

# 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

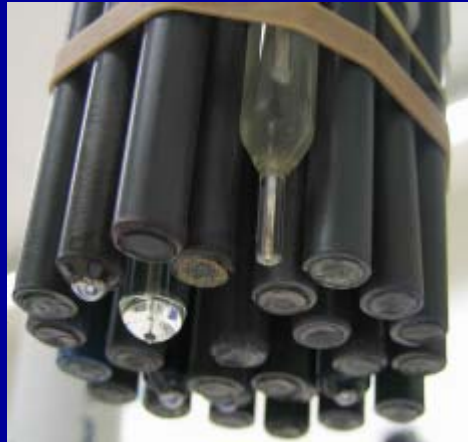


Assessment by a trained commercial sensory panel – estimation of taste and flavour and overall quality in accordance with a standard procedure.

13 samples

# Experimental *ET* measurements

- Sensor array
  - 21 potentiometric chemical sensors of different types
  - multichannel custom-made digital mV-meter
- Sample preparation
  - Filtering from CO<sub>2</sub> 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 CO<sub>2</sub>
- Minimum 3 replicate measurements



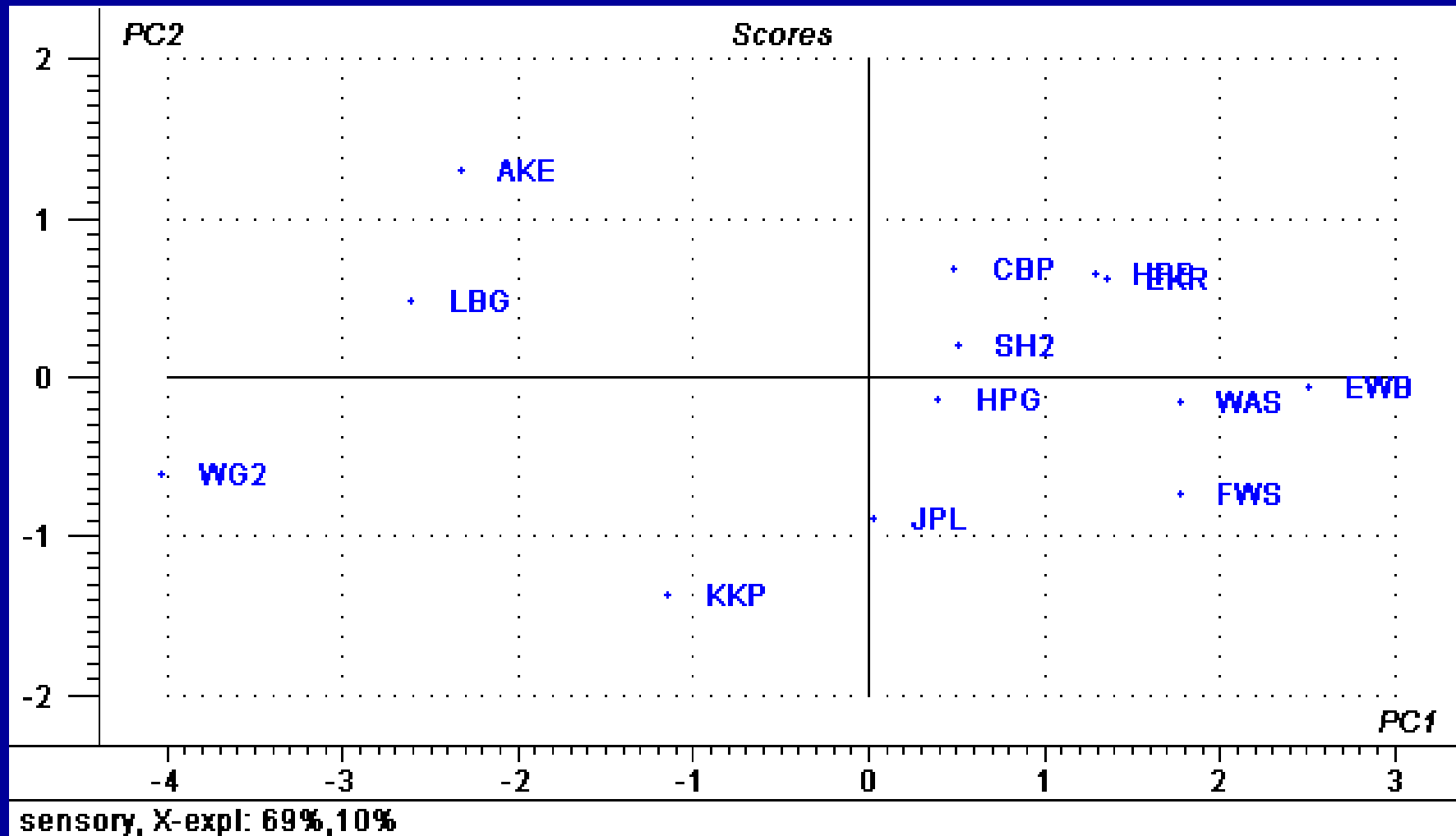
# Results

## Example of sensory panel report

<b>Prüfmerkmale</b>	<b>Beschreibung</b>	<b>Punkte</b>	<b>BW</b>
<b>Optik</b>			
Farbe	kräftiges gelb	5	1
Klarheit	glanzfein	5	1
Schaumbildung	sehr gut, kräf. Schaumbildung	5	1
Schaumhaltbarkeit	mäbig, etwas grobporig	3	2
Schaumhaftvermögen	gut	4	1
<b>Flavour</b>			
Reinheit des Geruchs	leichter Fehlgeruch	3	2
Geruch hefearomatisch	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
<b>Gesamteindruck</b>			
Gesamteindruck	leichte Fehler	3	2
Punktesumme	76		

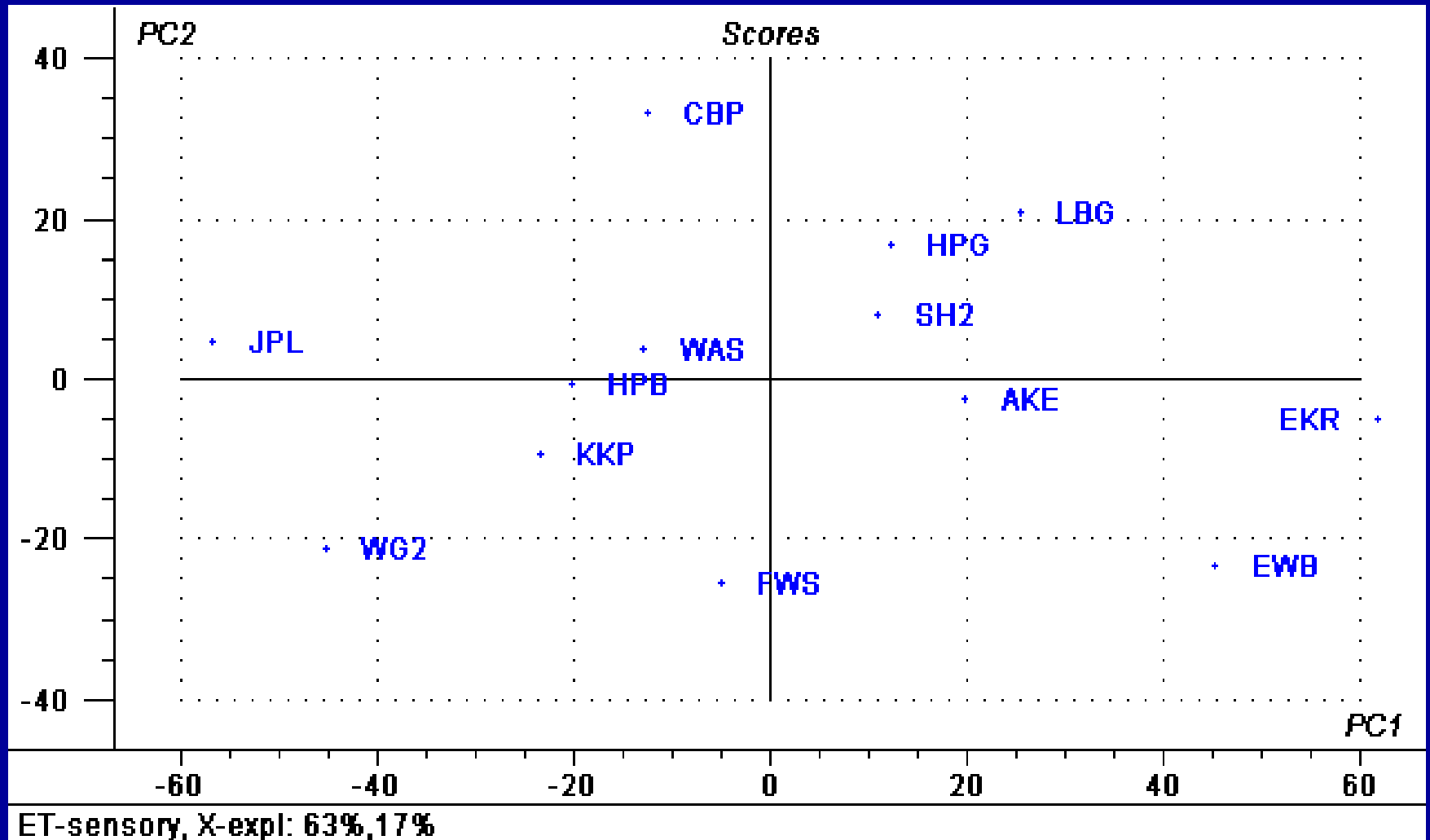
# Results

## Recognition with sensory panel



# Results

## *Recognition with ET*



# Results

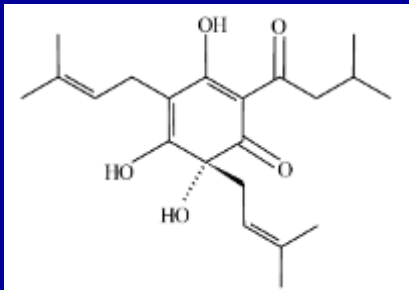
## *Estimation of bitterness by ET*

	Slope	Offset	RMSE	R <sup>2</sup>
<b>Calibration</b>	0.98	1.810	1.37	0.98
<b>Validation</b>	0.80	3.658	2.41	0.89

Sample pretreatment and measurement time 15 minutes

Standard technique: isooctane extract – absorbance measurements at 275 nm

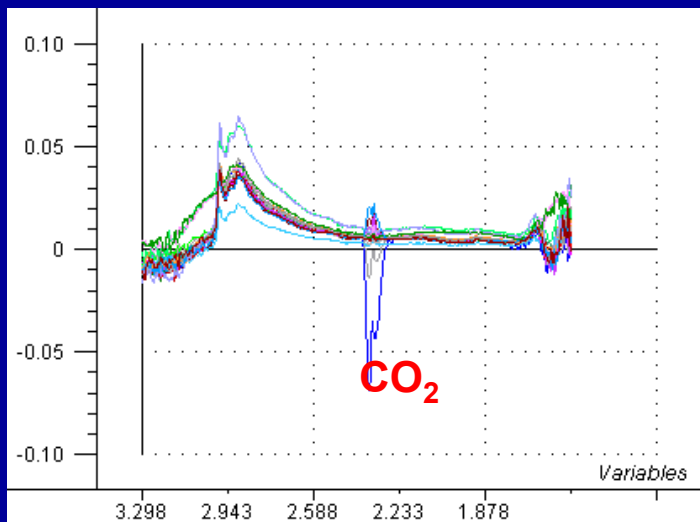
Sample pretreatment and measurement time 3 hours



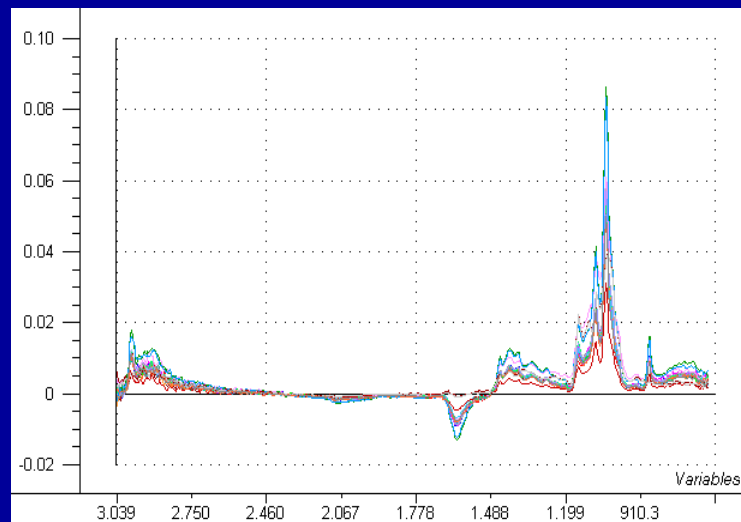
Iso-alpha-acids from hops

# Results

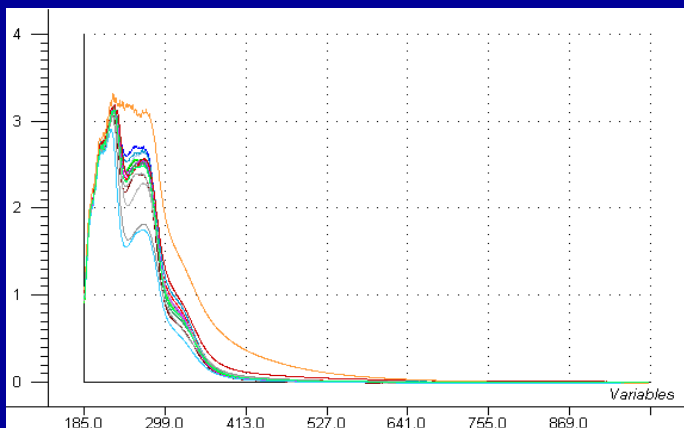
## Optical spectra



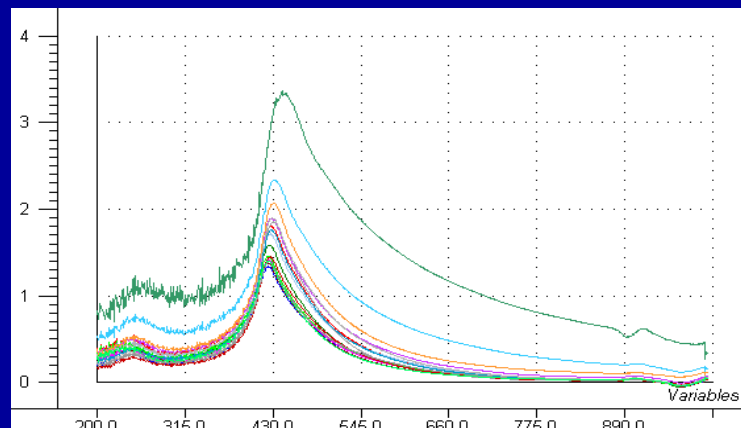
IR58 (CIR probe)



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**



# Acknowledgments

- **Bilateral project IB BMBF-FASIE N 6171p/8749**
- **A.R.T. Fotonics, Berlin, Germany**

**Thank you for your  
attention!**

