CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Potato sloughing
and
instrumental methods
for its assessment

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and
instrumental methods
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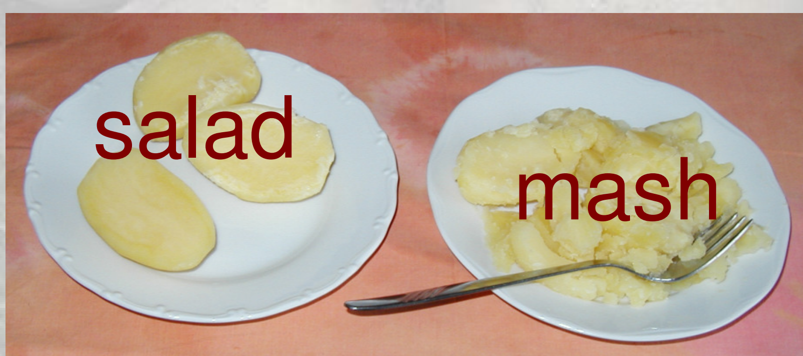
- Cooked potato quality and texture profile
- Sensory methods for texture assessment
- CPM/CPW (cooked potato mass/weight) tests for sloughing assessment
- CPEM (cooked potato effective mass) method as modification of CPM tests
- CT (cooking time) and disintegration rate - new sloughing parameters
- Sloughing
  - in different varieties
  - in different cultivation conditions
  - in relation to tuber density and starch content

Cooked potato quality

Cooking/utilization types:

A – Salad potato
B – Fairly firm all-purpose
C – Mealy
D – Very mealy



Potato texture profile

Texture attributes:

- Mealiness
- Hardness/softness
- Sloughing
- Moisture/dryness
- Graininess/structure

Sensory methods for its evaluation:

- Visually when crushed with a fork, 1= non-mealy, 7= very mealy
- The force necesssary to cut the wedges with a fork, 1=firm, 7=soft
- Visually according to pictures, 1=remaining whole, 7=completely disintegrated
- Orally, 1=moist, 7=dry
- Orally, 1=fine, 7= coarse

Potato sloughing

flaking and disintegration of the outer layers of potato tubers cooked in water

Sensory methods

visually according to pictures of cooked tubers

1 = remaining whole, 7 = completely disintegrated

Instrumental methods

determination of cooked potato tissue amount

- separating in water bath
- remaining on the cooked sample

Standard CPM/CPW test

(cooked potato mass/weight)

potato sloughing assessment

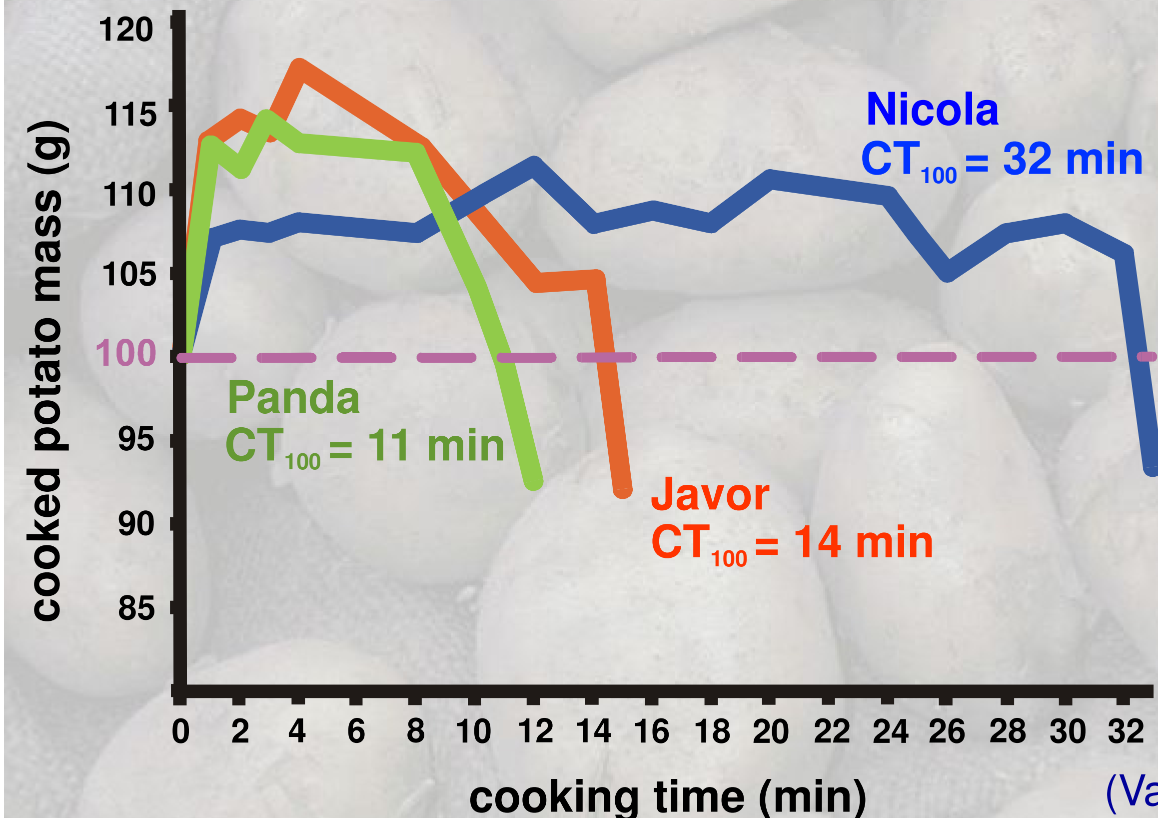
Potato sample
cut from inner parenchyma
100 g, 10x10x1.5 mm

Cooked and stirred
decanted

CPM value recorded
cooking curve: CPM ~ t

EAPR (*European Association of Potato Research)*, Wageningen,1977

CPM cooking curves



(Vacek, 1997)

Direct correlation between CT_{100} and cooking type was not found

$CT_{100} < 4$ min … very sloughed
$CT_{100} > 12$ min … non-sloughed

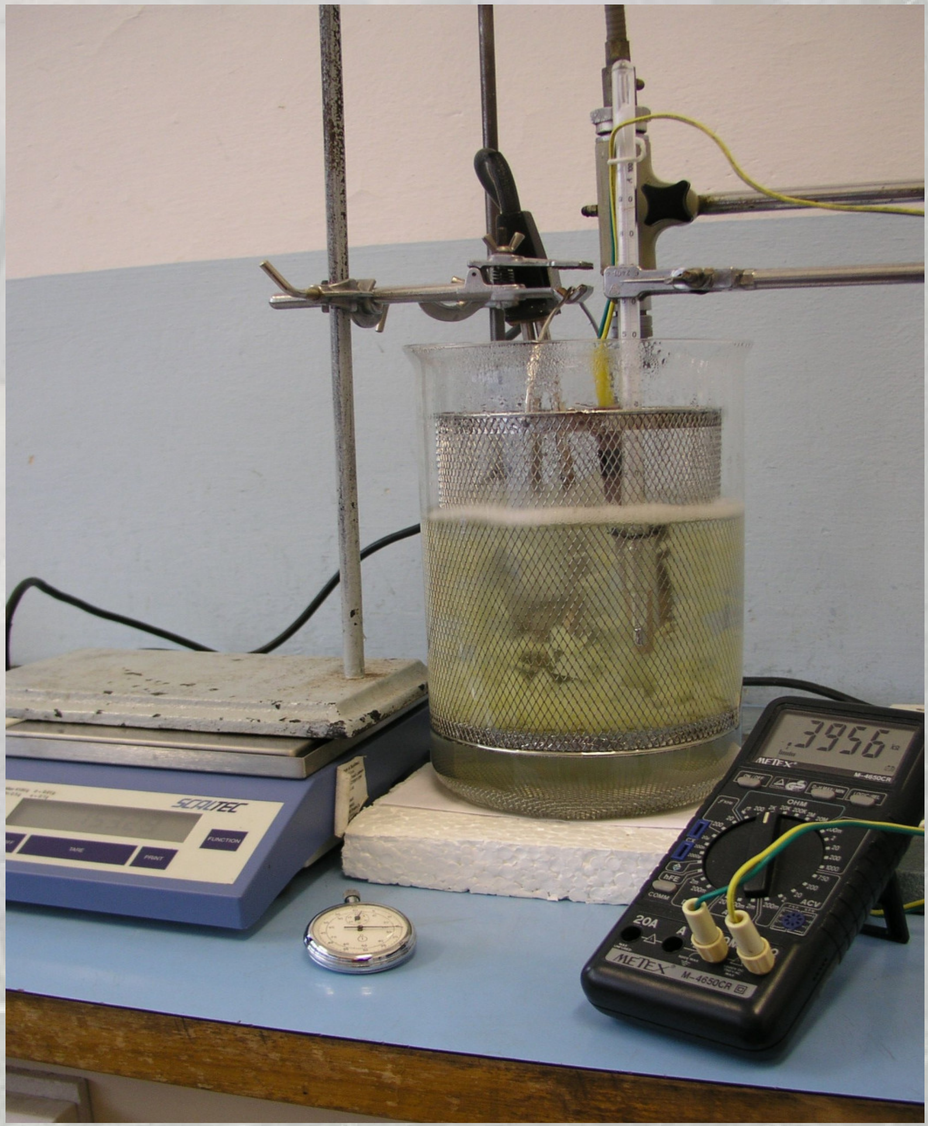
EAPR: recommends as a complement to sensory tests

100 g – mass of the raw potato sample
CT_{100} *(characteristic time)* – resistance against sloughing

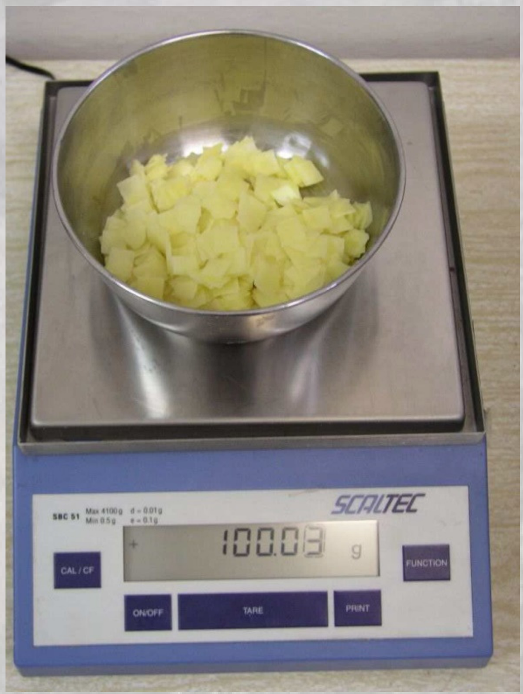
CPM cooking curve – result of 10-20 measurements

Modification: CPEM method

- Sample cooked and stirred on the sieve
- *Cooked potato effective mass* CPEM recorded continuously during cooking
- The whole cooking curve obtained in one test
- The sloughing can be studied in relation to tuber density



Sample preparation



3-4 tubers of the same size and density ρ (kg/m^3)

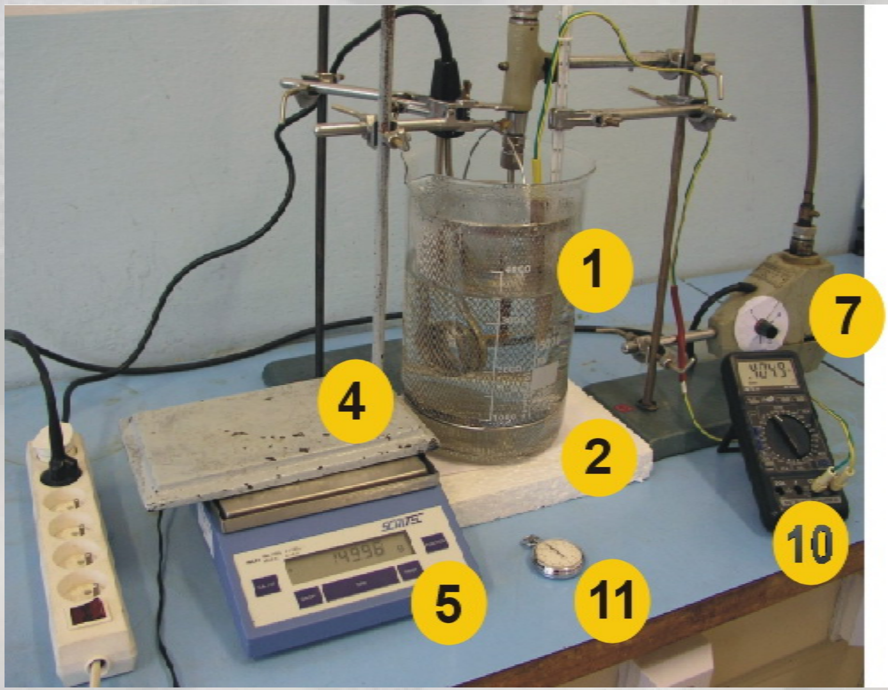
flakes 10x10x1.5 mm

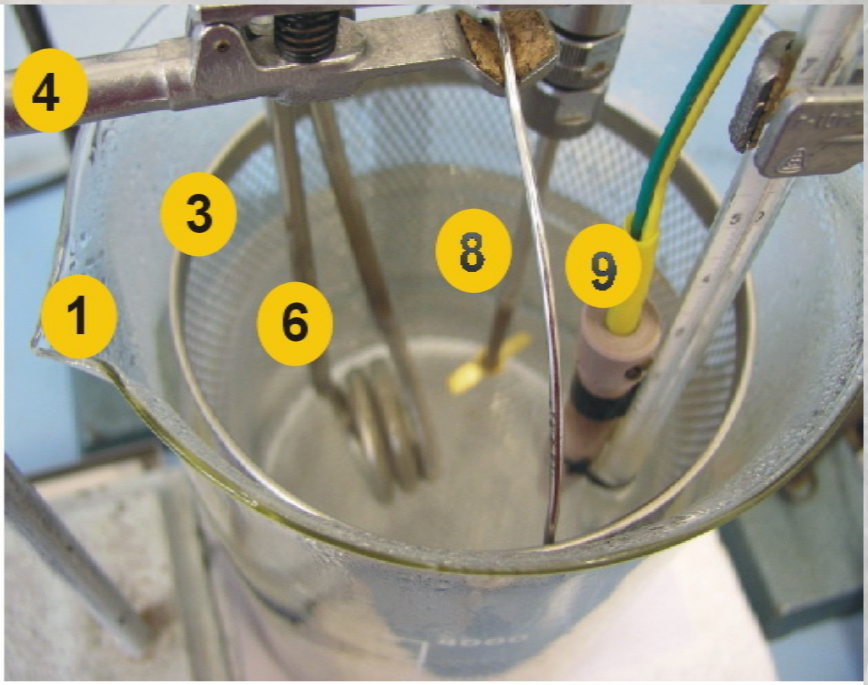
potato sample = 100 g

estimated by double weighing in air (m) and in water (m_{uww})

$$\rho = \rho_{water}\, m / (m - m_{uww})$$

CPEM experimental set-up

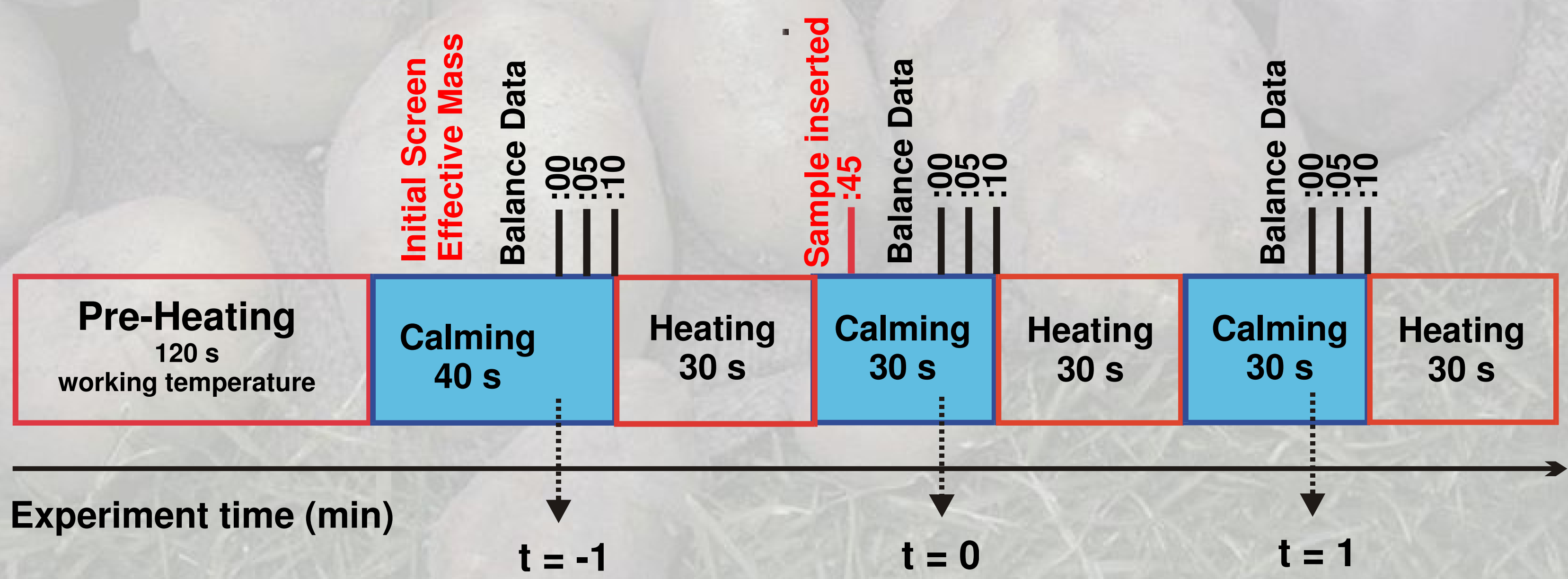




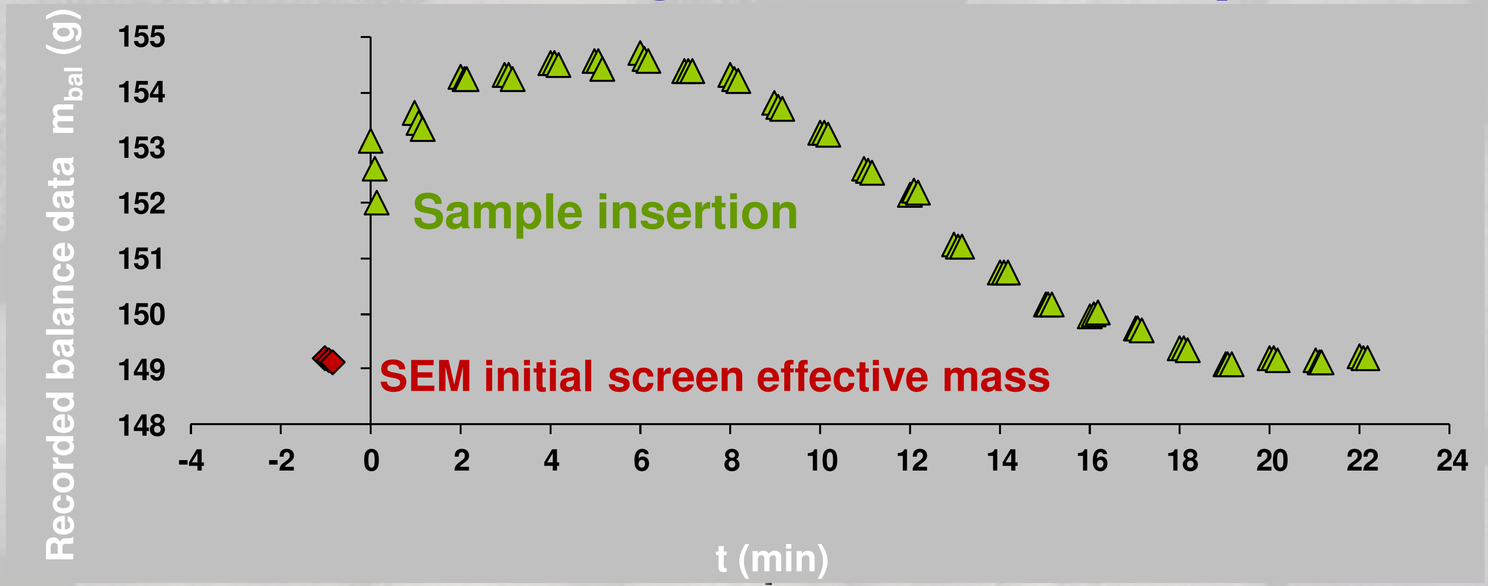
1 – glass beaker (5l, dia 180 mm) with a round metal sieve 2x2 mm placed 5 mm above the beaker bottom
2 – polystyrene desk
3 – screen basket (dia 150 mm, height 190 mm, diamond mesh 3x5 mm, part of a pasta cooker)
4 – laboratory stand

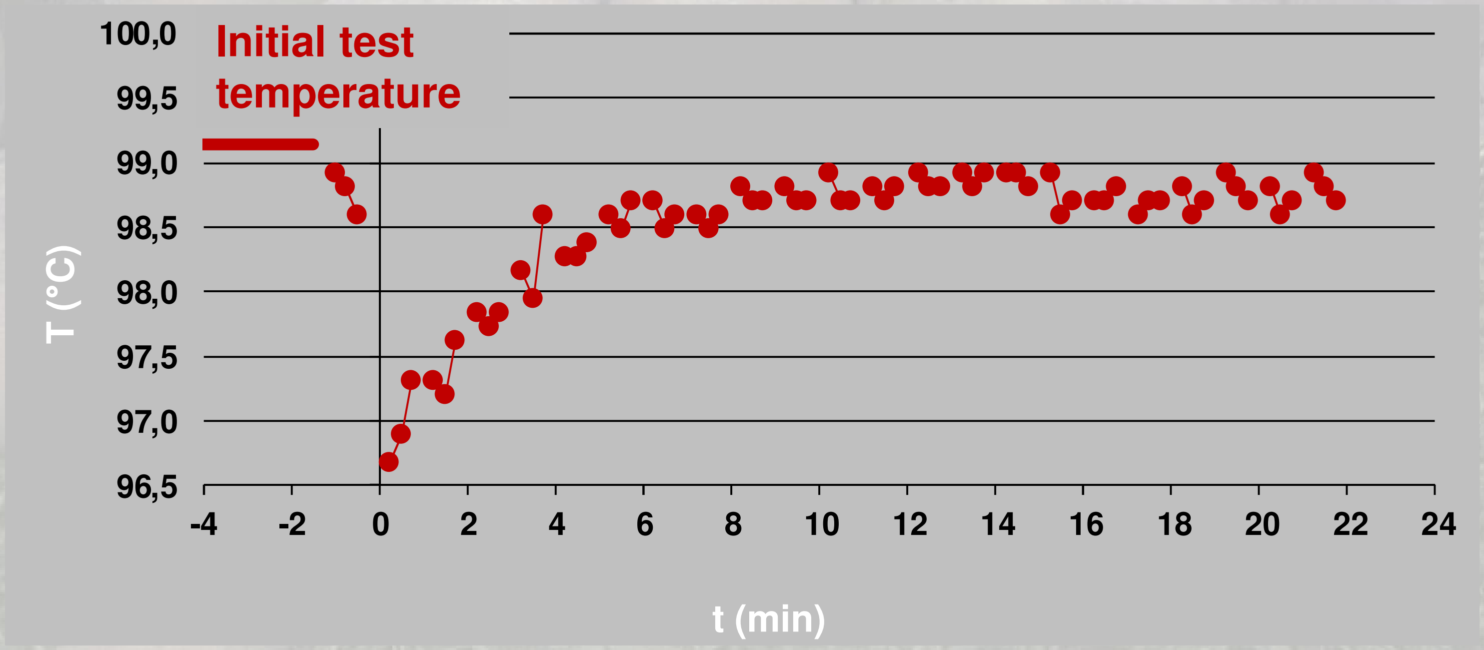
5 – analytical balance SCALTEC
6 – immersion heater (≈ 1 kW)
7 – stirring apparatus with metal propeller (VEB Prüfgeräte-Werk, Dresden, 1967)
8 – metal propeller
9 – NTC thermistor
10 – digital multimeter
11 - stopwatch

Time schedule of the CPEM test

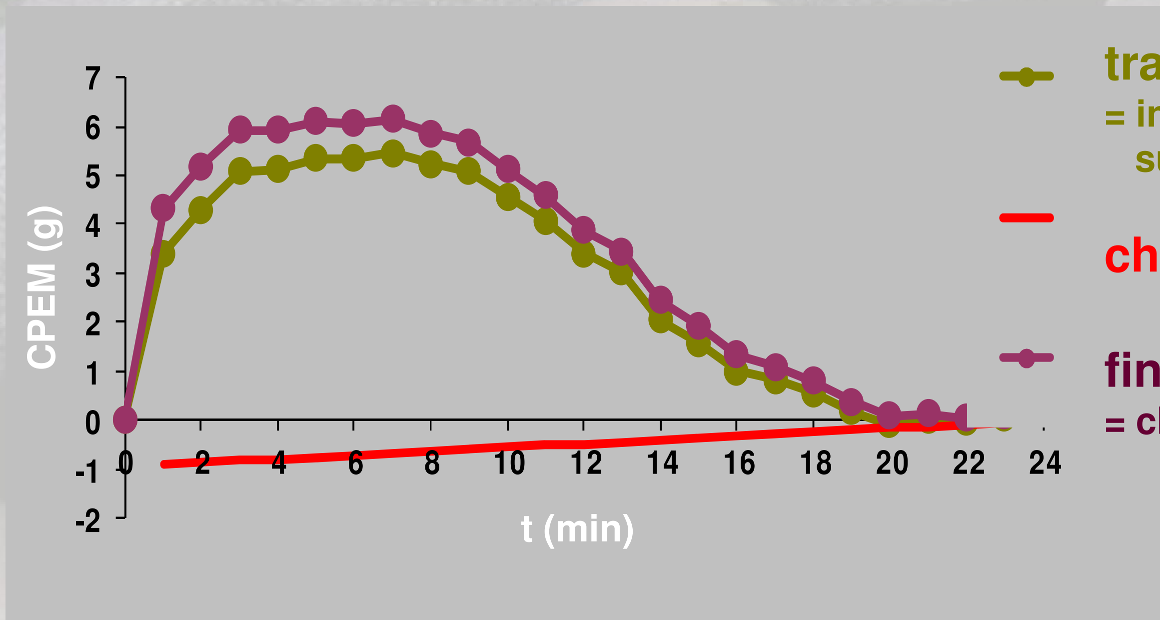


Recorded cooking curve and temperature





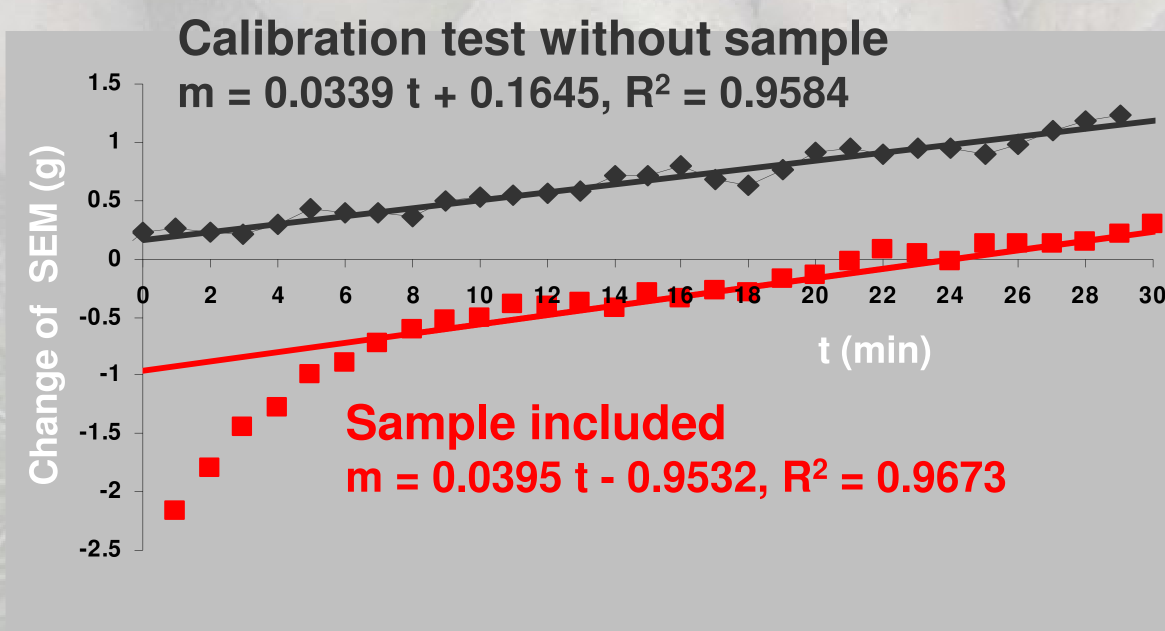
Calibration and final CPEM cooking curve

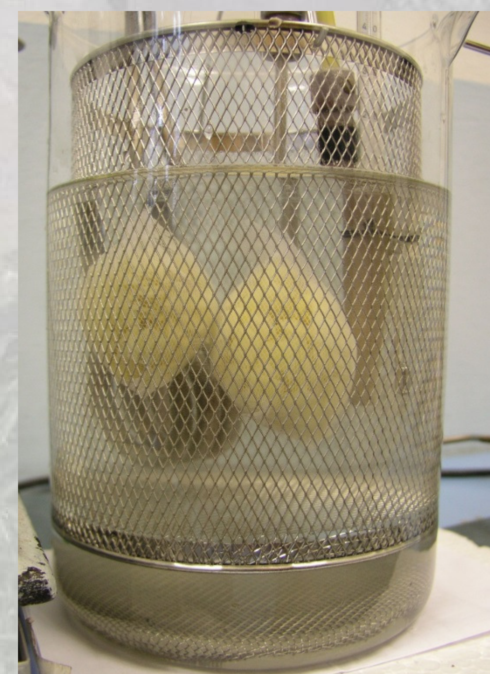


transformed CPEM curve
= initial screen effective mass SEM subtracted

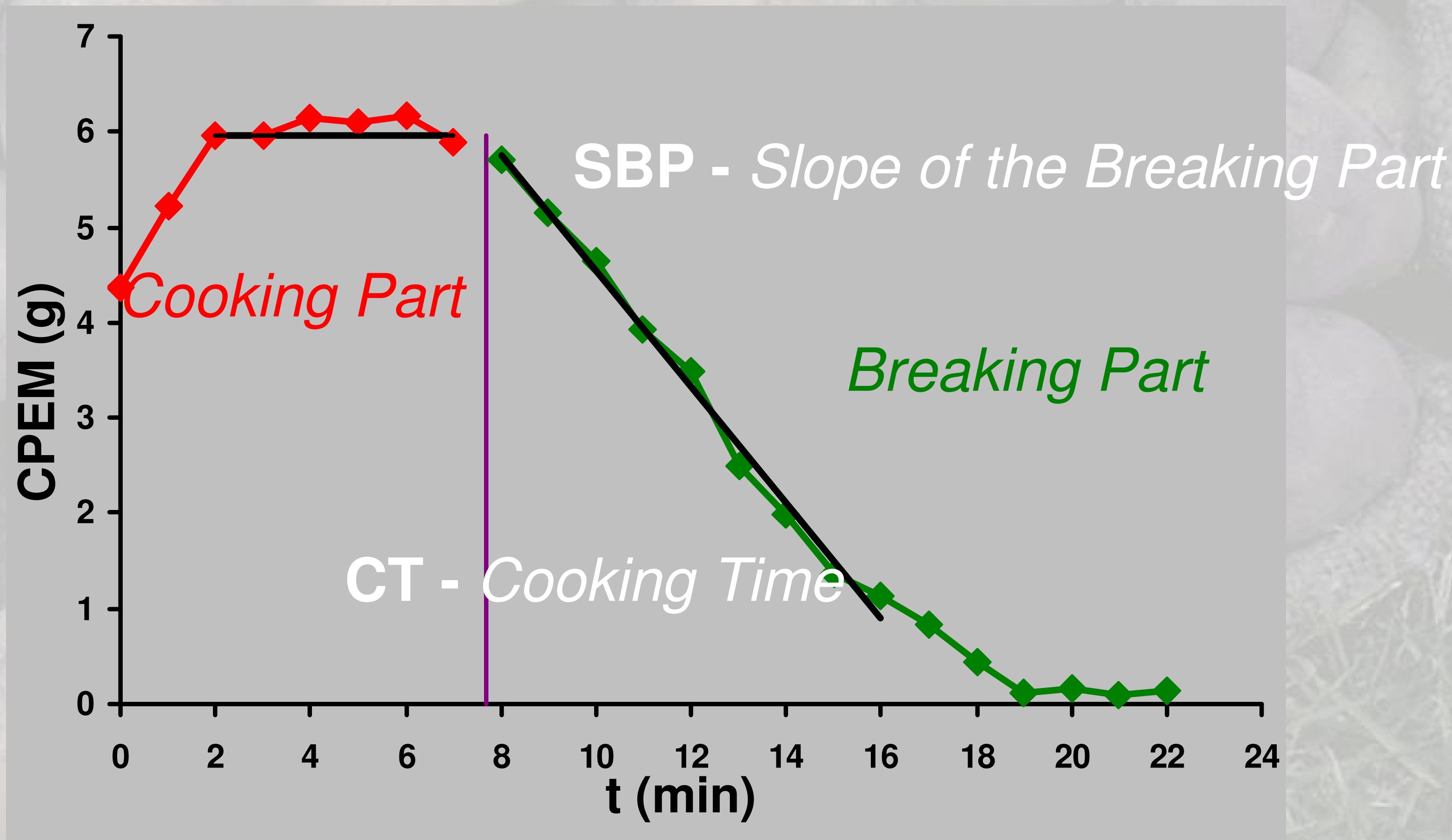
change in SEM

final CPEM curve
= change in SEM compensated



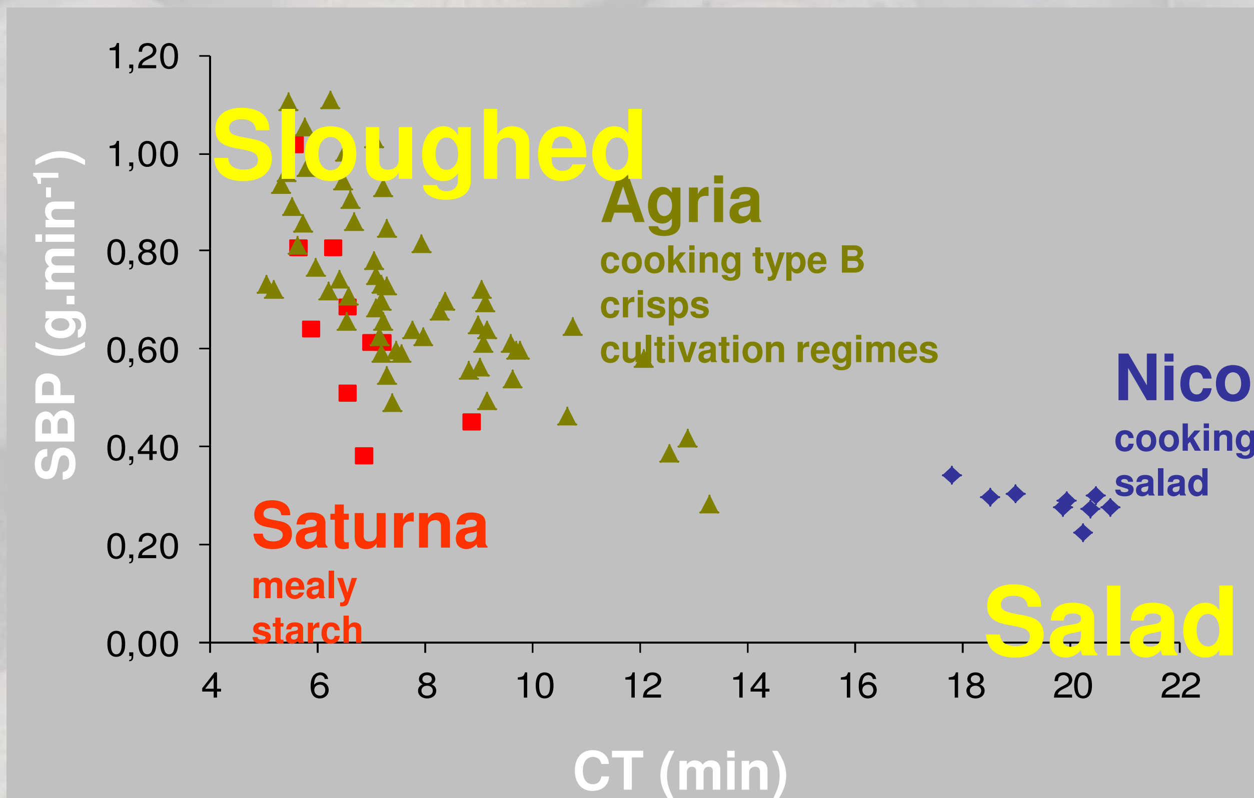


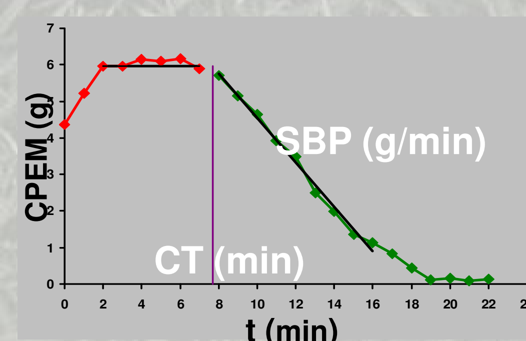
CPEM cooking curve and parameters



CT … cooking time required to start disintegration (min)
SBP … disintegration rate (g/min)

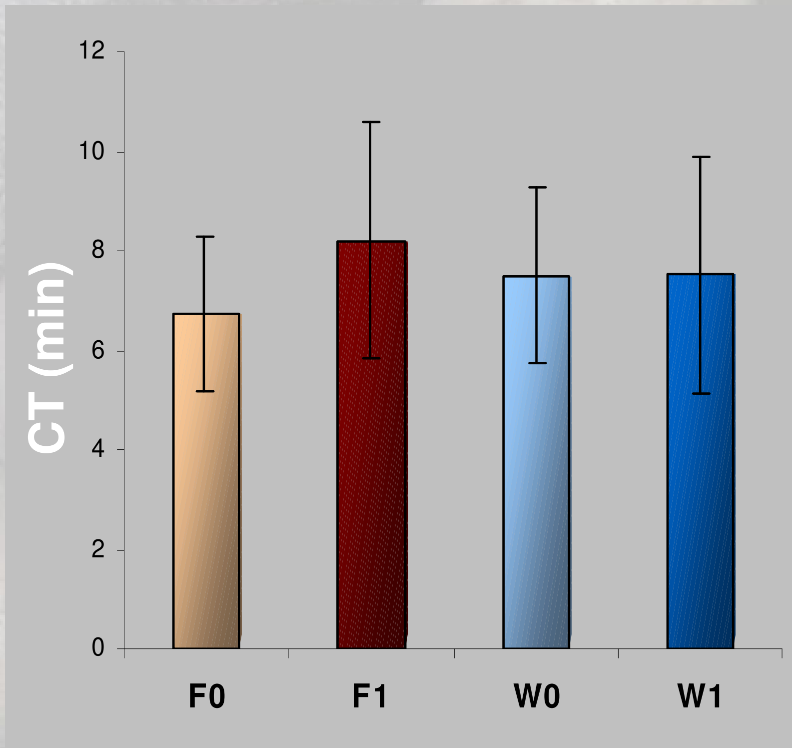
Sloughing in different cultivars

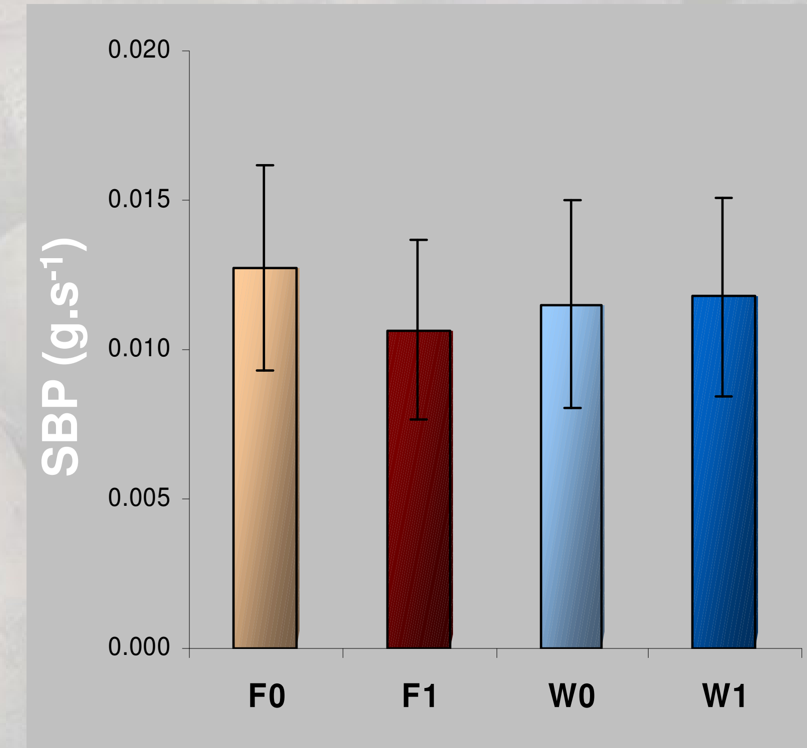




CT … cooking time required to start disintegration
SBP … disintegration rate

Different cultivation regimes



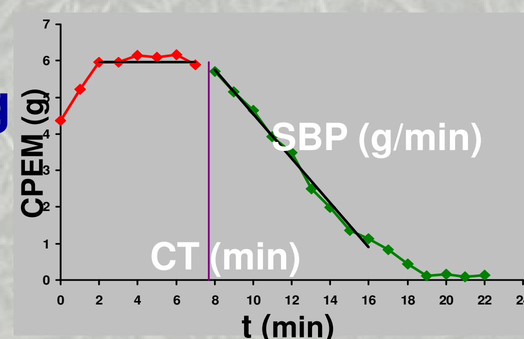


F Fertilization, W Irrigation

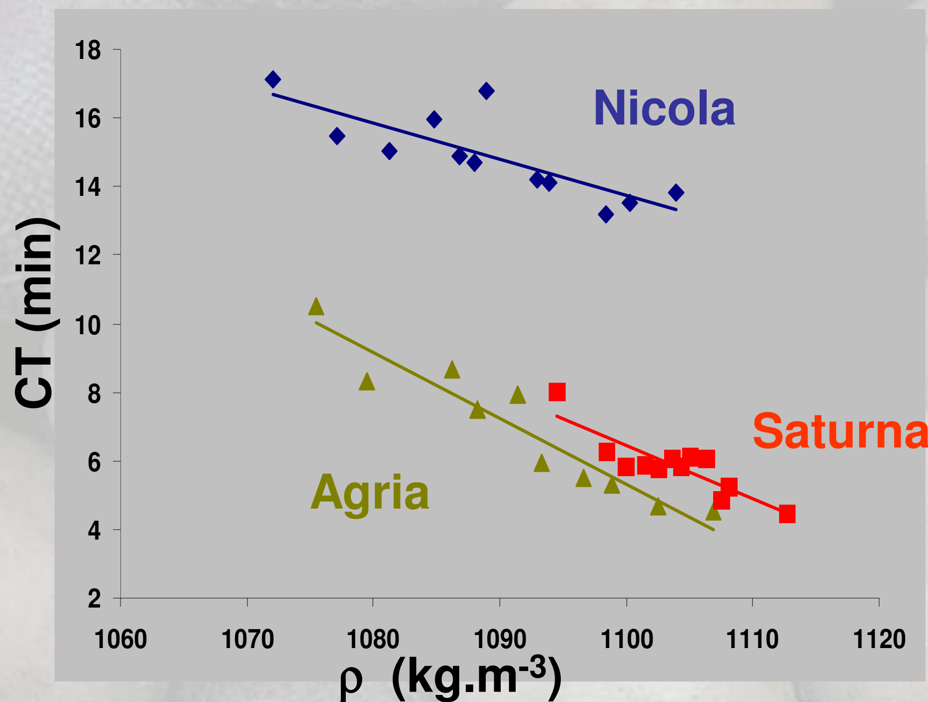
Agria 2004+2005

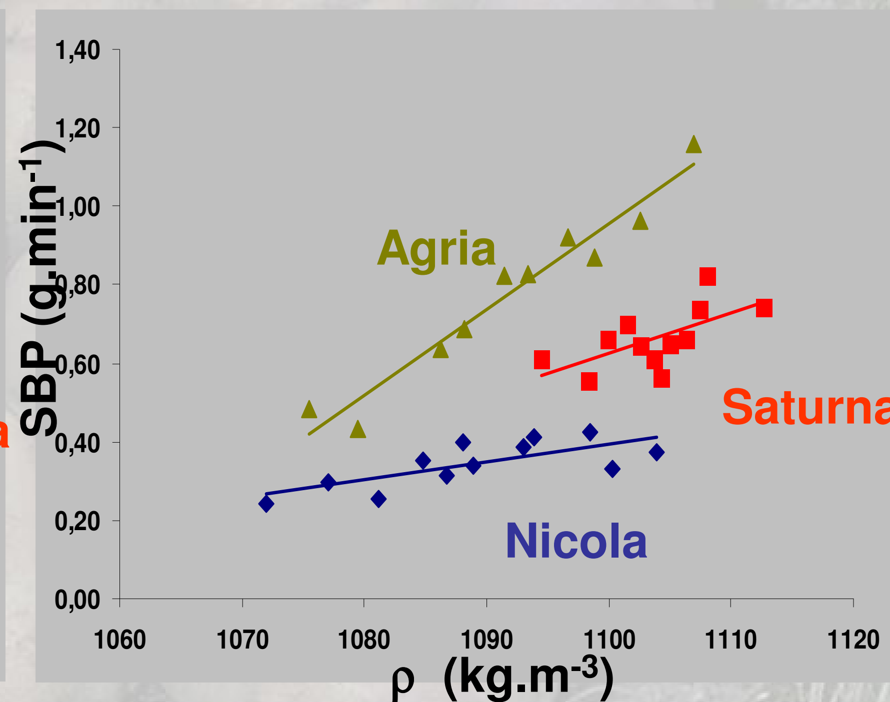
Fertilization ≈ lower degree of sloughing
Irrigation … no significant influence on sloughing

CT … cooking time required to start disintegration
SBP … disintegration rate



CPEM parameters in relation to tuber density

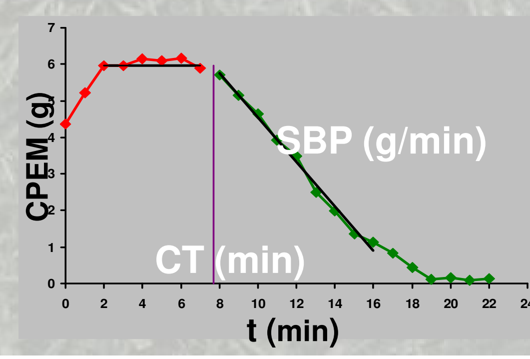




higher degree of sloughing ≈ higher tuber density

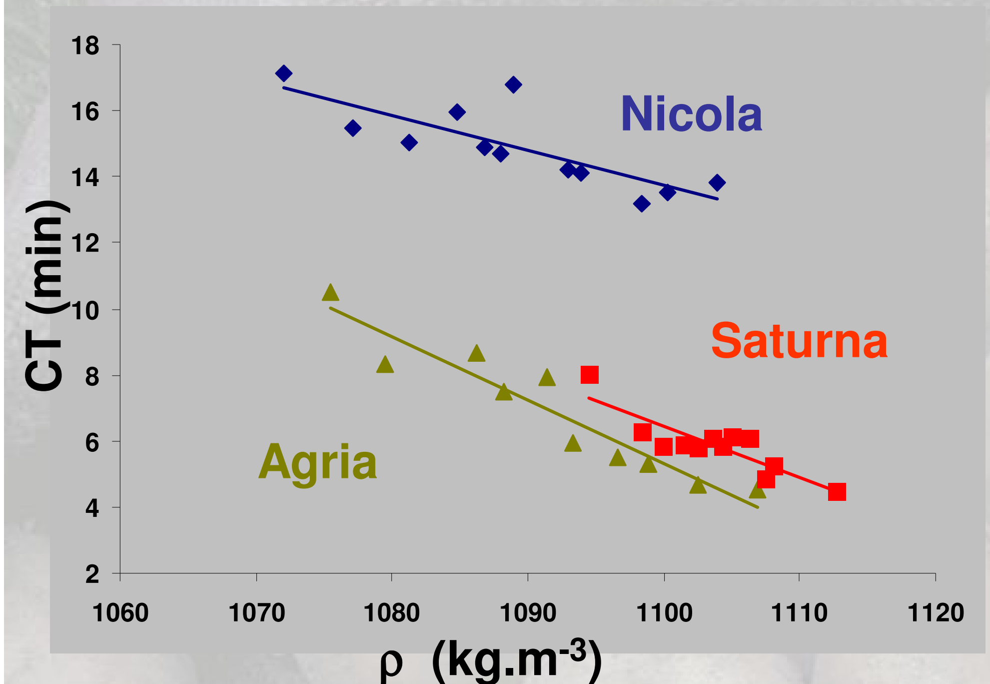
correlation between tuber density, dry matter and starch content

- Maercker´s tables (1880)
- Scheele´s formulas (1937)



CT … cooking time required to start disintegration
SBP … disintegration rate

Linear model of cooking stage I



$$CT \sim CT_{MV} - b\,(\rho - \rho_{MV})$$

R^2 … 0.5 – 0.92

b (min.m^3.kg^{-1})

- CT-sensitivity to tuber density and starch content
- Cooking parameter typical for variety, independent of growing conditions

ρ_{MV} (kg.m^{-3})

- Density mean value of tested tubers
- Correlates closely with starch content

CT_{MV} (min)

- Cooking time mean value
- Characteristic of potato variety

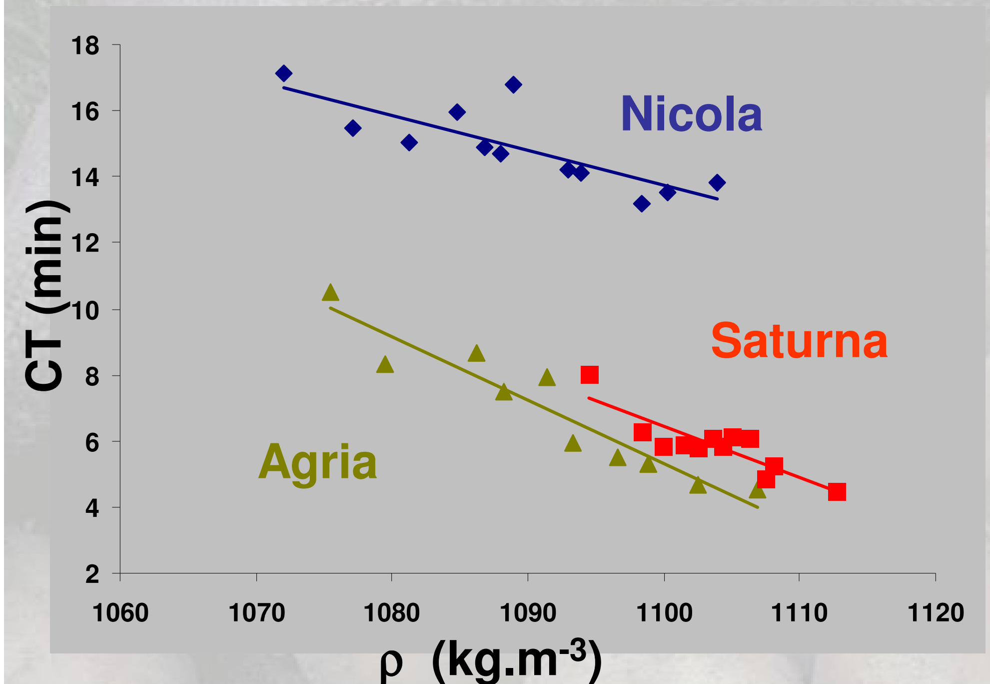
Why does the cooked potato tissue disintegrate?

- **Biological plant material**
- **Parenchyma cells**
- **Disintegration = potato cell rupture and/or separation**

Starch – starch swelling pressure due to gelatinisation, comparable with turgor pressure

Cell wall and middle lamella – degradation of pectic polymers

Linear model of cooking stage II



$$CT \sim a_{CT0} - b\,(\rho - \rho_0)$$

R^2 … 0.5 – 0.92

b (min.m^3.kg^{-1})

- CT-sensitivity to tuber density and starch content
- Cooking parameter typical for variety, independent of growing conditions

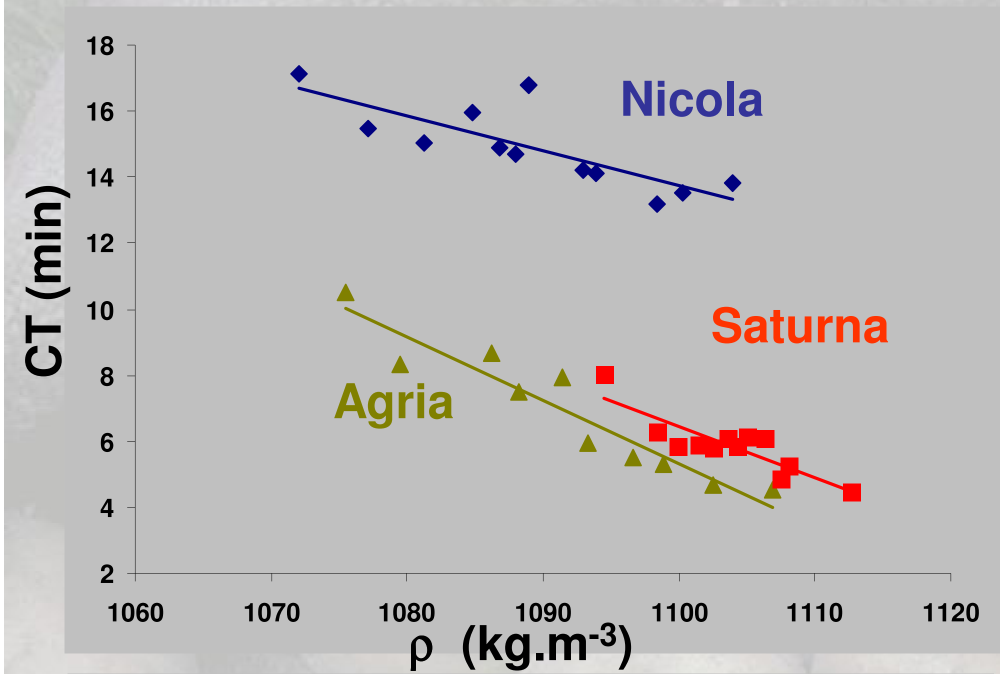
ρ_0 (kg.m^{-3})

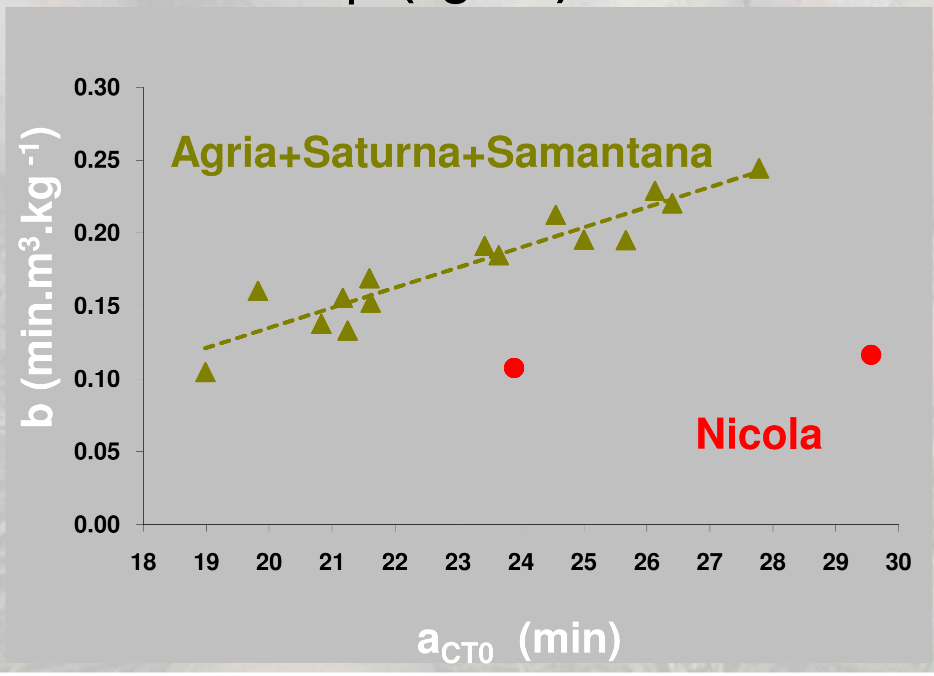
- Density of hypothetical potato tissue without starch
- Estimated as 1005 kg.m^{-3} (empirical formulas between density, dry matter and starch content - von Scheele)

a_{CT0} (min)

- Time of cooking necessary to start disintegration of fictive potato tissue without starch
- Characteristic related to cell wall and middle lamella properties

Linear model of cooking stage III





$$CT \sim a_{CT0} - b\,(\rho - \rho_0)$$

b (min.m^3.kg^{-1})

- CT-sensitivity to tuber density and starch content

***a*$_{CT0}$** (min)

- Time of cooking necessary to start disintegration of fictive potato tissue without starch
- Characteristic related to cell wall and middle lamella properties

The most varieties followed a common inner mechanism of cell tissue disintegration

Divergent behavior of salad cultivar Nicola was observed

Conclusions

CPEM method

- objective instrumental method for potato sloughing assessment
- reduces experimental material and operational time
- potato cooking properties can be studied in detail in relation to tuber density
- CT cooking time – main parameter
  - less than 6 min – sloughed (type C)
  - 6 – 14 min – moderately sloughed (type B)
  - more than 14 min – slightly and non-sloughed (type A)
- improvement of experimental set-up possible

Publications

Hejlová A., Blahovec J., Vacek, J. (2006) **Modified test for potato sloughing assessment**. *Journal of Food Engineering* 77(3), 411-415.

Blahovec J., Hejlová A. (2006) **Role of Tuber Density in Potato Sloughing**. *Journal of Texture Studies* 37,165-178.

Hejlová A., Blahovec J. (2008) **Sloughing in potatoes induced by tuber density and affected by variety**. *Czech Journal of Food Sciences,* 26(1): 41-50*.*

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Current research:

Blahovec, J., Hejlová, A., Čopíková J. and Novák, M. (2011). **Tensile Properties of Microbial β-Glucan Films**. *Polymer Engineering and Science,* 51:2564-2570.

Hejlová A., Blahovec J. (2015). **Stress Relaxation and Activation Volume in Tension in β-Glucan and Chitosan Films**. *Polymer Engineering and Science,* 55 (3): 624-633.

Thank you for your attention