

Beer Quality Assessment by Hybrid Spectroscopic-Electrochemical Technique

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Quality control



Sensory panel

- subjective
- time-consuming
- very expensive

Chemical analysis

- time-consuming
- expensive
- require skilled operators



Chemical composition of beer

In total more than 800 compounds

- *Carbohydrates* 3-4% dextrins, monosaccharides, oligosachcarides
- *Alcohols* 0.05-12.5% ethanol, glycerol, 3-methylbutanol
- *Inorganic compounds* 0.5-2g/l
- *Proteins, peptides, aminoacids* 0.2-0.6 g/100 ml
- *Amines, nucleic acids derivatives, vitamins, phenolic acids*
- *Hop and bitter acids* 10-100 mg/l
- *Sulphur compounds*

Each one contributes to the taste of beer

Scope of the study

Both optical spectroscopy and potentiometric ET have shown their use for lots of analytical application.

Hybrid technique of orthogonal analytical methods could yield an alternative for express beer quality estimation both for chemistry and taste.



Measuring techniques

Detection limits

<i>Instrument</i>	<i>DL</i>	<i>Sensitive to</i>
ET	$10^{-5} - 10^{-9}$ mol/L	Organic/inorganic cations/anions
ATR-IR	0.1%	Substances with a polar functional groups
NIR	0.5%	Substances with a polar functional groups
VIS	0.01-0.1%	Chromophores
UV	10^{-4} mol/L	Wide range of substances
Fluorescence	10^{-6} mol/L	Fluorophores

Experimental Samples

20 different brands from Germany, Russia, Czech Republic
purchased in local stores

1 stage

11 different types like pilsner, dark, alcohol-free, strong, yeast-containing,
filtered white beer, etc

2 stage

14 different pilsners and blonds

3 stage

Comparison of the same brands (2)
produced in Germany and in Russia



Experimental *Reference data*

Independent analysis by certified laboratories in Germany. 16 samples

Standard characterisation of the beer quality attributes in accordance with German regulations: extractivity, alcohol content, colour, pH, foam resistance, turbidity, concentrations of bitter-forming components and other



Assessment by a trained commercial sensory panel – estimation of taste and flavour and overall quality in accordance with a standard procedure.

13 samples

Experimental *ET* measurements

- Sensor array
 - 21 potentiometric chemical sensors of different types
 - multichannel custom-made digital mV-meter
- Sample preparation
 - Filtering from CO₂ at kieselguhr filter
 - dilution
 - 5-7 replicated measurements



Experimental

Spectroscopic measurements

All the samples were analyzed with a number of different spectroscopic techniques.

Attenuated total reflectance infrared spectroscopy (ATR-IR)

Near infrared (NIR),

Visible (Vis),

Ultraviolet (UV)

1D-fluorescence at two different excitation wavelengths

2D-fluorescence (full excitation-emission spectra)

UV-fluorescence

Sample preparation

- Ultrasonication for 10 min to remove CO₂
- Minimum 3 replicate measurements



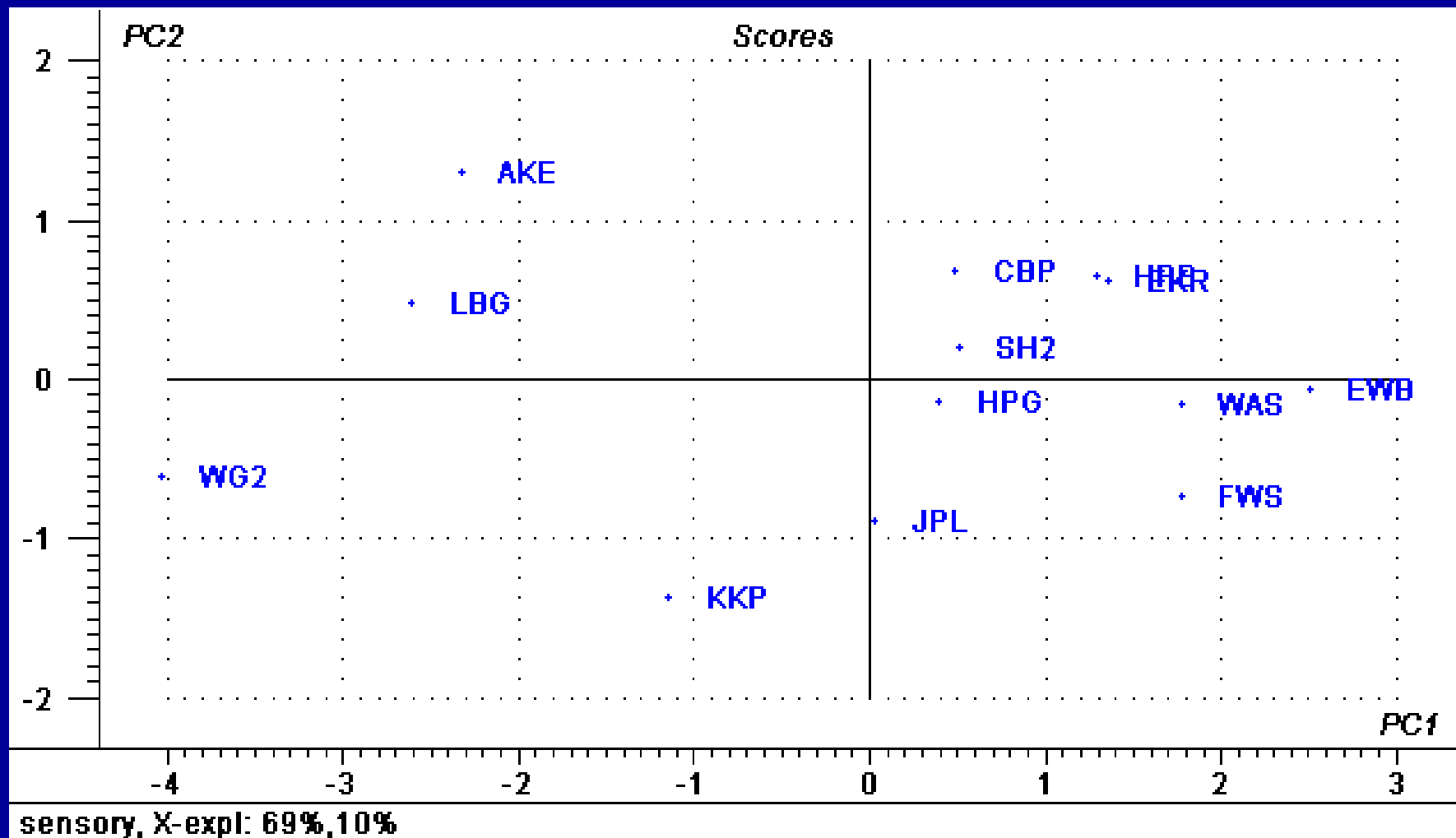
Results

Example of sensory panel report

<i>Prüfmerkmale</i>	<i>Beschreibung</i>	<i>Punkte</i>	<i>BW</i>
Optik			
Farbe	kräftiges gelb	5	1
Klarheit	glanzfein	5	1
Schaumbildung	sehr gut, kräf. Schaumbildung	5	1
Schaumhaltbarkeit	mäßig, etwas grobporig	3	2
Schaumhaftvermögen	gut	4	1
Flavour			
Reinheit des Geruchs	leichter Fehlgeruch	3	2
Geruch hefeearomatisch	überdeckt (Oxidation)	3	1
Reinheit des Geschmacks	leichter Geschmacksfehler	3	2
Rezenz	rezent	4	1
Vollmundigkeit	vollmundig, abgerundet	5	2
Intensität der Bittere	typengerecht	5	1
Qualität der Bittere	etwas breit	3	2
Nachtrunk	rund, harmonisch ausklingend	5	1
Gesamteindruck			
Gesamteindruck	leichte Fehler	3	2
Punktesumme	76		

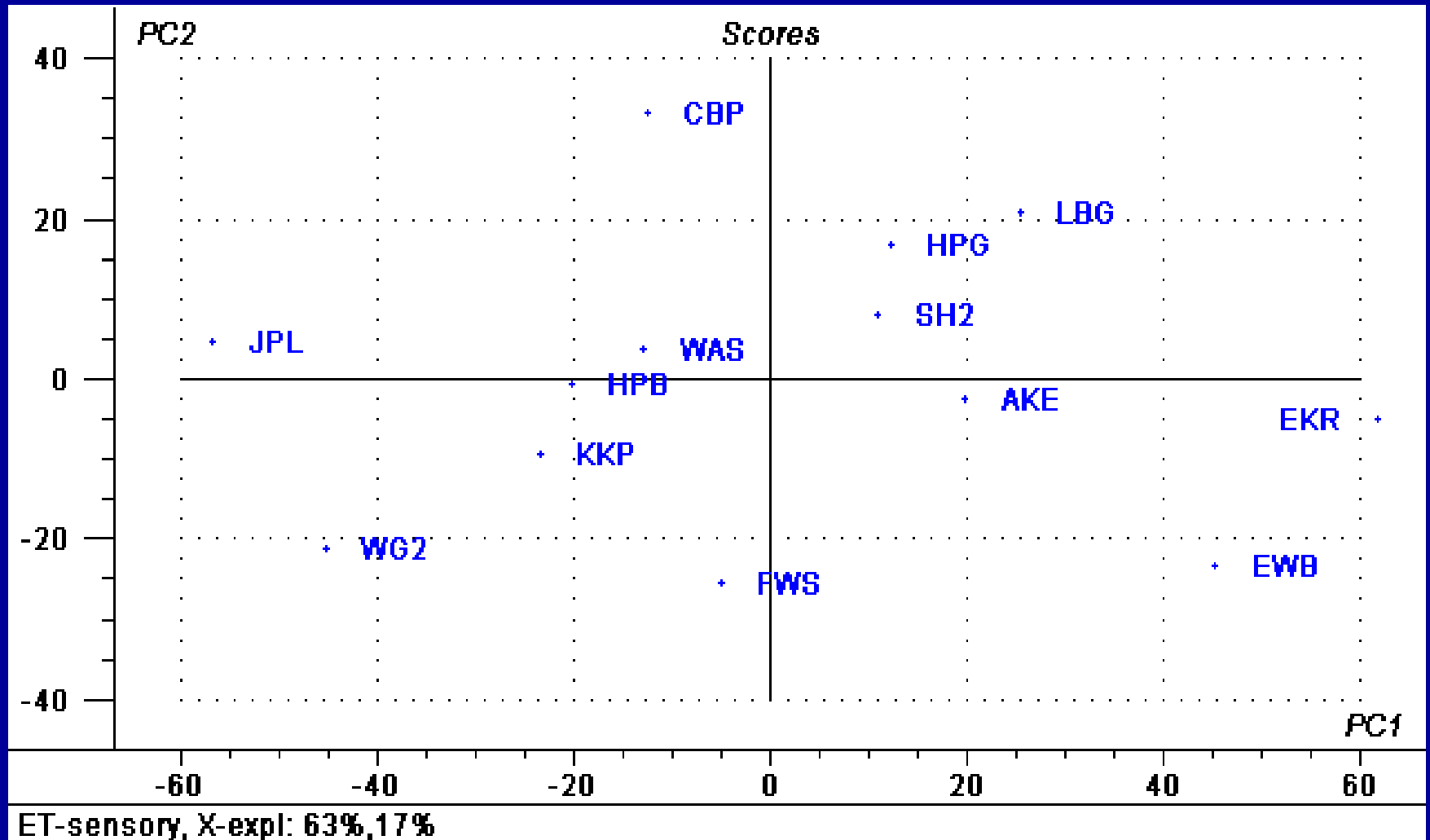
Results

Recognition with sensory panel



Results

Recognition with ET



Results

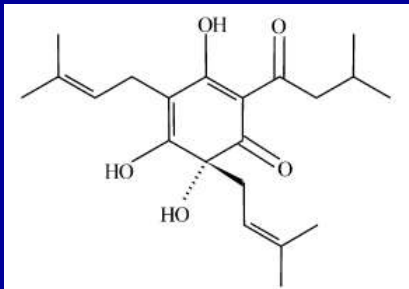
Estimation of bitterness by ET

	Slope	Offset	RMSE	R ²
Calibration	0.98	1.810	1.37	0.98
Validation	0.80	3.658	2.41	0.89

Sample pretreatment and measurement time 15 minutes

Standard technique: isooctane extract – absorbance measurements at 275 nm

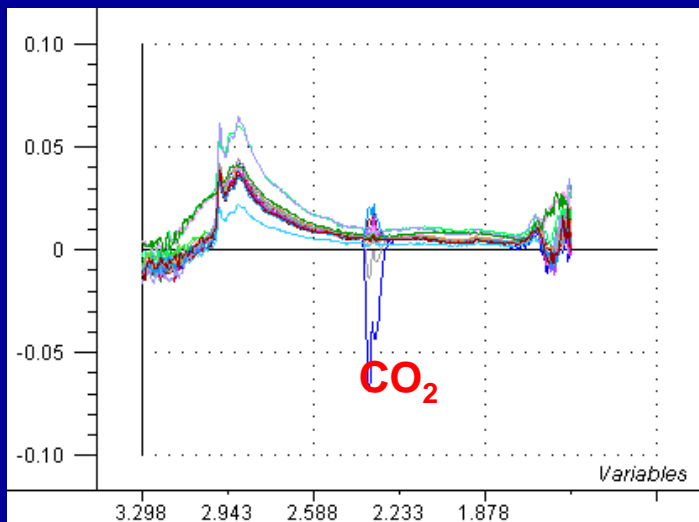
Sample pretreatment and measurement time 3 hours



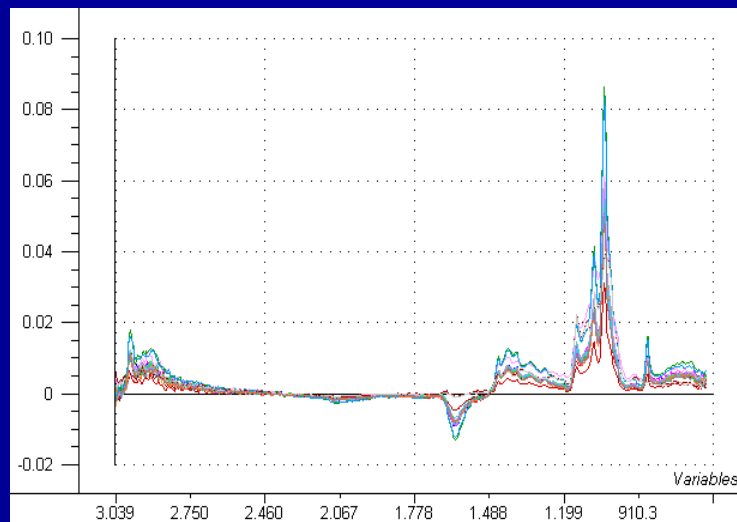
Iso-alpha-acids from hops

Results

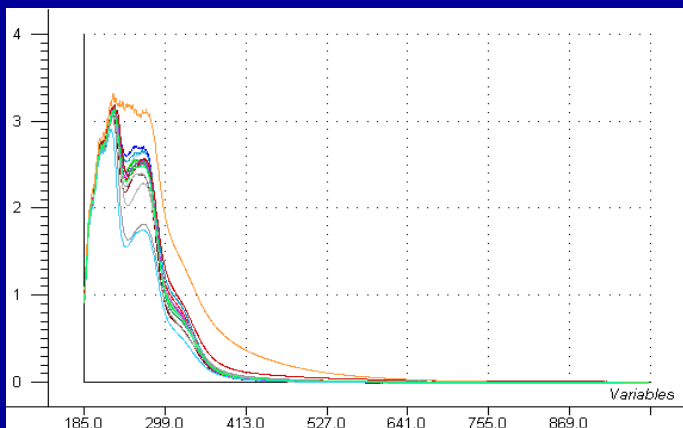
Optical spectra



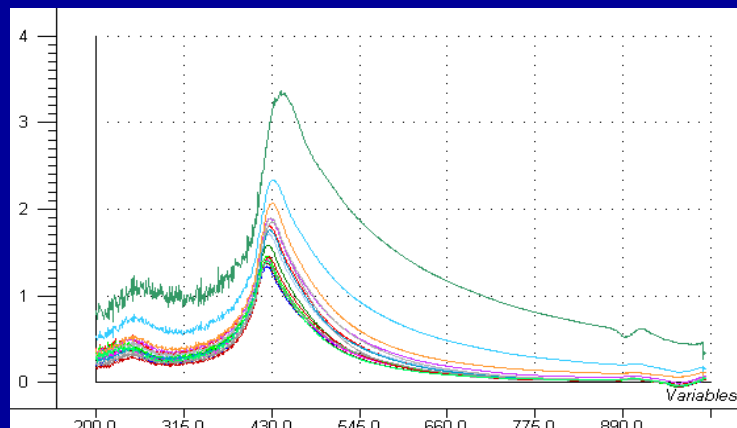
IR58 (CIR probe)



IR98 (PIR probe)



UV-Vis



Vis

Results

Estimation of different parameters by optical spectroscopy

	Wort extractivity	Alc., vol%	Extractivity act.	Fermentation degree	Turbidity	Foam stability	Color	Bitterness
IR58	99	99	99	94	-2	6	59	47
IR98	98	98	99	97	50	65	56	57
Vis	0	-26	15	-1	-25	65	97	31
UV-Vis	83	33	-43	0	-7	78	83	75
Fluorescence	54	27	46	-14	57	36	93	41

Correlation coeff. predicted vs. measured (validation)

Further activities

In-depth data analysis with taking into account beer chemistry

Correlations with sensory panel (approach to be chosen)

Data fusion ET + optical spectroscopy

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**Thank you for your
attention!**

