Scientific Papers. Series A. Agronomy, Vol. LXVII, No. 2, 2024
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

MALT QUALITY PARAMETERS OF DIFFERENT BARLEY VARIETIES

Liliana VASILESCU[1], Alexandrina SÎRBU[2], Vratislav PSOTA[3], Eugen PETCU[1], Silviu VASILESCU[1], Lidia CANĂ[1], Lenuța Iuliana EPURE[4], Maria TOADER[4]

[1]National Agricultural Research Development Institute Fundulea, 1 N. Titulescu, Fundulea, Romania
[2]"Constantin Brâncoveanu" University of Pitești, FMMAE Ramnicu Valcea, 39 Nicolae Balcescu Blvd, Rm. Valcea, Romania
[3]Research Institute of Brewing and Malting, Mostecká 971/7, 614 00 Brno, Czech Republic
[4]University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, Bucharest, Romania

Corresponding author email: svvasilescu@gmail.com

Abstract

The study presents the technological malt quality of the facultative six-row barley variety Smarald, winter six-row barley Ametist and Simbol varieties, and winter two-row barley Artemis and Wintmalt varieties. The Romanian genotypes were compared with one of the best varieties recommended for malt and beer in the Czech Republic, the winter two-row barley genotype Wintmalt. In the studied barley varieties, the protein content ranged between 9.3-12.5% and all the varieties (except the two-row Artemis variety) registered a starch content over the standard (60.0%). Regarding the extract, just one variety had a value of over 80% (six-row Smarald variety) with the highest malt extract, followed by Simbol and Wintmalt varieties (79.9% and 79.4% respectively). The values of diastatic power ranged from 189 ^{0}WK (Simbol variety) to 419 ^{0}WK (Wintmalt variety). The apparent final attenuation moved from 77.9 to 81.2 % in all varieties, the lowest value was registered by the Artemis barley variety. All the studied genotypes have presented an increased β-glucan content (479-1610 mg/l), except the Wintmalt variety which registered the lowest level of this quality index (216 mg/l).

Key words: *barley, variety, quality indices, malt.*

INTRODUCTION

Winter barley varieties are valuable sources of characters usable within the breeding programs targeted at malting, feeding, or other specific qualities of new barley varieties (fodder).
Growth conditions of barley greatly affect the malting properties and many features are correlated with barley variety so determining the varietal influence on the malt quality is very important. Romania is one of the Brewers of Europe members and of the total beer consumed in the national market, 90% is produced by the members of the Romanian Brewers Association (www.berariiromaniei.ro).
During the malting process, several main criteria are used to describe the technological quality of the barley grain: the malt extract, Kolbach index, friability, viscosity, and diastatic power (Jamar et al., 2011). One of the main malt parameters is the extract, represented by the amount of soluble substances present in malt (Briggs, 1978; Ayoub, 2003).
A parameter important mainly in Central Europe (Psota and Kosař, 2002) is the relative extract at 45°C which indicates enzymatic degradation.
One of the most common parameters used for the malt evaluation, given by the ratio between the total content of nitrogenous substances in malt and the soluble nitrogen in wort is the Kolbach index (www.e-malt.com). The optimal value of this parameter ranges from 35% to 45% (a value >45% means excessive decomposition of the total protein content from malt and the total protein content from the wort, meanwhile the value >41% shows the best decomposition and values between 35%-41% shows a good response for the decomposition process. Value <35% highlights insufficient decomposition of the previously mentioned compounds according to www.homebrewersassociation.org.
Diastatic power represents the combination between starch and 4 types of enzymes namely α-amylase, β-amylase, limit dextrinase, and α-glucosidase (Fox and Bettenhausen, 2023).

The significance of this parameter is underlined by the conversion of starch to extract.
Friability represents the degree of endosperm hydrolysis (Briggs, 1987). β-glucan enzyme content in sweet wort emphasizes the level of cytolytic modification (Psota and Kosař, 2002). The high level of β-glucans content negatively affects the brewing quality due to the increase of wort viscosity and the beer filtration (Simic et al., 2008).
The main purpose of this paper is to characterize the technological quality of some winter barley varieties, to study the variation of the six-row varieties main traits compared with one of the recommended two-row winter barley varieties for brewing, and also to the relationship between the main grain quality and malt parameters.

MATERIALS AND METHODS

This study presents the experimental data obtained during one growing season by five winter barley varieties (4 registered in Romania during the 2012-2015 period and one recommended by the Czech Republic malting industry, namely Wintmalt variety released in Germany).
Seed samples (2015's harvest year) were obtained from the barley breeding experimental field (NARDI Fundulea) and shipped to the Research Institute of Barley Malting (Czech Republic).
Malting quality of the studied winter barley varieties (3 six-row and 2 two-row winter barley varieties) was assessed taking into consideration the analyses performed at NARDI Fundulea (yield, thousands grain weight, protein, and starch content) meanwhile the malt and wort analyses were carried out in the Czech Republic, at RIBM (Research Institute of Barley Malting), Malting Institute Brno.
The micro-malting analyses were performed according to the methodology presented by the European Brewery Convention (2010) and Mitteleuropäische Brautechnische Analysenkommission (2011).

1. Determination of technological quality

The yield level was determined for each barley variety by weighing after the seeds were cleaned into a thresher following to be counted for thousand-grain weight (TGW). The protein and starch content were measured using infrared technology (INFRATECH 1241). Seed fractions have been determined using Sortimat in three replications and then presented as mean values.

2. Malting and malt analysis

Samples of barley varieties (500 g) were malted in the automatic micro malting equipment of KVM (Uničov, Czech Republic).
The Research Institute for Barley Malting always uses the same regime of steeping, germination, and kilning for varietal testing.
Steeping was performed in the steeping box for 72 h, with wet stages and air rests alternating. The air temperatures were maintained at 14.0°C and the duration of wet stages and air rest are as follows: on the first day, the humid stage took 5 h and the air rest 19 h, on the second day, the humid stage took 4 h and was followed by 20 hours air rest.
By steeping or spraying on the third day, the water content of the germinating grains was adjusted to 45% and the germination was performed in the germination box. The total germination time was 72 h and the temperature during germination was maintained at 14.0°C.

Table 1a. Conditions and schedule of steeping and germination

Time (h)		Temperature of outgoing air (°C)
Steeping	*	14.0
Wet period	5.0	
Dry period	19.0	
Wet period	4.0	
Dry period	20.0	
Wet period	24 h	
Dry period		
Germination	72 h	14.0

*Water content was adjusted to 45% by steeping or spraying.

Table 1b. Conditions and schedule of kilning

Time	Temperature of ingoing air	Temperature of outgoing air	Fan speed	Air recirculation
h	°C	°C	%	%
1.0	14.0 / *to* 55.0	14.0 / *to* 25.0	70	0
11.0	55.0	25.0 / *to* 35.0		0
1.0	55.0 / *to* 60.0	40.0 / *to* 45.0		40
1.0	60.0 / *to* 65.0	45.0 / *to* 50.0		40
2.0	65.0 / *to* 70.0	50.0 / *to* 55.0		40
1.0	70.0 / *to* 75.0	55.0 / *to* 65.0		40
1.0	75.0 / *to* 80.0	65.0 / *to* 78.0		80
4.0	80	78		80

Kilning took place in a single-floor electrically heated kiln. The free-drying stage lasted 12 h at 55°C. During the forced drying stage, the temperature was gradually increased for 6 h up to 75°C. The curing stage was carried out for 4 h at 80°C.

Conditions and procedure of malting are given in Tables 1a and 1b. For the micro malting test, only sieving fractions over 2.5 mm are used.

The following traits were determined in the unmalted barley grain and the malt and sweet wort produced: nitrogenous substances in the unmalted grain, extract in malt dry matter, relative extract at 45°C, Kolbach index, diastatic power, apparent final attenuation, friability, β-glucans in the sweet wort and turbidity of the sweet wort according to the methodologies presented in MEBAK (2011) and EBC Analysis committee (2010). Malt clarity determined visually was rated: 1-clear, 2-weakly opalizing, and 3-opalizing.

Malt quality and sweet wort produced from the tested varieties were assessed using the malt quality parameters (the malting quality index used in the Czech Republic and developed by Psota and Kosař, in 2002 at RIBM).

The obtained experimental results both from the field and laboratory were analyzed in EXCEL 2016 and interpreted according to the standard values established by the Analytica-European Brewery Commission Barley (EBC, 2010) and collection of Brewing Analysis Methods of the MEBAK (Mitteleuropäische Brautechnische Analysenkommission, 2011).

RESULTS AND DISCUSSIONS

The yield level (Figure 1) of the studied varieties ranged between 7.46 t/ha (Ametist six-row variety) and 9.19 t/ha Wintmalt two-row variety). Thousands grain weight (TGW, Figure 2) ranged between 49.9 g (Simbol variety) and 53.3 g (Artemis variety).

Barley grain samples of the tested varieties exhibited a content of nitrogenous substances (protein content exceeded in two cases, one case fulfilled the standard, and two cases under 9.5%) between 9.3% and 12.5% (Figure 3), according to a low quantity of nitrogen fertilizer applied (100 kg urea/ha commercial product with 46% a.s.) and rotation with pea (the best previous plant for barley rotation). All the varieties (except Artemis) registered a starch content (Figure 4) over the standard (60.0%).

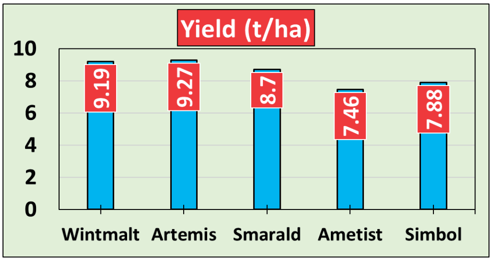

Figure 1. The average value of the yield

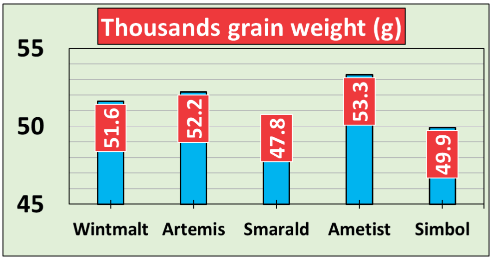

Figure 2. The average value of the TKW

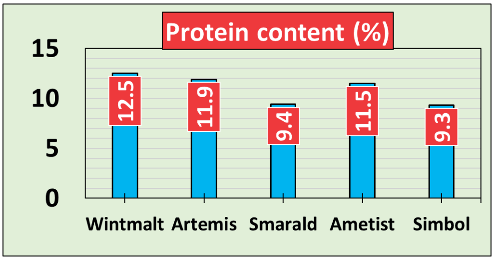

Figure 3. The average value of protein content

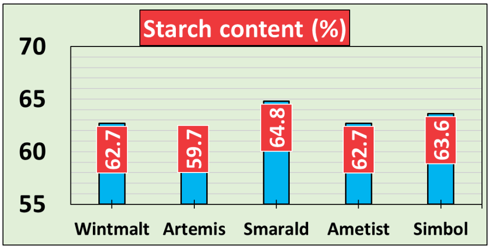

Figure 4. The average value of starch content

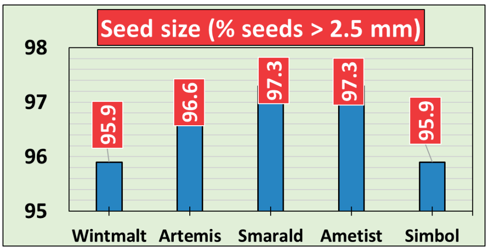

Figure 5. The average value of the seed size

Table 2. The methods used for malt analyses

No.	Methods	Units	References	Wintmalt	Artemis	Smarald	Ametist	Simbol
1	Bulk density	kg/hl	-	65.9	71.1	68.2	68.3	69.5
2	Moisture	%	-	11.7	11.7	11.5	11.2	11.6
3	Malt moisture	%	-	5.08	4.99	4.79	4.95	4.82
4	Saccharification rate	min	-	10	15	15	10	15
5	Extract	%	-	79.4	77.1	80.3	78.5	79.9
6	Relative extract at 45^0C	%	MEBAK 2011	30.3	30.2	31.6	33.8	31.2
7	Haze wort 15^0C	EBC	EBC 2010	6.35	9.96	10.97	4.91	21.59
8	Haze of wort 90^0C	EBC	EBC 2010	7.30	9.15	9.51	4.60	16.87
9	Wort Colour (Colorimeter)	-	-	3.2	3.1	4.2	3.1	4.3
10	Viscosity of wort	mPa.s	EBC 2010	1.493	2.061	1.661	1.826	1.716
11	Diastatic power	WK	EBC 2010	419	259	307	384	189
12	Friability	%	EBC 2010	72.4	51.1	72.2	51.4	70.1
13	Homogeneity by friabilimeter	%	EBC 2010	92.6	66.8	82.6	74.0	90.1
14	Partly unmodified grains	%	EBC 2010	7.4	33.2	7.4	26.0	9.9
15	Whole unmodified grain	%		0.6	4.6	0.2	0.4	0.1
16	β-glucans content	mg/l	EBC 2010	218	1610	479	993	606
17	Protein content of malt	%	EBC 2010	12.3	11.3	9.0	10.9	8.7
18	Total N of malt	%	EBC 2010	1.96	1.80	1.44	1.74	1.39
19	Soluble nitrogen in malt	%	EBC 2010	4.7	3.6	3.6	4.2	3.5
20	Kolbach index	%	EBC 2010	38.1	32.3	40.4	38.5	40.6
21	Apparent final attenuation	%	EBC 2010	79.9	77.9	81.2	80.0	80.1
22	Malting quality index	9-1	Psota et al., 2002	1.8	1.3	2.0	1.7	1.5

	Extract	Diastatic power	Homogeneity by friabilimeter	Beta-glucan content	Kolbach index	Malting quality index	Yield	Thousand grain weight	Protein content (%)	Starch content (%)	Seed size (> 2.5 mm diameter)
Extract	1										
Diastatic power	-0.02	1									
Homogeneity by friabilimeter	0.82	0.09	1								
Beta-glucan content	-0.89	-0.33	-0.93	1							
Kolbach index	0.94	0.01	0.73	-0.80	1						
Malting quality index	0.74	0.55	0.47	-0.76	0.68	1					
Yield (kg/ha)	-0.24	0.11	-0.03	0.04	-0.55	-0.06	1				
Thousand grain weight	-0.76	0.40	-0.44	0.49	-0.56	-0.50	-0.15	1			
Protein content (%)	-0.66	0.67	-0.26	0.25	-0.65	-0.23	0.41	0.79	1		
Starch content (%)	0.96	0.05	0.66	-0.80	0.99	0.81	-0.40	-0.70	-0.68	1	
Seed size (> 2.5 mm diameter)	-0.10	0.22	-0.60	0.30	0.01	0.37	-0.28	-0.05	-0.15	0.16	1

Figure 6. Correlation between studied quantity and quality parameters

The malt-analyzed parameters are presented in Table 2, including the methods used by the EBC Analysis Committee, 2010 and MEBAK, 2011. According to Pearson correlations (Figure 6), the yield was not correlated with other parameters. The thousands grain weight (TGW) was positively correlated with protein content and diastatic power.

Between protein and starch content, was shown a negative correlation (-0.68) and between seed size and grain friability (-0.60). The TGW was negatively correlated (-0.76) with the extract because a small seed shows a low extract. The highest correlations occurred between the extract and two of the malt parameters (friability and Kolbach index), which were 0.82 and 0.94, respectively. Also, it seems that the β-glucans content could be related to the TGW (0.49) and is negatively correlated with the Kolbach index and starch content (-0.80).

Wintmalt is a mid-early malting variety with good resistance to lodging (plants are medium to high), very high grain weight (over 51 g), and good assortment (sieving fractions above 2.5 mm was 95.9%). The variety is mid-resistant to powdery mildew and mid-resistant to net blotch. Under the 2015 climatic conditions, the yield was over 9 t/ha. Malt produced from the German variety Wintmalt had a low value of extract (around 79%), at 64.8% starch content and content of nitrogenous substances in non-malted grain at the level of 12.5%, with a low level of proteolytic modification (Kolback index 38.1%). The level of diastatic power was 419WK. Degradation of cell walls and β-glucans content in sweet wort were at the optimum level (218 mg/l) compared with the other varieties. This variety had the best homogeneity value by friabilimeter (92.6%). Apparent final attenuation moved around the value of 80%.

Evaluating the varieties for the malting quality index (from 9 highest to 1 lowest), the Wintmalt variety achieved 1.8.

Artemis is a mid-early malting variety with good resistance to lodging (plants are medium to high), very high grain weight (over 52 g), and good assortment (sieving fractions above 2.5 mm was 96.6%). The variety is mid-resistant to powdery mildew and mid-resistant to net blotch. Under the 2015 climatic conditions, the yield exceeded 9 t/ha. Malt of Romanian variety Artemis had the lowest level of extract (77.1%) at 11.9% seed nitrogen content, and 59.7% starch content with the lowest level of proteolytic modification (Kolback index 32.3%). The level of diastatic power was 259WK and b-glucan content in sweet wort was the highest level from all studied varieties (1392 g/ml over the Wintmalt variety). This content in β-glucans recommends another use of grain (food or forage). The homogeneity value by friabilimeter was under 70% and apparent final attenuation moved around the value of 78%.

The achieved values in the studied technological parameters, show the Artemis variety has a malting quality with the point evaluation 1.3.

Smarald is a mid-early malting variety with good resistance to lodging (plants are medium), good grain weight (over 47 g), and good assortment (sieving fractions above 2.5 mm was 97.3%). The variety is mid-resistant to powdery mildew and mid-resistant to net blotch. Under the 2015 climatic conditions, the yield was 8.7 t/ha. Malt of variety Smarald registered a slightly higher value of extract compared with two-row winter barley (80.3%), at 9.4% protein content, 64.8% starch content, and a value of 40.4% for Kolback index. The level of diastatic power was 307WK and β-glucans content was higher than the level of Wintmalt but the lowest from those three six-row winter barley studied (Table 2). The homogeneity value by friabilimeter was 82.6% and apparent final attenuation was around 81%. The achieved values in the studied technological parameters, show the Smarald variety has a malting quality with point evaluation 2.

Ametist is a mid-early malting variety with a good resistance to lodging (plants are medium to high), good grain weight (over 53 g) and good assortment (sieving fractions above 2.5 mm was 97.3%). The variety is mid-resistant to powdery mildew and mid-resistant to net blotch. Under the 2015 climatic conditions, the yield was 7.4 t/ha. Malt of variety Ametist gave an extract over 78%, at 11.5% protein content, 65.7% starch content, and a value of 38.5% for the Kolback index. The level of diastatic power was 384WK and b-glucan content was the highest level (993 g/l) compared with Smarald and Simbol. Also, this content in β-glucans recommends another use of grain (food or forage). The homogeneity value by friabilimeter was below 74% and apparent final attenuation moved around the value of 80%.

The achieved values in the studied technological parameters, show the Ametist variety has a malting quality with the point evaluation 1.7.

Simbol is a mid-early malting variety with good resistance to lodging (plants are high), good grain weight (over 49 g), and good assortment (sieving fractions above 2.5 mm were 95.9%). The variety is mid-resistant to powdery mildew and mid-resistant to net blotch. Under the 2015 climatic conditions, the yield was 7.8 t/ha.

Malt of variety Simbol gave a better value of extract (79.9%) at the content of nitrogenous substances in non-malted grain at the level of 9.3% protein and 63.6% starch content. The value of diastatic power was the lowest (189WK un) but the value of the Kolbach index was 40.6% (higher than two-row barley varieties). The level of β-glucans content was 606g/l, a mid-value between the Smarald and Ametist varieties. This genotype had a good homogeneity value by friabilimeter (90.1%) and a good value of apparent final attenuation (80.1%). The achieved values in the studied technological parameters, show the Simbol variety has a malting quality with the point evaluation 1.5.

CONCLUSIONS

The Smarald variety had the highest malt extract, followed by Simbol and Wintmalt varieties.
The values of diastatic power ranged from 189 WK (Simbol variety) to 419 WK (Wintmalt variety). All the studied genotypes have presented an increased β-glucans content (479-1610 mg/l), except the Wintmalt variety which registered the lowest level of these quality indices (218 mg/l).
The lowest b-glucan content was exhibited by the autochthonous barley variety Smarald.
New studies had to be initiated regarding the barley grain's β-glucans level content under different environments.

ACKNOWLEDGEMENTS

This research was carried out with the support of the Ministry of Agriculture and Rural Development, in the frame of the research project ADER 1.1.4.

REFERENCES

Ayoub, M. (2003). Marker-based selection in barley for QTL region affecting α-amylase activity of malt. *Crop Sci.*, 43, 556-561.

Baxter, E. D., O'Farrell, D. D. (1983). Use of the friable meter to assess the homogeneity of malt. *J. Inst. Brew.*, 89: 210–214.

Briggs, D.E. (1978). *Barley*. London: Chapman & Hall.

Broderick, H. (1977). El Cervecero en la Práctica: *Un Manual para la Industria Cervecera* (2nd ed.) (pp. 29–52)

EBC, 2010: Analysis committee. Analytica-EBC. Barley: 3.2 Moisture content of barley, 3.3.2 Total nitrogen of barley: Dumas combustion method, Malt: 4.2 Moisture content of malt, 4.3.2 Total nitrogen of malt: Dumas combustion method, 4.5.1 Extract of malt: Congress mash, Soluble nitrogen of malt: Dumas combustion method, 4.10 Free amino nitrogen of malt by spectrophotometry, 4.11 Fermentability, final attenuation of laboratory wort from malt, 4.12 Diastatic power of malt, 4.15 Friability, glassy corns and unmodified grains of malt by friable meter, 4.16.2 High molecular weight b-glucan content of malt: Fluorimetric method, Wort: EBC 8.7. Nüremberg: Fachverlag Hans Carl, 794 p. ISBN 978-3-418-00759-5.

Fox GP and Bettenhausen HM (2023). Variation in quality of grains used in malting and brewing. *Front. Plant Sci.* 14:1172028. doi: 10.3389/fpls.2023.1172028

Jamar, C., du Jardin, P., Fauconnier, M.L. (2011). Cell wall polysaccharides hydrolysis of malting barley (*Hordeum vulgare* L.): *Biotechnologie, Agronomie, Société et Environnement/Biotechnology, Agronomy, Society and Environment,* vol. 15.

MEBAK, 2011: Raw materials: Barley; Adjuncts; Malt; Hops and Hop Products. 1 Barley: 1.5.3 Micromalting; Malz: 3.1.4.11 Maischmethode nach Hartong-Kretschmer VZ 45°C. Collection of Brewing Analysis Methods of the Mitteleuropäische Brautechnische Analysenkommission (MEBAK), Freising-Weihenstephan, Germany. P. 341.

Psota, V., Kosař, K. (2002). Malting Quality Index, *Kvasny Prum.*, 47: 142–148.

Psota, V., Dvorackova, O., Sachambula, L., Necas, M., Musilova, M. (2015). Barley varieties registered in the Czech Republic in 2015, *Kvasny Prum.*, 61(5), 138-146

Simic, G., Lalic, A., Kovacevic, J., Horvat, D., Lenart, L. (2008). Effect of genotype and environment on spring barley hordeins. *Cereal Res. Commun.* 36, 1491–1494

https://www.e-malt.com/specifications/

www.homebrewersassociation.org/

www.berariiromaniei.ro/raport2023.pdf