KVASNÝ PRŮMYSL

Kvasny prumysl (2022) 68: 590–601
https://doi.org/10.18832/kp2021.68.590

Barley varieties registered in the Czech Republic after the harvest of 2021

Vratislav Psota[1*], Olga Dvořáčková[2], Markéta Musilová[1]

[1] *Research Institute of Brewing and Malting, Mostecká 971/7, 614 00 Brno, Czech Republic*
[2] *Central Institute for Supervising and Testing in Agriculture, National Plant Variety Office, Hroznová 63/2, 656 06 Brno, Czech Republic*

[*] *corresponding author: psota@beerresearch*

Abstract

Ten new varieties of malting barley were registered in the Czech Republic after the 2021 harvest. After four years of testing, the malting barley varieties Fangio and LG Slovan were registered, and after three years of testing, the spring barley varieties Evgenia, Guzel, LG Flamenco, LG Lodestar, LG Sedlak, Schiwago, SY Solar together with the winter barley variety Suez were registered. Based on the results obtained, LG Slovan and LG Sedlak were recommended for the production of beer with the protected geographical indication 'České pivo'. These varieties showed low activity of proteolytic and cytolytic enzymes and low level of final attenuation. The other spring barley varieties (Evgenia, Fangio, Guzel, LG Flamenco, LG Lodestar, Schiwago and SY Solar) gave wort with extract contents in malt dry matter ranging from 82.5 to 83.6%, with Guzel, Evgenia, Fangio and Schiwago showing extract contents above 83%. Proteolytic modification was mostly at an optimal level in these varieties, with only Fangio, Schiwago and Guzel having the Kolbach index above 50%. The β-glucan content in wort below 50 mg/l was recorded for Schiwago and Fangio. The level of final attenuation for these varieties ranged from 80.7 to 82.8%, while final attenuation level above 82.5% was observed for the varieties Fangio and Guzel. LG Lodestar and SY Solar always produced clear wort. Low to zero lipoxygenase enzyme activity was found in LG Lodestar. The winter barley variety Suez gave malt with an average extract content in malt dry matter of 81.9%. Proteolytic modification, cell wall degradation and malt quality were at an optimal level. The β-glucan content was 158 mg/l.

Keywords: barley, variety, malting quality

1 Introduction

In the Czech Republic, new barley varieties are registered under Act No.219/2003 Coll. According to this Act, the varietal trials are carried out by a state administration body, which is the Central Institute for Supervising and Testing in Agriculture (CISTA). CISTA performs field and laboratory tests to determine distinctness, uniformity, stability and utility value for cultivation and use according to methodologies laid down by the ministry. A variety has a utility value if, in the sum of its characteristics, it represents a clear benefit for cultivation or use or for products derived from it, in comparison with other registered varieties in at least one growing area. If a variety exhibits certain outstanding characteristics, certain inferior characteristics may be disregarded.

In the Czech Republic, 2/3 of the propagating areas were sown with spring barley varieties Bojos, Overture, Laudis 550, KWS Amadora, KWS Irina and RGT Planet (CISTA 2021).

Research Institute of Brewing and Malting
Published online: 15 April 2022

2 Material and methods

In the present study, the malting quality of spring barley varieties Fangio, LG Slovan, Evgenia, Guzel, LG Flamenco, LG Lodestar, LG Sedlak, Schiwago, SY Solar and winter barley variety Suez was evaluated (Table 1). Seed samples (grain fraction over 2.5 mm) were supplied by CISTA. The barley varieties were assessed according to the Methodology of Barley Utility Value (Dvořáčková, 2019).

Table 1 *Assortment of malting barley varieties registered after the harvest of 2021*

Variety / Code	Agent in the CR / Maintainer
spring barley	**malting varieties**
Fangio	**SOUFFLET AGRO a.s.**
SC 9447 S2	SECOBRA Recherches
LG Slovan	**Limagrain Česká republika, s.r.o.**
LGBHE4059	LIMAGRAIN EUROPE S.A.S.
Evgenia	**SOUFFLET AGRO a.s.**
SC 128-4I	SECOBRA Recherches
Guzel	**SOUFFLET AGRO a.s.**
SC 3523 U2	SECOBRA Recherches
LG Flamenco	**Limagrain Česká republika, s.r.o.**
LGBN16509-4	LIMAGRAIN EUROPE S.A.S.
LG Lodestar	**Limagrain Česká republika, s.r.o.**
	LIMAGRAIN EUROPE S.A.S.
LG Sedlak	**Limagrain Česká republika, s.r.o.**
LGBHE4303	LIMAGRAIN EUROPE S.A.S.
Schiwago	**SAATEN - UNION CZ s.r.o.**
NORD 17/2610	NORDSAAT Saatzucht GmbH
SY Solar	**Syngenta Czech s.r.o.**
SY 417021	Syngenta Crop Protection AG
winter barley	**malting varieties**
Suez	**SAATBAU ČESKÁ REPUBLIKA s.r.o.**
SZD U1232	Saatzucht Donau Ges.m.b.H. & CoKG

Selection of testing sites

Each year, grain samples of standard varieties are collected from the testing sites. The basic characteristics of the testing sites are given in the Barley Year Book (Psota et al., 2021). The nitrogen content of the grain samples of the standard varieties is determined. From the four experimental sites where the grain of the standard varieties had the optimum nitrogen content (10.2–11.0%) (Psota and Kosař, 2002), grain samples of all varieties tested under the registration procedure were taken for subsequent microsampling.

Malting and malt analyses

The malting quality of the varieties Fangio and LG Slovan was evaluated based on the analyses of 16 malt samples obtained between 2018 and 2021. The malting quality of the spring barley varieties Evgenia, Guzel, LG Flamenco, LG Lodestar, LG Sedlak, Schiwago, SY Solar and winter barley Suez was evaluated based on 12 malt samples obtained between 2019 and 2021.

Grain samples (0.5 kg) were malted in the micro-malting plant (KVM Czech Republic). The method traditionally used at the Research Institute of Brewing and Malting, which is almost identical with the method described in MEBAK (2011), was employed for laboratory malting. The grain fraction over 2.5 mm was malted.

Steeping was conducted in a steeping box. The length of steep was 5 hours and a 19-hour air rest on the first day, then 4 hours and a 20-hour air rest on the second day followed. On the third day, the water content was adjusted to 45% by steeping or spraying. The temperature of both water and air was maintained at 14.0 °C. After 72 hours in the steeping box, the germinated barley was transferred into the germination box.

Germination in the germination box also lasted 72 hours. During germination, the grain was manually turned over. The temperature during germination was 14.0 °C. The total time of steeping and germination was 144 hours.

Kilning was performed in a single-floor electrically heated kiln. The total kilning time was 22 hours, free-drying stage was carried out at 55 °C for 12 hours. During the forced drying stage, the temperature gradually increased to 75 °C over a 6-hour-period, during the last 4 hours of the curing stage, the temperature was 80 °C.

The characteristics given in the Malting Quality Index (MQI) (Psota and Kosař, 2002) and in the application for the protected geographical indication (PGI) 'České pivo' (Commission Regulation, 2008) were determined in the malt produced. The lipoxygenase (LOX) activity was determined in the malt of the LG Lodestar variety (Barone et al., 1999). The malting quality was determined according to the methods described in MEBAK (2011) and EBC Analysis Committee (2010). The methods used are listed in Table 2.

Agronomic characteristics

The agronomic characteristics of spring barley varieties Evgenia, Guzel, LG Flamenco, LG Lodestar, LG Sedlak, Schiwago, SY Solar were assessed based on the results obtained from trials carried out in 2019–2021. For the character grain yield and grain yield over 2.5 mm, an average of 9 trials were included in a maize testing area, 19 in a sugar-beet testing and cereal testing areas, and 7 trials in a potato testing area. The agronomic characteristics of the spring barley varieties Fangio and LG Slovan were obtained based on results from 2018–2021. The average included yields from 11 trials in a maize testing area, 26 trials in sugar-beet and cereal testing areas and 8 trials in a potato testing area. The yield of the winter variety Suez was assessed from 21 trials conducted in 2019–2021.

The assessed agronomic characteristics:

- Yield of grain at the standard 14% moisture content. Yield of grain and yield of grain over 2.5 mm in spring barley in terms of the response of the varieties to the soil and weather conditions and suitability of the use of grain for malting are assessed within the testing areas (maize testing area, sugar-beet testing and cereal testing areas, potato and forge testing areas) (Psota et al., 2021).
  For winter barley, yield of grain and yield of grain over 2.5 mm of two-row and six-row varieties are assessed separately and are not classified according to the areas due to the nature of the crop and varietal responses.
- Agronomic data (time to heading, maturity, straw length, resistance to lodging).
- Resistance to diseases, such as powdery mildew of barley (*Blumeria graminis*), leaf rust of barley (*Puccinia hordei*), the complex of leaf spots (*Pyrenophora teres*), scald of barley (*Rhynchosporium secalis*), head blight of barley (*Fusarium graminearum, Fusarium culmorum, Microdochium nivale*, etc.) and physiological leaf spots of barley (non-specific leaf spots).
- Grain quality parameters (thousand grain weight and sieving test).

The experiments were established in two variants: untreated and treated.

N – untreated variant:

- Seed treatment – effective against loose smut of barley (*Ustilago nuda*), stripe disease of barley (*Drechslera graminea*), complex of leaf spots (*primary infection*),
- Basic dosage of nitrogen,
- Without fungicidal treatment.

T – treated variant:

- Seed treatment – effective against loose smut of barley (*Ustilago nuda*), stripe disease of barley (*Drechslera graminea*), complex of leaf spots (primary infection),
- Basic dosage of nitrogen,
- Fungicide against take-all of barley (*Gaeumannomyces graminis*) (as necessary) and against leaf and ear diseases (first treatment to the end of shooting, second treatment at the beginning of ear heading and before anthesis).

Depending on the pre-crop and location, the total nitrogen dosage ranged between 20 and 70 kg of pure nutrients per hectare for spring barley and between 30 and 100 kg for winter barley. In the treated variant of winter barley, the regenerative nitrogen dosage was increased by 20 kg.

3 Results

The results of malt quality of the spring barley varieties Fangio, LG Slovan, Evgenia, Guzel, LG Flamenco, LG Lodestar, LG Sedlak, Schiwago, SY Solar and the winter barley variety Suez are summarised in Tables 2a, 2b, 2c. Important agronomic properties are given in Tables 3 and 4.

The newly registered spring barley variety Fangio, monitored for 4 years, had a similar malting quality as the standard variety KWS Amadora. The LG Slovan variety recommended for the production of beer with the PGI 'České pivo' (European Committee of the Regions, 2008) had a better malting quality than the standard variety Laudis 550. Over the same period, LG Slovan showed a higher value of extract content in dry malt.

The newly registered spring barley varieties Evgenia, SY Solar as well as LG Flamengo and LG Lodestar monitored for 3 years had very similar malting quality as the standard variety KWS Amadora. In addition, LG Lodestar showed reduced lypoxygenase activity. The varieties Schiwago and Guzel had a significant proteolytic enzyme activity. They were also similar to the standard variety KWS Amadora in other respects. The LG Sedlak variety recommended for the production of beer with the PGI 'České pivo' had a better malting quality than the standard Laudis 550 variety. Over the same period, LG Sedlak had a higher value of extract content in malt dry matter and a higher level of final attenuation, but significantly higher β-glucan content in the wort.

The newly registered winter barley variety Suez showed a significantly better malting quality than the comparative winter barley variety KWS Ariane, especially in terms of cytolytic and proteolytic modification. The Suez variety also had a higher level of extractability and fermentability.

Table 2a *Barley grain and malt analyses*

Methods	Unit	References	Spring Barley (2018–2021)				
			KWS Amadora S	KWS Irina S	Laudis 550 S	Fangio	LG Slovan
			$\bar{x} \pm s_x$	$\bar{x} \pm s_x$	$\bar{x} \pm s_x$	$\bar{x} \pm s_x$	$\bar{x} \pm s_x$
Protein content of barley (factor 6.25)	%	EBC 2010	**10.5** ± 0.7	**10.5** ± 0.8	**11.5** ± 0.5	**10.3** ± 0.6	**11.1** ± 0.8
Starch content of barley	%	NIR	**63.9** ± 0.9	**63.8** ± 1.1	**63.6** ± 1.2	**63.9** ± 1.0	**64.1** ± 1.3
Bulk density	g/l	MEBAK 2011	**64.7** ± 2.8	**63.2** ± 2.5	**68.7** ± 1.3	**63.0** ±3.3	**64.6** ± 2.9
Degree of steeping 1	%	–	**32.5** ± 1.6	**34.3** ± 1.4	**32.6** ± 1.1	**33.6** ± 1.7	**33.8** ± 1.7
Degree of steeping 2	%	–	**40.3** ± 1.8	**42.2** ± 1.4	**40.0** ± 1.0	**41.6** ± 1.9	**41.5** ± 1.7
Malt yield d. m.	%	Briggs 1998	**90.6** ± 0.9	**90.3** ± 0.8	**91.1** ± 0.8	**90.9** ± 0.9	**90.4** ± 0.5
Respiration losses d. m.	%	Briggs 1998	**4.8** ± 0.6	**4.9** ± 0.5	**4.2** ± 0.5	**4.5** ± 0.5	**4.4** ± 0.4
Rootlet losses d. m.	%	Briggs 1998	**4.6** ± 0.4	**4.8** ± 0.5	**4.6** ± 0.4	**4.6** ± 0.7	**5.2** ± 0.4
Extract of malt, congress mash	%	EBC 2010	**83.6** ± 0.9	**82.5** ± 1.5	**81.8** ± 0.8	**83.4** ± 1.2	**82.9** ± 1.2
VZ 45 °C	%	MEBAK 2011	**52.2** ± 5.0	**44.7** ± 4.7	**40.5** ± 4.3	**54.2** ± 3.4	**38.8** ± 3.4
Kolbach index	%	EBC 2010	**51.9** ± 5.8	**46.2** ± 3.2	**41.2** ± 2.3	**51.6** ± 3.0	**42.0** ± 2.7
Diastatic power	WK	EBC 2010	**403** ± 48	**328** ± 35	**338** ± 42	**402** ± 49	**294** ± 37
Apparent final attenuation	%	EBC 2010	**82.6** ± 0.7	**81.4** ± 0.9	**79.3** ± 1.8	**82.7** ± 0.6	**79.3** ± 1.3
Friability	%	EBC 2010	**96** ± 3	**81** ± 6	**78** ± 5	**96** ± 2	**80** ± 7
β-glucan content of malt, SFA	mg/l	EBC 2010	**42** ± 15	**211** ± 61	**217** ± 63	**48** ± 22	**200** ± 56
Protein content of malt (factor 6.25)	%	EBC 2010	**9.8** ± 0.7	**9.9** ± 0.9	**11.0** ± 0.6	**9.8** ± 0.6	**10.4** ± 0.8
Total nitrogen of malt, Kjeldahl method	%	EBC 2010	**1.57** ± 0.12	**1.58** ± 0.15	**1.76** ± 0.09	**1.57** ± 0.10	**1.66** ± 0.13
Soluble nitrogen of wort, Kjeldahl method	mg/l	EBC 2010	**934** ± 78	**826** ± 60	**839** ± 61	**924** ± 65	**805** ± 71
Soluble nitrogen of wort, Kjeldahl method	mg/100g	EBC 2010	**834** ± 68	**737** ± 52	**748** ± 54	**823** ± 57	**718** ± 63
Soluble nitrogen of malt, Kjeldahl method	%	EBC 2010	**5.2** ± 0.4	**4.6** ± 0.3	**4.7** ± 0.3	**5.1** ± 0.4	**4.5** ± 0.4
Viscosity of laboratory wort from malt	mPa.s	EBC 2010	**1.43** ± 0.03	**1.46** ± 0.02	**1.48** ± 0.03	**1.42** ± 0.02	**1.48** ± 0.03
Colour of malt, visual method	EBC	EBC 2010	**4.0** ± 0.5	**3.5** ± 0.5	**3.0** ± 0.5	**3.9** ± 0.5	**3.4** ± 0.5
Saccharification time	min	EBC 2010	**10.0** ± 0.0	**10.0** ± 1.0	**11.0** ± 1.0	**10.0** ± 1.0	**11.0** ± 1.0
Glassy corns	%	EBC 2010	**0.1** ± 0.1	**0.3** ± 0.2	**0.4** ± 0.5	**0.1** ± 0.1	**0.5** ± 0.4
Partly unmodified grains	%	EBC 2010	**0.4** ± 0.5	**2.7** ± 2.3	**4.3** ± 3.2	**0.3** ± 0.3	**4.1** ± 3.5
Homogeneity (by friabilimeter)	%	Baxter, O'Farrell, 1983	**99.6** ± 0.5	**97.3** ± 2.3	**95.7** ± 3.2	**99.7** ± 0.3	**95.9** ± 3.5
Appearance (clarity) of wort		MEBAK 2011	**1.00** ± 0.00	**1.00** ± 0.00	**1.13** ± 0.34	**1.19** ± 0.54	**1.19** ± 0.40
Haze of wort (90°)	EBC	EBC 2010	**0.89** ± 0.38	**0.77** ± 0.19	**1.06** ± 0.64	**1.32** ± 1.32	**1.53** ± 1.17
Haze of wort (12°)	EBC	EBC 2010	**1.10** ± 0.56	**0.87** ± 0.26	**1.06** ± 0.44	**1.47** ± 1.35	**1.51** ± 0.95
Total polyphenols in wort	mg/l	EBC 2010	**89** ± 24	**87** ± 19	**59** ± 17	**78** ± 18	**69** ± 14
Free amino nitrogen	mg/l	EBC 2010	**223** ± 23	**192** ± 18	**182** ± 19	**221** ± 19	**175** ± 19
Free amino nitrogen	mg/100g	EBC 2010	**200** ± 20	**172** ± 15	**162** ± 17	**197** ± 17	**156** ± 17

$\bar{x}$ = mean
s_x = sample standard deviation

S = standard varieties

Wort clarity 1 = clear
2 = weakly opalizing
3 = opalizing
4 = cloudy

Fangio is a variety bred in France. At the optimal content of protein (10.3%) in the non-malted grain, it gave the optimal level of the amylolytic modification (extract content in malt dry matter 83.4%, diastatic power 402 WK). Intensity of proteolytic modification was strong (Kolbach index 51.6%). The strong proteolysis was accompanied by higher values of relative extract at 45 °C (54.2%) and wort colour (3.9 EBC). Cytolytic modification was at the optimal level (friability 96%, β-glucan in wort 48 mg/l). Wort composition was also good (apparent final attenuation 82.7%) and the wort in most cases was clear. The advantages of Fangio are, besides the high quality of the wort, the rapid degradation of the cell walls and the low β-glucan con-

Table 2b *Barley grain and malt analyses*

Methods	Unit	References	Spring Barley (2019–2021)									
			KWS Amadora S	KWS Irina S	Laudis 550 S	Evgenia	Guzel	LG Flamenco	LG Lodestar	LG Sedlak	Schiwago	SY Solar
			$\bar{x} \pm s_x$	$\bar{x} \pm s_x$	$\bar{x} \pm s_x$	$\bar{x} \pm s_x$	$\bar{x} \pm s_x$	$\bar{x} \pm s_x$	$\bar{x} \pm s_x$	$\bar{x} \pm s_x$	$\bar{x} \pm s_x$	$\bar{x} \pm s_x$
Protein content of barley (factor 6.25)	%	EBC 2010	**10.5** ± 0.7	**10.6** ± 0.7	**11.5** ± 0.5	**10.5** ± 1.0	**10.6** ± 1.0	**10.3** ± 1.1	**10.7** ± 0.8	**11.0** ± 1.1	**10.5** ± 1.1	**10.3** ± 1.2
Starch content of barley	%	NIR	**63.9** ± 1.1	**63.8** ± 1.2	**63.7** ± 1.4	**64.1** ± 0.7	**63.8** ± 1.1	**64.4** ± 1.4	**64.2** ± 1.0	**63.7** ± 1.4	**64.3** ± 1.2	**64.3** ± 1.3
Bulk density	g/l	MEBAK 2011	**63.6** ± 2.2	**62.2** ± 1.9	**68.3** ± 1.3	**63.2** ± 2.7	**62.6** ± 3.8	**62.8** ± 2.4	**62.1** ± 3.9	**65.2** ± 2.5	**62.2** ± 2.9	**62.2** ± 3.1
Degree of steeping 1	%	–	**33.1** ± 1.4	**34.8** ± 1.2	**32.9** ± 1.0	**33.7** ± 1.0	**34.3** ± 1.1	**33.9** ± 1.2	**34.6** ± 1.4	**33.6** ± 1.2	**33.6** ± 1.2	**34.3** ± 1.4
Degree of steeping 2	%	–	**40.9** ± 1.7	**42.6** ± 1.3	**40.3** ± 0.9	**41.4** ± 1.3	**42.1** ± 1.4	**41.4** ± 1.3	**42.3** ± 1.6	**41.3** ± 1.2	**41.6** ± 1.5	**42.2** ± 1.6
Malt yield d. m.	%	Briggs 1998	**90.7** ± 0.8	**90.5** ± 0.7	**91.2** ± 0.8	**90.6** ± 0.8	**90.3** ± 1.0	**91.9** ± 0.7	**90.1** ± 0.7	**91.2** ± 0.7	**91.3** ± 0.6	**91.3** ± 1.0
Respiration losses d. m.	%	Briggs 1998	**4.7** ± 0.5	**4.7** ± 0.3	**4.2** ± 0.4	**4.4** ± 0.6	**4.7** ± 0.7	**4.0** ± 0.5	**4.8** ± 0.5	**4.0** ± 0.5	**4.5** ± 0.4	**4.2** ± 0.5
Rootlet losses d. m.	%	Briggs 1998	**4.6** ± 0.4	**4.8** ± 0.5	**4.6** ± 0.5	**5.0** ± 0.6	**5.0** ± 0.5	**4.1** ± 0.5	**5.2** ± 0.6	**4.8** ± 0.4	**4.2** ± 0.4	**4.5** ± 0.5
Extract of malt, congress mash	%	EBC 2010	**83.3** ± 0.8	**82.1** ± 1.3	**81.7** ± 0.7	**83.2** ± 1.4	**83.0** ± 1.3	**82.9** ± 1.5	**82.5** ± 1.8	**82.3** ± 1.3	**83.6** ± 1.3	**82.6** ± 1.5
VZ 45 °C	%	MEBAK 2011	**52.3** ± 5.5	**44.7** ± 5.1	**40.7** ± 4.4	**47.9** ± 3.4	**53.6** ± 3.5	**48.3** ± 3.0	**45.4** ± 3.2	**41.1** ± 3.1	**54.3** ± 4.1	**46.1** ± 3.6
Kolbach index	%	EBC 2010	**51.5** ± 2.2	**45.3** ± 2.0	**40.5** ± 1.6	**48.1** ± 2.8	**53.2** ± 2.9	**47.7** ± 2.9	**44.3** ± 2.2	**39.5** ± 2.3	**51.6** ± 2.8	**45.6** ± 3.4
Diastatic power	WK	EBC 2010	**397** ± 52	**320** ± 35	**328** ± 41	**359** ± 55	**409** ± 62	**309** ± 53	**302** ± 49	**273** ± 36	**407** ± 54	**313** ± 45
Apparent final attenuation	%	EBC 2010	**82.6** ± 0.6	**81.1** ± 0.8	**78.8** ± 1.8	**81.5** ± 0.9	**82.8** ± 0.7	**80.7** ± 0.8	**81.6** ± 0.9	**79.7** ± 0.6	**81.8** ± 0.8	**81.6** ± 1.1
Friability	%	EBC 2010	**96** ± 3	**80** ± 6	**78** ± 5	**87** ± 7	**93** ± 5	**86** ± 7	**89** ± 7	**80** ± 7	**96** ± 4	**88** ± 8
β-glucan content of malt, SFA	mg/l	EBC 2010	**41** ± 17	**222** ± 66	**219** ± 68	**166** ± 62	**71** ± 37	**178** ± 62	**151** ± 48	**316** ± 109	**42** ± 21	**132** ± 52
Protein content of malt (factor 6.25)	%	EBC 2010	**9.9** ± 0.7	**10.0** ± 0.9	**11.2** ± 0.6	**9.9** ± 1.0	**10.1** ± 1.0	**9.7** ± 1.2	**10.1** ± 1.0	**10.6** ± 1.1	**9.9** ± 1.1	**9.6** ± 1.2
Total nitrogen of malt, Kjeldahl method	%	EBC 2010	**1.58** ± 0.11	**1.60** ± 0.14	**1.78** ± 0.09	**1.59** ± 0.16	**1.61** ± 0.17	**1.55** ± 0.19	**1.61** ± 0.16	**1.69** ± 0.17	**1.59** ± 0.18	**1.54** ± 0.19
Soluble nitrogen of wort, Kjeldahl method	mg/l	EBC 2010	**948** ± 83	**837** ± 66	**851** ± 62	**881** ± 61	**979** ± 83	**852** ± 71	**816** ± 54	**788** ± 64	**941** ± 95	**812** ± 76
Soluble nitrogen of wort, Kjeldahl method	mg/100g	EBC 2010	**845** ± 73	**746** ± 58	**758** ± 55	**786** ± 53	**874** ± 74	**758** ± 62	**727** ± 48	**702** ± 57	**840** ± 84	**722** ± 66
Soluble nitrogen of malt, Kjeldahl method	%	EBC 2010	**5.3** ± 0.5	**4.7** ± 0.3	**4.7** ± 0.3	**4.9** ± 0.3	**5.5** ±0.5	**4.7** ± 0.4	**4.5** ± 0.3	**4.4** ± 0.4	**5.2** ± 0.5	**4.5** ± 0.4
Viscosity of laboratory wort from malt	mPa.s	EBC 2010	**1.42** ± 0.02	**1.46** ± 0.02	**1.47** ± 0.03	**1.44** ± 0.03	**1.41** ±0.02	**1.45** ± 0.03	**1.43** ± 0.03	**1.48** ± 0.04	**1.42** ± 0.02	**1.44** ± 0.02
Colour of malt, visual method	EBC	EBC 2010	**4.2** ± 0.4	**3.6** ± 0.5	**3.0** ± 0.6	**3.9** ± 0.7	**4.0** ± 0.4	**4.3** ± 0.6	**3.2** ± 0.6	**3.4** ± 0.5	**4.7** ± 0.9	**3.6** ± 0.6
Saccharification time	min	EBC 2010	**10.0** ± 0.0	**11.0** ± 1.0	**11.0** ± 1.0	**11.0** ± 1.0	**10.0** ± 0.0	**10.0** ± 1.0	**10.0** ± 0.0	**11.0** ± 1.0	**10.0** ± 1.0	**10.0** ± 1.0
Glassy corns	%	EBC 2010	**0.1** ± 0.1	**0.3** ± 0.3	**0.5** ± 0.5	**0.3** ± 0.2	**0.1** ± 0.1	**0.2** ± 0.3	**0.3** ± 0.2	**0.4** ± 0.4	**0.1** ± 0.1	**0.2** ± 0.2
Partly unmodified grains	%	EBC 2010	**0.4** ± 0.6	**3.1** ± 2.5	**4.6** ± 3.6	**2.2** ± 1.6	**0.6** ± 0.8	**1.6** ± 1.6	**1.6** ± 1.5	**3.7** ± 3.4	**0.2** ± 0.3	**1.3** ± 1.1
Homogeneity (by friabilimeter)	%	Baxter, O'Farrell 1983	**99.6** ± 0.6	**96.9** ± 2.5	**95.4** ± 3.6	**97.8** ± 1.6	**99.4** ± 0.8	**98.4** ± 1.6	**98.4** ± 1.5	**96.3** ± 3.4	**99.8** ± 0.3	**98.7** ± 1.1
Appearance (clarity) of wort		MEBAK 2011	**1.00** ± 0.00	**1.00** ± 0.00	**1.17** ± 0.39	**1.17** ± 0.39	**1.58** ± 0.90	**1.08** ± 0.29	**1.00** ± 0.00	**1.58** ± 0.90	**1.50** ± 0.80	**1.00** ± 0.0
Haze of wort (90°)	EBC	EBC 2010	**0.90** ± 0.38	**0.75** ± 0.19	**1.12** ± 0.78	**0.99** ± 0.81	**2.62** ± 3.11	**1.06** ± 0.39	**0.75** ± 0.21	**2.41** ± 2.28	**2.21** ± 2.14	**0.84** ± 0.21
Haze of wort (12°)	EBC	EBC 2010	**1.15** ± 0.59	**0.83** ± 0.24	**1.10** ± 0.47	**1.11** ± 0.84	**2.64** ± 2.79	**1.15** ± 0.52	**0.92** ± 0.33	**2.26** ± 1.77	**2.43** ± 2.16	**0.89** ± 0.22
Total polyphenols in wort	mg/l	EBC 2010	**87** ± 26	**85** ± 21	**60** ± 17	**75** ± 17	**75** ± 17	**80** ± 19	**71** ± 16	**57** ± 13	**86** ± 19	**80**± 20
Free amino nitrogen	mg/l	EBC 2010	**228** ± 24	**195** ± 19	**185** ± 20	**208** ± 18	**237** ± 25	**198** ± 15	**182** ± 13	**171** ± 17	**228** ± 27	**184** ± 17
Free amino nitrogen	mg/100g	EBC 2010	**204** ± 21	**174** ± 17	**165** ± 18	**186** ± 16	**211** ± 22	**177** ± 13	**162** ± 11	**153** ± 15	**203** ± 24	**164** ± 14

$\bar{x}$ = mean

s_x = sample standard deviation

S = standard varieties

Wort clarity: 1 = clear; 2 = weakly opalizing; 3 = opalizing; 4 = cloudy

Table 2c *Barley grain and malt analyses*

Methods	Unit	References	Winter Barley (2019–2021)	
			KWS Ariane S	Suez
			$\bar{x} \pm s_x$	$\bar{x} \pm s_x$
Protein content of barley (factor 6.25)	%	EBC 2010	**11.2** ± 1.0	**10.3** ± 0.9
Starch content of barley	%	NIR	**63.3** ± 1.2	**64.8** ± 0.9
Bulk density	g/l	MEBAK 2011	**66.4** ± 4.0	**67.5** ± 3.4
Degree of steeping 1	%	–	**32.5** ± 1.6	**31.7** ± 1.4
Degree of steeping 2	%	–	**39.8** ± 1.6	**39.1** ± 1.5
Malt yield d. m.	%	Briggs 1998	**91.3** ± 0.9	**91.4** ± 0.3
Respiration losses d. m.	%	Briggs 1998	**4.1** ± 0.6	**4.0** ± 0.2
Rootlet losses d. m.	%	Briggs 1998	**4.7** ± 0.4	**4.6** ± 0.2
Extract of malt, congress mash	%	EBC 2010	**80.5** ± 2.0	**81.9** ± 1.8
VZ 45 °C	%	MEBAK 2011	**39.2** ± 5.3	**40.8** ± 6.0
Kolbach index	%	EBC 2010	**44.6** ± 4.7	**45.1** ± 4.8
Diastatic power	WK	EBC 2010	**489** ± 88	**462** ± 85
Apparent final attenuation	%	EBC 2010	**81.7** ± 1.2	**82.4** ± 0.9
Friability	%	EBC 2010	**83.8** ± 5.2	**86.2** ± 6.2
β-glucan content of malt, SFA	mg/l	EBC 2010	**164** ± 77	**158** ± 59
Protein content of malt (factor 6.25)	%	EBC 2010	**10.8** ± 1.1	**10.0** ± 0.9
Total nitrogen of malt, Kjeldahl method	%	EBC 2010	**1.73** ± 0.18	**1.60** ± 0.15
Soluble nitrogen of wort, Kjeldahl method	mg/l	EBC 2010	**859** ± 67	**802** ± 55
Soluble nitrogen of wort, Kjeldahl method	mg/100g	EBC 2010	**766** ± 58	**715** ± 48
Soluble nitrogen of malt, Kjeldahl method	%	EBC 2010	**4.8** ± 0.4	**4.5** ± 0.3
Viscosity of laboratory wort from malt	mPa.s	EBC 2010	**1.48** ± 0.03	**1.49** ± 0.03
Colour of malt, visual method	EBC	EBC 2010	**2.8** ± 0.3	**3.1** ± 0.6
Saccharification time	min	EBC 2010	**10.0** ± 1.0	**10.0** ± 0.0
Glassy corns	%	EBC 2010	**0.2** ± 0.1	**0.1** ± 0.2
Partly unmodified grains	%	EBC 2010	**1.5** ± 1.1	**1.5** ± 1.5
Homogeneity (by friabilimeter)	%		**98.4** ± 1.1	**98.5** ± 1.4
Appearance (clarity) of wort		MEBAK 2011	**1.58** ± 0.79	**1.25** ± 0.62
Haze of wort (90°)	EBC	EBC 2010	**2.79** ± 2.30	**1.67** ± 1.58
Haze of wort (12°)	EBC	EBC 2010	**2.74** ± 2.11	**1.74** ± 1.46
Total polyphenols in wort	mg/l	EBC 2010	**86** ± 16	**95** ± 24
Free amino nitrogen	mg/l	EBC 2010	**179** ± 18	**175** ± 16
Free amino nitrogen	mg/100g	EBC 2010	**165** ± 13	**159** ± 17

$\bar{x}$ = mean
s_x = sample standard deviation
S = standard variety
Wort clarity
1 = clear
2 = weakly opalizing
3 = opalizing
4 = cloudy

tent of the wort, the higher soluble nitrogen content (924 mg/l) and the free amino nitrogen (FAN) content of the wort (221 mg/l). Thus, FAN accounted for 24% of the soluble nitrogen (Table 2a).

Fangio is a malting, mid-early variety. The plants are medium high to high. The variety is medium to less resistant to lodging, medium resistant to stem breaking. It provides medium big to big grains and a medium high portion of sieving fractions over 2.5 mm. The variety is medium resistant to powdery mildew of barley on the leaf, medium resistant to leaf rust of barley, medium resistant to the complex of leaf spots, resistant to scald of barley, medium resistant to head blight of barley. The variety achieved a very high yield of grain over 2.5 mm in

Table 3 *Important agronomic characters of spring barley*

Variety	Intesity	2018–2021						2019–2021										
		spring barley																
		Mean of the standard varieties	KWS Amadora	KWS Irina	Laudis 550	Fangio	LG Slovan	Mean of the standard varieties	Bente	KWS Amadora	KWS Irina	Laudis 550	Evgenia	Guzel	LG Flamenco	LG Lodestar	LG Sedlak	Schiwago	SY Solar
Grain yield (t/ha)		t/ha	S	S	S				S	S	S	S							
maize growing area	N	6.39	6.30	6.48	6.39	6.68	6.58	6.93	7.32	6.81	6.83	6.74	7.59	7.33	7.69	7.10	7.20	7.42	7.32
	T	6.70	6.69	6.86	6.55	6.85	7.03	7.27	7.92	7.04	7.21	6.90	7.79	7.86	7.95	7.26	7.61	7.78	7.96
sugar beet and cereal growing areas	N	7.12	7.09	7.25	7.01	7.50	7.34	7.43	8.00	7.20	7.40	7.11	7.82	7.77	8.18	7.18	7.73	7.95	7.70
	T	7.73	7.78	7.87	7.54	8.11	7.81	7.97	8.38	7.92	8.04	7.53	8.24	8.36	8.74	7.54	8.06	8.39	8.34
potato and forage growing areas	N	6.50	6.60	6.43	6.46	6.69	6.56	6.61	7.04	6.64	6.31	6.44	7.00	7.00	7.46	6.72	6.77	6.98	6.98
	T	7.59	7.92	7.72	7.14	8.12	7.61	7.81	8.25	7.99	7.82	7.17	8.18	7.83	8.95	7.44	7.95	8.07	8.29
Grain over 2.5 mm (t/ha)																			
maize growing area	N	5.03	5.06	4.68	5.34	5.09	5.26	5.61	5.96	5.56	5.03	5.88	6.35	6.22	6.28	6.14	6.25	5.89	5.97
	T	5.36	5.45	5.19	5.44	5.44	5.80	6.11	6.69	5.89	5.71	6.16	6.18	6.76	6.49	6.41	6.64	6.34	6.76
sugar beet and cereal growing areas	N	6.07	6.14	5.93	6.14	6.40	6.38	6.22	6.90	6.00	5.90	6.09	6.63	6.72	6.94	6.31	6.82	6.67	6.57
	T	6.91	7.03	6.84	6.85	7.21	7.05	7.03	7.51	7.04	6.85	6.71	7.34	7.60	7.68	6.83	7.24	7.27	7.39
potato and forage growing areas	N	6.13	6.30	5.96	6.14	6.36	6.03	6.16	6.64	6.22	5.69	6.08	6.57	6.79	7.02	6.50	6.47	6.67	6.69
	T	7.30	7.65	7.35	6.89	7.91	7.16	7.55	8.05	7.78	7.43	6.95	7.87	7.68	8.61	7.20	7.71	7.80	7.97
Agronomic data																			
straw length (cm)			69	67	73	74	71		75	70	68	76	76	75	69	74	76	72	72
earliness of ripening**			115	115	115	115	116		119	120	121	120	120	120	121	121	121	120	120
standing power (lodging resistance) (9–1)			4.7	6.9	6.1	5.5	6.1		6.7	5.3	7.1	6.3	5.9	5.5	6.4	5.4	6.8	6.3	6.0
Resistance to diseases (9–1)																			
powdery mildew (*Blumeria graminis*)			9.0	8.0	8.3	7.1	8.8		5.9	8.9	8.9	8.9	8.8	8.8	8.6	8.8	8.9	8.7	8.8
leaf rust of barley (*Puccinia hordei*)			4.8	6.9	6.6	6.5	7.6		6.4	5.1	7.0	6.9	6.6	6.3	6.3	6.1	6.2	6.5	6.8
comlex of leaf spots (*Pyrenophora teres*)			7.1	6.3	5.8	6.0	6.5		6.3	6.9	6.3	6.0	6.7	6.6	6.2	7.1	6.8	6.8	6.8
leaf scald (*Rhynchosporium secalis*)			7.4	7.3	7.5	8.0	7.6		7.0	7.6	6.5	7.6	7.7	7.3	7.9	7.3	7.5	7.3	7.4
head blight of barley (*Fusarium graminearum, F. culmorum, Microdochium nivale etc.*)			7.1	6.7	7.3	7.2	6.5		6.4	7.1	6.8	7.3	7.5	7.2	7.3	6.5	6.7	7.4	7.2
physiological leaf spots of barley			8.0	7.8	5.4	7.9	7.2		8.0	7.9	7.9	5.6	7.7	7.0	7.2	8.1	8.1	7.7	8.0
Grain quality																			
1000 grain weight (g)			45	45	44	47	46		50	44	44	44	48	48	47	44	51	50	47
sieving fractions over 2.5 mm (%)			88	83	89	86	87		86	87	82	89	87	90	86	90	90	86	87

Comments: S = standard varieties

Point evaluation

1 = fully lodging, fully attacked 9 = non lodging, resistant to diseases

Weight of 1000 grains relates to sieving fractions over 2.0 mm at 14% humidity.

** days from sowing to harvest maturity

Intensity:

N – non treated with fungicides and morphoregulators T – treated with fungicides and morphoregulators

Table 4 *Important agronomic characters of winter barley*

Variety		2019–2021 winter barley				
		Mean of the standard varieties	Leopard	Padura	KWS Ariane	Suez
			S	S	S	
Number of rows			2	2	2	2
Grain yield (t/ha)	N	8.43	**8.51**	**8.35**	**7.93**	**8.23**
	T	9.42	**9.54**	**9.30**	**9.17**	**9.33**
Grain over 2.5 mm (t/ha)	N	6.75	**6.17**	**7.33**	**6.73**	**7.37**
	T	7.92	**7.53**	**8.32**	**8.02**	**8.53**
Agronomic data						
straw length (cm)			**85**	**92**	**87**	**85**
earliness of ripening**			**190**	**189**	**189**	**190**
standing power (lodging resistance)			**6.1**	**6.4**	**6.6**	**5.8**
Resistance to diseases						
powdery mildew (*Blumeria graminis*)			**7.9**	**7.9**	**8.4**	**8.2**
leaf rust of barley (*Puccinia hordei*)			**8.1**	**7.9**	**7.2**	**7.9**
comlex of leaf spots (*Pyrenophora teres*)			**6.4**	**7.4**	**7.2**	**7.2**
leaf scald (*Rhynchosporium secalis*)			**6.5**	**8.1**	**7.7**	**7.7**
head blight of barley (*Fusarium graminearum*, *F. culmorum*, *Microdochium nivale* etc.)			**7.2**	**8.2**	**8.1**	**8.0**
physiological leaf spots of barley			**7.4**	**7.3**	**7.5**	**7.2**
Grain quality						
1000 grain weight (g)			**48**	**49**	**43**	**44**
sieving fractions over 2.5 mm (%)			**75**	**88**	**86**	**90**

Comments: S = standard varieties

Point evaluation

1 = fully lodging, fully attacked 9 = non lodging, resistant to diseases

Weight of 1000 grains relates to sieving fractions over 2.0 mm at 14% humidity.

** days from sowing to harvest maturity

Intensity:

N – non treated with fungicides and morphoregulators

T – treated with fungicides and morphoregulators

the treated variant of growing in a potato area, high in both variants in sugar-beet-cereal areas, medium in both variants of growing in a maize area and in the untreated variant in a potato area.

The utility value is given by the combination of a very high yield of sieving fractions over 2.5 mm in the treated variant of growing in a potato growing area, high yield of sieving fractions over 2.5 mm in both variants of growing in sugar-beet-cereal areas and malting quality.

LG Slovan is a variety bred in the Czech Republic. At the optimal protein content (11.1%) in the non-malted grain, it gave the optimal level of the extract content (82.9%) and optimal level of the diastatic power (294 WK). The cell wall degradation was optimal (Kolbach index 42.0%). A greater difference was found between the relative extract value at 45 °C (38.8%) and the value of the Kolbach Index. Cell wall degradation was slow. The friability was at 80%, corresponding to the high β-glucan

content of the wort (200 mg/l). The quality of the wort was very low (apparent final attenuation 79.3%). In most cases, the variety provided clear wort with a higher level of malt colour (3.4 EBC). The FAN content of the wort was at a medium level (175 mg/l) and accounted for 22% of the soluble nitrogen. LG Slovan fulfilled the requirements specified in the application for the PGI 'České pivo' (European Committee of the Regions, 2008) and for this reason the Research Institute of Brewing and Malting recommended it for the production of beer with the protected geographical indication 'České pivo' (Table 2a).

LG Slovan is a malting, mid-early to mid-late variety. The plants are medium high. The variety is medium resistant to lodging, resistant to stem breaking. It provides medium big grains and a medium high portion of sieving fractions over 2.5 mm. The variety is resistant to powdery mildew of barley on the leaf, medium resistant to resistant to leaf rust of barley, medium resistant to the complex of leaf spots, medium resistant to resistant to scald of barley, medium resistant to head blight of barley. The variety achieved a high yield of grain over 2.5 mm in the treated variant of growing in a maize area and in the untreated variant in sugar-beet-cereal areas, medium high in the untreated variant of growing in a maize area and in the treated variant in sugar-beet-cereal areas, low in both variants of growing in a potato area.

The utility value is given by the combination of a high yield of sieving fractions over 2.5 mm in the treated variant of growing in the maize area and in the untreated variant of growing in the sugar-beet-cereal areas, medium resistance to resistance to brown rust of barley and malting quality meeting the requirements for the production of beer with the PGI 'České pivo'.

Evgenia is a variety bred in Germany. At the optimal protein content (10.5%) in the non-malted grain, it gave malt with the optimal extract content (83.2%) and optimal level of diastatic power (395 WK). Intensity of proteolytic modification was also optimal (Kolbach index 48.1%). The degradation of cell walls characterized by friability was at an optimal level (87%) and the β-glucan content of the wort was at a satisfactory level (166 mg/l). The composition of the wort was optimal (apparent final attenuation 81.5%). In most cases, the variety gave clear wort. The high FAN content (average 208 mg/l) in the wort, which accounted for 24% of the soluble nitrogen, is a benefit of the variety Evgenia (Table 2b).

Evgenia is a malting, mid-early variety. The plants are medium high to high. The variety is medium resistant to lodging, medium resistant to stem breaking. It has medium big grains and a medium high portion of sieving fractions over 2.5 mm. The variety is resistant to powdery mildew of barley on the leaf, medium resistant to leaf rust of barley, medium resistant to the complex of leaf spots, medium resistant to resistant to scald of barley, medium resistant to resistant to head blight of barley.

The variety achieved a very high yield of grain over 2.5 mm in the untreated variant of growing in a maize area, high in both variants in sugar-beet-cereal and potato areas, medium high in the treated variant of growing in a maize area.

The utility value is given by the combination of a very high yield of sieving fractions over 2.5 mm in the untreated variant of growing in a maize area, high yield of sieving fractions over 2.5 mm in both variants of growing in sugar-beet-cereal areas and a potato area and very good malting quality.

Guzel is a variety bred in France. At the optimal protein content (10.6%) in the non-malted grain, it gave the optimal level of the amylolytic modification (extract content in malt dry matter 83.0%, diastatic power 409 WK). Intensity of proteolytic modification was high (Kolbach index 53.2%). The strong proteolysis was accompanied by higher values of relative extract at 45 °C (53.6%) and malt colour (4.0 EBC). Cytolytic modification was at the optimal level (friability 93%, β-glucan content in wort 71 mg/l). The composition of the wort was optimal (apparent final attenuation 82.8%). The variety did not always provide clear wort. The advantage of Guzel is, besides the high quality of the wort, the low β-glucan content of the wort, the higher soluble nitrogen content (979 mg/l) and the high FAN content of the wort (237 mg/l). Thus, FAN accounted for 24% of the soluble nitrogen (Table 2b).

Guzel is a malting, mid-early to early variety. The plants are medium high to high. The variety is medium to less resistant to lodging, medium resistant to stem breaking. It provides medium big grain and high portion of sieving fractions over 2.5 mm. The variety is resistant to powdery mildew of barley on the leaf, medium resistant to leaf rust of barley, medium resistant to the complex of leaf spots, medium resistant to scald of barley, medium resistant to head blight of barley.

The variety achieved a very high yield of grain over 2.5 mm in the untreated variant of growing in maize and potato areas and in both variants of growing in sugar-beet-cereal areas, high in the treated variant in a maize area, medium in the treated variant of growing in a potato area.

The utility value is given by the combination of a very high yield of sieving fractions over 2.5 mm in the untreated variant of growing in the maize and potato areas and in both variants of growing in the sugar-beet-cereal production areas and malting quality.

The variety **LG Flamenco** was bred in the Netherlands. At the optimal protein content (10.3%) in the non-malted grain, it provided malt with the optimal extract content (82.9%) and optimal level of the diastatic power (309 WK). Intensity of proteolytic modification was also good (Kolbach index 47.7%). The degradation of cell walls was at an optimal level (friability 86%). The β-glucan content of the wort was at a satisfactory level (178 mg/l). The wort composition was satisfactory (apparent final attenuation 80.7%). The variety gave clear wort nearly in most cases. The advantage of LG Flamenco is a higher FAN content (198 mg/l on average), which represents 23% of soluble nitrogen. (Table 2b).

According to the EU Plant Variety Database (2022), the variety is registered in France and Germany.

LG Flamenco is a malting, mid-early variety. The plants are medium high to low. The variety is medium to resistant to lodging, medium resistant to resistant to stem breaking. It has medium big grains and a medium high portion of sieving fractions over 2.5 mm. The variety is resistant to powdery mildew of barley on the leaf, medium resistant to leaf rust of barley, medium resistant to the complex of leaf spots, resistant to scald of barley, medium resistant to head blight of barley. The variety achieved a very high yield of grain over 2.5 mm in the untreated variant of growing in a maize area and in both variants in sugar-beet-cereal and potato areas, high in the treated variant of growing in a maize area.

The utility value is given by the combination of a very high yield of sieving fractions over 2.5 mm in the untreated variant of growing in a maize area and in both variants of growing in sugar-beet and cereal production areas and a potato area, high yield of sieving fractions over 2.5 mm in the treated variant of growing in a maize area and a very good malting quality.

LG Lodestar is a variety bred in Great Britain. At the optimal protein content (10.7%) in the non-malted grain, it gave malt with a satisfactory extract content in malt dry matter (82.5%) and optimal level of diastatic power (302 WK). level of diastatic power (302 WK). Intensity of proteolytic modification was optimal (Kolbach index 44.3%). The cell wall degradation was at the optimal level (friability 89%) and the β-glucan content of the wort was at a satisfactory level (151 mg/l). The wort composition was optimal (apparent final attenuation 81.6%). In all cases, the variety provided clear wort. FAN was medium (on average 182 mg/l), it accounted for 22% of soluble nitrogen. LG Lodestar had low to zero lipoxygenase activity (LOX). The advantages of LG Lodestar include low to zero LOX activity which achieved the following average values in the respective years: <2.00; <2.00 and 1.84 U/mg. (Table 2b).

According to the EU Plant Variety Database (2022), the variety is registered in Slovak Republik (Psota et al., 2018).

LG Lodestar is a malting, mid-late to late variety. The plants are medium high. The variety is medium to less resistant to lodging, medium resistant to resistant to stem breaking. It has small grains and a high portion of sieving fractions over 2.5 mm. The variety is resistant to powdery mildew of barley on the leaf, medium resistant to leaf rust of barley, medium resistant to the complex of leaf spots, medium resistant to scald of barley, medium resistant to head blight of barley. The variety achieved a high yield of grain over 2.5 mm in the untreated variant of growing in a maize area, medium high to high in the untreated variant in a potato area, medium high in the treated variant of growing in maize and in the untreated variant in sugar-beet-cereal areas and low in the treated variant in sugar-beet-cereal and in potato areas.

The utility value is given by the combination of a high yield of sieving fractions over 2.5 mm in the untreated variant of growing in the maize area, very good malting quality and low to zero lipoxygenase activity.

LG Sedlak is a variety bred in the Czech Republic. At the optimal protein content (11%) in the non-malted grain, it gave malt with the acceptable extract content (82.3%) and suitable level of the diastatic power (273 WK). Degradation of nitrogenous substances was very low (Kolbach index 39.5%). The cell wall degradation was very slow (friability 80%), corresponding to the very high β-glucan content in wort (316 mg/l). Quality of the wort was low (apparent final attenuation 79.7%). The wort was not always clear. FAN content in the wort was at medium level (171 mg/l) and accounted for 22% of soluble nitrogen. LG Sedlak fulfilled the requirements set out in the application for the PGI 'České pivo' (European Committee of the Regions, 2008) and was therefore recommended by the Research Institute of Brewing and Malting for the production of beer with the protected geographical indication 'České pivo' (Table 2b).

LG Sedlak is a malting, mid-early variety. The plants are medium high to high. The variety is medium resistant to lodging, resistant to stem breaking. It has big grain and high portion of sieving fractions over 2.5 mm. The variety is resistant to powdery mildew of barley on the leaf, medium resistant to leaf rust of barley, medium resistant to the complex of leaf spots, medium resistant to resistant to scald of barley, medium resistant to head blight of barley. The variety achieved a high yield of grain over 2.5 mm in both variants of growing in a maize area and in the untreated variant in sugar-beet-cereal areas, in the treated variant in sugar-beet-cereal areas and medium high in both variants of growing in a potato area.

The utility value is given by the combination of a high yield of sieving fractions over 2.5 mm in the untreated variant of growing in the sugar-beet and cereal production areas and in both variants of growing in the maize area and malting quality meeting the requirements for the production of beer with the PGI 'České pivo'.

Schiwago is a variety bred in Germany. At the optimal protein content (10.5%) in the non-malted grain, it gave malt with the optimal level of the amylolytic modification. Extract content in malt dry matter (83.6%) and diastatic power (407 WK) were at the optimal level of amylolytic modification. Intensity of proteolytic modification was strong (Kolbach index 51.6%). Strong proteolysis was accompanied with higher values of relative extract at 45°C (54.3%) and wort colour (4.7 EBC). Cytolytic modification was at the optimal level (friability 96%; β-glucan content in wort 42 mg/l). The composition of wort was optimal (apparent final attenuation 81.8%), wort was not always clear. The advantage of Schiwago, besides its rich extract and rapid degradation of cell walls, is the higher soluble nitrogen content (941 mg/l) and the high FAN content of the wort (228 mg/l). Thus, FAN accounted for 24% of the soluble nitrogen (Table 2b).

According to the EU Plant Variety Database (2022), the variety Schiwago is registered in Germany, France and Poland.

Schiwago is a malting, mid-early variety. The plants are medium high. The variety is medium resistant to lodging, medium resistant to stem breaking. Its grain is big, with medium high portion of sieving fractions over 2.5 mm. The variety is resistant to powdery mildew of barley on the leaf, medium resistant to leaf rust of barley, medium resistant to the complex of leaf spots, medium resistant to scald of barley, medium resistant to head blight of barley. The variety achieved a high to very high yield of grain over 2.5 mm in the untreated variant of growing in sugar-beet-cereal areas and in a potato area, medium high to high in the untreated variant of growing in a maize area and in the treated variant in sugar-beet-cereal areas, medium in the treated variant in maize and potato areas.

The utility value is given by the combination of a high to very high yield of sieving fractions over 2.5 mm in the untreated variant of growing in the sugar-beet and cereal and potato production areas and malting quality.

The variety **SY Solar**, was bred in Great Britain. At the optimal protein content (10.3%) in the non-malted grain, it gave malt with the suitable extract content (82.6%) and optimal level of diastatic power (313 WK). Intensity of proteolytic modification was also optimal (Kolbach index 45.6%). Cytolytic modification achieved optimal values (friability 88%, β-glucan content in wort 132 mg/l). The wort composition was good (apparent final attenuation 81.6%) and wort was clear in all cases. FAN content in the wort was at a medium level (184 mg/l) and accounted for 23% of soluble nitrogen (Table 2b).

According to the EU Plant Variety Database (2022), the variety is registered in Austria, Germany, Estonia, Lithuania and Latvia.

SY Solar is a malting, mid-early variety. The plants are medium high. The variety is medium resistant to lodging, medium resistant to stem breaking. It provides medium big grain and medium high portion of sieving fractions over 2.5 mm. The variety is resistant to powdery mildew of barley on the leaf, medium resistant to leaf rust of barley, medium resistant to the complex of leaf spots, medium resistant to scald of barley, medium resistant to head blight of barley. The yield of grain over 2.5 mm in the untreated variant of growing in a potato area is high to very high, in both variants of growing in a maize area and sugar-beet-cereal areas and in the treated variant in a potato area high.

The utility value is given by the combination of a high to very high yield of sieving fractions over 2.5 mm in the untreated variant of growing in a potato production area, high yield of grain in both variants of growing in maize, sugar-beet-cereal production areas and treated variant of growing in a potato area and very good malting quality.

Suez is a winter barley variety bred in Austria. At the optimal protein content (10.3%) in the non-malted grain, it gave malt with the low extract content (81.9%), but with the optimal level of diastatic power (462 WK). Degradation of nitrogenous substances was optimal (Kolbach index 45.1%). The degradation of cell walls was optimal (friability 86%) and the β-glucan content of the wort was at a satisfactory level (158 mg/l). The wort composition was optimal (apparent final attenuation 82.4%). The wort provided by the variety was not always clear. FAN content in the wort was at the medium level (179 mg/l), forming 21% of soluble nitrogen (Table 2c).

According to the EU Plant Variety Database (2022), the variety is registered in Croatia, Poland and the Slovak Republic.

Suez is a two-row, mid-late variety. The plants are low. The variety is medium resistant to lodging, medium resistant to resistant to stem breaking. It provides medium big to small grain and high portion of sieving fractions over 2.5 mm. The variety is resistant to powdery mildew of barley on the leaf, resistant to leaf rust of barley, medium resistant to the complex of leaf spots, medium resistant to resistant to scald of barley. According to cold hardiness tests, the variety is less resistant to frost. Within the collection of two-row varieties in both variants of growing, the yield of

sieving fractions over 2.5 mm was high to very high.

The utility value is given by the combination of a high to very high yield of sieving fractions over 2.5 mm in both variants of growing, resistance to powdery mildew of barley on the leaf and malting quality.

4 Conclusion

After the harvest of 2021, the results of the trials of the barley varieties tested within the registration procedure were evaluated. Micro-malting trials were carried out in the spring barley varieties Fangio and LG Slovan, Evgenia, Guzel, LG Flamenco, LG Lodestar, LG Sedlak, Schiwago, SY Solar and the winter barley variety Suez.

The malts showed an optimal extract content with the exception of Suez, LG Sedlak, LG Lodestar, SY Solar. Furthermore, they showed mostly a very good solubility of the cell walls, which only in LG Slovan and LG Sedlak, i.e. the varieties recommended for the production of beer with the PGI 'České pivo', reached a friability of 80%. The highest content of the soluble proteins in the wort was detected in Guzel, Schiwago, Fangio, Evgenia and LG Flamengo, with Guzel, Schiwago and Fangio showing high values of the Kolbach index and relative extract at 45 °C. These varieties also had the highest values of diastatic power, accompanied by high degree of apparent final attenuation and high value of wort colour.

On average, the worts contained favourable to optimal levels of β-glucans. Only the varieties recommended for the production of beer with the PGI 'České pivo' LG Slovan and LG Sedlak had a higher β-glucan content in the wort (above 200 mg/l). Apparent final attenuation was generally high again except for LG Slovan and LG Sedlak. The varieties showed a generally good level of α-amino nitrogen in the wort.

5 Acknowledgement

Supported by the Ministry of Agriculture of the Czech Republic, institutional support MZE-RO1918.

6 References

Act No. 219/2003 Coll., on the marketing of seed and planting material of cultivated plants and amending certain acts (Act on the marketing of seed and planting material).

Barone, R., Briante, R., D'Auria, S., Febbraio, F., Vaccaro, C., Del Giudice, L., Borrelli, G. M., Di Fonzo, N., Nucci, R. (1999). Purification and characterization of a lipoxygenase enzyme from durum wheat semolina. Journal of Agricultural and Food Chemistry, 47(5), 11924–11931. https://doi.org/10.1021/jf980853z

Baxter, E. D., O'Farrell, D.D. (1983). Use of the friabilimeter to assess homogeneity of malt. Journal of the Institute of Brewing, 89(3), 210–214. https://doi.org/10.1002/j.2050-0416.1983.tb04169.x

Briggs, D. E. (1998). Malts and Malting. Blackie Academic and Professional, London, pp. 622–624. ISBN 10 0412298007

CISTA (2021). Summary of entered propagating areas 2021. Division of Seed and Planting Materials. CISTA Brno.

Dvořáčková, O. (2019). Metodika zkoušek užitné hodnoty – ječmen. ÚKZÚZ NOÚ, Brno. Available in Czech from: https://eagri.cz/public/web/file/112373/Priloha_10_ZUH10_2019_Jecmen_revize_2021.pdf

EBC Analysis committee (2010). Analytica-EBC. 3.13 Moisture and Total Nitrogen in Barley by Near Infrare Spectroscopy, 4.3.1 Total Nitrogen of Malt: Kjeldahl Method, 4.2 Moisture Content of Malt, 4.3.2 Total Nitrogen of Malt: Dumas Combustion Method, 4.5.1 Extract of Malt: Congress Mash, 4.9.1 Soluble Nitrogen of Malt: Kjeldahl Method, 4.10 Free Amino Nitrogen of Malt by Spectrophotometry, 4.11.1 Fermentability, Final Attenuation of Laboratory Wort from Malt, 4.12.2 Diastatic Power of Malt by Segmented Flow Analysis, 4.15 Friability, Glassy Corns and Unmodified Grains of Malt by Friabilimeter, 4.16.2 High Molecular Weight β-Glucan Content of Malt and Malt Wort: Fluorimetric, 8.12 Total Polyphenols in Wort by Spectrophotometry, 9.29 Haze in Beer: Calibration of Haze Meters, Nüremberg: Fachverlag Hans Carl, pp. 794 ISBN 978-3-418-00759-5.

European Committee of the Regions (2008). Other acts Commission Publication of an application pursuant to Article 6(2) of Council Regulation (EC) No 510/2006 on the protection of geographical indications and designations of origin for agricultural products and foodstuffs. Official Journal of the European Union. C16, 14–22.

EU Plant Variety Database (2022). https://ec.europa.eu/food/plant/plant_propagation_material/plant_variety_catalogues_databases/search/public/index.cfm [2022-03-31]

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. 2011. 341 p.

Psota, V., Kosař, K. (2002). Malting quality index. Kvasny prumysl, 48(6), 142–148. https://doi.org/10.18832/kp2002011

Psota, V., Svorad, M., Musilová, M. (2018). Barley varieties registered in the Slovak Republic after harvest 2017. Kvasny prumysl, 64(3), 111–116. https://doi.org/10.18832/kp201818

Psota, V. Dvořáčková, O., Musilová, M., Nečas, M. (2021). Barley and Malt. In: Psota, V. (ed.) Barley Year Book 2021. VÚPS Praha. ISBN 978-80-86576-94-7