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Short Communication

Industrial evaluation for malting quality of Indian barley varieties

Dinesh Kumar*, Ramesh Pal Singh Verma, Ajit Singh Kharub and Gyanendra Pratap Singh

ICAR-Indian Institute of Wheat & Barley Research, Karnal – 132001, India

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****Corresponding author:*** *dinesh.kumar3@icar.gov.in*

Barley is the main cereals for industrial uses in malting and brewing. Malt is the major raw material for brewing, nutraceutical energy drinks and distilled malt whiskeys. In the early nineties when Indian economy was liberalized, several new brewing units started their operations in India, which was followed by entry of world's leading brewing companies looking into the immense potential market in country. However, initially one of the major bottlenecks for the industry was availability of indigenous raw material in absence of malt barley varieties with international malt standards in India. An organized malt barley improvement programme was initiated at ICAR-Indian Institute of Wheat & Barley Research, Karnal and its collaborating centers under the "All India Coordinated Research Program" and several improved two row malt barley varieties have been released for timely and late sown irrigated conditions of northern plains (Kumar *et al.*, 2014). In addition, a few high yielding six row cultivars with good malting quality amongst this type were also released for commercial cultivation. The varieties were evaluated for the malting quality standards (Table 1) developed in collaboration of the industry in the country. The new malt quality variety has to meet these quality standards in addition to the regular requirement of good yield, disease and pest resistance. Further the aspect of heat stress tolerance was also taken into consideration and malt varieties for late sowing were also developed to fit into the cropping-system of the cotton belt of the north western plains, where there was a special niche for barley over wheat under low input conditions. One of the major achievements of barley breeding programme in country has been the release of variety DWRUB 52, which was developed in public-private partnership (Verma *et al.*, 2007). The variety was well received by the industry for contract farming and is still the major Indian malt barley with greater share of area among two rowed malt barley. Several more varieties have also been developed after DWRUB 52, however industry felt the crunch of raw material because of lower diastatic power and higher β-glucan content, which are now becoming the latest additional requirements. The malt barley import was expected to be around one million tonnes from April 2020-2021. India's annual production of barley is around 16.0-18.0 lakh tones, while annual demand for barley for malting is estimated to be around 4.0-4.5 lakh tones, which is well below the total production (Anonymous 2021a). The issue is for lack of adequate quality of the barley production in the required quantity and availability for malting. Due to lack of remunerative price, farmers are reluctant to grow the malt grade varieties to fulfil the industrial demand. The industrial demand of malt barley is also increasing due to higher consumption of beer (Anonymous 2021b) in country. The Indian market is being currently supplied grain/malt primarily by Canada and Europe, where a comparatively cooler climate enables unmitigated malting barley to be exported to India. However, in the current scenario Australia may also become the major supplier in the future (Anonymous 2021c). Barley grown under comparatively cooler and longer reproductive phase seasons is superior in quality due to greater duration of grain filling. However, the Indian programme has made consistent changes in its priorities to match quality of international standard and several new good malt quality cultivars are now available. Therefore, in order to create awareness among the malting and brewing industries and to get vetted the performance of Indian barley varieties, it was considered essential to get these new genotypes tested by industry under their respective malting processing recipe.

Eight barley varieties were grown at ICAR-Indian Institute of Wheat & Barley Research Farm, Karnal during the *rabi* season of 2018-19 with recommended agronomic practices. The experiment was planted on 24.11.2018 and it was harvested on 12.04.2019. After harvesting, threshing and cleaning, the produce was stored at room temperature in closed iron boxes with fumigation. The grain samples of these eight varieties were then given to four industries (M/s AB InBev India Pvt Ltd, M/s Barmalt India Pvt Ltd, M/s PMV Maltings Pvt Ltd, and M/s United Breweries Pvt Ltd) for malting quality analysis in September, 2019. The acceptable range/values of some of the malt traits have been mentioned in Table 1.

Table 1. Malt Barley Quality Specifications

Traits	Malting quality minimum standards		
	Fox *et al.* (2003)	ICAR-IIWBR (2020), India	
		2-row	6-row
Friability (%)	>70	>65	>60
Diastatic Power (°L)	62-105	>90	>90
Filtration Rate (ml/hr)	NA	>250	>250
Hot Water Extract (fine) (%)	>80.0	>80	>78
Free Amino Nitrogen (ppm)	140-180	>150	>150
Kolbach Index (%)	35-49.9	40-44	40-44
Wort β-glucan (ppm)	<200	<200	<200
α-Amylase (DU)	>60	NA	NA

The data received were analysed and are presented in Table 2 and Fig 1. The wort β-glucan and α-amylase values were received from one industry only. The trait wise results are discussed below for the varieties evaluated:

Friability: Friability analysis is a measure of fraction of malt which is easily grounded as flour on applying pressure and is a good and robust indicator of modification of grain endosperm components (Muller, 2003). The friability of sample has negative correlation with wort viscosity and therefore higher values of friability are desirable (Bathgate, 1983). The mean friability values ranged from 57.3% (DWRB 92) to 82.5% (DWRUB 52). The friability as per international standard was achieved in four genotypes (DWRUB 52, DWRUB 64, DWRB 91 and DWRB 101), however considering the Indian standard all the varieties except DWRB 92 were found acceptable.

Diastatic power: The diastatic power of malt is the collective activity of several starch degrading enzymes, which accumulate or get activated during malting (Gibson *et al.,* 1995). The mean diastatic power values ranged from 56°L (DWRB 101) to 116°L (DWRB 92). Except DWRB 101 and DWRUB 52, all the varieties had acceptable diastatic power as per international standards and DWRB 92 and DWRB 137 have diastatic power of >90 ° L. The higher diastatic power is now being considered to be an essential quality characteristic for malting and brewing, whereas moderate activity was being preferred in the beginning of malt barley breeding programme in mid-nineties. Diastatic power is mainly determined by the genotype, but is also influenced by growing conditions and cultural practices (Arends *et al.*, 1995). Therefore, improvement in the diastatic power in barley has become a critical objective of barley breeding programmes in recent past.

Filtration rate: A faster rate of wort filtration is important to get higher efficiency in the malting and brewing process (Kumar *et al.*, 2013). The average filtration rate ranged from 188 ml hr^{-1} (DWRB 91) to 302 ml hr^{-1} (DWRUB 64). All the genotypes except DWRB 91 and DWRB 137 have required filtration rate of 250 ml hr^{-1} or more.

Hot water extract (HWE): Hot water extract is the measure of the soluble materials from malt, when hydrolytic enzymes have acted optimally (Eneje *et al.*, 2012). Hot water extract is the most important parameter for malt barley improvement programme anywhere in the world and is the major criteria for acceptability of any malt variety by the malt industry. The average values of hot water extract ranged from 77.8 to 81% fgdb (fine grind dry basis). The hot water extract values of 80% or above were obtained in DWRUB52, DWRB91 and DWRB101 in two row type and >78% in DWRUB 64 and DWRB 137 among six rowed. The latest released six-row feed barley variety DWRB 137, can also be considered taking into account by industry based on Indian specifications (Table 1).

Free amino nitrogen (FAN): The individual amino acids and small peptides (dipeptides and tripeptides) present in wort are known collectively as free amino nitrogen. FAN is believed to be a good index for potential yeast growth and fermentation efficiency. Adequate levels of FAN in wort ensure efficient yeast cell growth and, hence, a desirable fermentation performance (Lekkas *et al.,* 2005). The average FAN content of varieties ranged from 130 to 168 ppm. The genotypes DWRUB 52, DWRB 91, DWRB 92, DWRB 101 and DWRB 137 were found suitable with respect to international standards. There has been much debate regarding the minimal FAN required to achieve satisfactory yeast growth and fermentation performance in normal gravity wort, and it is generally agreed to be around 130 mg FAN/L, with the minimum varying between 100 mg FAN/L and 140 mg FAN/L (Hill and Stewart, 2019).

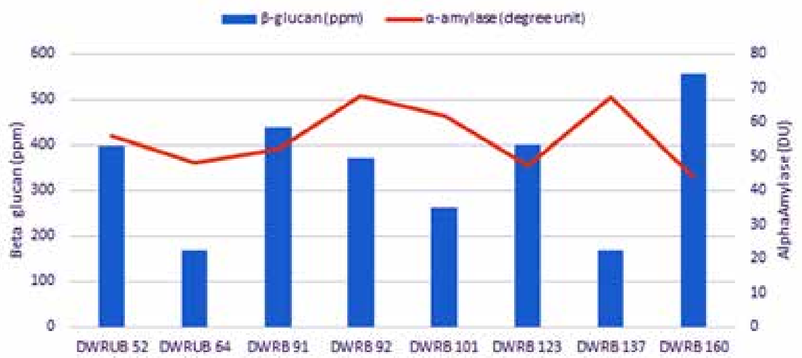

Fig 1. Wort β-glucan content and malt α-amylase activity

Table 2: Malt quality of Indian barley varieties assessed by four companies (under A, B, C and D columns).

Variety	A	B	C	D	Mean	A	B	C	D	Mean
	Friability (%)					FAN (ppm)				
DWRUB 52	86	NA	79	NA	**82.5**	155	NA	161	136	**150.7**
DWRUB 64	81	84	71	NA	**78.7**	133	126	135	127	130.3
DWRB 91	78	75	NA	NA	**76.5**	178	143	NA	161	**160.7**
DWRB 92	60	61	51	NA	57.3	167	145	136	151	149.8
DWRB 101	79	79	75	NA	**77.7**	167	175	170	160	**168.0**
DWRB 123	70	62	62	NA	64.7	121	147	142	111	130.3
DWRB 137	71	70	52	NA	64.3	157	176	142	145	**155.0**
DWRB 160	77	63	60	NA	66.7	141	119	144	115	129.8
	Diastatic Power (° Linter)				Mean	Kolbach Index				Mean
DWRUB 52	61	NA	64	46	57.0	44	NA	NA	47	**45.5**
DWRUB 64	75	101	72	101	87.3	45	45	NA	46	**45.3**
DWRB 91	83	75	NA	96	84.7	48	44	NA	47	**46.3**
DWRB 92	83	125	113	144	**116.3**	35	39	NA	38	37.3
DWRB 101	58	52	56	57	55.8	51	43	NA	42	**45.3**
DWRB 123	68	86	61	66	70.3	38	41	NA	41	**40.0**
DWRB 137	100	105	87	129	**105.3**	49	44	NA	44	**45.7**
DWRB 160	74	81	72	92	79.8	46	39	NA	44	**43.0**

	HWE (%fgdb)				Mean	Filtration Rate (ml/hr)				Mean
DWRUB 52	80	NA	79	82	**80.3**	310	NA	200	NA	255.0
DWRUB 64	79	80	78	83	**80.0**	280	375	250	NA	**301.7**
DWRB 91	81	79	NA	83	**81.0**	200	175	NA	NA	187.5
DWRB 92	77	77	77	80	77.8	310	NA	270	NA	**290.0**
DWRB 101	80	79	79	82	**80.0**	300	327	200	NA	**275.7**
DWRB 123	79	78	79	80	79.0	310	245	NA	NA	**277.5**
DWRB 137	79	79	78	81	**79.3**	310	165	240	NA	238.3
DWRB 160	78	75	78	80	77.8	270	260	280	NA	**270.0**

Kolbach index (KI): Kolbach index is typically measured as the ratio of soluble nitrogen to total nitrogen in the wort (Fang *et al.*, 2019). The relationship between the protein degradation degree (Kolbach index) and other quality parameters of malt is complex owing to the diversity of protein types that are present in the grain and their range of functions in malting and brewing. During the malting and brewing process, malt proteinases completely or partially hydrolyse storage proteins and modify other proteins. The solubilization of malt storage proteins affects the qualities of the malt and the wort, and finally affects the beer quality, including the beer's nutritional value, haze stability and foam characteristics (Jin *et al.*, 2012). The mean Kolbach Index ranged from 37 (DWRB 92) to 46 per cent (DWRB 91) and was in desirable range for all varieties except variety DWRB 92 as per national international standard.

Wort β-glucan (WBG): β-glucan is the major component of barley grain endosperm cell wall and contribute upto 75% of total cell wall composition. Incomplete degradation of endosperm β-glucan during malting and mashing causes excessive wort β-glucan, which would influence the hot water extract content and quality in the wort. Excessive residual β-glucan in the malt will lead to an increase of viscosity, which is not conducive to the filtration of wort and beer, and results in reduced beer quality. Although WBG is affected by both genotypic and environmental factors, the genetic background is more significant (Fang *et al.*, 2019). The WBG content varied from 168 ppm (DWRUB 64) to 557 (DWRB 160) as analyzed and provided by one industry. The genotypes DWRB 64, DWRB 137 (six rowed) and DWRB101 (two row) were observed with lower WBG contents (Fig. 1).

α-amylase (AA): α-amylase activity develops mainly after germination of barley grain and usually remains undetectable in ungerminated grain (Greenwood and McGregor, 1965). The values ranged from 47 DU (DWRB 123) to 68 DU (DWRB 92) as analyzed and provided by one industry. Desirable values were obtained in three genotypes *i.e.,* DWRB 92, DWRB 101 and DWRB 137 (Fig. 1).

Since the malting and brewing quality is a combination of various biochemical traits of the malt, some of them are negatively correlated and it is difficult to get the most desired values of each trait in to single genotype, the only option left is to optimize these values in one genetic background/ variety (Kumar *et al.*, 2014). In this direction based on the overall interpretation and considering optimum level of these traits, it can be concluded that in the case of two row barley varieties, DWRUB 52 and DWRB 101 are perfect for all the quality parameters except having little lower diastatic power. Similarly, DWRB 91 is also very good for most of the traits except having little lower filtration rate. Among the six-row type DWRUB 64 and DWRB 137 fulfills the desired specifications except one or two parameters. The genotypes DWRB 92 and DWRB 160, having high thousand grain weight (>50g), may need special malting recipe to get better quality malt. Based on this one-year industrial evaluation study, it is clear that the above varieties developed by Indian malt barley improvement programme fulfill the requirement of industry from malting quality point of view. However, the selection of cultivars by industry for cultivation under their contract farming program will depend upon their specific requirements, though the options are available from indigenous varieties. Another advantage of these varieties is their adaptation to the local agroclimatic situation as well as resistance to the prevailing diseases, as these two factors lower the grain quality of the exotic introductions. This independent evaluation by local industries has also allayed the misconception that locally bred malt barley cultivars do not possess the international grade quality parameters, and we need to import the good malting quality grain from outside India. The cultivation of the malt barley by farmers needs optimum crop management to avoid any kind of stress, which may adversely affect the quality of the produce.

Conflict of Interest

Authors declare that they have no conflict of interest

Ethical Compliance Statement

NA

Author's Contribution

Dinesh Kumar (Planning, execution and writing of MS); Ramesh Pal Singh Verma (Major Editing of MS); Ajit Singh Kharub (Planning and Editing); Gyanendra Pratap Singh (Planning and Guidance)

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