Potato sloughing and instrumental methods for its assessment

Anna Hejlová, Jiří Blahovec
Potato sloughing and instrumental methods for its assessment

- 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

salad  mash

A  B  C
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 necessary 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

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

(Vacek, 1997)
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 \( \rho \) (kg/m\(^3\))

flakes 10x10x1.5 mm

potato sample = 100 g

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

\[
\rho = \frac{\rho_{water} \cdot m}{m - m_{uww}}
\]
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

Pre-Heating: 120 s working temperature

Calming: 40 s

Heating: 30 s

Calming: 30 s

Heating: 30 s

Calming: 30 s

Heating: 30 s

Experiment time (min): t = -1, t = 0, t = 1
Recorded cooking curve and temperature

Sample insertion

SEM initial screen effective mass

Recorded balance data $m_{bal}$ (g)

Initial test temperature

$T \, (^\circ\text{C})$

$t \, (\text{min})$
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

Calibration test without sample

\[ m = 0.0339 \, t + 0.1645, \quad R^2 = 0.9584 \]

Sample included

\[ m = 0.0395 \, t - 0.9532, \quad R^2 = 0.9673 \]
CPEM cooking curve and parameters

CT - Cooking Time
SBP - Slope of the Breaking Part

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

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

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

Agria 2004+2005
CPEM parameters in relation to tuber density

higher degree of sloughing $\approx$ 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

\[ CT \sim CT_{MV} - b (\rho - \rho_{MV}) \]

\( b \) (min.m\(^3\).kg\(^{-1}\))
- CT-sensitivity to tuber density and starch content
- Cooking parameter typical for variety, independent of growing conditions

\( \rho_{MV} \) (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
  Starch – starch swelling pressure due to gelatinisation, comparable with turgor pressure

• Parenchyma cells

• Disintegration = potato cell rupture and/or separation
  Cell wall and middle lamella – degradation of pectic polymers
Linear model of cooking stage II

\[ CT \sim a_{CT0} - b (\rho - \rho_0) \]

- \( b \) (min.m^{3}.kg^{-1})
  - CT-sensitivity to tuber density and starch content
  - Cooking parameter typical for variety, independent of growing conditions

- \( a_{CT0} \) (min)
  - Time of cooking necessary to start disintegration of fictive potato tissue without starch
  - Characteristic related to cell wall and middle lamella properties

\( \rho_0 \) (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)
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


Current research:


Thank you for your attention