Technical Bulletin No. 27

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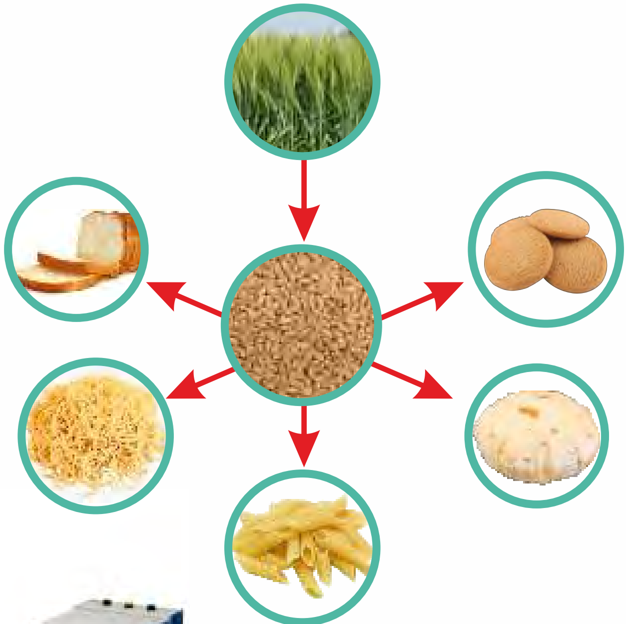

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PREFACE

Wheat is an important cereal crop which contributes significantly in food and nutritional security across the globe. Wheat provides not only carbohydrates but also proteins, fibre, bioactive compounds and nutrients. India is the second-largest wheat-producing country (109.52 MT as per 4th advance estimate, MoA&FW, 2020-21) in the world. Therefore, information about quality traits of Indian wheat cultivars is required for utilization by farmers, industry and consumers. This will help in selection of varieties suitable for different products as there are quite large differences in grain composition and processing quality among wheat cultivars. For example hard wheat with strong gluten and high protein content are used for bread making while soft wheat with low protein content and weak gluten for cookie making. The suitability of a particular product largely depends on the quality of wheat flour.

The ability to supply wheat that meets local demand for specific end-use quality requirements will thus become more and more crucial. Also, with the surplus wheat meant to export, India has to improve and maintain wheat quality to compete in the domestic and international markets. This will lead to cultivation of wheat varieties suitable for different products ensuring better prices & quality for farmers and consumers, respectively. As the demand for wheat-based processed food is increasing worldwide, especially in economically emerging countries, improving the wheat quality has become major activity in wheat breeding programme in India. Therefore, wheat varieties having desirable quality traits and suitable for different agroecological conditions in different zones across the country are being developed.

ICAR-IIWBR, Karnal serves as the nodal centre in the country to evaluate the nutritional, processing and baking quality of wheat samples for their suitability for different end products grown across all the five wheat growing zones under All India Coordinated Research Project on Wheat and Barley (AICRPW&B). This enables us to identify promising wheat lines having excellent nutritional and processing quality suited for different end products. Here, we have presented the zone wise summary of wheat quality data for various parameters such as bread, biscuit, chapati, pasta, gluten content, Fe and Zn *etc*. We have set a benchmark for identifying superior genotypes for processing and nutritional quality traits. In the end, we have described in brief analytical procedures for evaluating various quality attributes of wheat. This bulletin will suffice the valuable resource of first-hand information to all the stakeholders, including researchers, extension agencies, farmers and industry personals, academicians and policymakers, in making a wise selection of wheat genotypes to cater for their varying requirements.

Authors

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Processing and nutritional quality of Indian wheat cultivars

Preamble

In India, wheat is grown on an area of about 31 million hectares and the cultivation extends from 9^0N (Palni hills) to above 35^0N (Srinagar valley of J & K), and thus, the wheat crop is exposed to a wide range of agro-climatic changes such as humidity, temperature, photoperiod during crop season, soil types, altitudes, latitudes and cropping systems. Considering these agro-climatic conditions, extension of wheat cultivation in non-traditional areas and based on land use planning, the country has been divided into following 5 major zones; i) Northern Hills Zone (NHZ), ii) North Western Plains Zone (NWPZ), iii) North Eastern Plains Zone (NEPZ), iv) Central Zone (CZ) and v) Peninsular Zone (PZ) (Fig. 1). The Zone-wise details of the area covered and the list of funded centers in each zone of AICRPW&B has been given in Table 1. It was based on agro-climatic conditions prevailing in different parts of the country and agreed by the stakeholders. As a result of this, number of land races and cultivars of wheat possessing varying degree of heat tolerance have come to stay and survive under different shades of temperature prevailing in different zones. For instance, the magnitude of variation in mean minimum and maximum temperatures is quite high between NHZ (9.7°C & 18.5°C) and PZ (20.8°C & 29.8°C). Since, the temperature remains comparatively much lower in NHZ as compared to remaining parts of the country, hence the wheat varieties grown in NHZ take longer duration to mature and these are adapted to cooler climatic conditions. On the contrary, wheat varieties evolved / developed for Peninsular and Central Zones are better acclimatized to drier and hotter conditions prevailing during crop season in these parts of the country. However, the main wheat granary of the country lying in the Indo-Gangetic region is exposed to longer winter conditions mainly in NWPZ as compared to its eastern part in NEPZ where short winter duration is accompanied with hot and humid environmental conditions. Overall, this indicates that the wheat varieties grown in India are well adapted to much larger variations in temperature. The exposer of segregating generations to higher temperatures during selection followed by multi-location testing in AICRPW&B trials has helped to develop and identify wheat varieties possessing varying degrees of heat tolerance. As a result, the wheat varieties released in Peninsular and Central Zones are endowed with higher degree of heat tolerance than those available for cultivation in Indo-Gangetic plains and northern hills. Therefore, we in India, can successfully tackle a predictable uniform change in temperature during crop season through choosing suitable varieties from available varietal diversity. This has led to wide variations in quality of wheat varieties developed for different zones (detailed quality aspects of different varieties are given in tables in further sections).

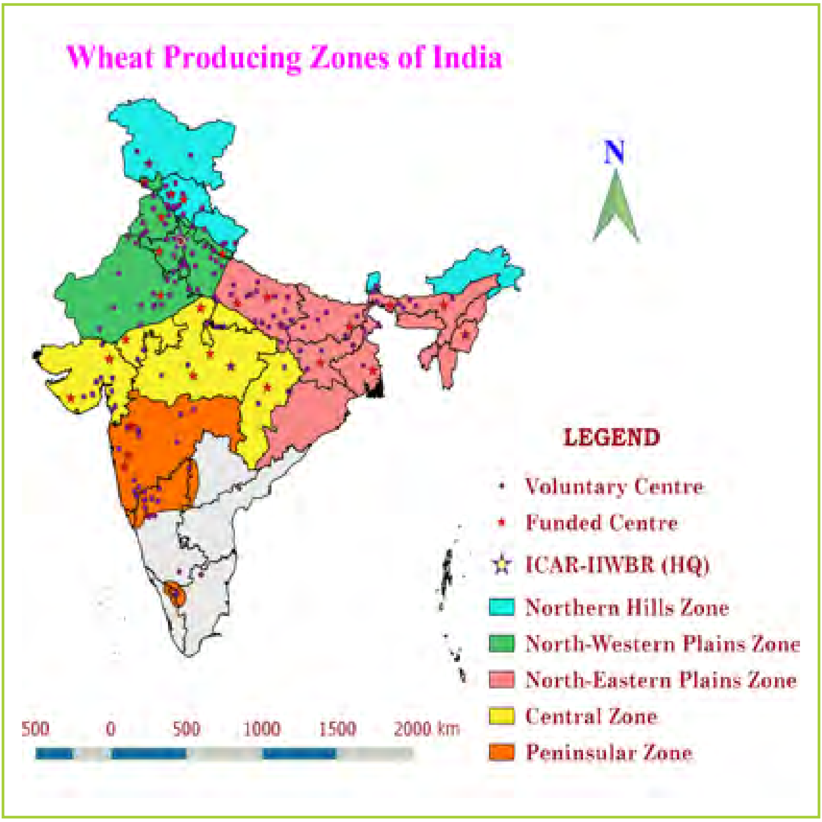

Fig. 1. Different zones earmarked for wheat crop

Table 1. Zone-wise details of area covered and list of funded centers in each zone

Zone	Area Covered	Funded Center
Northern Hills Zone (NHZ)	Western Himalayan regions of J&K (except Jammu and Kathua distt.); H.P. (except Una and Paonta Valley); Uttaranchal (except Tarai area); Sikkim and hills of West Bengal and N.E. States	CSK-HPKVV, Palampur CSK-HPKVV, Bajaura CAU, Imphal SKUAST-K, Srinagar
North Western Plains Zone (NWPZ)	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions) and Western UP (except Jhansi division), parts of J&K (Jammu and Kathua distt.) and parts of HP (Una dist. And Paonta valley) and Uttaranchal (Tarai region)	PAU, Ludhiana CCSHAU, Hisar GBPUAT, Pantnagar RAU, Durgapura SKUAST-J, Jammu
North Eastern Plains Zone (NEPZ)	Eastern UP, Bihar, Jharkhand, Orissa, West Bengal, Assam and plains of NE States.	CSAUAT, Kanpur NDUAT, Faizabad BHU, Varanasi BAU, Sabour BAU, Ranchi BCKVV, Kalyani UBKV, Coochbehar AAU, Shillongani
Peninsular Zone (PZ)	Maharashtra, Karnataka, Andhra Pradesh, Goa, plains of Tamil Nadu, Hilly areas of Tamil Nadu and Kerala comprising the Nilgiri and Palni hills of Southern plateau.	UAS, Dharwad MPKVV, Niphad MPKVV, Mahabaleshwar ARI, Pune
Central Zone (CZ)	Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of Uttar Pradesh	IGKVV, Bilaspur SDAU, Vijapur JAU, Junagarh MPUAT, Udaipur JNKVV, Jabalpur JNKVV, Sagar JNKVV, Powerkhera RVSKVV, Gwalior

Wheat is the main source of the world's food energy and nutrition. India is the second-largest wheat producer globally, and large numbers of wheat-based end-use products such as chapati, bread, biscuit, cakes, pretzels, noodles and pasta are consumed by human beings world-wide. However, there are relatively significant differences in grain composition and processing quality among various wheat cultivars. Hence, one cultivar may be suitable to prepare one food type but unsuitable for a different product. Due to important global economic and social trends, quality differences among wheat cultivars have gained even more importance in grain trading. As a consequence, wheat processing industries now require various distinct wheat supplies possessing specific grain quality attributes. For example, hard wheat with strong gluten and high protein content is used for bread making, while soft wheat with low protein content and weak gluten for cookie making. Therefore, it is our priority to develop wheat varieties suited to meet the requirements of these end-use products. The list of important wheat varieties released recently and suitable for different end-use products is given in Table 2.

Table 2. Selected wheat varieties representing different zones suitable for different products

Product	Varieties
Chapati Score (>8.0/10.0)	HD3086 (NWPZ-HYPT), HD2967 (NEPZ-ITS), K0307 (NEPZ-ITS), PBW757 and DBW71 (NWPZ & NEPZ, SPL-VLS), WH1124 (NWPZ-IR-LS), PBW771 (NWPZ-ILS), DBW303 (NWPZ-HYPT), HI1634 (CZ-IR-LS), HD3237 (NWPZ-RITS), DBW39 (NEPZ–ITS), HD2888 (NEPZ–RITS), NIAW1415 (PZ–RITS), MP3288 (CZ–RITS), HI1500 (CZ-RITS)
Bread Loaf Volume (>600 ml)	DBW187 (NWPZ & NEPZ -ITS), HD3226 and WH1105 (NWPZ-ITS), HD3059, WH1124 and DBW173 (NWPZ-IR-LS), WH1080 (NWPZ-RITS), DBW93 (PZ-RITS), HD2733 (NEPZ–ITS), WH1080, DBW71 and DBW222 (NWPZ-ITS), HD3298 (NWPZ-IR-LS), WH1254 (HYPT-NWPZ), NIAW1415 (PZ–RITS)
Biscuit Spread Factor (>10.0)	HS490 (NHZ), NIAW3170 (NWPZ & PZ-RITS), DBW168 (PZ-ITS)
Yellow pigment in Durum for pasta (>7.0/9.0 ppm)	UAS446(d) (PZ-RITS), DDW48(d) (PZ-ITS), DDW47(d) (CZ-ITS) (Yellow pigment >7.50 ppm)

Quality data demonstrate significant improvement in quality traits during the last decade

Though around 500 wheat varieties have been released in India over past five decades, recently released varieties for different zones have been evaluated for different quality traits. In recent times, significant improvements have been made in varieties developed for North Western Plains Zone especially regarding grain protein and strong gluten content. Substantial progress has been made in improving sedimentation volume during the last fourteen years. The average value of sedimentation volume has increased to around 55.0 ml from 45.0 ml (Fig. 2.) during the last fourteen years except for the NHZ varieties.

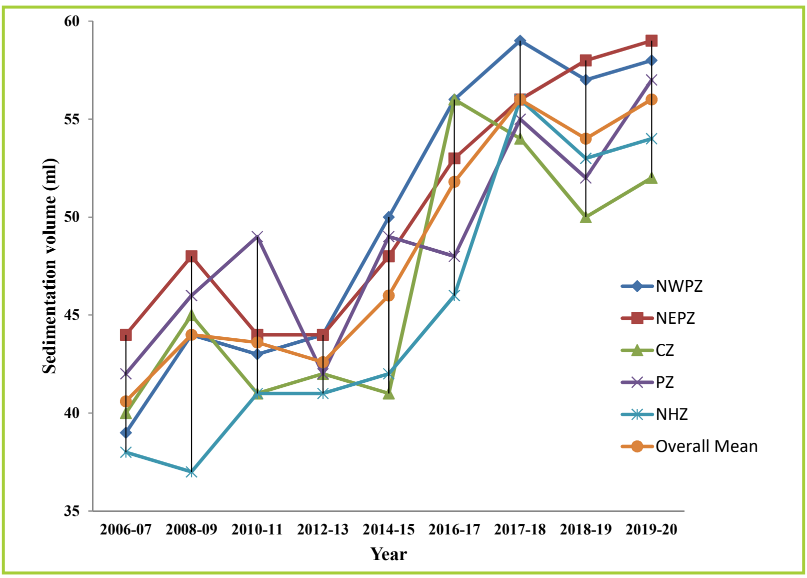

Fig. 2. Average sedimentation volume of AVT entries during last 14 years

Three years data for processing and nutritional quality traits (2017-2020)

The average data of three years (2017-2020) is given in the tables below (Tables 3-9) for important processing and nutritional quality traits. The data clearly demonstrates that wheat varieties are available in all the wheat growing zones for both processing and nutritional quality traits. Most of the entries representing different zones showed higher hectolitre (hl) weight than recommended minimum requirements of 76 kg/hl. The varieties in Northern Hills Zone showed lower protein and wet gluten content and hence are not suitable for the bread quality. The hardness index data (measured by SKCS) exhibited that most of the wheat cultivars developed in India are genetically hard and suitable for chapati and bread making. One variety each in NHZ (HS490) and NWPZ (NIAW3170), while two DBW168 (ITS) and NIAW3170 (RITS) in PZ exhibited soft grain characteristics suitable for biscuit making quality. The protein content is expressed on a 12% moisture basis, and sedimentation is based on a 6-gram flour test.

Table: 3. Quality traits of Northern Hills Zone varieties (Three year's average)

Variety	Hectolitre Weight (Kg/hl)	Protein Content (%)	Sedimentation Volume (ml)	Wet Gluten (%)	Hardness Index	Iron Content (ppm)	Zinc Content (ppm)
ITS (Irrigated timely sown)							
HS507	81.1	9.6	48.5	23.4	81.9	37.1	31.4
HS562	80.4	8.7	57.5	21.8	79.2	37.4	29.7
HPW349	80.9	8.9	58.9	22.3	68.9	35.3	31.6

Variety	Hectolitre Weight (Kg/hl)	Protein Content (%)	Sedimentation Volume (ml)	Wet Gluten (%)	Hardness Index	Iron Content (ppm)	Zinc Content (ppm)
VL907	79.0	9.4	42.0	25.2	71.3	37.0	30.4
Mean	**80.4**	**9.2**	**51.7**	**23.2**	**75.3**	**36.7**	**30.8**
RIL (Restricted irrigated late sown)							
VL892	78.7	10.7	49.8	20.6	71.7	40.8	36.0
HS490	75.5	10.5	42.1	20.9	24.1	39.0	35.3
Mean	**77.1**	**10.6**	**46.0**	**20.8**	**47.9**	**39.9**	**35.7**
RES (Rainfed early sown)							
HS542	81.2	10.4	48.6	22.8	67.0	40.4	37.8
VL829	79.8	10.2	39.5	21.8	75.0	37.5	33.2
HPW251	80.2	10.4	37.4	21.2	74.0	42.5	38.4
Mean	**80.4**	**10.3**	**41.8**	**21.9**	**72.0**	**40.1**	**36.5**

Table 4. Quality traits of North Western Plains Zone varieties (Three year's average)

Variety	Hectolitre Weight (Kg/hl)	Protein Content (%)	Sedimentation Volume (ml)	Wet Gluten (%)	Hardness Index	Iron Content (ppm)	Zinc Content (ppm)
ITS (Irrigated timely sown)							
DBW187	77.9	11.0	66.0	25.9	70.0	42.8	35.6
DBW222	77.0	10.7	52.0	27.3	75.0	37.5	31.8
PBW550	77.8	11.7	51.0	30.5	81.0	37.2	42.6
HD3226	78.3	12.6	62.0	30.9	76.0	39.6	36.8
HD2967	78.1	11.5	60.0	27.3	76.0	37.3	36.0
WH1105	78.6	11.8	62.0	27.3	75.0	39.9	38.1
HD3086	79.1	11.4	56.0	27.5	82.0	41.2	34.8
DBW88	78.1	11.8	61.0	28.5	77.0	39.6	34.5
DPW621-50	75.9	12.2	60.0	28.0	82.0	39.7	30.7
Mean	**77.9**	**11.6**	**58.9**	**28.1**	**77.1**	**39.4**	**34.8**
ILS (Irrigated late sown)							

Variety	Hectolitre Weight (Kg/hl)	Protein Content (%)	Sedimentation Volume (ml)	Wet Gluten (%)	Hardness Index	Iron Content (ppm)	Zinc Content (ppm)
HD3298	76.1	11.6	56.0	29.6	83.0	37.7	39.0
PBW771	78.6	11.7	52.0	30.0	83.0	39.1	42.8
PBW752	79.6	12.5	66.0	29.6	85.0	39.9	38.1
HD3059	79.7	12.0	64.0	28.8	88.0	37.8	34.9
DBW90	77.9	11.8	63.0	29.1	90.0	40.1	36.9
WH1021	78.8	12.0	45.0	31.2	87.0	37.3	38.1
WH1124	77.9	11.6	61.0	27.7	88.0	40.4	35.1
DBW173	78.1	11.8	65.0	27.9	84.0	39.1	33.4
Mean	**78.3**	**11.9**	**59.0**	**29.2**	**86.0**	**38.9**	**37.3**
RITS (Restricted irrigated timely sown)							
NIAW3170	78.2	11.4	47.0	24.6	28.0	36.0	34.7
HI1628	79.0	10.9	52.0	23.9	81.0	33.6	35.2
HD3237	78.5	10.4	53.0	24.4	79.0	38.1	35.5
HI1620	78.0	11.4	64.0	26.6	86.0	37.3	33.2
WH1080	77.1	11.3	62.0	26.2	80.0	34.8	30.8
PBW644	78.4	11.2	50.0	26.7	82.0	36.4	34.6
HD3043	78.4	11.6	49.0	28.1	83.0	37.0	38.3
WH1142	78.2	11.1	52.0	27.3	91.0	37.9	32.9
Mean	**78.2**	**11.2**	**53.6**	**26.0**	**76.3**	**36.4**	**34.4**

Table 5. Quality traits of North Eastern Plains Zone varieties (Three year's average)

Variety	Hectolitre Weight (Kg/hl)	Protein (%)	Sedimentation Volume (ml)	Wet Gluten (%)	Hardness Index	Iron (ppm)	Zinc (ppm)
ITS (Irrigated timely sown)							
HD3249	77.9	10.7	59.0	24.7	70.0	42.5	31.0
DBW187	77.0	11.4	64.0	25.4	71.0	43.5	35.3

Variety	Hectolitre Weight (Kg/hl)	Protein (%)	Sedimentation Volume (ml)	Wet Gluten (%)	Hardness Index	Iron (ppm)	Zinc (ppm)
HD2733	78.0	11.2	48.0	25.5	72.0	37.5	35.2
K0307	78.6	11.1	42.0	27.2	80.0	40.8	37.3
DBW39	77.0	11.0	49.0	25.8	72.0	40.2	38.3
K1006	78.2	10.7	42.0	26.0	75.0	41.2	38.1
HD2967	77.0	11.8	61.0	27.6	75.0	39.3	39.2
Mean	**77.7**	**11.1**	**52.1**	**26.0**	**73.6**	**40.7**	**35.8**
RITS (Restricted irrigated timely sown)							
HD3293	78.2	10.7	49.0	29.0	63.0	35.0	34.3
DBW252	77.9	11.2	56.0	33.0	75.0	38.4	37.2
HD2888	80.5	11.7	48.0	27.4	81.0	41.5	37.0
K8027	80.9	10.9	46.0	27.9	76.0	41.1	36.2
HD3171	79.0	11.0	64.0	25.1	67.0	41.7	30.9
K1317	80.4	11.4	55.0	28.3	71.0	38.4	31.3
HI1612	78.5	11.2	64.0	24.8	77.0	39.7	33.2
Mean	**79.3**	**11.2**	**54.6**	**27.9**	**72.9**	**39.4**	**34.3**
ILS (Irrigated late sown)							
HI1563	78.8	12.2	45.0	28.3	71.0	43.7	37.4
DBW14	76.3	12.7	41.0	29.2	61.0	44.4	40.1
HD3118	79.2	12.6	49.0	29.8	71.0	43.6	39.6
DBW107	77.0	12.7	40.0	30.7	69.0	44.7	39.0
Mean	**77.8**	**12.6**	**43.8**	**29.5**	**68.0**	**44.1**	**39.0**
RTS (Rainfed timely sown)							
HD2888	79.0	12.1	45.0	29.4	79.0	45.4	43.8
C306	79.1	11.8	43.0	29.6	85.0	43.1	41.6
K8027	77.0	12.1	44.0	30.4	74.0	41.7	42.9
Mean	**78.4**	**12.0**	**44.0**	**29.8**	**79.3**	**43.4**	**42.8**

Table 6. Quality traits of Central Zone varieties (Bread wheat) (Three year's average)

Variety	Hectolitre Weight (Kg/hl)	Protein Content (%)	Sedimentation Volume (ml)	Wet Gluten (%)	Hardness Index	Iron Content (ppm)	Zinc Content (ppm)
ITS (Irrigated timely sown)							
GW322	79.0	11.2	48.0	28.3	83.0	34.9	33.8
HI1544	83.1	11.3	47.0	29.6	83.0	34.7	34.0
Mean	**81.1**	**11.3**	**47.5**	**29.0**	**83.0**	**34.8**	**33.9**
RITS (Restricted irrigated timely sown)							
DBW110	80.4	11.8	60.0	27.2	78.0	39.5	38.1
MP3288	82.3	12.4	61.0	29.5	76.0	39.6	37.9
Mean	**81.4**	**12.1**	**60.5**	**28.4**	**77.0**	**39.6**	**38.0**
ILS (Irrigated late sown)							
CG1029	81.5	11.9	39.0	29.0	61.3	38.2	35.1
HI1634	81.8	12.1	45.0	27.6	81.4	37.9	36.0
HD2932	80.7	12.5	52.0	30.4	70.8	36.6	35.4
MP3336	82.3	12.7	44.0	33.0	71.0	38.1	38.1
HD2864	82.1	12.1	44.0	29.2	73.8	38.7	35.0
Mean	**81.7**	**12.3**	**44.8**	**29.8**	**71.7**	**37.9**	**35.9**

Table 7. Quality traits of Central Zone varieties (Durum) (Three year's average)

Variety	Hectolitre Weight (Kg/hl)	Protein Content (%)	Sedimentation Volume (ml)	Iron Content (ppm)	Zinc Content (ppm)	Yellow Pigment (ppm)
ITS (Irrigated timely sown)						
HI8713(d)	82.9	12.0	37.0	40.2	33.4	6.9
HI8737(d)	83.9	12.2	39.0	40.0	40.2	5.2
Mean	**83.4**	**12.1**	**38.0**	**40.1**	**36.8**	**6.1**
RITS (Restricted irrigated timely sown)						
HI8627(d)	82.6	12.8	35.0	39.35	41.0	6.0

Variety	Hectolitre Weight (Kg/hl)	Protein Content (%)	Sedimentation Volume (ml)	Iron Content (ppm)	Zinc Content (ppm)	Yellow Pigment (ppm)
UAS 466	83.9	12.3	41.0	39.9	36.9	5.6
DDW47	82.3	12.7	39.0	40.1	39.5	7.6
Mean	**82.9**	**12.6**	**38.3**	**39.8**	**39.1**	**6.4**

Table 8. Quality traits of Peninsular Zone varieties (Bread wheat) (Three year's average)

Variety	Hectolitre Weight (Kg/hl)	Protein Content (%)	Sedimentation Volume (ml)	Wet Gluten (%)	Hardness Index	Iron Content (ppm)	Zinc Content (ppm)
ITS (Irrigated timely sown)							
MACS6222	81.3	11.7	43.0	32.9	78.0	38.9	33.2
MACS6478	78.6	12.0	50.0	31.4	77.0	35.8	35.1
DBW168	77.8	12.3	43.0	29.4	37.0	37.5	32.1
Mean	**79.2**	**12.0**	**45.3**	**31.2**	**64.0**	**37.4**	**33.5**
ILS (Irrigated late sown)							
HI1633	80.3	12.4	45.0	34.4	78.0	41.6	41.1
HD3090	78.8	12.5	51.0	34.2	78.0	39.8	40.2
HD2932	77.0	14.4	48.0	32.7	71.0	38.3	42.0
Raj4083	77.0	13.7	53.0	34.4	76.0	43.9	44.6
NIAW34	76.8	15.5	50.0	38.1	73.0	39.5	45.5
Mean	**78.0**	**13.7**	**49.4**	**34.8**	**75.2**	**40.6**	**42.7**
RITS (Restricted irrigated timely sown)							
NIAW3170	79.4	12.0	54.0	27.5	43.0	40.0	33.1
HI1605	81.1	13.0	61.0	30.4	86.0	42.5	34.3
DBW93	80.8	12.6	49.0	31.2	81.0	42.2	37.3
Mean	**80.4**	**12.5**	**54.7**	**29.7**	**70.0**	**41.6**	**34.9**
RTS (Rainfed timely sown)							
NI5439	79.2	14.5	58.0	--	--	45.7	34.1
NIAW1415	80.7	14.3	52.0	--	--	45.9	34.3

Variety	Hectolitre Weight (Kg/hl)	Protein Content (%)	Sedimentation Volume (ml)	Wet Gluten (%)	Hardness Index	Iron Content (ppm)	Zinc Content (ppm)
Mean	**80.0**	**14.4**	**55.0**			**45.8**	**34.2**

Table 9. Quality traits of Peninsular Zone varieties (Durum) (Three year's average)

Variety	Hectolitre Weight (Kg/hl)	Protein Content (%)	Sedimentation Volume (ml)	Iron Content (ppm)	Zinc Content (ppm)	Yellow Pigment (ppm)
ITS (Irrigated timely sown)						
MACS3949(d)	82.9	11.3	49.0	36.1	36.6	5.5
UAS428(d)	80.7	11.3	45.0	37.0	37.9	5.2
DDW48(I)	83.0	12.1	38.0	38.8	39.7	5.6
Mean	**82.2**	**11.6**	**44.0**	**37.3**	**38.1**	**5.4**
RITS (Restricted irrigated timely sown)						
NIDW1149	80.8	11.4	36.0	39.1	36.4	4.7
HI8805	82.5	12.0	48.0	39.1	37.5	4.8
AKDW2997-16(d)	80.7	11.4	46.0	39.1	31.7	3.6
UAS 446(d)	81.2	11.3	50.0	40.7	33.2	5.6
Mean	**81.3**	**11.5**	**45.0**	**39.5**	**34.7**	**4.7**
RTS (Rainfed timely sown)						
AKDW2997-16(d)	81.5	13.5	38.0	44.5	35.6	3.7
UAS446(d)	81.0	14.5	42.0	44.5	40.9	5.2
Mean	**81.3**	**14.0**	**40.0**	**44.5**	**38.3**	**4.5**

Identification of benchmarks for the development of product-specific varieties

The development of product-specific varieties depends on the knowledge of the quality requirements of different end-use products and the genetic components controlling different quality traits. For example, soft wheat with low protein content and weak and extensible gluten are preferred for biscuit making. Hard wheat with high protein content (>13%) along with strong and extensible gluten are preferred for bread making, while hard wheat with medium strong gluten and high protein content for chapati making. Waxy wheat has been found associated with an improved shelf-life of breads. White salted Japanese noodles need partial waxy wheat with soft grain characteristics, medium protein content and gluten strength. Partial waxy wheat with comparatively lower amylose content and higher starch paste viscosity improves the texture of white salted noodles. Yellow alkaline noodles need comparatively harder wheat with medium-strong gluten and without the waxy trait. Pasta made from durum wheat requires stronger gluten, high protein content and higher content of yellow pigments. In addition, there are some nutritional quality traits important for human beings, especially those whose sole diets are cereal-based. The micronutrient bioavailability and starch quality are major nutritional quality traits for improvement. The above facts clearly demonstrate that major grain components determining wheat quality are grain hardness, gluten strength, protein, micronutrient, yellow pigment content and components related to water absorption.

Based on the above criteria, benchmarks have been developed for wheat quality traits for the promotion of advanced entries under a coordinated programme taking into account distinct quality attributes. Since the environment also affects quality traits, the combination of traits is required to ascertain better wheat quality. Five major groups have been proposed based on end-product and nutritional quality traits. Group I contains varieties having desired quality traits suitable for chapati, group II for bread, group III for biscuit and other soft wheat products, group IV for pasta products and group V for nutritional quality traits. The benchmark details are given in the table below (Table 10).

Table 10. Benchmarks for identification of superior genotypes for processing and nutritional quality traits

S. No.	Traits	Group I Hard wheat for chapati	Group II Hard wheat for bread	Group III Soft wheat for biscuits etc.	Group IV Durum wheat for pasta	Group V Nutritional quality
1	Hectolitre weight (kg/hl)	>76	>76	>76	>78	>76 (A) >78(D)
2	Grain protein % (at 12% MB)	>12.5	>13.0	<11.0	>13.0	>13.0
3	Sedimentation volume (ml) 6g test	50-60	>60	<35	>45	-

S. No.	Traits	Group I Hard wheat for chapati	Group II Hard wheat for bread	Group III Soft wheat for biscuits etc.	Group IV Durum wheat for pasta	Group V Nutritional quality
4	Grain hardness index by SKCS	>80	>75	<35	>80	-
5	Phenol reaction (1-10 scale)	<3.0	-	-	-	-
6	Yellow pigment (ppm)	-	-	-	>8.0 ppm	-
7	Fe (ppm)	-	-	-	-	>40
8	Zn (ppm)	-	-	-	-	>40

A= Aestivum; D=Durum

In addition to the above traits, the wheat genotypes for chapati should have chapati score >8.0/10.0, for biscuit, it should have a spread factor >10.0, for bread, it should have bread loaf >600 ml and pasta products with the hedonic scale of >7.5/9.0.

Evaluation methods of wheat quality parameters

A. PHYSICAL METHODS

1. Hectolitre weight or test weight

Test weight is the weight of a specific volume of grain and indicates the bulk density of the grain associated with flour recovery. It is also known as bushel weight or hectolitre weight (Kg/hl). The wheat quality group at ICAR-IIWBR has devised a low-cost instrument where around 90 g of seed is sufficient to record the value.

Procedure

- Close the slit of the hopper and keep the cylinder slit open.
- Fill the hopper with around 90 g grain.
- Open the hopper slit and allow the grain to drop in the cylinder.
- Close the cylinder slit to remove extra grains.
- Weigh the grain from the cylinder.

2. Grain hardness (GH)

GH is measured using a single-kernel characterization system (SKCS 4100) (Perten) instrument.

Procedure

- A sample of wheat kernels is prepared by removing broken kernels, weed seeds, and other foreign materials.
- The sample is poured into the access hopper of the SKCS instrument.
- The SKCS instrument analyzes 50 kernels individually and records the results on a computer graph.
- The kernel hardness is expressed as an index of –20 to 120. Based on the hardness index, the grains with HI < 40 are classified as soft, 40 – 55 as medium-hard, and > 55 as hard.

B. CHEMICAL METHODS

1. Protein content

The protein content is estimated using the Infratec™ 1241 (FOSS) instrument, a whole grain analyzer using near-infrared transmittance technology.

Procedure

- Select the programme and set the number of subsets.
- Pour around 150 g clean grains into the hopper.
- Press the analyze button and read results from the screen.

- If the sample volume is less, select the appropriate programme, pour grains into the cuvette of STM (Sample Transport Module), insert the cuvette into the module, press analyze and read.

- For protein estimation in flour samples, fill up the cup with flour and place it into the hopper, press analyze button and read the results
- Results are expressed in percentage on 12% moisture basis.

2. Sedimentation volume

The SDS sedimentation test measures the sedimentation volume of the suspension of flour in SDS-lactic acid solution.

Procedure

- Take 100 ml glass measuring cylinders with stoppers.
- For each sample, add 6 g whole meal flour to 50 ml distilled water. Shake rapidly for 15 sec and place it undisturbed for 5 min. Keep the 50 ml SDS/Lactic acid reagent ready in 50ml cylinders.
- Shake rapidly for 10 sec and add 50 ml SDS/Lactic acid reagent, mix well and put it undisturbed for 10 min followed by calculation of sedimentation volume against graduated tube.
- Sedimentation volumes can be in the range of 20 ml or less to as high as 80 ml. Sedimentation volumes

>60 ml, 30-60 ml and <30 ml are preferred for making good quality bread, chapati and biscuit, respectively.

3. **Gluten content**

Procedure

- A 10-gram sample of wheat flour is weighed and placed into the glutomatic washing chamber.
- 4.8 ml of salt solution (2% NaCl) is added to the flour samples.

- The flour and the salt solution are mixed to form a dough for 20 seconds.
- After termination of the mixing phase, the washing automatically starts and continues for five minutes.
- After 30 seconds of washing, the undivided wet gluten piece is centrifuged for one minute at 6000 rpm.
- The fraction passed through the sieves is scraped off, along with the fraction remaining inside the sieve.
- The total wet gluten is dried at 150°C for four minutes and weighed.
- The amount of gluten remaining on the centrifuge sieve in relation to total wet gluten weight is the Gluten Index.
- Wet gluten content results are expressed as a percentage on a 14% moisture basis.

4. Yellow pigment content

Reagents

Water Saturated Butanol (WSB) and ß-carotene standard.

Procedure

- Weigh 8 g flour sample and add 40 ml WSB in a glass tube with stopper.
- Shake gently and allow to stand for 16-18 hrs at room temperature in dark.
- Mix and filter completely through the filter paper (Whatman No. 1).
- Measure the optical density of the clear filtrate at 435 nm using water-saturated n-butanol as blank in a spectrophotometer.
- Calculate the amount of yellow pigments using the ß-carotene standard curve prepared by using ß-carotene dilutions in the range of 2.5 to 15.0 µg.
- Yellow pigment is essentially a preferable feature of durum wheat where >8 ppm yellow pigment is desired for pasta products.

Preparation of standard curve

- Make a standard ß-carotene solution of concentration 1mg/ml in WSB.
- Make dilutions in the range of 2.5 to 15.0µg and read at 435 nm.
- Prepare a standard curve and determine the linear regression equation.
- Use the equation to calculate the content of yellow pigment in samples.

5. Estimation of Fe and Zn

The Oxford Instruments X-Supreme 8000 uses X-ray fluorescence (XRF) spectrum of the photon released to estimate Fe and Zn content non-destructively.

Procedure

- The instrument is to be switched on and left to 'warm up' for 90 minutes.
- Samples used for analysis are harvested as mentioned in the sampling section and it has to be ensured that no contamination is present.
- A minimum of 3 g grain samples (in duplicate) are loaded in the aluminium cups with plastic inserts (4 µm film) and a total of 10 samples can be evaluated at a time.
- The appropriate program with the required instrumental parameters for the elements to be assessed is selected.
- The results obtained are expressed in ppm. Benchmark of 40.0 ppm is considered for both Fe and Zn content in wheat grains for the identification of bio-fortified varieties.

6. Phenol test

- This test is basically used for testing of varietal purity qualitatively. Phenol colour reaction is also correlated to the darkening of the whole meal dough and chapati quality. The colour of the phenol reaction is negatively correlated to the chapati quality. The enzyme polyphenol oxidase present in the outer layers of wheat grain, reacts with the phenol and oxidizes it to quinones which are subsequently converted to dark coloured melanins by polymerisation and interaction with protein. Intensity of colour depends on the amount of enzyme.

Procedure

- Clean the grains of any damaged kernels or foreign material and put in a Petri dish.
- Add 1% phenol solution such that all the seeds are dipped in the solution.
- Keep for 2 hrs, drain the solution and dry the seeds on a filter paper sheet.
- After complete drying, grade the colour on the scale of 0 – 10.
- Dark colour indicates high polyphenol oxidase activity and hence not suitable for chapati.

C. END-PRODUCT EVALUATION METHODS

1. Bread

Ingredients: 100 g flour, 2.5 g dry yeast, 5.0 g sugar, 2.0 g salt, 3.0 g ghee and 60 ml water.

Procedure

- Mix all the above ingredients except ghee and knead together in a dough mixer for 1 minute to form a dough.
- Leave the dough for 1 hour 40 minutes at 30-32°C for fermentation.
- Again knead the dough with ghee for 40 seconds, mold in desired shape and place in an oiled baking mold.
- Place the baking molds inside the proofing chamber, which is maintained at 35.5°C with 92% humidity. Leave the loaves for 50 minutes.
- Loaves are baked in a rotary oven maintained at 220°C for 12 minutes.
- Volume of the baked loaves is immediately measured by the loaf volume meter.
- The final evaluation of bread is done after 18 hours as per loaf score parameters and and standard scoring method.

2. **Biscuit**

Solution A: 79.8 g sodium bicarbonate in 1 L distilled water.
Solution B: 101.6 g ammonium chloride and 88.8 g NaCl in 1 L distilled water.

Biscuit paste: 10.4 g sodium bicarbonate, 31.2 g milk powder, 624 g sugar, 312 g ghee.

Procedure

- 37.6 grams of biscuit paste is mixed with 4.0 ml solution A, 2.0 ml solution B and 2.0 ml water followed by mixing for 5 minutes.
- 39.2 g flour is added and mixed for 25-30 seconds to form a dough.
- The dough is rolled out to a consistent thickness, cut into circles and place on a greased cookie sheet.
- The cookies are baked at 205°C for 11 minutes.
- The cookies are allowed to cool on the cookie sheet for 5 minutes before removing to a cooling rack and both thickness and diameter are measured using Vernier Caliper and the spread factor is calculated by dividing diameter with thickness.
- Spread factor (>10.0) is considered good for biscuit making quality.

3. **Chapati**

Procedure

- Appropriate amount of water is added to 100 g whole wheat flour and kneaded manually.

- The dough is covered with a moist muslin cloth and allowed to rest for half an hour.
- Dough is divided into two parts of 40 g each and the balls are rolled into chapati of around 15 cm diameter and 1.5 mm thickness and again weighed.
- The chapati is cooked on both sides on a hot griddle and then puffed on a wire mesh.
- The puffing height is measured and chapati is immediately weighed.
- One puffed chapati is immediately kept covered in a cloth for four hours and then evaluated for their chapati quality score. The other chapati is also evaluated for chapati quality score immediately after puffing.
- Chapatis are scored (0–10) subjectively for the parameters like appearance, colour, taste, aroma, pliability, puffing height as per the chapati quality score.

आज़ादी का अमृत महोत्सव

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