



Czech research and development in the field of brewing raw materials

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Barley, malt, hops and beer in the Czech Republic

- **Barley and malt** production in the Czech Republic (2012)
 - ✓ 1,100 thousand tons of malting spring barley
 - ✓ 493 000 tons of malt (250 exported) (29 malthouses)
- **Hop** production in the Czech Republic (2013)
 - ✓ 5 300 tons
- **Beer** production in the Czech Republic (2012)
 - ✓ 17,620 000 hl (48 breweries, 200 craft breweries)
 - ✓ More than 70% of beer is produced according to PGI Czech Beer
- Brewing raw materials and beer production is a significant sector of the national economy.
- Beer production according to PGI Czech beer supports the breeding of barley and hops and the production of these materials



Research Institute of Brewing and Malting, Plc.



Praha - Brewing Institut

Brno - Malting Institute



hops, beer and beverages

The only research institute in the Czech Republic specializing in the field of brewing and malting
(since 1887)



barley, malt and plant products

Number of employees: 58

Number of researchers : 23



The main research objectives are focused on supporting the sustainability protected geographical indication (PGI) Czech beer



- RIBM initiated idea of registration of Czech beer in the EU
 - ✓ The Institute prepared fundamental documentation for Czech beer registration application
 - ✓ The Institute obtained authorization to approve new barley and hop varieties suitable for Czech beer
 - ✓ The Institute continues further research on specific markers of Czech beer



Research of brewing raw materials

- The main activities are targeted to:
 - ✓ Ensure high quality varieties for domestic production and export
 - ✓ Evaluate the quality of brewing raw materials from the current harvest
 - ✓ Both with special attention to raw materials for Czech beer
- Research projects funded mostly by Czech grant agencies (National agency for agricultural research, Technological Agency of the CR) and co-financed by Czech breeding, malting and brewing industry are focused on :
 - ✓ Malting and brewing properties of new barley varieties
 - ✓ Brewing properties of new hop varieties
 - ✓ Evaluation of the crops (barley, hops)
 - ✓ Research on new markers and substances with health benefit
 - ✓ Development of new methods of analysis and sensory evaluation



Cooperation in raw materials research

- RIBM cooperates with:
- Breeders :
 - Barley: Limagrain Central Europe Cereals, Selgen, Ltd.
 - Hops: Hop Research Institute, Ltd., Žatec
- Growers
- Government authorities
 - Central Institute for Supervising and Testing in Agriculture
 - Ministry of Agriculture of the CR (Department of plant commodities)
- Industry
 - Czech Beer and Malt Association members :
 - Malting houses (e.g. Malterie Soufflet CR)
 - Breweries (e.g. Pilsner Urquell, Budějovický Budvar, Heineken CR)



Research of malting barley varieties (with specific focus on properties suitable for Czech beer)

- The aim is to provide information on the technological quality of malting barley varieties in the registration procedure.
- Methods :
 - Analysis of samples of standard varieties of barley harvest obtained from all 22 testing stations
 - Selection of four test stations, analysis of barley
 - Micro-malting and malt analysis of samples from four test stations.
 - Based on the three-year results new varieties are registered.
- Results 2013:
 - In 2013 spring barley malting varieties Arthur, Danielle, Laudis 550, Olympic, Petrus, Shuffle, Vendela and Zhana were registered.
 - Varieties Laudis 550, Zhana, Petrus and Vendela were recommended for brewing according to a protected geographical indication "Czech beer"



Results (Example)

List of recommended spring barley varieties (2010-2012)

	MQI	NLb	E	RE45	K	DM	DSP	F	BGw
Malz	5,5	11,1	82,7	40,0	40,8	281	80,2	86	295
Bojos	5,8	11,3	82,4	38,0	44,3	349	79,6	90	161
Sebastian	7,7	10,4	83,3	42,2	46,9	375	82,5	88	176
Xanadu	8,3	11,1	83,0	47,1	48,1	401	81,3	89	124
Blaník	5,4	11,1	82,2	38,6	43,2	383	81,5	84	272
Aksamit	4,4	10,8	82,2	37,1	40,8	361	81,7	81	284
Kangoo	6,4	10,9	82,1	42,6	45,3	444	83,1	94	125
Aktiv	3,9	11,1	81,4	41,8	44,8	330	81,8	84	263
Delphi	7,3	10,3	83,9	46,9	48,0	334	83,0	86	202
Sunshine	7,6	10,9	82,9	45,7	50,7	422	83,3	97	48
Signum	6,9	10,9	83,4	41,5	47,2	315	79,7	89	146
Zeppelin	9,0	10,4	83,7	43,8	47,0	332	82,5	94	91
Explorer	6,4	10,5	82,2	45,3	50,6	321	83,0	95	71

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4 - 5

6 - 7

8 - 9



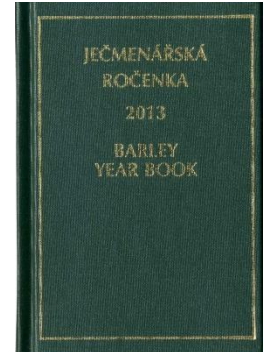
Evaluation of the quality of the malting barley harvest

- The aim is to timely information on malting barley qualities of the current harvest (with the accent on varieties recommended for production of Czech beer).
- Methods:
 - Samples collected from growers (223 samples)
 - Monitoring the malting barley quality (barley analysis)
 - Elaboration of „Malting barley quality“ report
 - Micro-malting tests (malt analysis)
 - Elaboration of „Recommended malting technology for barley from the current harvest“



Dissemination of results

- Research results are disseminated and utilized at three levels:
- Industry (breeders, growers, malthouses, breweries)
 - RIBM elaborates current and annual research reports for participants
 - RIBM organizes special workshops during harvest
- Government authorities
 - Results of evaluation of malting barley varieties are the basis for the registration of varieties by Central Institute for Supervising and Testing in Agriculture
 - Results of the harvest of malting barley are used by the Ministry of Agriculture (Department of plant commodities)
- Professional community
 - Research articles published in Journals (Kvasný průmysl, Farmář, Úroda) and Barley yearbook
 - Presentations at professional conferences and congresses



Hop research in the Czech Republic



- Hop Research Institute, Ltd. (Žatec) carries out research on :
 - hop genetics and breeding, hop chemistry, hop biotechnology, hop protection, hop cultivation



- Research institute of brewing and malting, Plc. (Praha) carries out research on:
 - brewing quality of hop varieties, the quality of the hop harvest, hop chemistry
- Both institutes cooperate on the basis of long-term cooperation agreements
- Institutes solve collaborative projects



Evaluation of brewing quality of the new Czech hop varieties methods

- Chemical composition of hops is varietal dependend. Its impact on the sensory properties of beer should be verified by brewing experiments.
- RIBM tested all the new Czech varieties (parallel with the Hop Research Institute in Žatec)
- **Stage A** : Brewing trials with promising new breeding (40 L).
 - ➡ Influencing the of breeding goals from the beginning.
- **Stage B** : Three years trials brewing with recently registered varieties (200 L)
 - ➡ Recommendation the variety for PGI "Czech beer"
 - ➡ Recommendation the variety for beer production in CR.
- Detailed chemical analysis of fresh and stored beer: foaming, polyphenols, prenylflavonoids, antioxidant activity (AOX), essential oils in beer (since 2011)
- Detailed sensory analysis of fresh and stored beers: profile, overall impact, bitterness character and lingering . Panel of certified evaluators (FlavorActiv)

Evaluation of brewing quality of the new Czech hop varieties methods

- All malt pale lager brews are made according to PGI Czech beer
 - Double decoction mashing procedure
 - Atmospheric 90 min. wort boiling. Hopping divided in three doses (30 - 50 - 20%)
 - Two-stage fermentation and maturation (CCT + lager tank)
 - Filtration, bottling, pasteurization

Stage A (40 L brewhouse)



Stage B (200 L brewhouse)



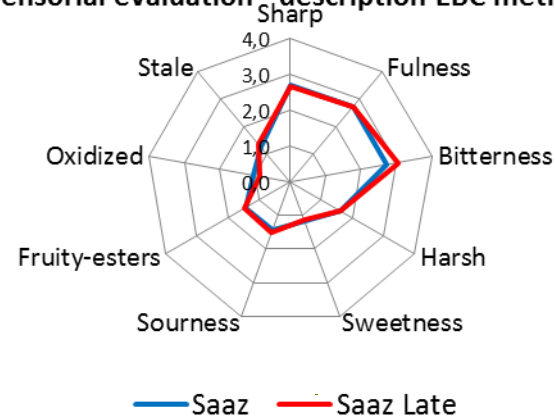
Evaluation of brewing quality of the new Czech hop varieties Results (example)

Average results of the chemical beer analysis

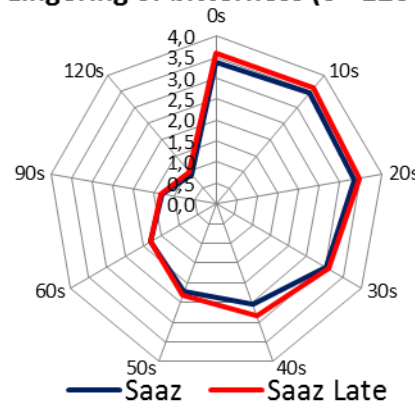
Parameter/variety	Saaz	Saaz Late
Original extract (%)	12,4	12,3
Attenuation apparent (% rel.)	76,4	75,2
Attenuation real (% rel.)	62,7	61,8
Color (EBC)	9,8	9,8
pH	4,48	4,47
Head retention NIBEM	300	301
ARA2-DPPH (% rel.)	75,1	59,7
Bitterness (IBU)	31,1	31,6
iso-alpha-acids (mg/l)	31,9	33
cis-iso-alpha-acids (mg/l)	22,5	23,1
trans-iso-alpha-acids (mg/l)	9,3	9,8
cis/trans Ratio	2,44	2,37
Hop oils in beer (µg/l)		
α-pinene	0,12	0,15
β-pinene	0,04	0,05
myrcene	0,49	0,56
limonene	0,31	0,75
linalool	6,45	10,18
β-karyophyllene	2,78	1,32
4-terpineol	2,03	0,9
β-farnesene	34,24	21,48
α-humulene	47,77	15,6
α-terpinol	65,22	23,66
cis-geraniol	1,2	1,24
α-ionon	0,48	0,51
β-ionone	0,35	0,13
α-irone	0,37	0,23
β-karyophyllene epoxid	2,2	1,2
farnesol1	27,39	31,62
farnesol2	36,02	30,93

- Mikyška, A., Slabý, M., Jurková, M., Krofta, K., Patzak, J., Nesvadba, V.: Saaz Late - The Czech Hop Variety Recommended for Czech Beer. Kvasny Prum. 59(10-11): 296-305, 2013

Sensorial evaluation - description EBC method



Lingering of bitterness (0 - 120 s)



51. Seminar o hmeljarstvu



Evaluation of the hop harvest in the Czech Republic methods

- The assessment of alpha acid contents in Czech hops is carried out in three phases:
 - ✓ Pre-harvest prognoses for Saaz aroma hops carry out the Hop Research Institute Žatec.
 - ✓ Harvest prognoses for Saaz and hybrid varieties are done by the Research Institute of Brewing and Malting Praha. Hop Research Institute perform harvest prognoses for hybrid varieties too, in different file of samples.
 - ✓ The assessment of final and true contents carry out together Hop Research Institute and Chmelařství, cooperative Žatec after hops purchasing process is finished in November.
- Pre-harvest prognoses and final and true alpha acid contents are carried out as lead conductance value.
- All harvest prognoses are carried out from results obtained by HPLC analytical method (EBC 7.7)



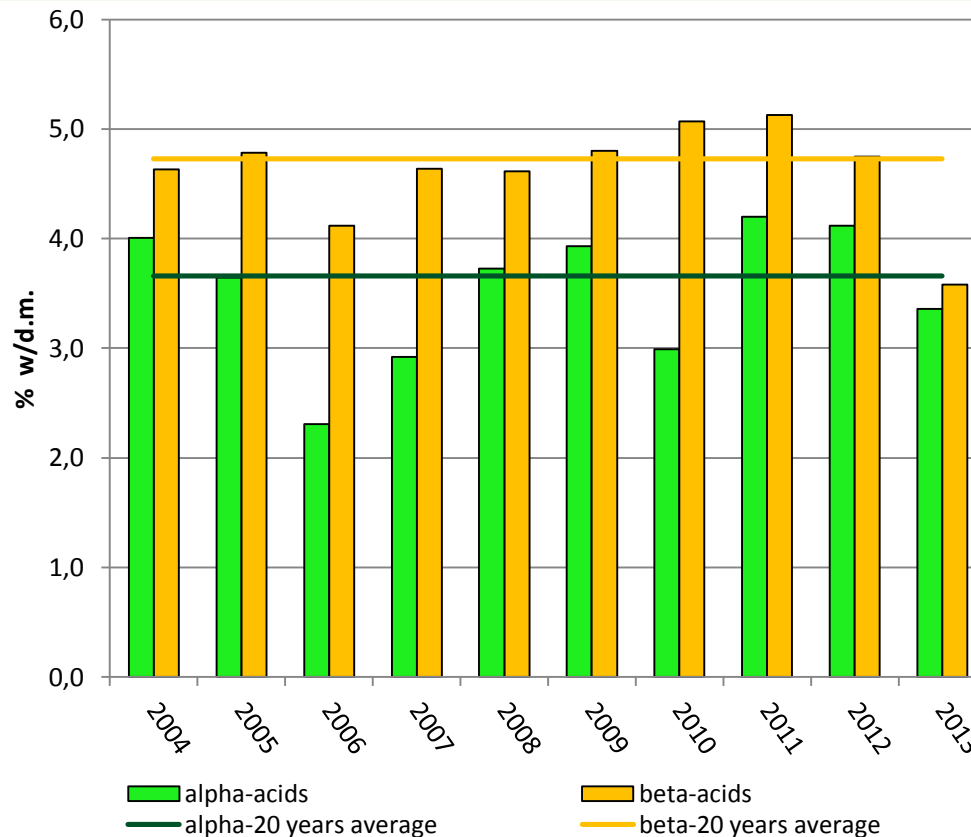
Evaluation of the hop harvest in the Czech Republic in RIBM (since 1956)

- Selected hop samples originating in all three hop growing regions (Žatec, Ústěck and Tršice region) are collected in the course of hop harvest.
- Appr. 115 samples of Saaz hops, 30 samples of Premiant and Sládek and 10 samples of Agnus hops are analyzed every year
- Since 1993 samples are analyzed by HPLC method according to EBC 7.7.
- Results of alpha and beta acid contents are processed for each growing region and the whole CR.
- Results are available till the end of October.



Evaluation of the hop harvest in the Czech Republic Saaz 2013 (87,2 % of acreage)

- The average value of alpha acids was 18.9% rel. lower compared with the year 2012 and 8.7% rel. lower compared with the average for 20 years.

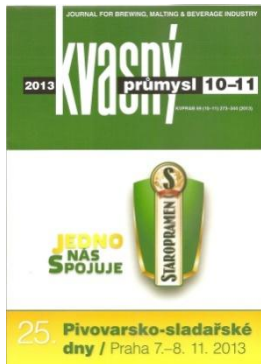
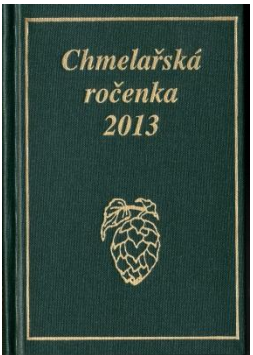
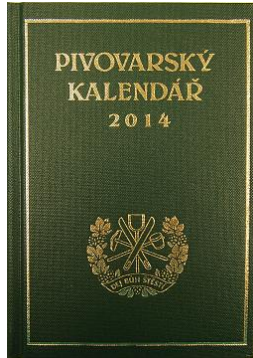


Mikyška, A., Jurková M.: Evaluation of alpha and beta acids content in Czech hops from the 2013 harvest. The Hop Yearbook 2014, RIBM 2014, pp. 203-208



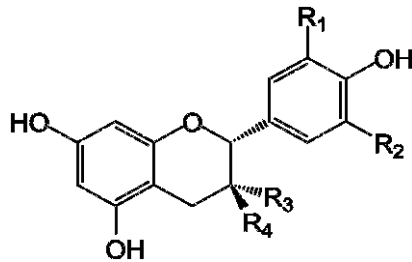
Dissemination of results

- Research results are disseminated and utilized at three levels:
- Industry (breeders, growers, breweries)
 - RIBM elaborates current and annual research reports for participants
 - RIBM take part at workshops organized by Hop Research Institute Žatec
- Government authorities
 - Results of the hop harvest and varietal tests are used by the Ministry of Agriculture (Department of plant commodities – annual publications „Czech Hops“ and „Situation and outlook report beer and hops“)
- Professional community
 - Research articles published in Journals (Kvasný průmysl, Chmelařství) and yearbooks (Brewery calendar. Hop yearbook)
 - RIBM organizes conference "Brewing and Malting Days"
 - Presentations at professional conferences and congresses



Hops are not only alpha acids : Proanthocyanidins

- Proanthocyanidins (flavan-3-ol oligomers) are antioxidants, are probably capable of fighting a broad spectrum of bacteria
- Hop proanthocyanidins were analysed by the use of UHPLC-TOF MS method elaborated in 2011



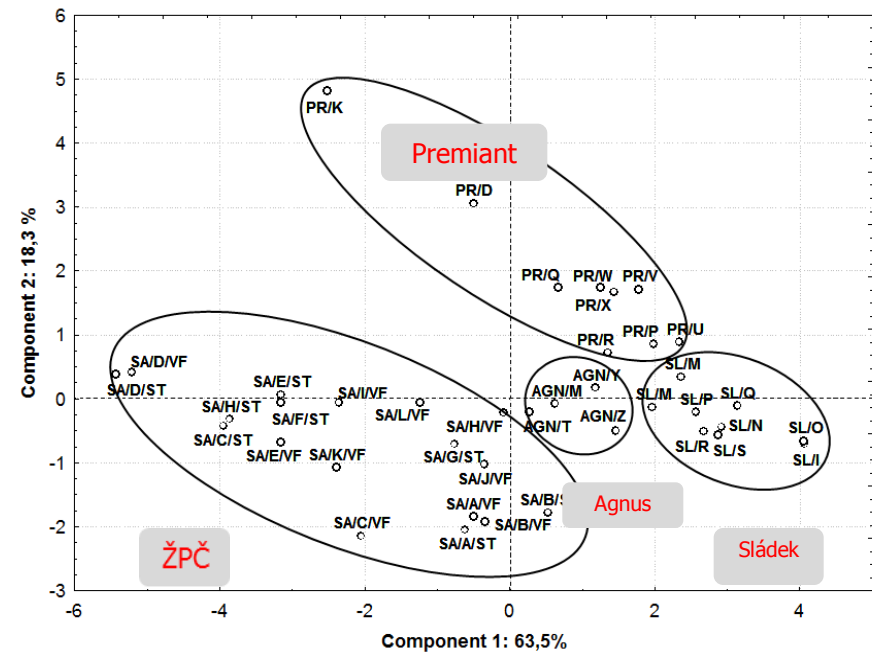
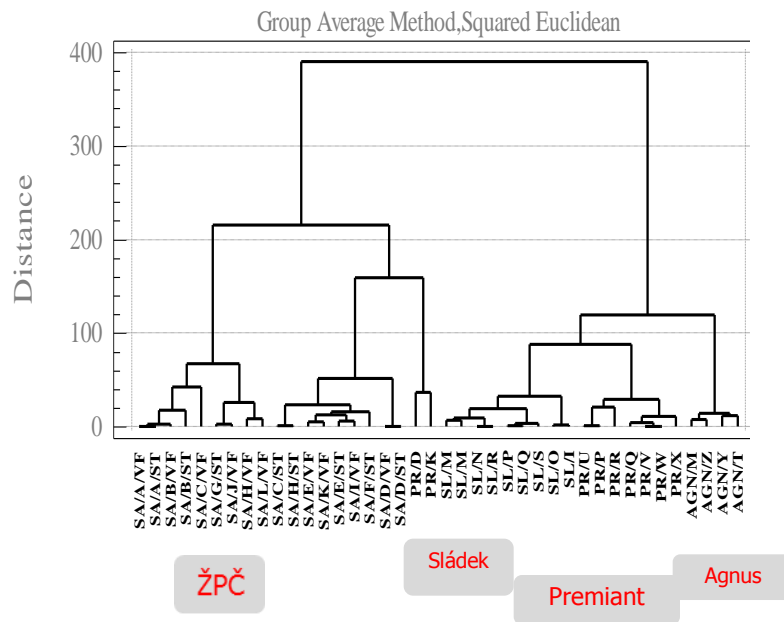
Flavan-3-ol monomers	R1	R2	R3	R4
Catechin	OH	H	H	OH
Epicatechin	OH	H	OH	H
Gallocatechin	OH	H	H	OH
Epigallocatechin	OH	OH	OH	H
Afzelechin	H	OH	H	OH
Epiafzelechin	H	H	OH	H

Number of units	Type of units	Relative amount of proanthocyanidins (%)							
		2011				2012			
		Saaz	Sladek	Premiant	Agnus	Saaz	Sladek	Premiant	Agnus
1	C	19.4	18.1	16.5	6.8	18.2	15.4	17.1	7.9
1	E	2.8	2.9	3.2	11.4	3.3	3.4	3.5	9.0
1	(E)G	0.5	1.3	1.7	0.8	0.6	1.0	1.5	1.0
2	(E)C-(E)C	36.5	33.4	32.9	33.5	38.2	36.2	35.7	35.7
2	(E)C-(E)G	4.1	7.1	7.9	7.8	5.3	6.9	8.6	8.0
2	(E)A-(E)C	< 0.5	< 0.5	< 0.5	< 0.5	0.5	< 0.5	< 0.5	< 0.5
2	(E)G-(E)G	3.6	6.3	6.0	9.9	4.6	6.7	6.1	9.5
3	(E)C-(E)C-(E)C	26.6	21.8	21.9	21.2	23.0	22.9	19.6	20.8
3	(E)C-(E)C-(E)G	2.0	3.8	4.8	3.2	2.0	3.0	4.5	3.1
3	(E)C-(E)G-(E)G	< 0.5	0.7	1.0	0.5	< 0.5	< 0.5	< 0.5	< 0.5
4	(E)C-(E)C-(E)C-(E)C	4.0	4.2	4.0	4.6	4.2	4.3	3.3	4.7
5	(E)C-(E)C-(E)C-(E)C-(E)C	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5



Proanthocyanidins

- The amount and composition of proanthocyanidins depends on the variety (and location).
- Saaz contains more oligomers formed only by catechin and epicatechin units
- Premiant and Agnus contain relatively more oligomers formed by gallocatechin and epigallocatechin units.



Olšovská J., Kameník Z., Čejka P., Jurková M., Mikyška A.: Ultra-high-performance liquid chromatography profiling method for chemical screening of proanthocyanidins in Czech hops. *Talanta* 116(2013) pp 919–926

Hops are not only alpha acids : beta acids

- Research project „The importance of hop beta-acids for Czech beer“ (Research Institute of Brewing and Malting + Hop Research Institute Žatec)
- Model brewing trials showed :
 - ✓ Bitter substances in beer, derived from hop beta acids (lupulons) are oxidation products called hulupons (hulupone, cohulupone, adhulupone).
 - ✓ Other oxidation products (epoxy hulupons, cyclic and peroxide compounds) are found in hops and wort but are not present or only to a negligible amount in beer.
 - ✓ Hulupons in beer have demonstrated intense pleasant bitterness with less aftertaste compared to iso-alpha acids.
 - ✓ Hulupons are formed during hop processing and storage. Oxidation of beta acids occurring during wort boiling have only limited impact.
- In 2013, method for the determination of beta acids analogs and their transformation products, hulupons and other substances in solid matrix (hops) and the liquid matrix (wort, beer) was elaborated. The technique UPLC HR-MS/MS was used.
- Research will continue in the future.



Hops are not only alpha acids : beta acids

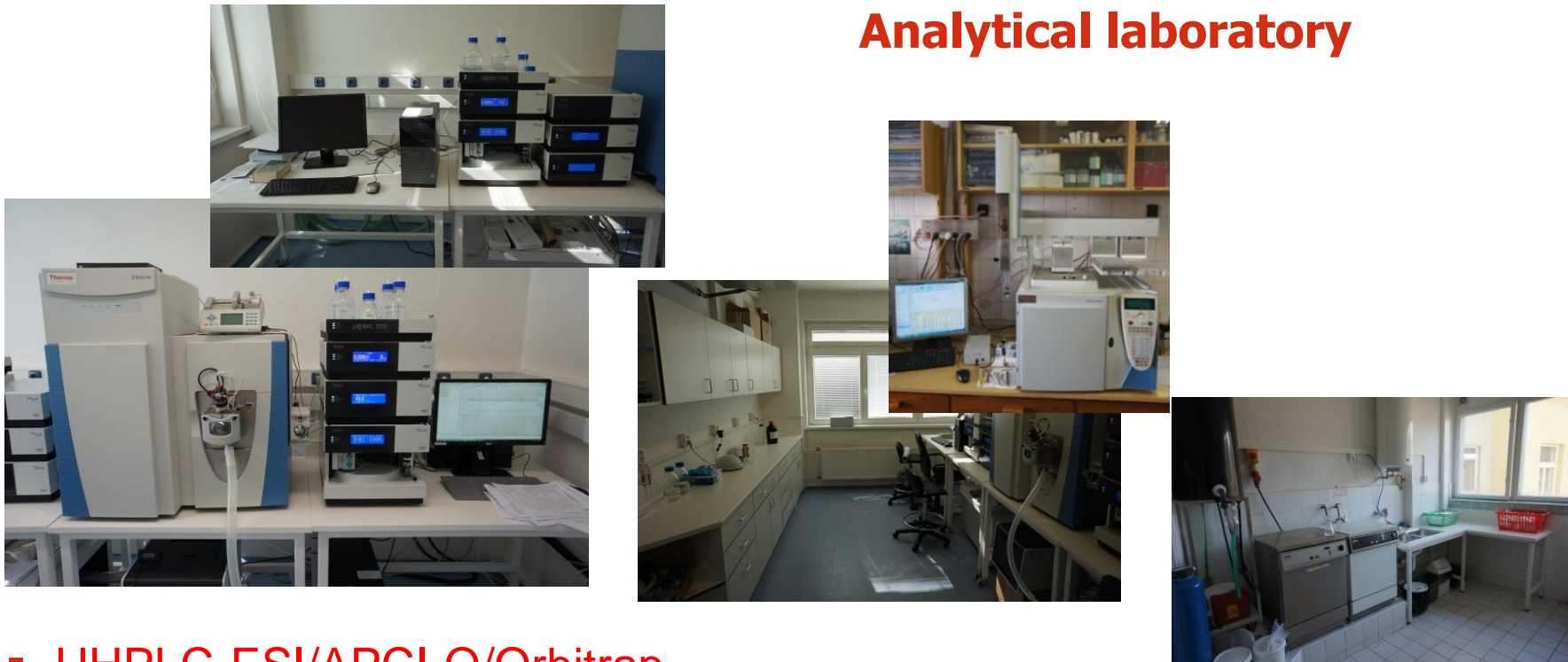
- Some results have been already published:
 - ✓ Krofta, K., Vrabcová, S., Mikyška, A., Jurková, M., Čajka, T., Hajšlová, T.: Stability of hop beta acids and their decomposition products during natural ageing. Proceedings of the Third International Humulus Symposium, Acta Horticulture No. 1010. Belgium, International Society for Horticultural Science , p. 221-230, 2013. ISBN 978-90-6605-696-1, ISSN 0567-7572.
 - ✓ Mikyška, A., Krofta, K.: Assessment of changes in hop resins and polyphenols during long-term storage. J. Inst.Brew. 118 (3): 2012, 269-279.
 - ✓ Krofta, K., Vrabcová, S., Mikyška, A. Jurková, M.: The effect of hop beta acids oxidation products on beer bitterness. Kvasny prum. 59 (10/11), 2013, 296-305
 - ✓ Dušek, M., Mikyška, A., Olšovská, J.: New application of LC-HR-MS analysis of beer and raw materials for its production. Proceedings of the 3rd Conference of the Czech Society for Mass Spectrometry. Olomouc, Czech Society for Mass Spectrometry, p 26, 2013. ISBN 978-80-905045-3-0



Outlook for the future: Improving the research and beer of brewing raw materials

New Sensory Centre (opened 2013)

Analytical laboratory



- UHPLC-ESI/APCI-Q/Orbitrap
- UHPLC-UV/FL
- combined GC sampler

The synergistic effect of linking the pilot brewery, new analytical and sensory laboratories

New equipment allows the creation a better link between analytical and sensory characteristics of beer in terms of qualitative features of brewing raw materials

ANALYTICAL LABORATORY



PILOT BREWERY



SENSORY LABORATORY



Thank you for your attention

Results were obtained within the projects

RO 10-13 of the Ministry of Agriculture of the Czech Republic and
QI91B227 of the National Agency for Agricultural Research.

