograph ratio of dough tenacity or P (maximum height of the curve) to extensibility or L (length of the curve) is around 0.8 and the total work force (W) needed to cause rupture of the dough is above 200 (erg/g, or 10^{-4} J) then the bread volume tends to be high and the quality of the product is good. If the flour is stored at a high temperature (40 °C) the dough becomes inextensible (Censkowski *et al.*, 2000), and in many parts of India such high ambient temperatures prevail for several days during summer and contribute to the quality variations in bread during different seasons of the year. The milling and baking industries, located primarily in the southern states, are short of wheat grain suitable for bread and biscuit manufacture. Wheat sample data from different zones show (Tab. 44) that the PZ produces the best wheat available for bread, as the loaf volume and bread rating are high, but the quality is still below what is achieved elsewhere in the world. The NHZ produce meets biscuit quality needs, as the spread factor is the best. In both NHZ and PZ wheat production is lower and there is hardly any marketable surplus. Also these places are far away from the location of the biscuit industry, which makes surface transport of the grain expensive and difficult. The CZ grain meets the demand of the whole grain flour market for the flat, non-fermented Indian bread or *chapatti* and that of NWPZ and NEPZ is rated next only to the CZ. Growing urbanization and the increasing employment of women has changed kitchen needs, and the branded whole grain flour or *atta* has created a new market.

India has approximately 1.5 mio ha under durum wheat. It is mostly confined to PZ and CZ, but there are very small areas in Punjab and NWPZ too. The Indian durum has very hard grain and good (approximately 7 ppm) beta carotene. The protein content is approximately 15% in Khapli wheat, the grain is long and deep-golden, with shrivelled cheeks. These tetraploids are used to manufacture semolina, bulgur and several extruded products of high quality.

Tab. 44: Quality attributes of bread wheat samples of 2002, from different zones[a]

Parameters		NHZ	NWPZ	NEPZ	CZ	PZ
Hardness		5.1	5.4	5.5	5.6	6.7
Extraction rate	%	68.2	69.4	70.4	69.8	69.6
Sedimentation		34	40	45	43	41
P/L		1.48	1.76	1.13	1.57	1.09
W	$J \cdot 10^{-4}$	150.3	137.6	171.8	151.6	207.9
Chapatti rating		6.63	6.52	6.87	7.11	6.48
Loaf volume	mL	510	529	565	507	568
Bread quality		6.58	7.00	7.87	6.41	8.13
Spread factor		8.00	6.75	6.45	6.50	6.11
AWRC	%	68.2	71	69	72	70

[a] *Gupta* et al., *2002*

9.5 Grain Classification

Wheat grain classification is essential for trade and quality control as the buyer is able to understand the utilities of the supply and negotiate a price. The approach rests on two parameters, namely the physical purity or "Grade" and the other grouping called "Class" which is based on the grain quality traits. Tab. 45 shows the different grades recommended for adoption in India (Gupta, 2002).

The following section describes the five major Indian wheat classes.

Tab. 45: Suggested grading standards for Indian wheat.

Grade factor	Wheat grades					
	I	II	II	IV	V	Sample wheat
	Minimum limits (kg/hL)					
Hectolitre weight						
i) *T. aestivum*	76.5	75.5	73.0	70.0	67	< 67
ii) *T. durum*	78.0	76.0	74.0	71.0	67	< 67
	Minimum limits (%)					
Damaged kernels	2.5	5.0	8.0	10.0	15.0	> 15.0
Foreign material	0.5	1.0	2.0	4.0	6.0	> 6.0
Shrunken & broken	4.0	6.0	8.0	12.0	20.0	> 20.0
Total defects	5.0	8.0	10.0	15.0	20.0	> 20.0
Contrasting classes	1.0	2.0	3.0	10.0	10.0	> 10.0
Total, including contrasting classes	3.0	5.0	10.0	10.0	10.0	> 12.0
Stones	0.1	0.1	0.1	0.1	0.1	> 0.1

9.6 Classes of Indian Wheat

11.6.1 Indian Medium Hard Bread Wheat

This is the standard mill quality wheat. Medium grain size and appearance, medium hard, dry gluten 9%, protein › 10%, › HLW 76, seed moisture 11%, total defects 6%, extraction efficiency ‹ 69% sedimentation value ‹ 40. The flour is suitable for non-fermented flat Indian bread *chapatti* and a number of other ethnic food preparations such as *naan, tandori, rumali, roti, puri, bhatore* etc. All these ethnic foods are made out of the whole grain flour of this class. This is the largest wheat surplus India produces. It is consumed domestically in various forms. The wheat varieties PBW 343, HD 2786, Raj 3077, Lok 1, GW 273 etc., fall into this class.

9.6.2 Indian Hard Bread Wheat (Premium Wheat)

Bold and lustrous grain, dry gluten 9%, protein › 12%, HLW approx. 80, seed moisture 11%; extraction efficiency is approx. 70%. It is suitable for a variety of fermented and non-fermented breads. The bread quality and rating is high, and a variety of flours can be made from the grain. The varieties C 306, Sujatha, HW

2004, HD 2189, DWR 162, GW 496, Lok 1 (some samples from PZ) and HD 2733 fall into this class. The "cream" of wheat, *maida*[12] and extruded products made from this class have a market chiefly in South Indian states.

9.6.3 Indian Soft Bread Wheat (Biscuit Wheat)

Yellowish / white grain, grain hardness ‹ 5.3, soft textured, dry gluten 7%, protein ‹ 9.5%, HLW 75, seed moisture 12%, extraction efficiency approx. 68%, biscuit spread factor › 7.5. It is suitable for eastern food habits, biscuit-making etc. Local land races of the NHZ and Pissi, a local land race of CZ, fall into this cluster and meet the requirements of the biscuit industry.

9.6.4 Indian Durum Wheat

Large and hard kernel, vitreous grain, beta-carotene › 5 ppm, protein › 12%, HLW › 78. Seed moisture is approx. 11%. The durum varieties PDW 233, WH 896, HI 8498, Raj 1555, MACS 2846 etc., fall into this class. It is extensively used for extruded products, semolina and pasta, and for pizza bases, *bulgur* etc.

9.6.5 Indian Dicoccum Wheat

Hard kernel, longish grain, not plump, beta-carotene › 5 ppm, HLW › 78, protein › 13% and seed moisture 10%. It is suitable for breakfast cereal, semolina, for porridge, extruded products and for high-protein foods. Local Khapli land races, NP 200, DDK 1009 etc., fall into this class.

9.7 Current Indian Wheat Grading System

Indian wheat is currently divided into different grades based on physical purity, admixtures, broken kernels, shrivelled kernels etc. The suggested grades (Nagarajan, 2004) have not been put into practice as there is no declared difference in price, although in the grain market there is a variation in price on the basis of arbitrary assessment made by the grain merchant. The Indian grain grading system is therefore comparable with the practices followed in other parts of the world and aimed at promoting proper auctioning and pricing of the produce. These developments should be viewed in the context of our need to have harmonized and well accepted grain quality standards and of India's preparedness to become a partner in the global grain trade.

9.8 References

- *Cenkowski S, Dexter JE and Scanlon MG, 2000. Mechanical compaction of flour: The effect of temperature on storage and rheological properties. Canadian Agricultural Engineering. 42(1):33-41.*
- *Directorate of Wheat Research. 2004. Progress report of the All India Coordinated Wheat Improvement Project (AICWIP). Quality and basic sciences, Vol. V.*
- *Gupta RK, Sewa Ram and Chauhan DS, 2002. Quality of Indian wheat. Directorate of Wheat Research, Karnal – 132001. Research Bulletin No. 14.*
- *Nagarajan S, 2004. Sustaining the green revolution in India. A success story of wheat. APAARI publication 2004/3. Bangkok.*
- *Pena RJ, 1995. Quality improvement of wheat and triticale. In: Wheat breeding at CIMMYT: Commemorating 50 years of research in Mexico for global wheat improvement. Wheat special report No.29. Mexico, D.F., CIMMYT. Rajaram S and Hettel GP (eds.).*

[12] *Maida is a white all purpose flour with about 0.7 % ash*