

Suitability of Indian Finger Millet for malting: A Pilot Study

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Abstract

Forty-six finger millet genotypes including 23 released varieties grown across the country were evaluated for grain and malt quality traits for two consecutive years to identify suitable genotypes for quality malt extraction. The grain protein content of genotypes varied from 5.6-10.6 in first year and 6.1-12.0 in the second year. All the finger millet genotypes showed high malt yield in both the years of evaluation. Best genotype for Hot Water Extract (HWE) was VL 348 (61.3%) in first year and IE 518 (60.5%), VHC 3766 (60.3%), VL 352 (64.1%), VL 384 (66.0%) were in second year. Overall, the results indicated that although variability is present in finger millet genotypes for malt quality traits, it may need separate breeding programme to select genotypes for malt with superior malting quality.

Keywords: *Eleusine coracana*, Finger Millet, Hot water extract, Malt yield, Protein content

1. Introduction

Millets are the excellent source of essential nutrients; they are also called as 'nutritious cereals'. The Indian Millets are nutritionally superior to wheat and rice as they are rich in protein, vitamins, and minerals. They are also gluten-free and have a low glycemic index, making them ideal for people with celiac disease or diabetes (Kumari *et al.*, 2024). India is the world's largest producer of millets with a share of 38.4% of world's production (FAO, 2023). Among Millets, Finger millet (*Eleusine coracana* L.) is an important crop in Asia and Africa and has wide adaptability ranging from coastal areas to Himalayan region. It is mostly used in the production of traditional foods with very limited industrial application in bakery industry. The finger millet grains are rich source of minerals, dietary fibre, and essential amino acids (Murungweni *et al.*, 2025; Kalsi *et al.*, 2023; Sood *et al.*, 2019; Sood *et al.*, 2017; Sood *et al.*, 2016). These grains can be stored for years together without any damage. Due to lack of industrial application, the crop grains do not fetch premium price and there is decreased interest among farming community for

cultivation of these crops. Bringing back these grains in daily food routine due to easy availability of wheat and rice at cheaper price under public distribution system in India is also challenging. Therefore, alternative uses of this nutritionally important crops need to be investigated and one of the potential alternative uses could be use of finger millet grains in malting industry (Sahoo *et al.*, 2024). Finger millet and other cereals have been used to brew traditional opaque beer since time immemorial in Asia and Africa (Nout and Davies, 1982; Usai *et al.*, 2013; Kubo, 2016; Pathare *et al.*, 2025). Brewing of local traditional opaque beer using finger millet malt is significant in many countries including India and Nepal (Karki and Kharel, 2013). Opaque beer production involves both lactic acid and alcoholic fermentation stages and takes about 5 to 7 days to brew depending on temperature. It could be a potential substitute for production of gluten free malt especially for celiac patients (Rubio-Flores and Serena-Saldivar, 2016; Murungweni *et al.*, 2025). Therefore, there is need to identify varieties or genotypes suitable



for processing and value addition in order to enhance the income of stakeholders. There are number of grain and malt traits identified in barley, which are considered essential or important by malting and brewing industries. In barley minimum standards for grain and malt traits have been finalized in order to classify them into malt and non-malt types. However, there is no fixed criterion in case of finger millet for classifying the genotypes as malt or non-malt types. However, in case of finger millet, there is no categorization of genotypes for malt quality. The germplasm has not been characterized for malt quality in order to use the selected parental lines for breeding malt type finger millet genotypes. Quantitative genetic studies are useful in making decisions on selection of lines for desired traits. Genetic diversity studies help in clustering of germplasm into different groups and also indicate the extent of diversity in the material. Moreover, the malt

quality characteristics in finger millet are not well defined. Therefore, malt quality traits standardized for barley were used for evaluation of finger millet genotypes in the present study. The present study, therefore, was conducted to identify suitable finger millet genotypes for malting purpose among all varieties and elite lines of finger millet.

2. Materials and Methods

Forty-six finger millet genotypes including 23 released varieties across India, elite breeding lines and germplasm collections were taken in the present study (Table 1). All these were grown under standard package & practices at ICAR-VPKAS, Almora. The crop was harvested at maturity and grain samples of these genotypes were evaluated for grain and malt quality traits at ICAR-IIWBR, Karnal utilizing the standard methods standardized for barley grains.

Table 1. Finger millet genotypes along with their origin/type, source and area of adaptation

S. No.	Sample ID	Origin/ type	Source	Area of adaptation
1	GPHCPB 31	Local germplasm	GBPUA&T, Pantnagar	Uttarakhand hills
2	GPHCPB 45	Local germplasm	GBPUA&T, Pantnagar	Uttarakhand hills
3	GPHCPB 52	Local germplasm	GBPUA&T, Pantnagar	Uttarakhand hills
4	GPU 26	Released variety	PC unit, AICSMIP, UAS, Bengaluru	Karnataka
5	GPU 28	Popular Released variety	PC unit, AICSMIP, UAS, Bengaluru	Karnataka
6	GPU 45	Released Variety	PC unit, AICSMIP, UAS, Bengaluru	Karnataka
7	GPU 48	Released Variety	PC unit, AICSMIP, UAS, Bengaluru	Karnataka
8	GPU 67	Released Variety	PC unit, AICSMIP, UAS, Bengaluru	Karnataka
9	IE 2710	Malawi	ICRISAT	Africa
10	IE 4491	Zimbabwe	ICRISAT	Africa
11	IE 4570	Zimbabwe	ICRISAT	Africa
12	IE 4797	Maldives	ICRISAT	Maldives
13	IE 5066	Senegal	ICRISAT	Africa
14	IE 518	India	ICRISAT	India
15	IE 6059	Nepal	ICRISAT	Nepal
16	IE 6337	Zimbabwe	ICRISAT	Africa
17	IE 7320	-	ICRISAT	-
18	PRM 1	Released variety	GBPUA&T, Pantnagar	Uttarakhand hills



19	PRM 801	Released variety	GBPUA&T, Pantnagar	Uttarakhand hills
20	VHC 3568	Local germplasm	ICAR-VPKAS, Almora	Uttarakhand hills
21	VHC 3569	Local germplasm	ICAR-VPKAS, Almora	Uttarakhand hills
22	VHC 3570	Local germplasm	ICAR-VPKAS, Almora	Uttarakhand hills
23	VHC 3575	Local germplasm	ICAR-VPKAS, Almora	Uttarakhand hills
24	VHC 3610	Local germplasm	ICAR-VPKAS, Almora	Uttarakhand hills
25	VHC 3771	Local germplasm	ICAR-VPKAS, Almora	Uttarakhand hills
26	VHC 3803	Local germplasm	ICAR-VPKAS, Almora	Uttarakhand hills
27	VHC 3873	Local germplasm	ICAR-VPKAS, Almora	Uttarakhand hills
28	VHC 3876	Local germplasm	ICAR-VPKAS, Almora	Uttarakhand hills
29	VHC 3962	Local germplasm	ICAR-VPKAS, Almora	Uttarakhand hills
30	VHC 3970	Local germplasm	ICAR-VPKAS, Almora	Uttarakhand hills
31	VL 146	Released variety	ICAR-VPKAS, Almora	Uttarakhand hills
32	VL 149	Popular Released variety	ICAR-VPKAS, Almora	All finger millet growing states of India
33	VL 315	Released variety	ICAR-VPKAS, Almora	Uttarakhand hills
34	VL 324	Popular Released variety	ICAR-VPKAS, Almora	Uttarakhand hills
35	VL 340	Advanced breeding line	ICAR-VPKAS, Almora	-
36	VL 347	Released variety	ICAR-VPKAS, Almora	All finger millet growing states of India
37	VL 348	Released variety	ICAR-VPKAS, Almora	Uttarakhand hills
38	VL 352	Popular Released variety	ICAR-VPKAS, Almora	All finger millet growing states of India
39	VL 367	Advanced breeding line	ICAR-VPKAS, Almora	-
40	VL 376	Released variety	ICAR-VPKAS, Almora	All finger millet growing states of India
41	VL 379	Released variety	ICAR-VPKAS, Almora	Northern and Central states of India
42	VL 382	Released variety	ICAR-VPKAS, Almora	Uttarakhand hills
43	VL 384	Advanced breeding line	ICAR-VPKAS, Almora	-
44	VL 501	Advanced breeding line	ICAR-VPKAS, Almora	-
45	VL 502	Advanced breeding line	ICAR-VPKAS, Almora	-
46	VR 708	Popular Released variety	ARS, Vizianagram, AP	All finger millet growing states of India

Grain Traits: The thousand grain weight (TGW) of grains was taken utilizing the equipment seed counter (Pfeuffer make), test weight/grain density/hectolitre weight was measured in kg/hl as weight of one hectolitre grains using test weight instrument developed by IIWBR, Karnal and crude protein content was estimated using Kjeldahl's

method and by using the multiplication factor as per EBC Analytica IV 2003.

Malt preparation: Finger millet grain samples (100g) of each genotype were malted using automatic micro malting system (Joe White make, Australia), with slight modifications due to germination time differences with



barley. Grains were malted as per the protocol of Narwal *et al* (2016) and details are given in the table below. In nutshell, the malting was carried out in three stages of steeping, germination and kilning. Total period of 36 hours was given for steeping (comprising of 8 hrs water dip, 10 hrs air rest, 6hrs water dip and then 12 hrs air rest), 60 hrs for germination and 24 hrs for kilning. The temperatures of each stage are as below:

Step	Duration (hours)	Temperature (°C)
Steeping	8	18
	10	18
	6	18
	12	18
Germination	24	18
	24	17
	12	16
Kilning	2	30
	3	45
	3	50
	3	55
	3	60
	3	65
	3	70
	3	75
	1	80

After completion of micro-malting the malt after removal of dried rootlets was stored at room temperature in plastic interlocking envelopes to avoid moisture uptake by the malt. The malt thus obtained from each genotype was analysed for the different malt quality traits as per EBC Analytica IV 2003. The malt yield was calculated after weighing the material after removal of rootlets. The malt was then grounded in Buhler Mill using fine grinding setting and mashing was done in IEC make Mashing Bath (Australia) as per EBC protocol. The extract was filtered through Whatman No. 2555 ½ filter paper to calculate filtration rate as ml per hour. The hot water extract or malt extract was determined as per EBC protocol using specific gravity method. Besides the hot water extract (HWE), wort colour, pH and saccharification rates were determined (Kumar *et al.*, 2022).

2.1. Statistical analysis

Basic statistics and correlation analysis was performed in SPSS software (SPSS version 20, SPSS Inc., Chicago, IL,

USA). The cluster analysis was performed in DARwin 6.0 (Perrierand Jacquemoud-Collet, 2006).

3. Results and Discussion

Although there are numerous grain and malt parameters important in barley, however, amongst them hot water extract (HWE) is of paramount importance for industrial use (Verma *et al.*, 2008; Kumar *et al.*, 2013; Kumar *et al.*, 2022;). There are several uses of millet-based malts, especially in case gluten free products (Malleshia *et al.*, 2025), however little or no information was available on the genetic diversity for malting quality traits as well as on the sources of important quality traits in finger millet genotypes of India. It is therefore important to study the genetic diversity for different grain and malt quality traits in different finger millet varieties and to identify the best malting finger millet genotypes. Moisture content affects the grain quality and germination capacity. Moisture level needs to be low enough (<12%) to inactivate the enzymes involved in seed germination and growth of diseases (Kumar *et al.*, 2013). All the finger millet samples were thus oven dried to a moisture level of around 10 per cent for further analysis.

The range of variation for grain as well as malt traits observed during both the years of study is presented in Table2 and 3. All the finger millet genotypes showed high malt yield in both the years of evaluation. The malt yield recovery was high in finger millet but it requires precise analysis as it was difficult to remove the roots from each and every grain of finger millet due to its very small size. Therefore, malt yield recovery needs more observations and specific instrument in case of finger millet. The hot water extract (HWE)percentage varied from 41.0-61.3 in 2015 to 40.5-66.0 in 2016. The average value was 45.93 and 47.59% in 2015 and 2016, respectively. Singh *et al.* (2018) however observed higher range of 42.7 to 73.5% under different malting conditions. None of the finger millet genotypes had more than 80% HWE value however, VL 348 (61.3%) in 2015 and IE 518 (60.5%), VHC 3766 (60.3%), VL 352 (64.1%), VL 384 (66.0%) in 2016 were the best genotypes. Nine genotypes in 2015 and 34 in 2016 had high filtration rate of more than 250 ml/hr (Table 2 & 3). High wort filtration rate of 250 ml/hr is desirable in brewing industry (Kumar *et al.*, 2022).



Table 2. Grain and malt trait analysis of different finger millet genotypes grown in first year

S. No.	Sample ID	Test Wt (kg/hl)	TGW (g)	Grain Protein (%)	Malt yield (%)	Filtration rate (ml/hr)	HWE (% dwb)	Wort colour	Wort pH	Sach. rate (min)
1	GPHCPB 31	76.6	2	8.4	85.6	240	53.2	6	6	10
2	GPHCPB 45	70.6	2.5	8.2	86.4	245	52.4	6	6.1	10
3	GPHCPB 52	70.6	2.3	7.4	86.9	275	46.3	6	6.1	10
4	GPU 28	62.9	2.2	7.6	84.3	120	44.3	6	5.8	5
5	GPU 45	74.7	2.8	8.3	85.5	205	51.8	6	6	5
6	GPU 48	70.3	3.5	10.3	86.8	190	42.6	6	6	10
7	GPU 67	67.9	2.3	7.5	84.9	245	59.2	6	6	10
8	IE 2710	71.1	2.8	7.7	83.1	180	42.5	6	6	5
9	IE 4491	73.1	2	8.9	86.2	220	43.8	5	5.8	5
10	IE 4570	67.4	2.4	6.6	82.5	180	43.3	6	6.1	10
11	IE 4797	70.4	1.5	10.3	84.1	250	42.9	6	6	5
12	IE 5066	61.8	1.6	9	82.2	265	44.7	6	6.1	10
13	IE 518	69.8	2.3	6.9	88.3	275	53.8	6	6.3	10
14	IE 6059	74.8	1.2	8.3	83.3	240	41	5	6.1	10
15	IE 6337	69.7	2.2	8.1	85.3	240	45.2	5	6	10
16	IE 7320	69.7	1.4	8.8	84.8	250	44	6	6.1	5
17	PRM 1	72.7	3.2	8.9	83.9	250	46	6	6.5	5
18	PRM 801	68.2	2.1	7.8	85.7	80	44.8	5.5	6.9	10
19	VHC 3568	76.3	2.5	7.5	90.3	260	44.5	5	6.2	5
20	VHC 3569	63	2.1	8.2	87	220	43.5	5.5	6.4	5
21	VHC 3570	64.7	1	9.6	84.9	185	48.7	6	6.1	5
22	VHC 3575	70.8	2.2	8.7	85.9	225	44.3	2.5	6	5
23	VHC 3610	63.5	2	7.4	88.4	240	53.8	2	5.3	10
24	VHC 3771	77.2	1.7	7.2	86.4	270	41.9	5.5	6.1	10
25	VHC 3803	67	1.8	7.4	88.5	215	46.8	6	5.8	5
26	VHC 3873	62.6	1.7	5.6	83.3	105	42.5	4	6	10
27	VHC 3876	67.8	2.4	10.6	86.3	230	42.8	5.5	6.4	10
28	VHC 3962	71.3	2.3	6.3	88.5	260	47.6	5	6	5
29	VHC 3970	73.5	2.2	9.1	83.4	280	41.7	6	5.7	5
30	VL 146	64.3	2.8	7.4	86.7	260	42	6	6.3	10
31	VL 149	70.2	1.9	9.3	85.4	270	42.9	6	6.3	5
32	VL 315	67.5	2.3	6.7	87.9	270	42.1	2	6.4	5
33	VL 324	68.7	2.5	8.6	86	215	43	2	5.9	5
34	VL 340	75.4	2.3	7.5	88	250	41.9	2	5.3	5
35	VL 347	71.8	2.2	7.2	87.5	275	47.9	6	6.3	10



36	VL 348	73.8	1.9	8.9	86.6	260	61.3	6	6.4	10
37	VL 352	68.6	2.2	7.5	82.3	265	45.5	6	5.5	10
38	VL 367	68.1	1.7	6.6	81.3	240	42	2	6.3	10
39	VL 376	68.8	2.3	7	89.4	210	48.7	2.5	5.5	10
40	VL 379	70.1	1.7	6.1	87	210	47.4	2	5.3	10
41	VL 382	72.6	2.1	7.3	89.9	285	44.3	2	6	10
42	VL 384	68.6	1.9	8.5	87.7	245	43.1	6	6.1	10
43	VL 501	70.2	2.6	9.2	87.3	265	48	2	6.3	10
44	VL 502	68.2	2	6.9	86.2	190	43.3	6	6.4	10
45	VR 708	70.2	1.8	7	88.8	245	43.8	5.5	5.9	5
	Mean	69.8	2.09	7.98	85.93	231	45.93	4.96	5.96	7.89
	Range	61.8-77.2	1.0-3.5	5.6-10.6	81.3-90.3	80-285	41-61.3	2.0-6.0	5.3-6.9	5.0-10.0
	STDEV	3.78	0.52	1.14	2.21	45.02	4.61	1.65	0.3	2.5

Table 3. Grain and malt trait analysis of different finger millet genotypes grown in second year

S. No.	Sample ID	Test Wt (kg/hl)	TGW (g)	Grain Protein (%)	Malt yield (%)	Filtration rate (ml/hr)	HWE (% dwb)	Wort colour	Wort pH	Sach. rate (min)
1	GPHCPB 31	68.3	2.2	8.4	81.8	270	51.6	6	6.4	5
2	GPHCPB 45	69.3	2.5	10.3	84.7	270	43.1	6	6.3	5
3	GPHCPB 52	72.9	2.3	8.2	82.8	305	41.7	5.5	6.5	5
4	GPU 26	69.2	2.5	7.2	82.6	255	40.8	6	6.5	5
5	GPU 28	66.7	2.8	7.4	81.3	255	41.5	6	6.6	5
6	GPU 45	64.5	2.9	7.7	82.1	250	47.6	4.5	6.6	5
7	GPU 48	68.2	2	6.2	83.4	245	53.2	6	6.6	5
8	GPU 67	65.1	2.3	7.6	81.2	255	46.9	6	6.3	5
9	IE 2043	64.3	2.8	8	80.5	275	40.7	6	6.6	5
10	IE 2710	65.6	3.2	7.5	82.1	256	52.5	6	6.6	5
11	IE 4028	64.3	3	7.3	83.3	260	40.9	6	6.6	5
12	IE 4570	64.5	2.4	7.9	81.1	275	41.3	6	6.3	5
13	IE 4646	65.7	2.4	8.3	77.3	285	40.5	6	6.5	5
14	IE 4673	64.7	2.5	8.8	85.6	260	40.9	6	6.7	5
15	IE 518	73.5	2.4	7	78.1	290	60.5	2	6.5	5
16	IE 5537	71.5	3.3	6.7	79.1	240	45.9	6	6.4	5
17	IE 6221	63.3	2.2	9.4	80.7	290	41	6	6.6	5
18	IE 7079	66.2	2.5	7.9	82.1	250	42.8	6	6.5	5
19	PRM 1	63.2	2.6	8.3	81.8	240	49.6	6	6.7	5
20	PRM 801	60.8	2.2	10.1	83.5	275	44.5	6	6.5	5
21	VHC 3569	72.7	2.5	12	77.3	260	48.3	3.5	6	5
22	VHC 3597	74.8	2.8	8.9	84.3	275	50.9	5	5.9	5
23	VHC 3610	69.9	2.1	7.3	84.5	265	49.7	2	6.5	5



24	VHC 3752	63.9	2.4	8.2	84.4	240	50.9	4	6.2	5
25	VHC 3766	69.5	2.3	6.7	78.9	275	60.3	5.5	6	5
26	VHC 3803	61.2	3.1	7	78.6	260	49.9	5.5	6	5
27	VHC 3852	68.7	2.3	6.9	78.4	195	41.6	2.5	6.1	5
28	VHC 3917	68.7	2	7.7	80.7	230	49.4	2	6	5
29	VHC 3930	59.9	2.6	8.5	76.8	220	53.9	5.5	6.1	5
30	VHC 3962	75.6	2.6	8.2	83.4	285	49.6	2.5	6	5
31	VL 146	68.6	2	8.4	82.7	190	44.6	5.5	6.3	5
32	VL 149	68.2	2.6	7.7	79.3	235	42.2	6	6.6	5
33	VL 315	63.1	2.7	6.8	86.7	260	44.3	2	6.6	5
34	VL 324	70.5	3.2	7.6	84.7	260	42.7	2	6.5	5
35	VL 340	76.3	2.9	7.1	86.5	270	44.1	5	6.5	5
36	VL 347	69.2	2.6	9.4	61.6	295	53.2	2	6.6	5
37	VL 348	74.7	3.2	8.5	84.3	275	53.4	2	6.5	5
38	VL 352	74	2.2	6.1	87.3	265	64.1	2	6.3	5
39	VL 367	69.4	2.5	7.5	67.8	275	41.2	2	6.6	5
40	VL 376	66.6	2.3	7.7	80.3	265	40.9	2	6.3	5
41	VL 379	63.7	3.3	9.8	63.3	280	48	2	6.3	5
42	VL 382	70.4	2.9	6.8	84.2	135	41.9	2	6.5	5
43	VL 384	76.5	1.9	9.9	82.7	280	66	2	6.5	5
44	VL 501	70.5	2.8	9.1	81.8	105	51.6	2	6.7	5
45	VL 502	62.3	2.3	7	81.1	80	44.3	2	6.5	5
46	VR 708	70.3	2.6	9.8	74.4	295	54.4	6	5.8	5
	Mean	68.04	2.46	8.04	80.63	251.54	47.59	4.35	6.3	5
	Range	59.9-76.5	1.9-3.3	6.1-12.0	61.6-87.3	80-305	40.5-66.0	2.0-6.0	5.8-6.7	
	STDEV	4.37	0.5	1.19	5.21	45.46	6.46	1.88	0.47	

The grains used for malting should be uniform and plump to allow for consistent processing and high malt yield. In finger millet, the grain size is small and grains at the top and bottom of the panicle are variable in size. To access shape and size, test weight and thousand grain weight were measured for all the genotypes (Table 2). Test weight (kg/hl) and thousand grain weight (g) varied from 61.8-77.2 and 1.0-3.5 in 2015 to 59.9-76.5 and 1.9-3.3 in 2016, and with maximum test weight in VHC 3771, VL 384 and TGW in GPU 48 and VL 379 (Table 2&3). Verma *et al.* (2008) have suggested that hectolitre weight can be effectively used to shortlist the material in initial screening of large number of breeding lines in early generations for breeding malting barley.

Protein content is another important parameter in selection for malt quality. It is known that high protein genotypes

result in low malt extract. Very low protein content too is undesirable due to lack of enzymes necessary for breakdown of starch during brewing (Kumar *et al.*, 2013; Kumar *et al.*, 2022). In finger millet the grain protein content varied from 5.6-10.6% in 2015 and 6.1-12.0% in 2016 (Table 2& 3). Most of the genotypes however had moderate protein content. High malt extract and moderate protein content renders the genotypes acceptable for industrial use.

The correlations among different traits showed that filtration rate in 2015 and HWE in 2016 had highly significant positive correlation with test weight (Table 4). These all traits need to be improved individually to improve the malt quality of finger millet.



Table 4. Correlation among grain and malt traits in finger millet

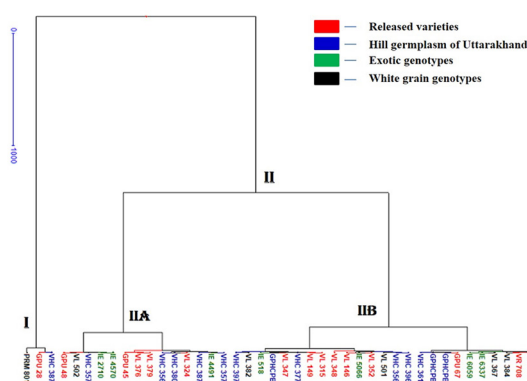
	Test Wt (kg/hl)	TGW (g)	Grain Protein (%)	Malt yield (%)	Filtration rate (ml/hr)	HWE (% dwb)	Wort colour	Wort pH
Test Wt (kg/hl)		0.044	0.073	0.219	0.408**	0.090	0.006	-0.028
TGW (g)	-0.019		0.081	0.085	-0.058	-0.017	0.032	0.026
Grain Protein (%)	0.030	-0.034		-0.236	0.040	-0.039	0.241	0.198
Malt yield* (%)	0.121	-0.129	-0.301		0.250	0.229	-0.244	-0.177
Filtration rate (ml/hr)	0.181	-0.055	0.209	-0.165		0.145	-0.065	-0.268
HWE (% dwb)	0.378**	0.005	0.014	-0.041	0.117		0.098	-0.101
Wort colour	-0.349	-0.030	0.033	0.162	0.236	-0.256		0.458**
Wort pH	-0.324	0.342*	-0.066	-0.099	-0.022	-0.186	0.130	

*Significant at $P < 0.05$; **Significant at $P < 0.01$ (1-tailed test)

Cluster analysis of genotypes for malt traits showed distribution of genotypes into two major clusters in both the evaluation years (Fig. 1 & 2). The second cluster was again divided into two sub-clusters. Varieties, advanced breeding lines, local hill collections as well as African accessions were all scattered in all the sub clusters of clusters 2, whereas cluster 1 contained only advanced breeding lines and local accessions. The cluster analysis was carried out to see whether any group of genotypes

show separate cluster based on malt traits to infer about its superiority or inferiority for malt traits in finger millet. However, no group was better or poor for malt traits and genotypes performed irrespective of their geographic location for malt traits in finger millet. However, the variation for malt quality traits separated the genotypes into two clusters.

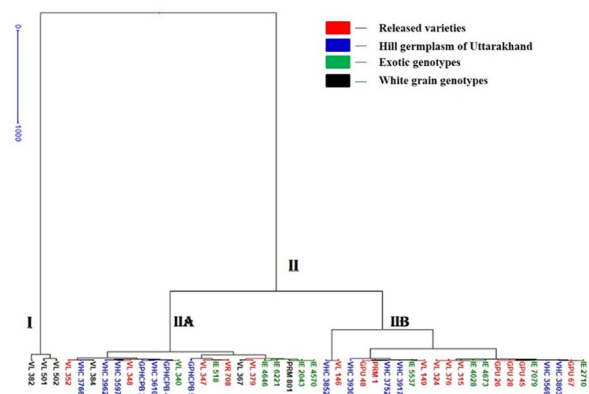
Overall, the results indicated that although finger millet could be an alternative potential source for malt making,

**Fig. 1:** Clustering of finger millet genotypes based on malt quality traits evaluated in first year

it need separate breeding programme to select genotypes for malt with higher extract value. Grain size in finger millet is too small and bold seeded genotypes will be better suited for malt crop.

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**Fig. 2:** Clustering of finger millet genotypes based on malt quality traits evaluated in second year

Authors' contributions

SS and LK conceived and designed the study, SS contributed the material, DK conducted all the biochemical analysis, SS analyzed the data and wrote the draft manuscript, and all authors contributed to editing and approved the final manuscript.

Conflict of Interest

The authors declare that they do not have any conflict of interest.



Ethical Approval

The article doesn't contain any study involving ethical approval.

Generative AI or AI/Assisted Technologies use in Manuscript Preparation

No

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