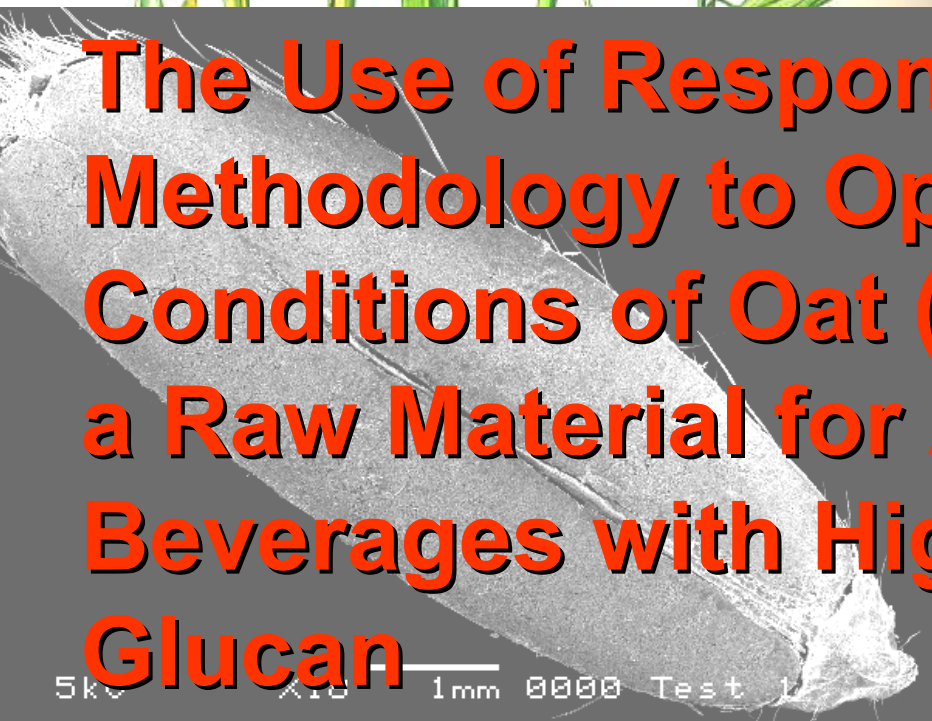


**INTERNATIONAL OAT
CONFERENCE**
June 28-July 2008
Minneapolis



Martin Zarnkow

**The Use of Response Surface
Methodology to Optimise Malting
Conditions of Oat (*Avena sativa* L.) as
a Raw Material for Alternate Fermented
Beverages with High Content of β -
Glucan**



Structure

- **Oat – traditional brewing cereal**
- **special aspects of oat as brewing cereal**
- **response surface methodology**
- **malting trials**
- **wort**

Oat (*Avena sativa*)

grow
between
40°–55°
north and
20°–40°
south

available!

**and
accepted by
the
consumer!**



Thomé, O. W.:
Flora von
Deutschland
Österreich und
der Schweiz;
Gera 1885

Oat – Traditional Brewing Cereal



- **middle ages use for brewing was popular (Switzerland, Germany and England)**
- **going down with purity law in German 1516**
- **diminished over the centuries**
- **only used for brewing cheaper beers**
- **during World War II return because of the rationing of barley (UK)**

Attributes for Brewing - Barley

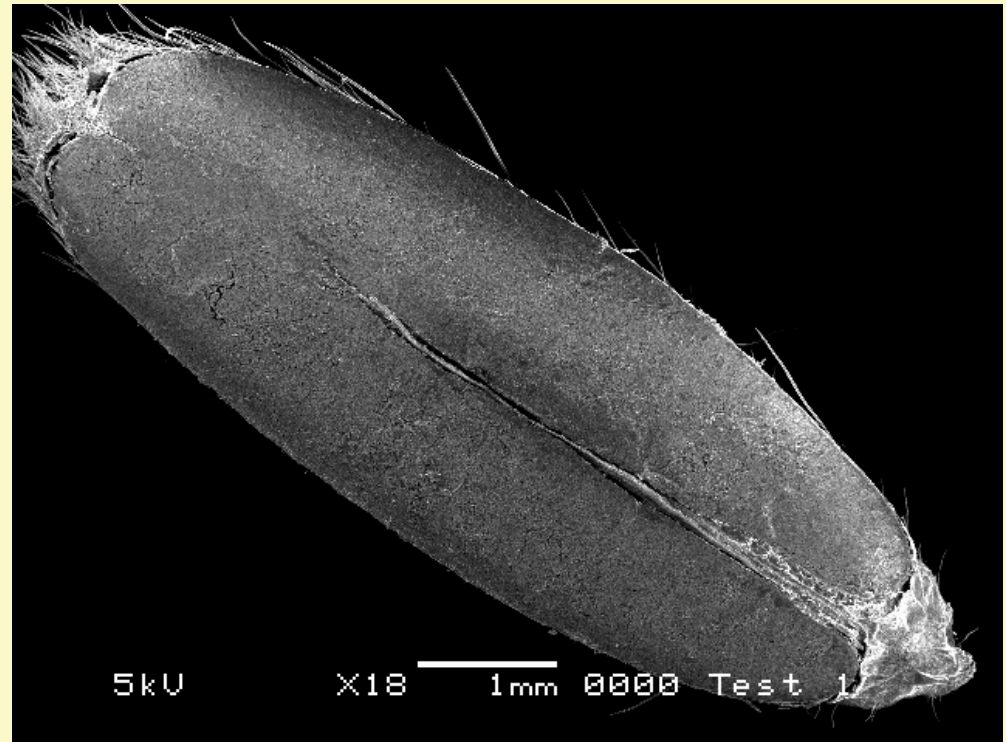
barley:

- high extract
- protein < 12 %
- fatty acids: - good as yeast nutrition
 - bad aging stability
- β -Gucan in 65-°C-mash < 350 mg/L

Attributes of Oat

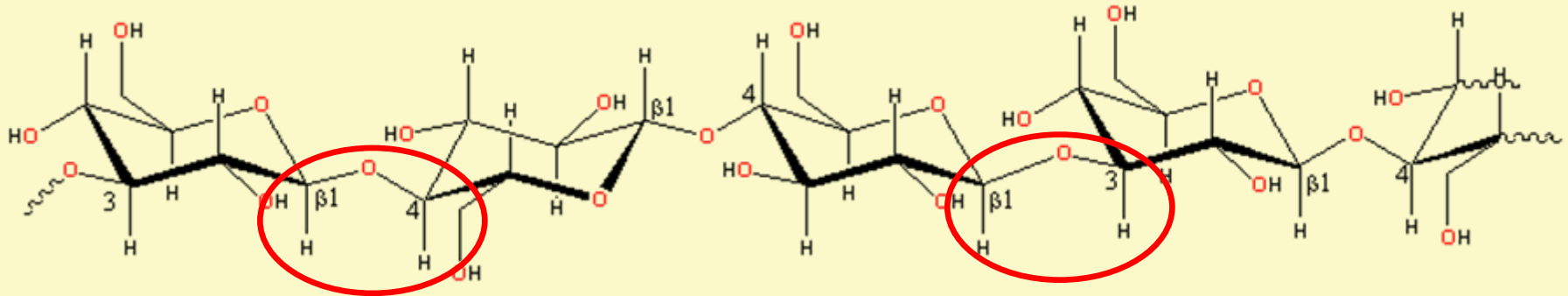
oat:

- **low in starch**
- **rich in protein**
- **rich in lipids**
- **rich in β -glucan!**



source: diploma thesis Alexander Mauch, UCC
TUM 2007

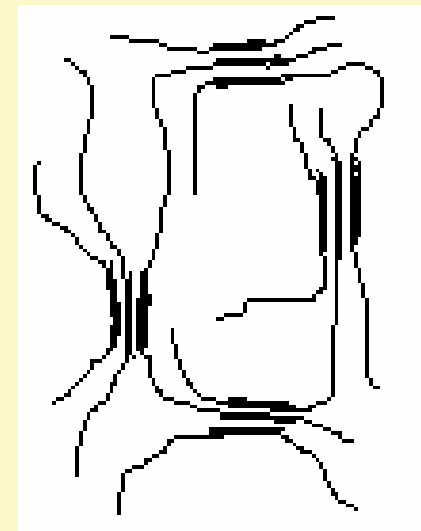
Oat – β -glucan



structure of β -glucan molecule

β -glucan-gel (better β -Glucan-Cluster)

- β -glucan concentration
- temperature
- time
- shearing force
- alcohol
- carbohydrates concentration



Gelbildung nach Rehage

Impact of β -Glucan in Wort and Beer

- **increase of viscosity**
 - lautering problems
 - foam stability?
 - body?
 - gushing?
- **ability for gel formation**
 - filtration problems
- **health claim**
 - cholesterol-lowering
 - moderating effect on
 - posprandial blood
 - glucose and insulin
 - ...

Chemical Composition

- **carbohydrates 72.2 %**
- **protein 13.0 (N × 6.25)**
- **fat 5.5 %**
- **minerals 1.4 %**
- **identified enzymes: close to common cereals**

Oat – Harvest 2007

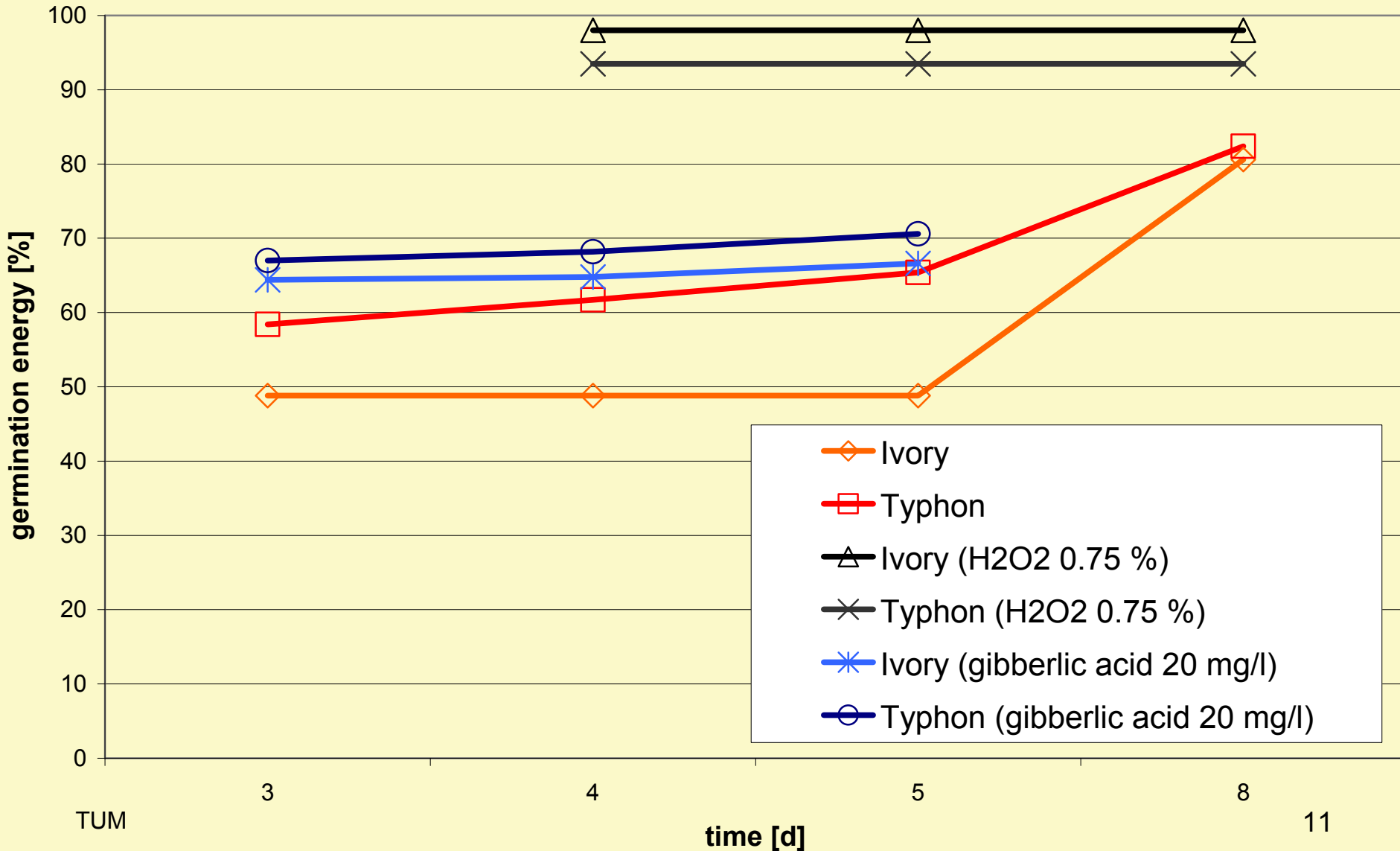
mould!



source: Reichenwallner, H., Zarnkow, M. ©

Oat – Harvest 2007

low germination capacity



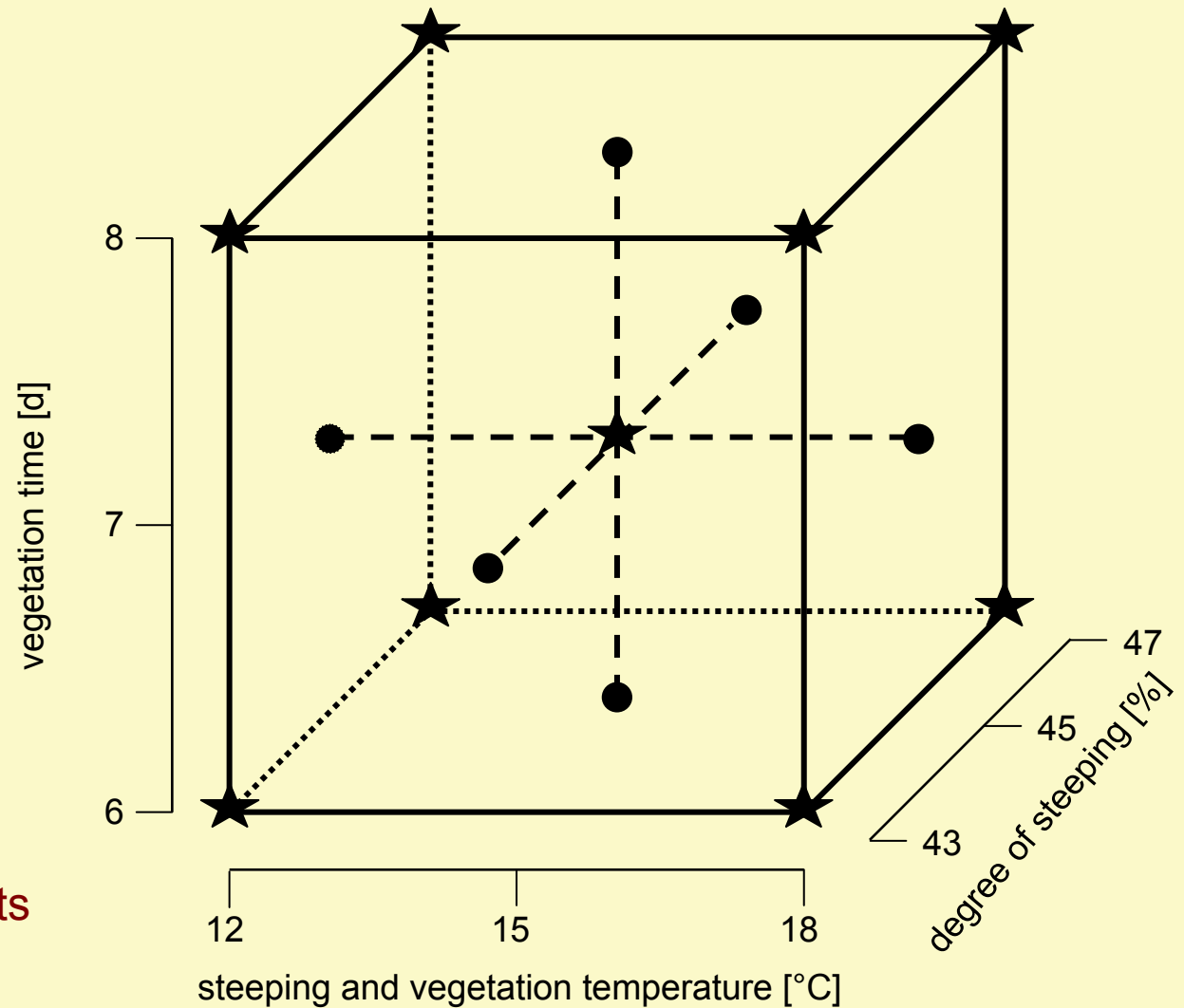
Oat – Raw Material

**varieties: Ivory and Typhon from
Granskevitz/Germany**

attribute	Ivory	Typhon
water content [%]	13.8	13.4
protein (N × 6.25) [%]	11.9	12.9
germination energy [%]	95.0	94.0

Response Surface Methodology

1000 g scale

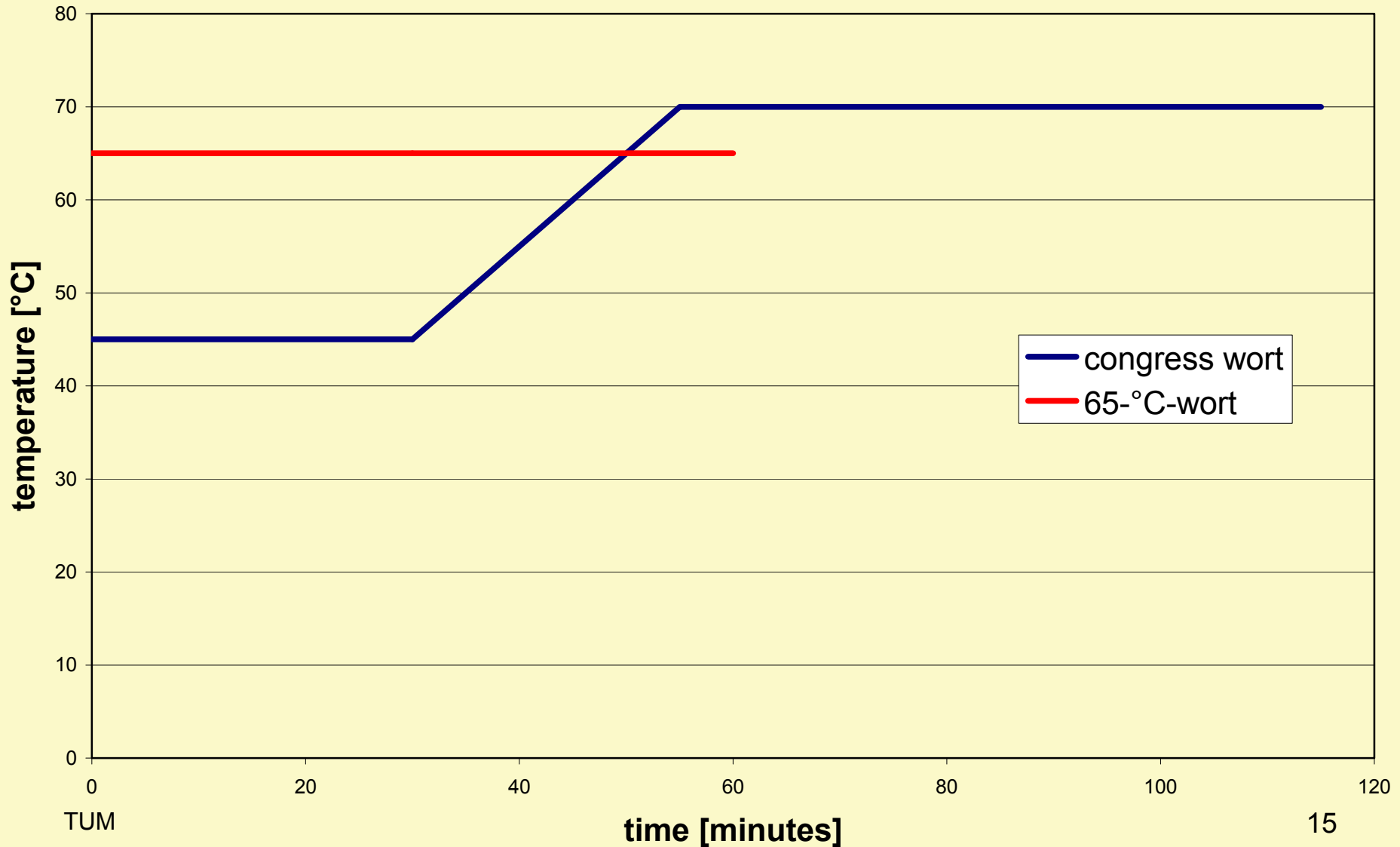


Face-centred design
(double replicates of the
factorial and centre points
= ★)

Response Surface Methodology

attributes	units	oat malt (Ivory)				oat malt (Typhon)			
		calculated		measured		calculated		measured	
		min	max	min	max	min	max	min	max
extract	%	71.8 (6/47/12)	75.0 (8/47/12)	72.5 (6/47/12)	75.0 (8/47/17)	70.5 (6/47/12)	72.7 (8/47/12)	70.9 (6/45/18)	72.4 (8/43/16)
AAL	%	49.8 (6/47/12)	83.8 (8/47/18)	54.2 (6/47/12)	83.7 (7/47/18)	47.3 (6/43/12)	77.1 (8/47/18)	49.8 (6/43/12)	77.1 (8/47/16)
β-glucan	mg/L	16 (8/47/18)	746 (6/43/12)	11 (8/47/17)	680 (6/47/12)	56 (6/47/18)	1214 (6/43/12)	51 (7/45/17)	1053 (6/43/12)
viscosity	mPa × s	1.467 (7/47/15)	1.589 (6/47/12)	1.471 (6/47/18)	1.577 (6/47/12)	1.484 (7/45/15)	1.670 (6/43/12)	1.484 (8/45/15)	1.627 (6/43/12)
Kolbachinde x	%	26.1 (6/43/12)	41.0 (8/47/18)	26.7 (6/45/12)	40.0 (8/47/18)	25.3 (6/47/12)	34.4 (8/47/18)	26.0 (6/47/12)	34.2 (8/47/17)
colour	EBC	6.9 (7/47/15)	28.8 (6/47/12)	6.1 (7/46/17)	23.0 (6/43/12)	7.1 (7/47/15)	13.7 (6/43/12)	6.9 (8/46/17)	13.4 (6/43/12)
FAN	mg/100 ml	97 (6/43/12)	154 (8/47/18)	103 (6/43/12)	154 (8/47/18)	90 (6/43/12)	219 (6/47/18)	90 (6/43/12)	153 (8/47/18)

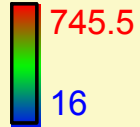
Congress Wort – 65-°C-Wort



β -Glucan in Congress Wort (Ivory)

Design-Expert® Software

beta Glucan (CW)

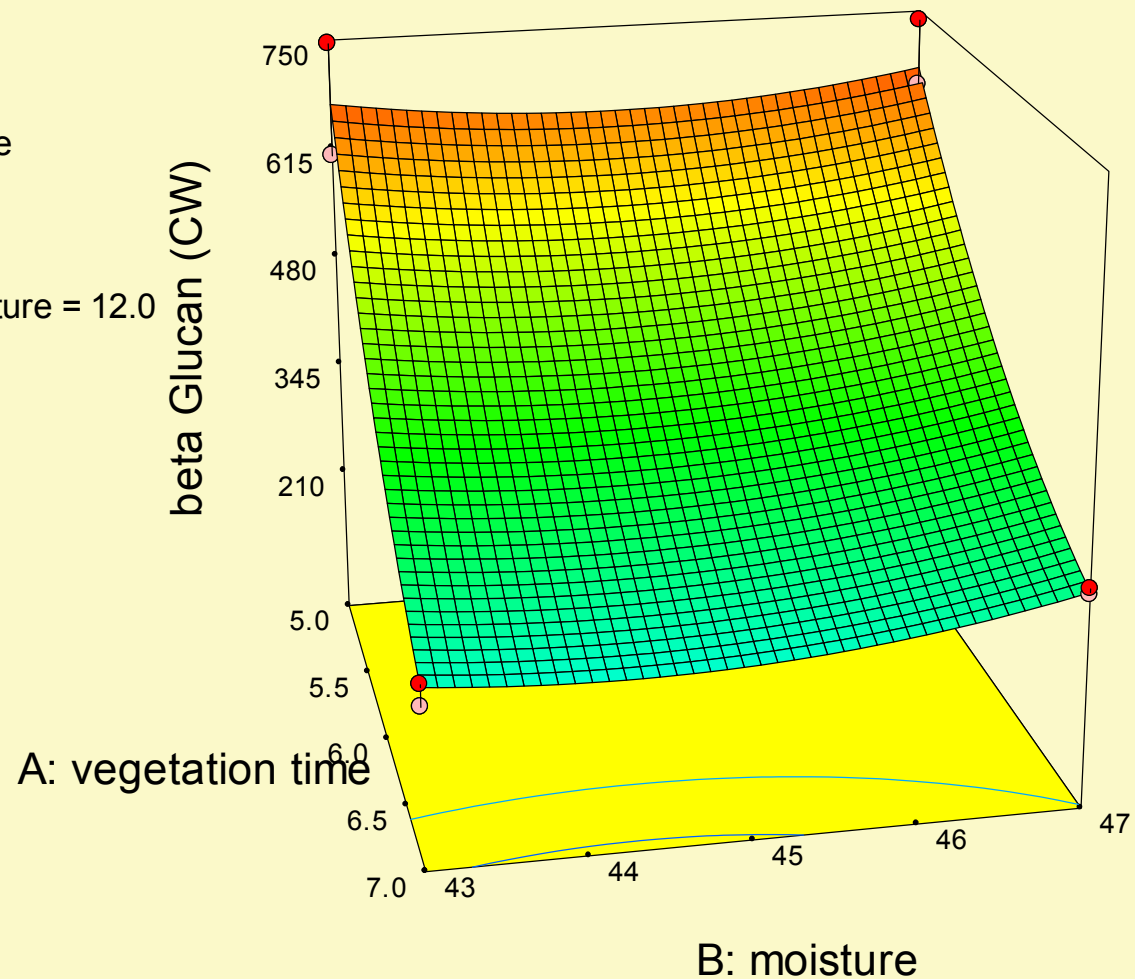


X1 = A: vegetation time

X2 = B: moisture

Actual Factor

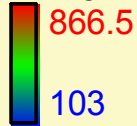
C: vegetation temperature = 12.0



β -Glucan in 65-°C-Wort (Ivory)

Design-Expert® Software

beta-glucan (65-°C-wort)

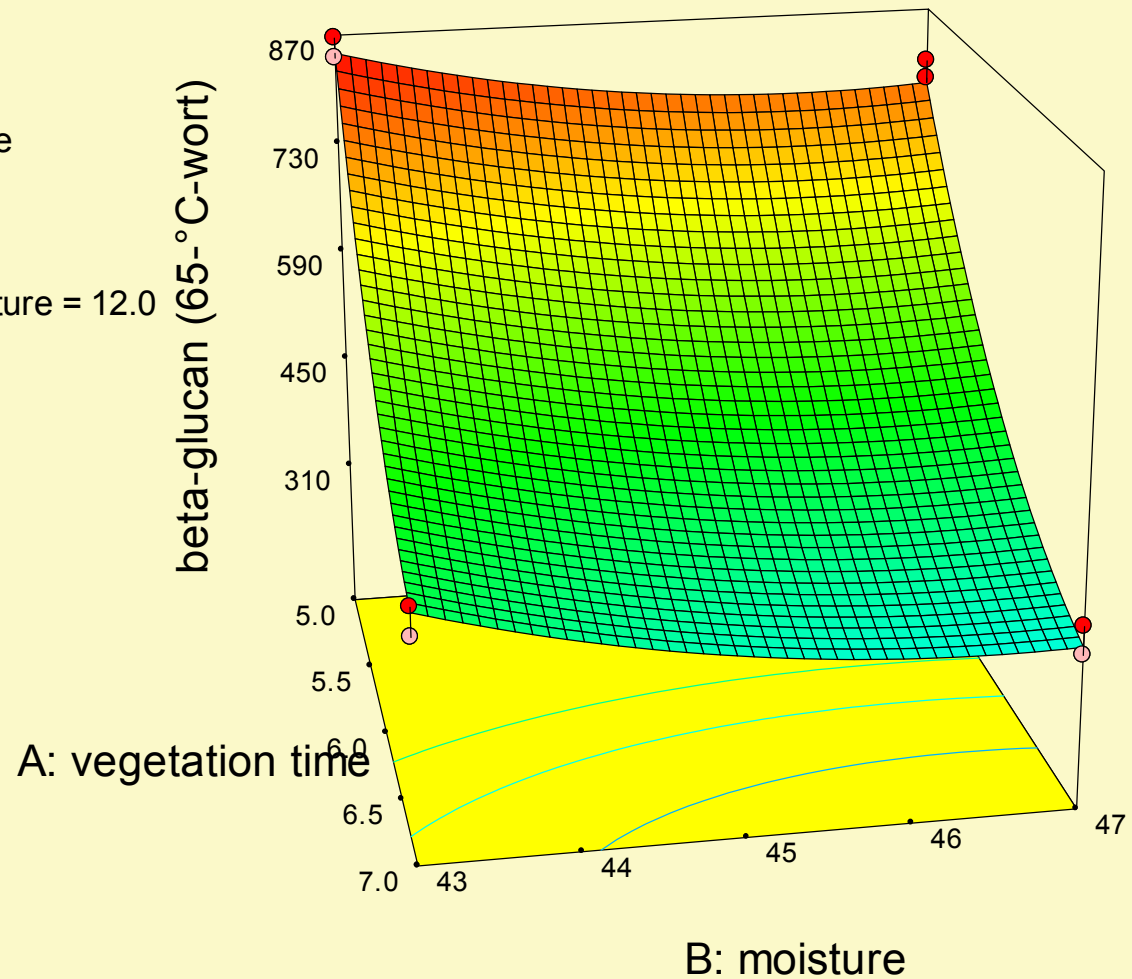


X1 = A: vegetation time

X2 = B: moisture

Actual Factor

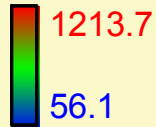
C: vegetation temperature = 12.0



β -Glucan in Congress Wort (Typhon)

Design-Expert® Software

beta Glucan (CW)

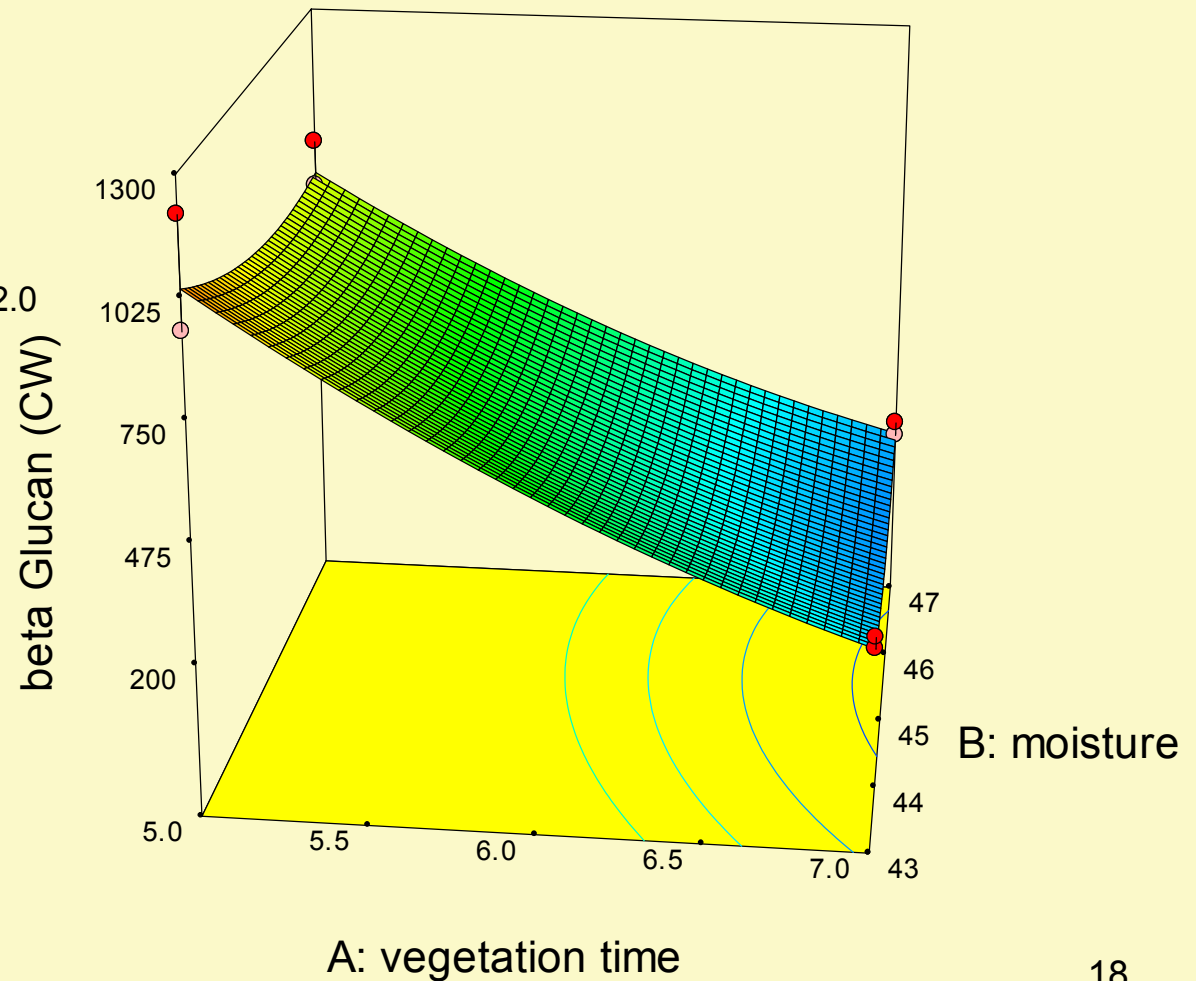


X1 = A: vegetation time

X2 = B: moisture

Actual Factor

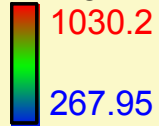
C: vegetation temperature = 12.0



β -Glucan in 65-°C-Wort (Typhon)

Design-Expert® Software

beta-glucan (65-°C-wort)

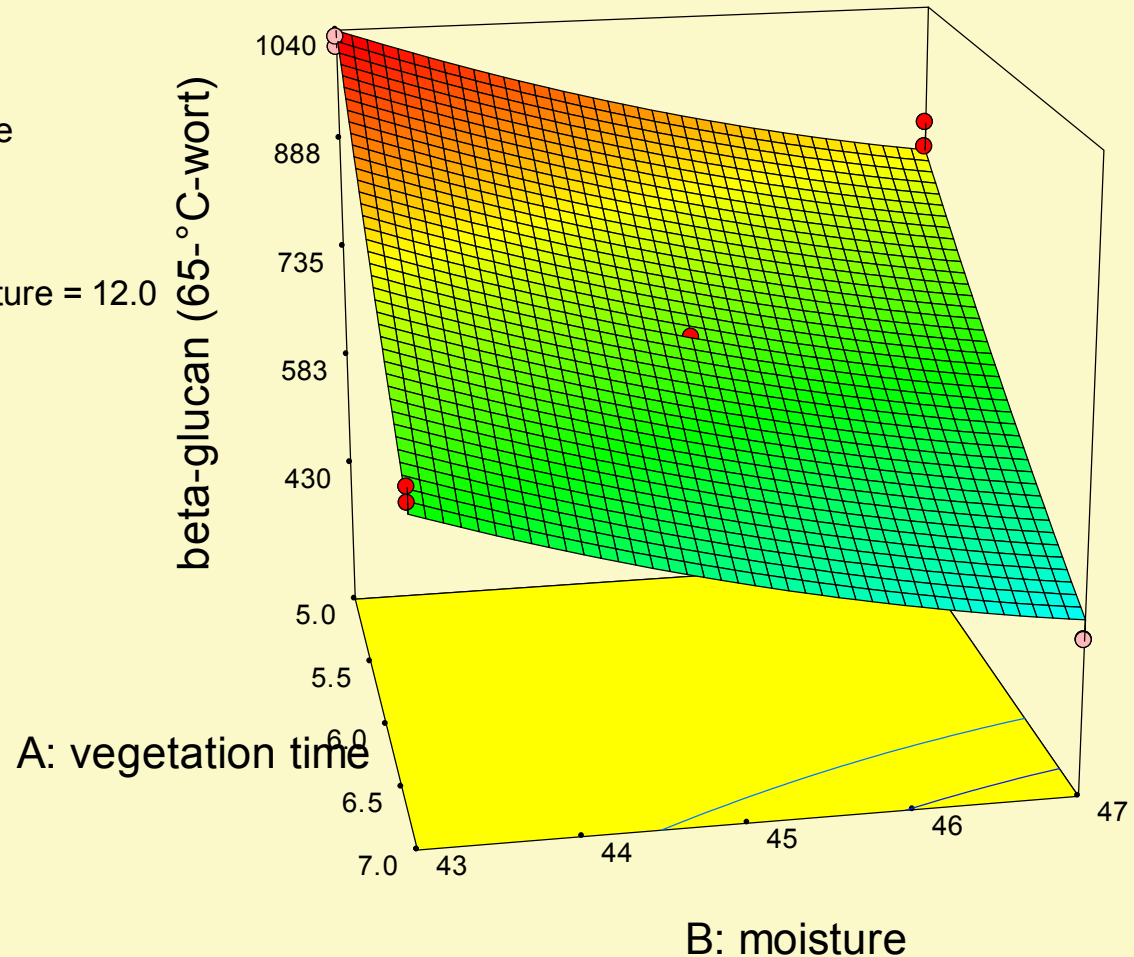


X1 = A: vegetation time

X2 = B: moisture

Actual Factor

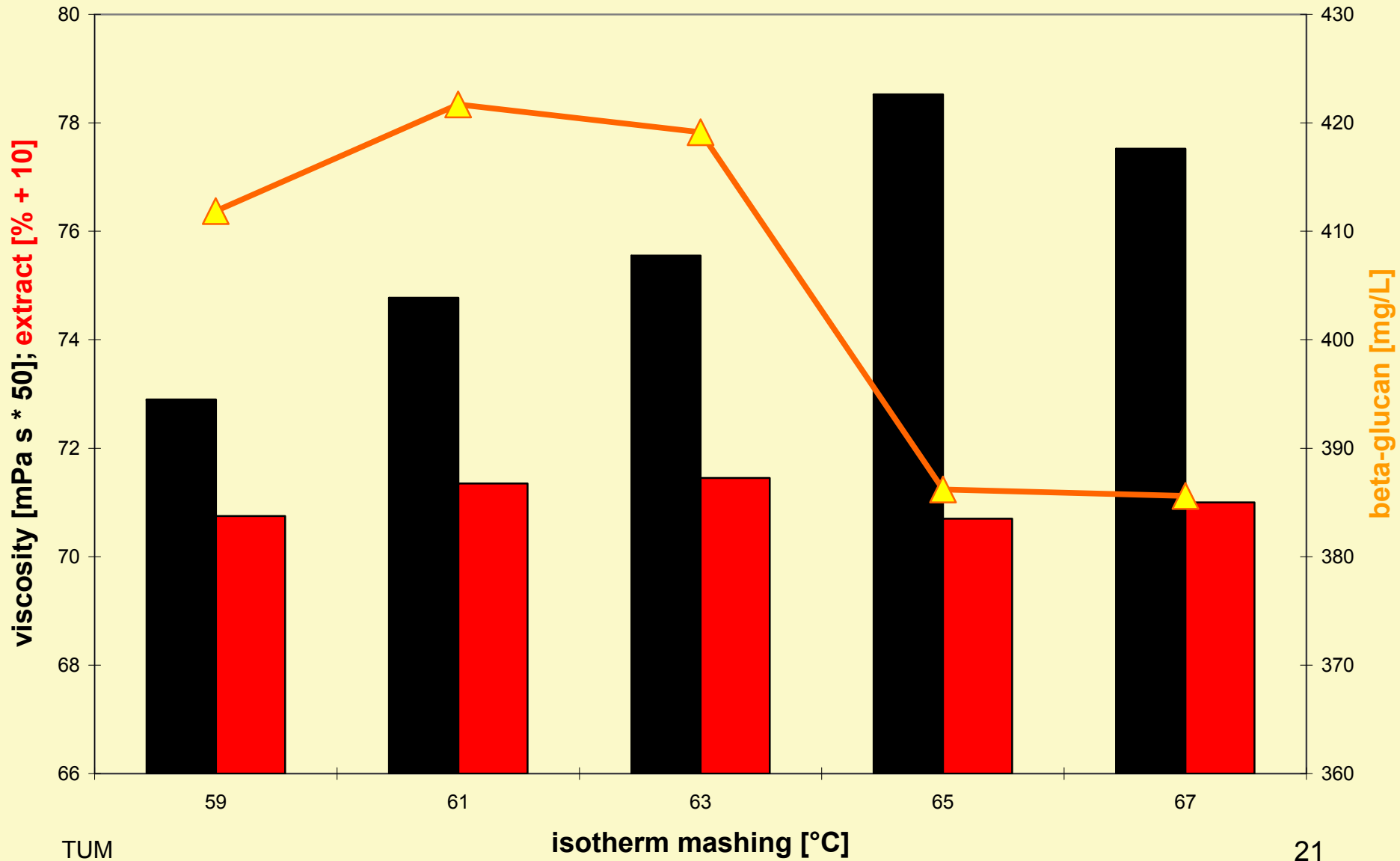
C: vegetation temperature = 12.0



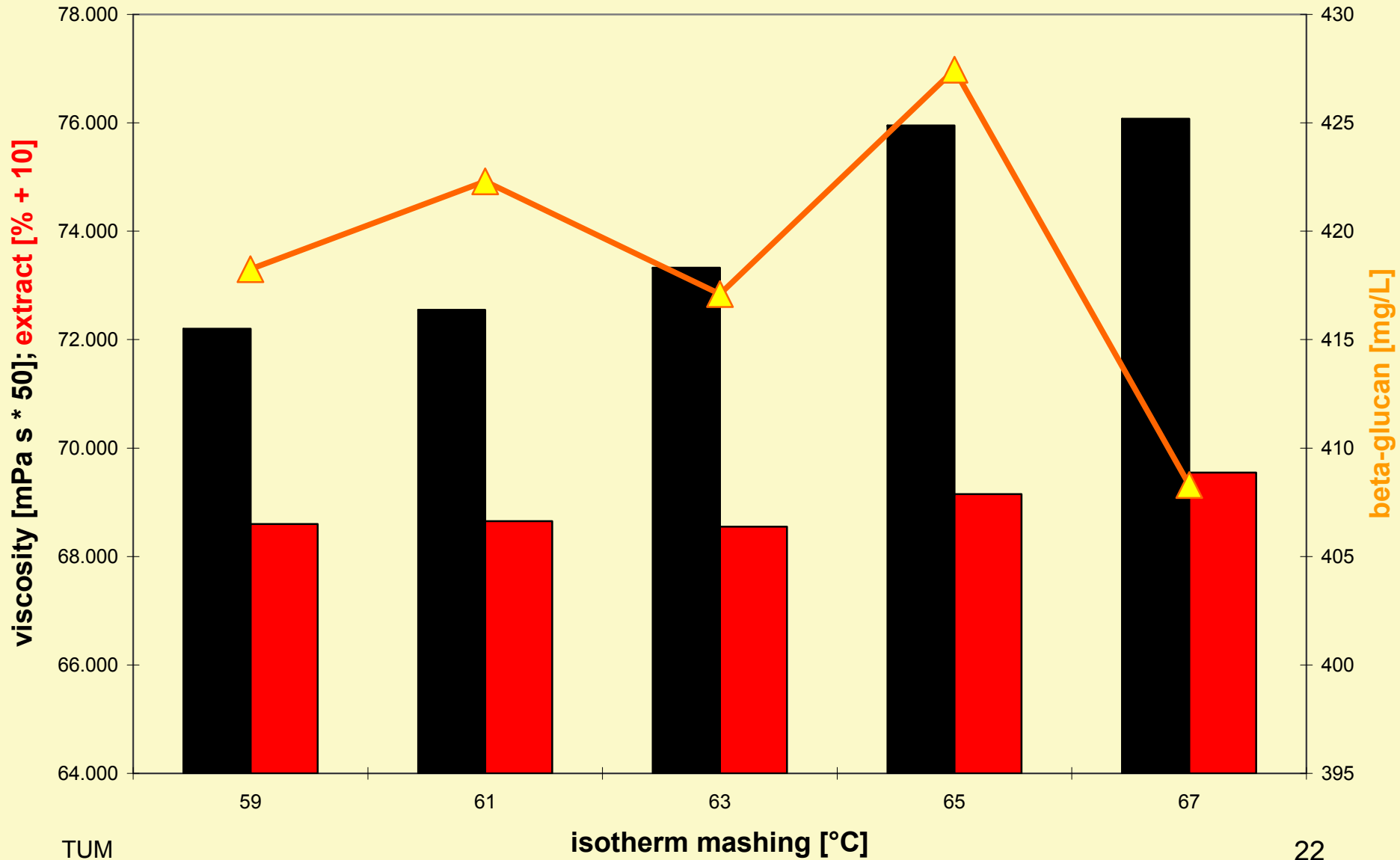
Optimal Germination Condition

		Ivory		Typhon	
vegetation time	d	7		6	
moisture	%	45		45	
vegetation temperature	°C	12		15	
		predicted	measured	predicted	measured
extract	%, dm.	73.5	71.6	71.6	68.4
apparent attenuation	%	62.6	68.3	63.2	73.7
Kolbach index	%	29.2	31.2	29.2	26.1
FAN	mg/100 mL	112	119	115	115
β -glucan (CW)	mg/L	447	393	448	363
β -glucan (65-°C-wort)	mg/L	549	386	520	428
viscosity (CW)	mPa \times s	1.544	1,500	1.523	1.468
viscosity (65-°C-wort)	mPa \times s	1.597	1,571	1.571	1.519

Mashing – Ivory



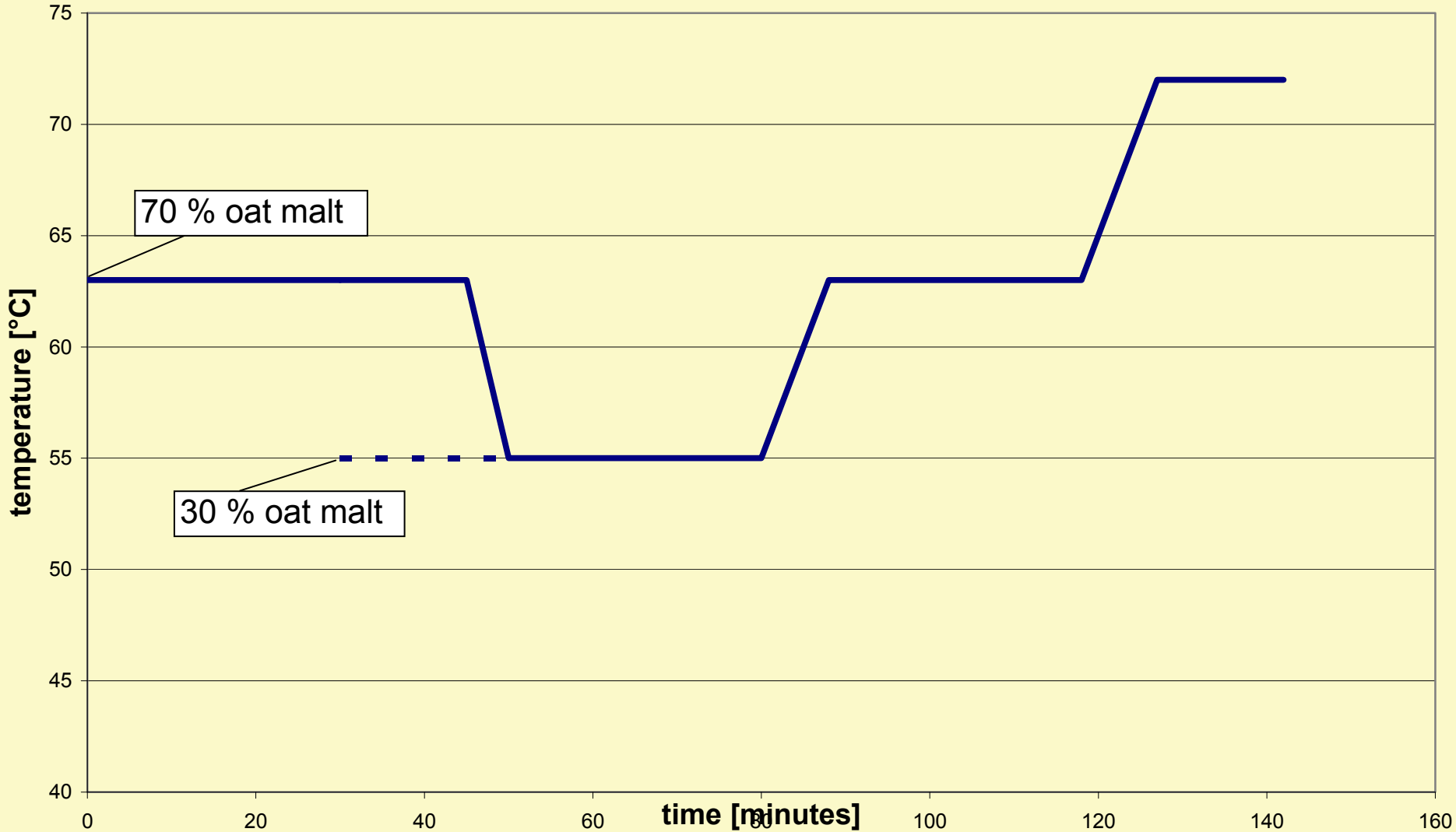
Mashing – Typhon



Glucan Specific Enzymes - Barley

	temperature optimum [°C]	deactivation [°C]	optimal pH
endo-β-1,4-glucanase	40–45	55	4.5–4.8
endo-β-1,3-glucanase	60	70	4.5/5.5
barley endo-β-glucanase	similar endo- β -1,4-glucanase		
β-glucansolubilase	62	73	4.6
exo-β-glucanase	< 40	> 40	4.5
cellobiase	20	–	4.5–5.0
laminaribiase	37	> 55	5

Optimal Mashing



Conclusion

- alternative cereal
- biodiversity
- possible to handle high amount of β -glucan in production process
- new innovative beverage despite purity law
- response surface methodology worthy tool to evaluate malting abilities

Ongoing Work

- mashing trials
- use of response surface methodology for mashing

	units	low actual	mean	high actual
mashing temperature	°C	62	65	68
mashing time	min	30	45	60
malt charge		7	8.5	10

- β -glucan content in fermented beverage?

many thanks to

Alicia Munoz Isa

Stefan Beuch

Elke Arendt

Werner Back

Felix Burberg

Rene Schneider

Martina Garstl

many thanks for your attention!

Martin Zarnkow

E-Mail: Martin.Zarnkow@wzw.tum.de

Tel.: 0049/8161/71-3263

Lautering

“the husks give a more open texture to the mash and accelerate wort separation” (Hornsey, 1999, Habich, 1883, Pelz und Habich, 1876, Briggs, 1998).

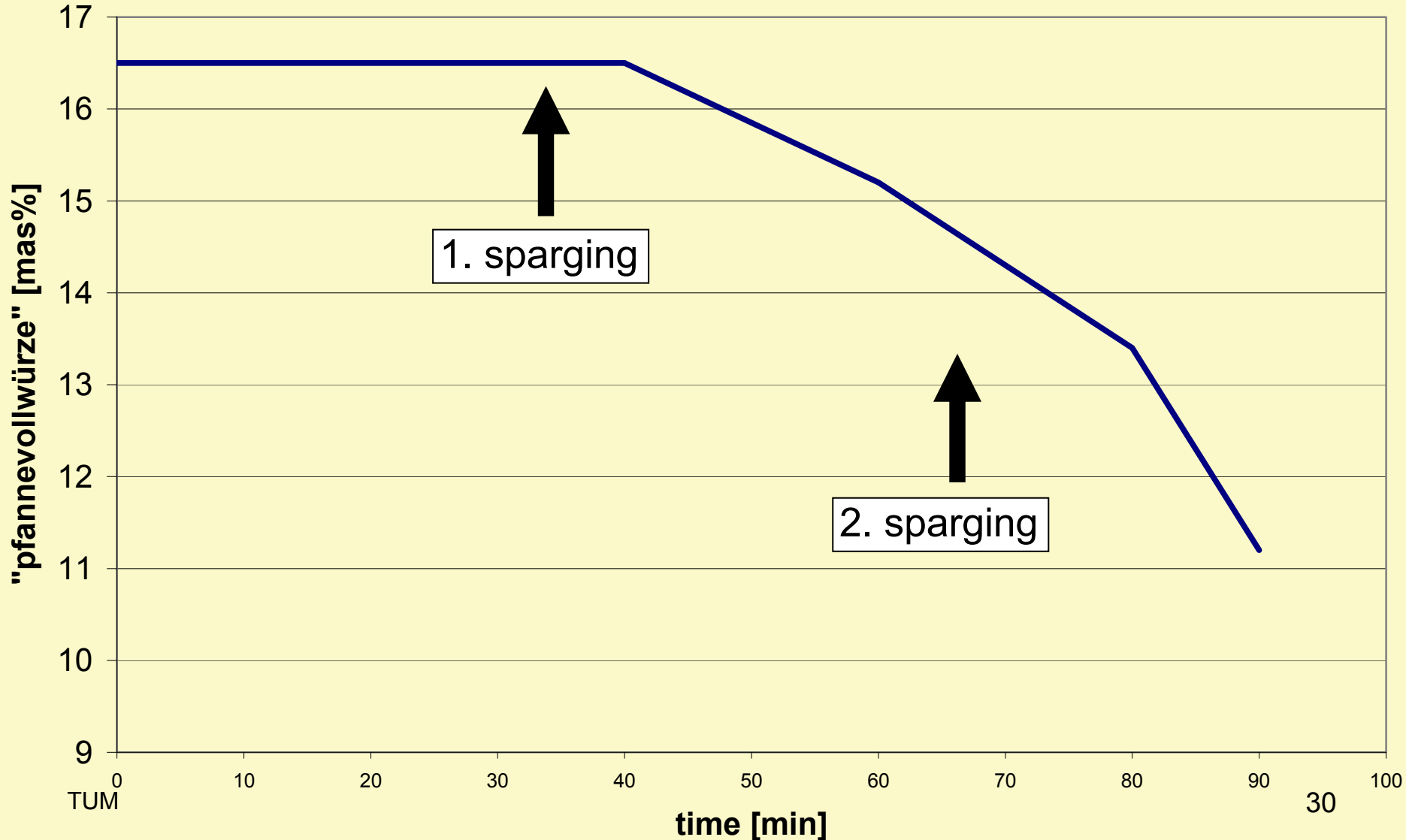
lautering time pilot scale:

barley malt “normal” vintage:	2–2,5 h
barley malt vintage 2006:	2,5–2,75 h

Lautering – Oat Malt

lautering time pilot scale:

1,5 h



Stable Turbidity

