An experimental study of the swelling behavior of starch granules under heat treatment

Artemio Plana-Fattori, Giana Almeida, Gabrielle Moulin, Christophe Doursat, Denis Flick

AN EXPERIMENTAL STUDY OF THE SWELLING BEHAVIOR OF STARCH GRANULES UNDER HEAT TREATMENT

Artemio Plana-Fattori, Giana Almeida-Perré,

Gabrielle Moulin, Christophe Doursat, Denis Flick

(contr. FaBE2017-062; book of abstracts: page 65)

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Ingénierie Procédés Aliments
(Food & Process Engineering)

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INSTITUT DES SCIENCES ET INDUSTRIES DU VIVANT ET DE L'ENVIRONNEMENT
PARIS INSTITUTE OF TECHNOLOGY FOR LIFE, FOOD AND ENVIRONMENTAL SCIENCES

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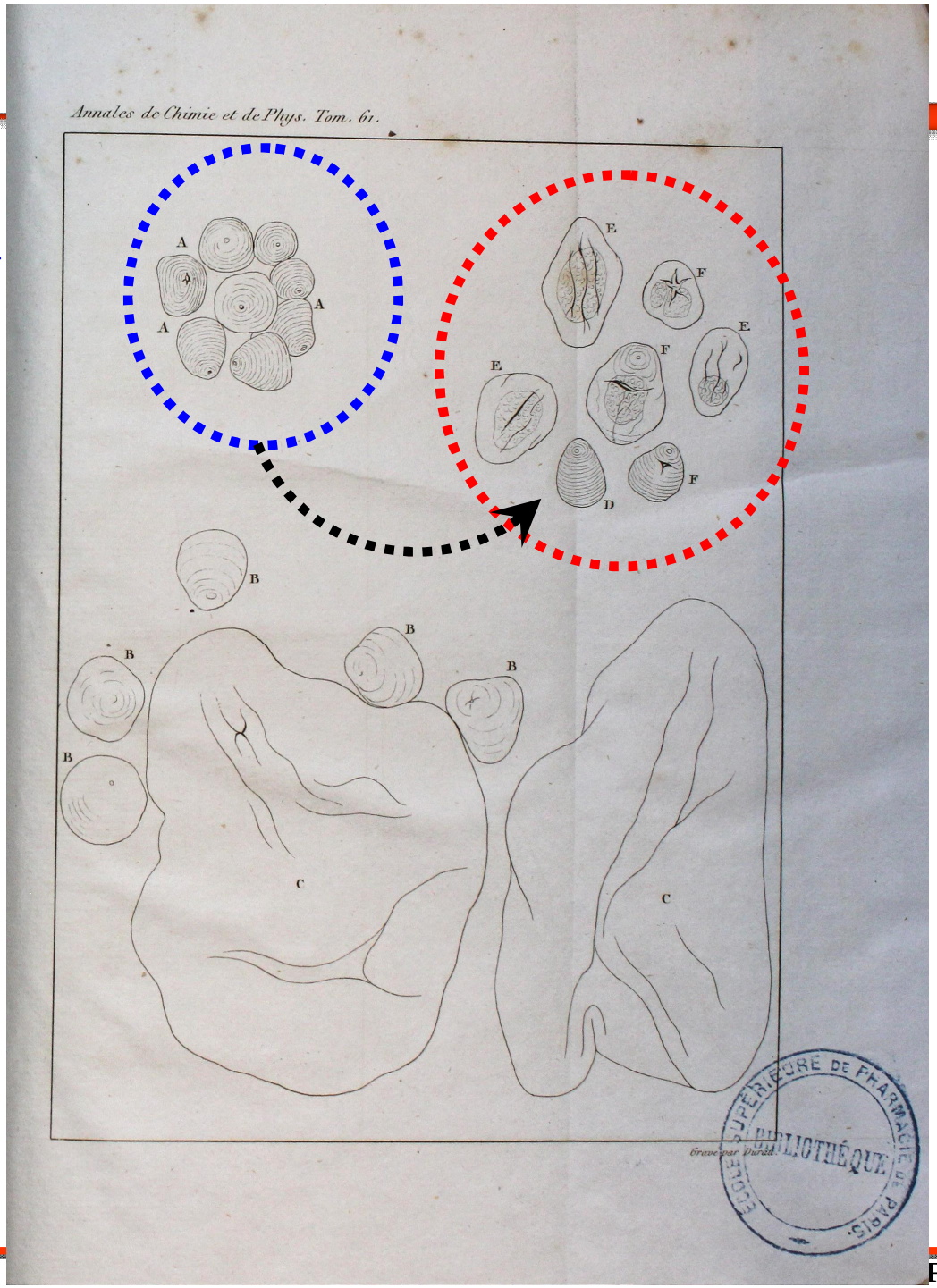
scope

uncooked starch granules in water



swollen starch granules after heating in water

Payen / Annales de Chimie et de Physique 61 (1836) 355-374

scope

- **theories and reviews about starch transformation**
  - ✓ ...gelatinization & sequence of phase transitions
    - e.g. Ratnayake and Jackson (2008)
  - ✓ ...retro-gradation (...different meanings)
    - e.g. Matignon and Tecante (2017)

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- **swelling of starch suspensions under heat treatment**
  - ✓ ...rheological behavior of many food products
  - ✓ ...difficult subject: transient phenomena

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- **swelling of starch suspensions under heat treatment**
  - ✓ ...rheological behavior of many food products
  - ✓ ...challenging subject: transient phenomena
- **in this study:**
  - ✓ **diversity of granules size along their thermal history**
  - ✓ **diversity of temperatures at the swelling onset**

this presentation

- scope 
- methods
- diversity of thermal histories
- swelling onset and initial granule size
- influence of granule orientation (...?)
- summary and future work

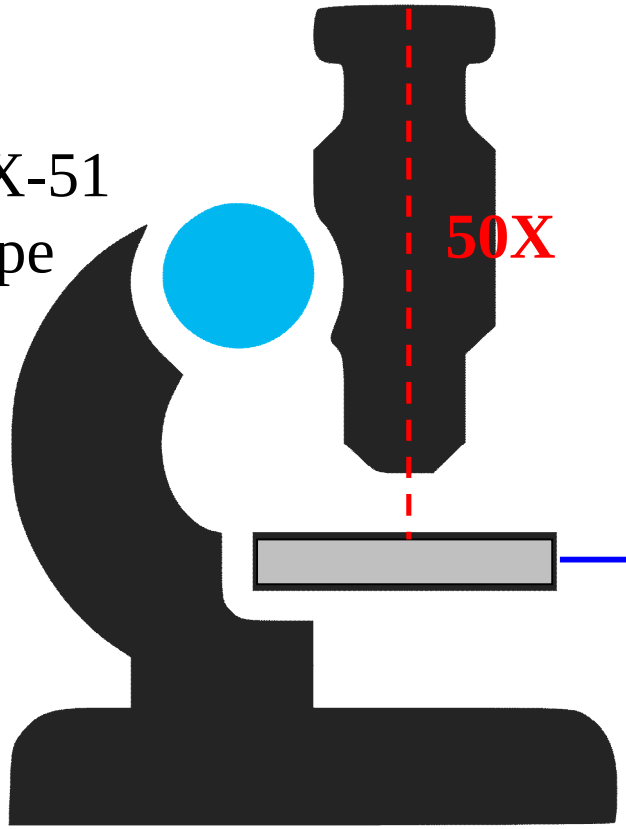
methods

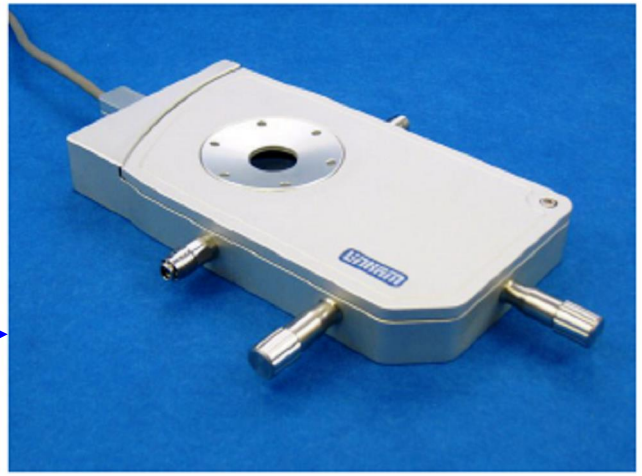
- **hot-stage microscopy**

Basler A102fc digital camera

0.5 mL of modified waxy maize starch suspension (5 g/kg)

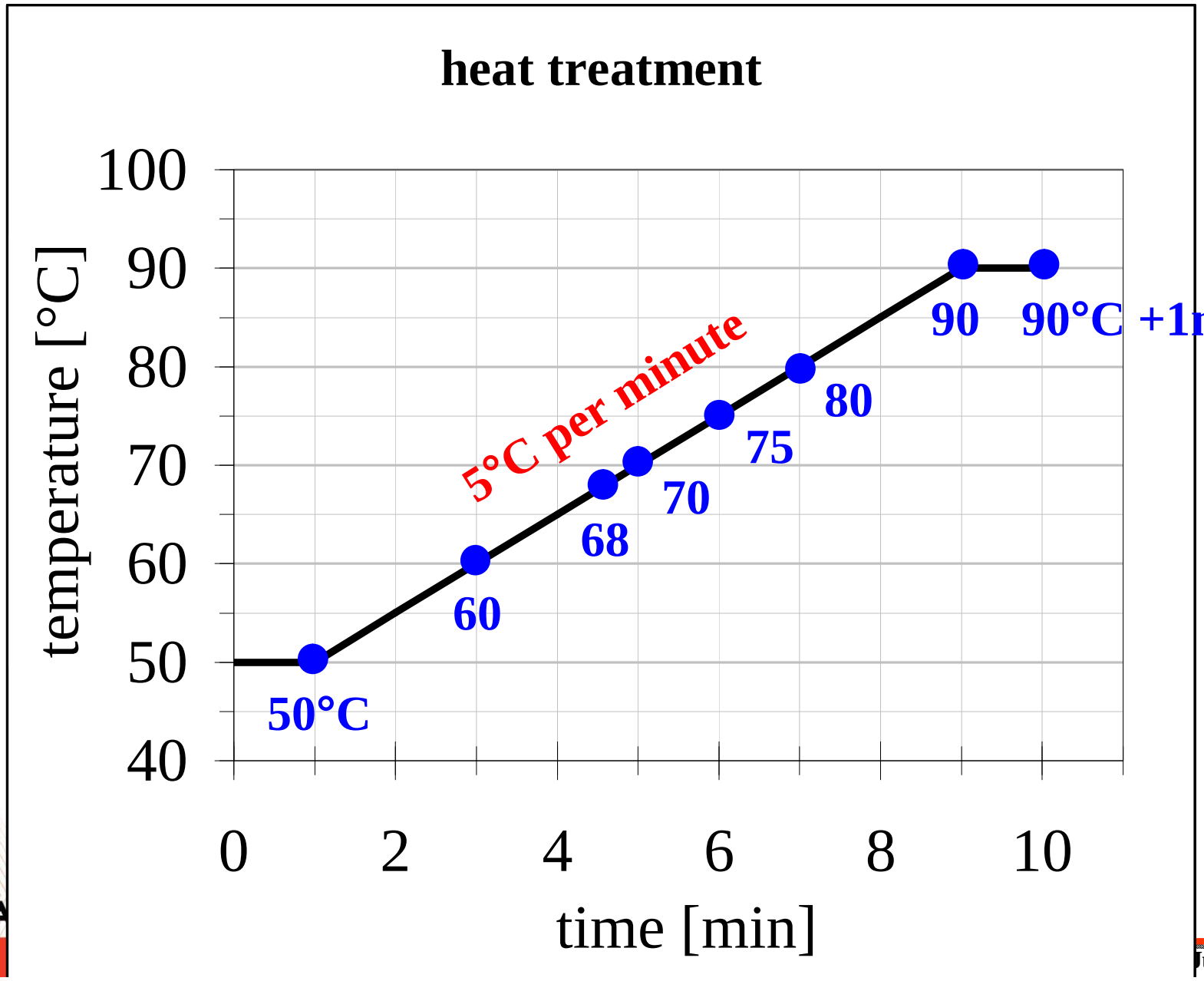
Olympus BX-51 microscope





Linkam LTS120 stage

methods


heat treatment
temperature [°C]
100
90
80
70
60
50
40
0
2
4
6
8
10
time [min]
5°C per minute
50°C
60
68
70
75
80
90
90°C +1min

methods

heat treatment

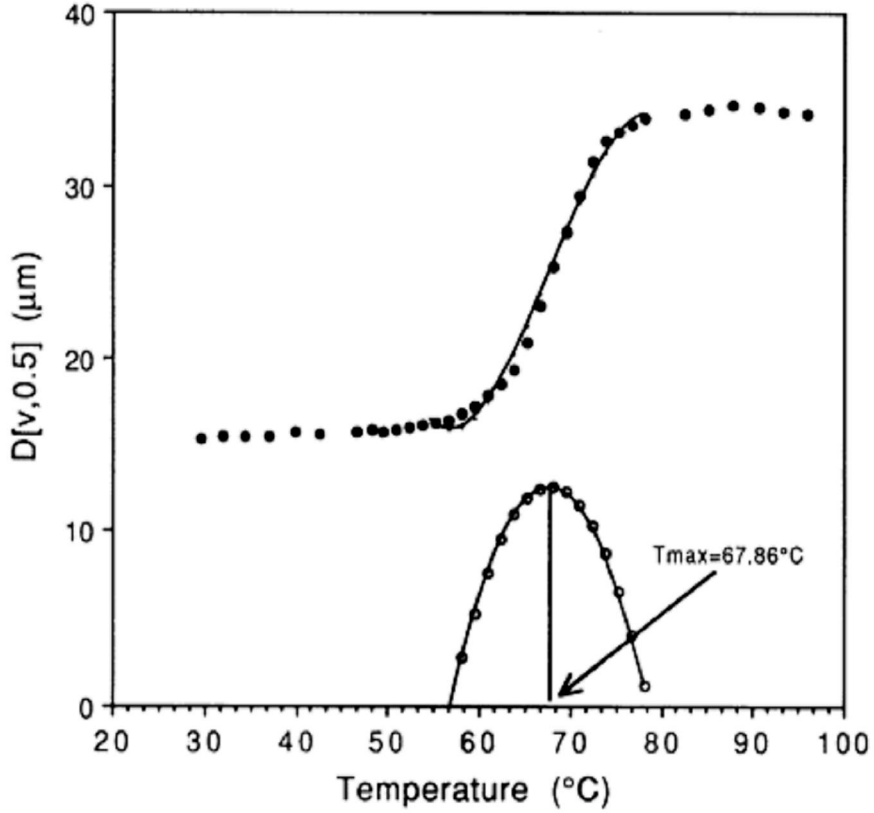
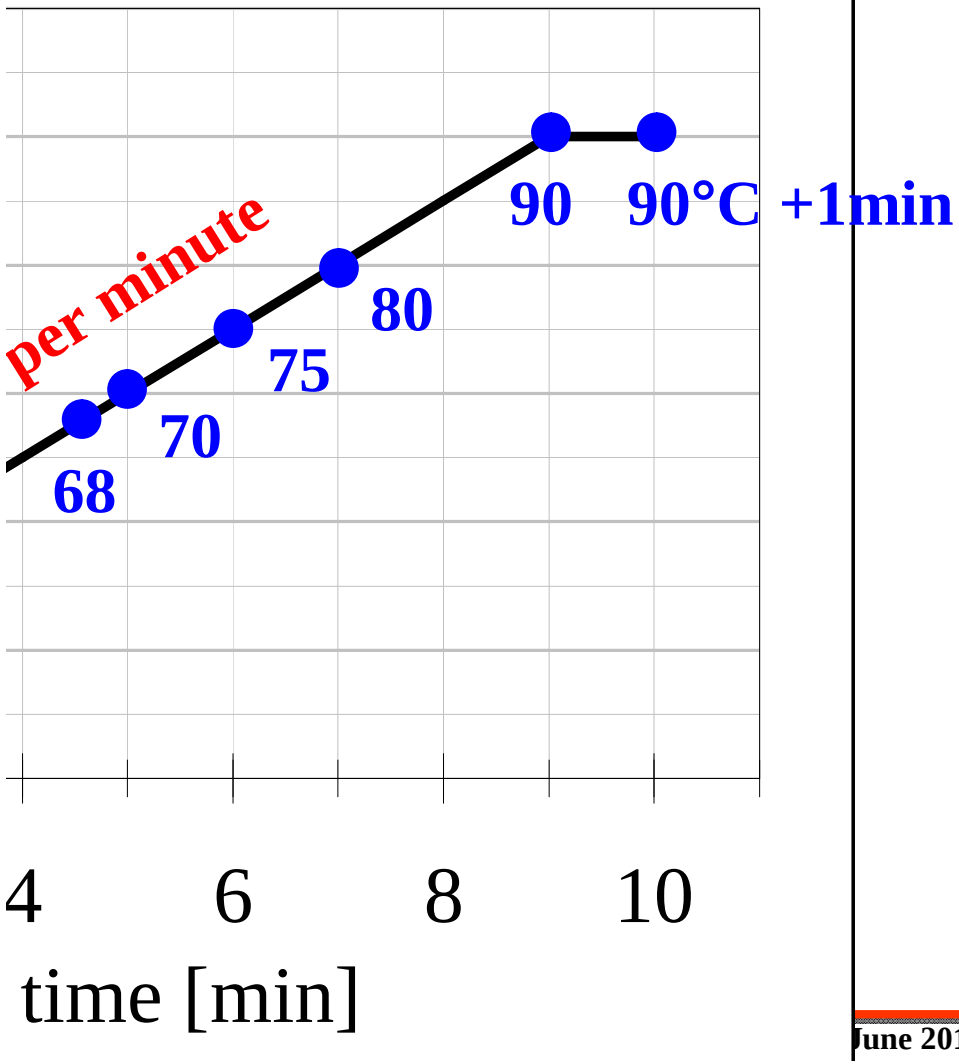
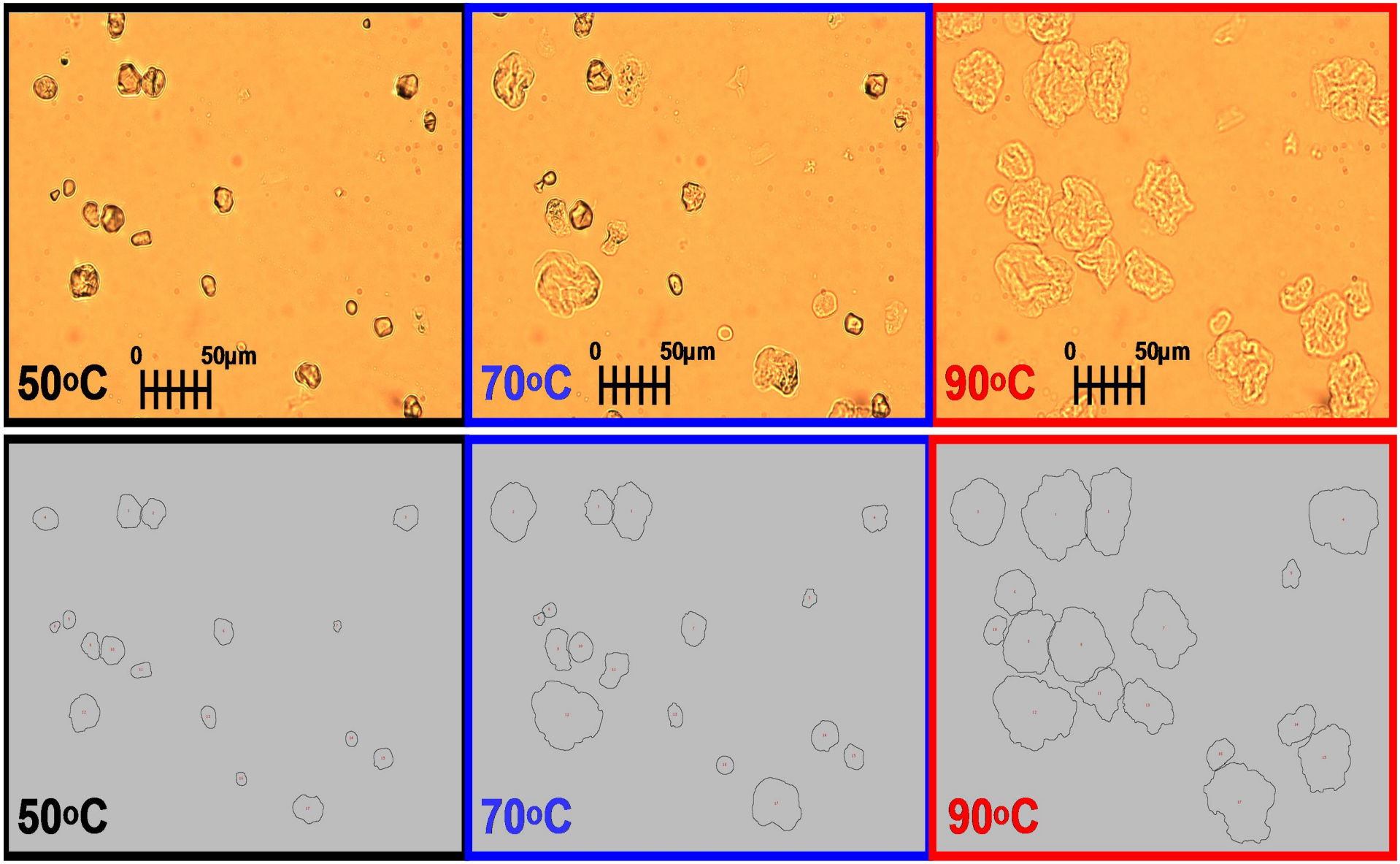


Fig. 4. Determination of T_{max} for starch swelling from diameter-temperature data (●) for a sample of common corn starch heated at 4.8°C/min. R^2 for the 3rd order polynomial regression of $D[v,0.5]$ vs. temperature was 0.993. ○ = 1st derivative of the polynomial.



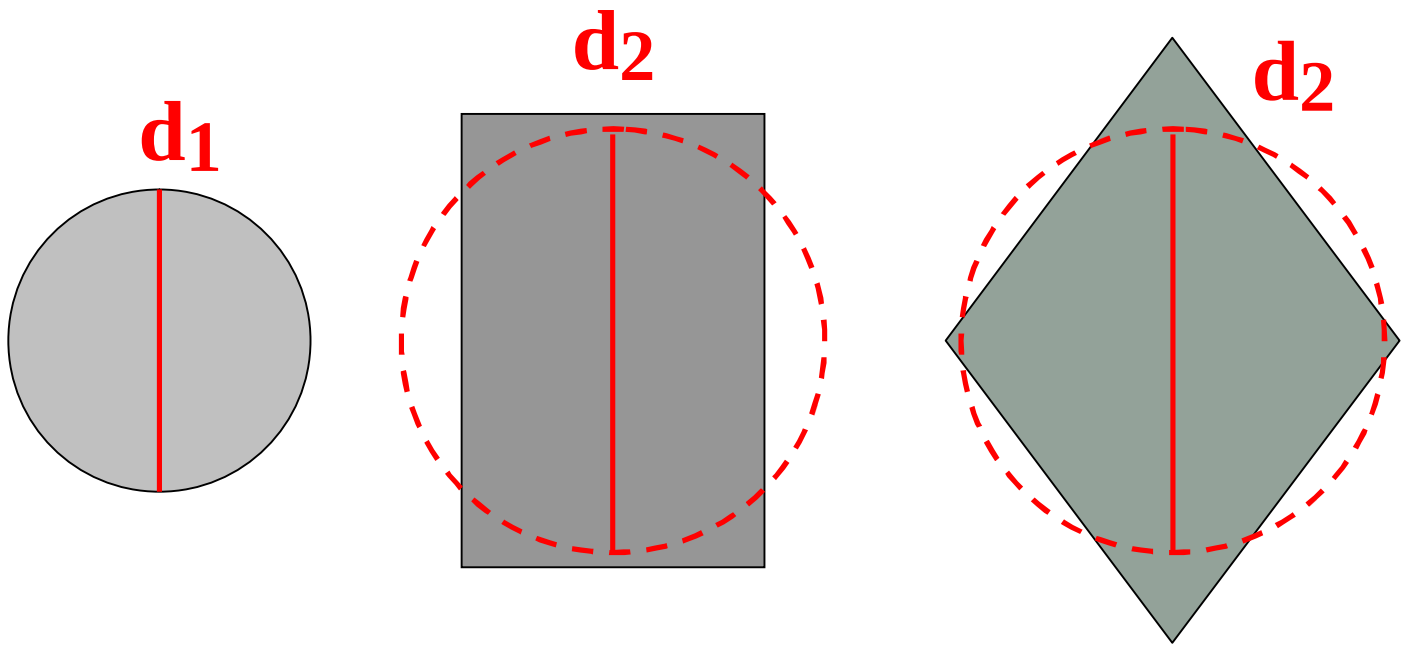
Ziegler et al. (1993)

methods

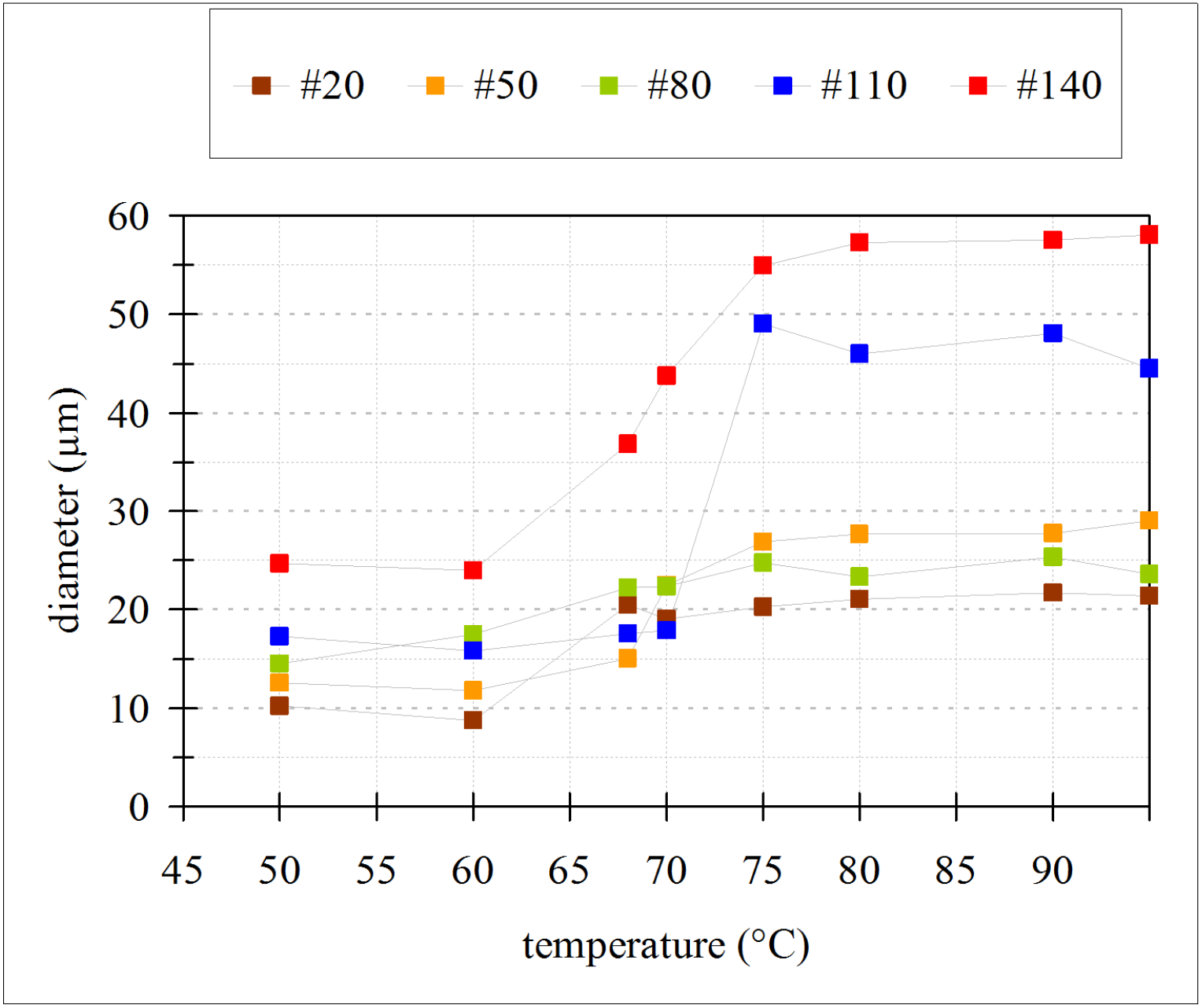


methods

- **measure of starch granule (apparent) "size"**
  - ✓ software Image-J estimates the granule mean diameter from its apparent surface



diversity of thermal histories



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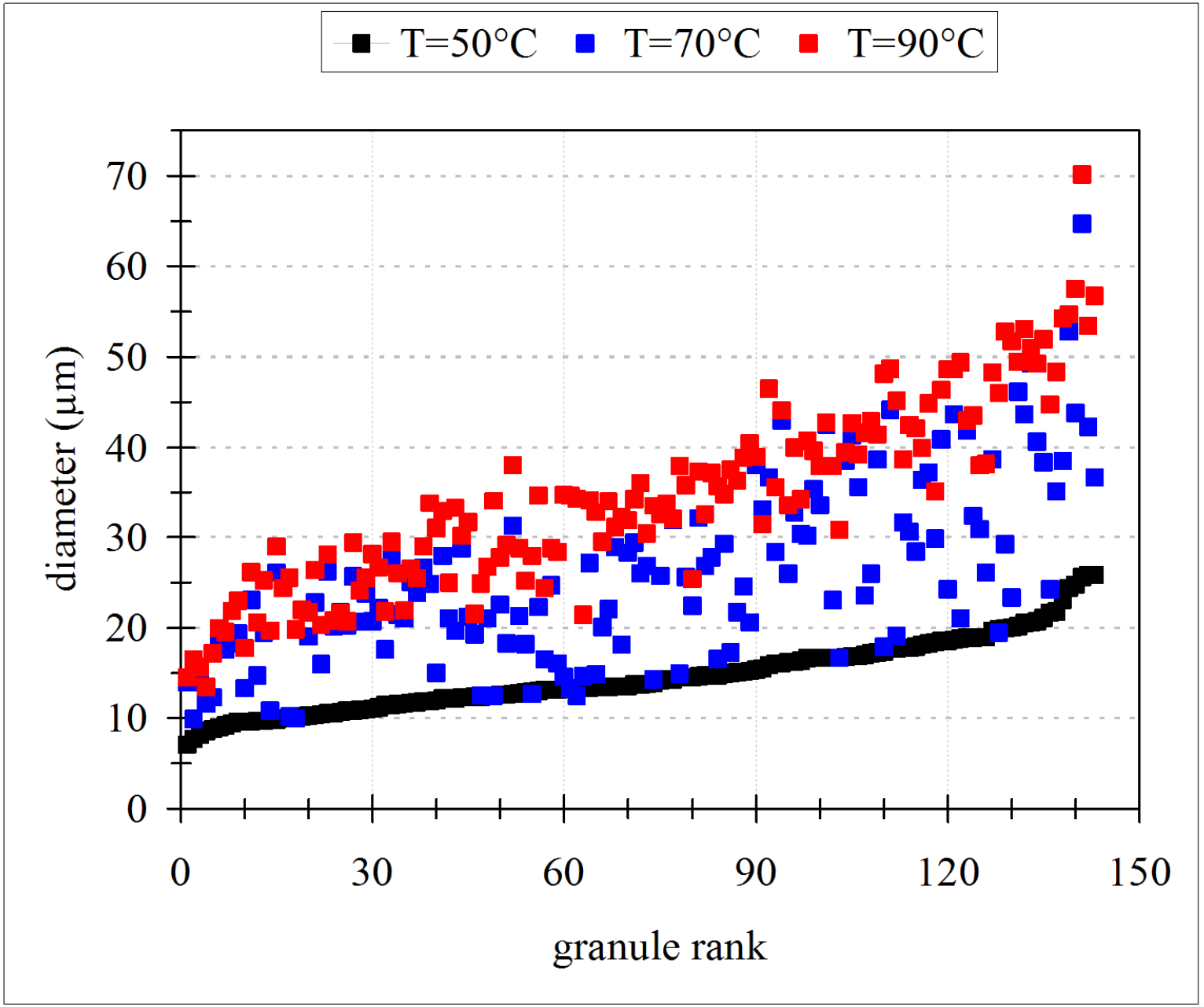
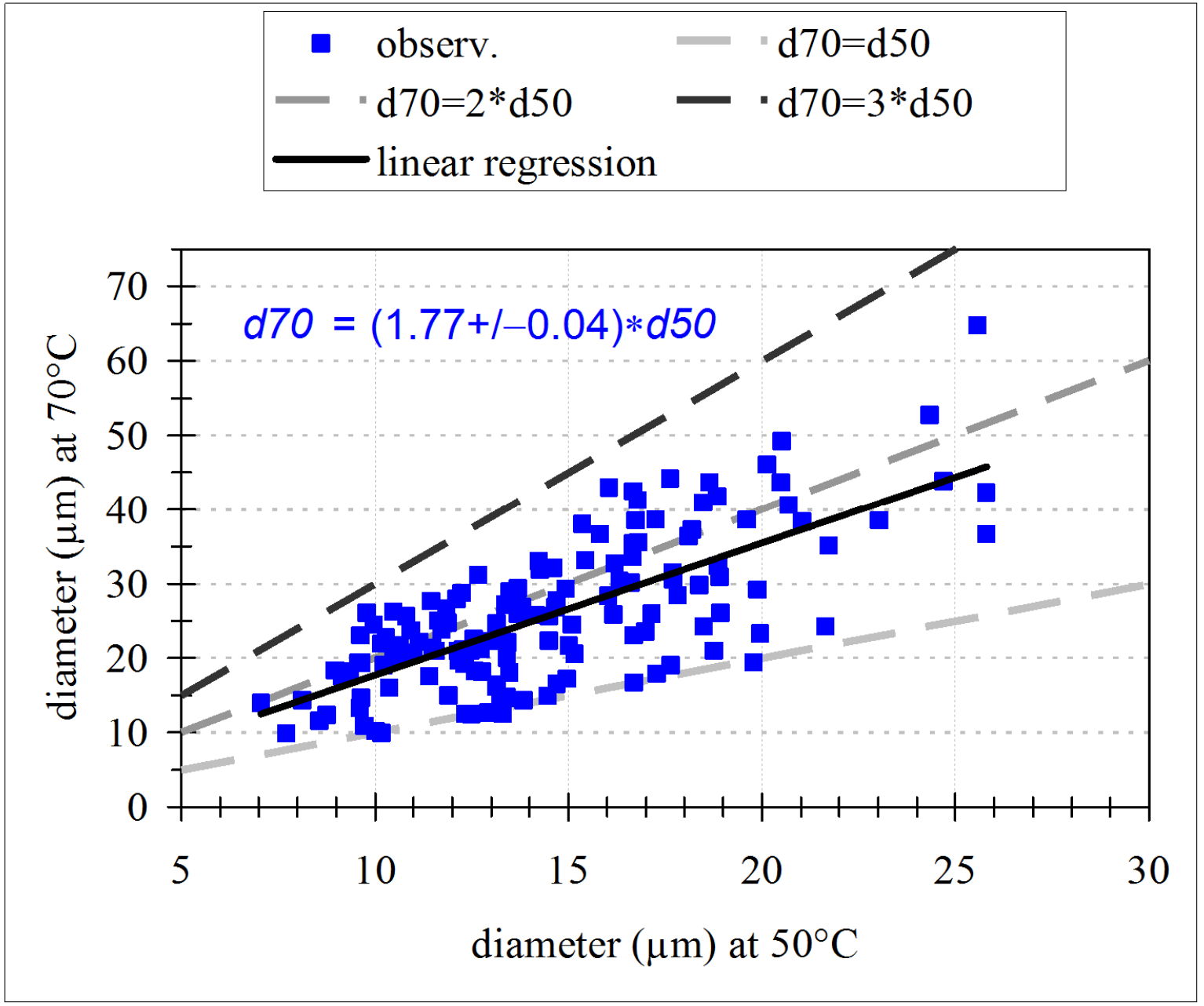


swelling onset and initial granule size



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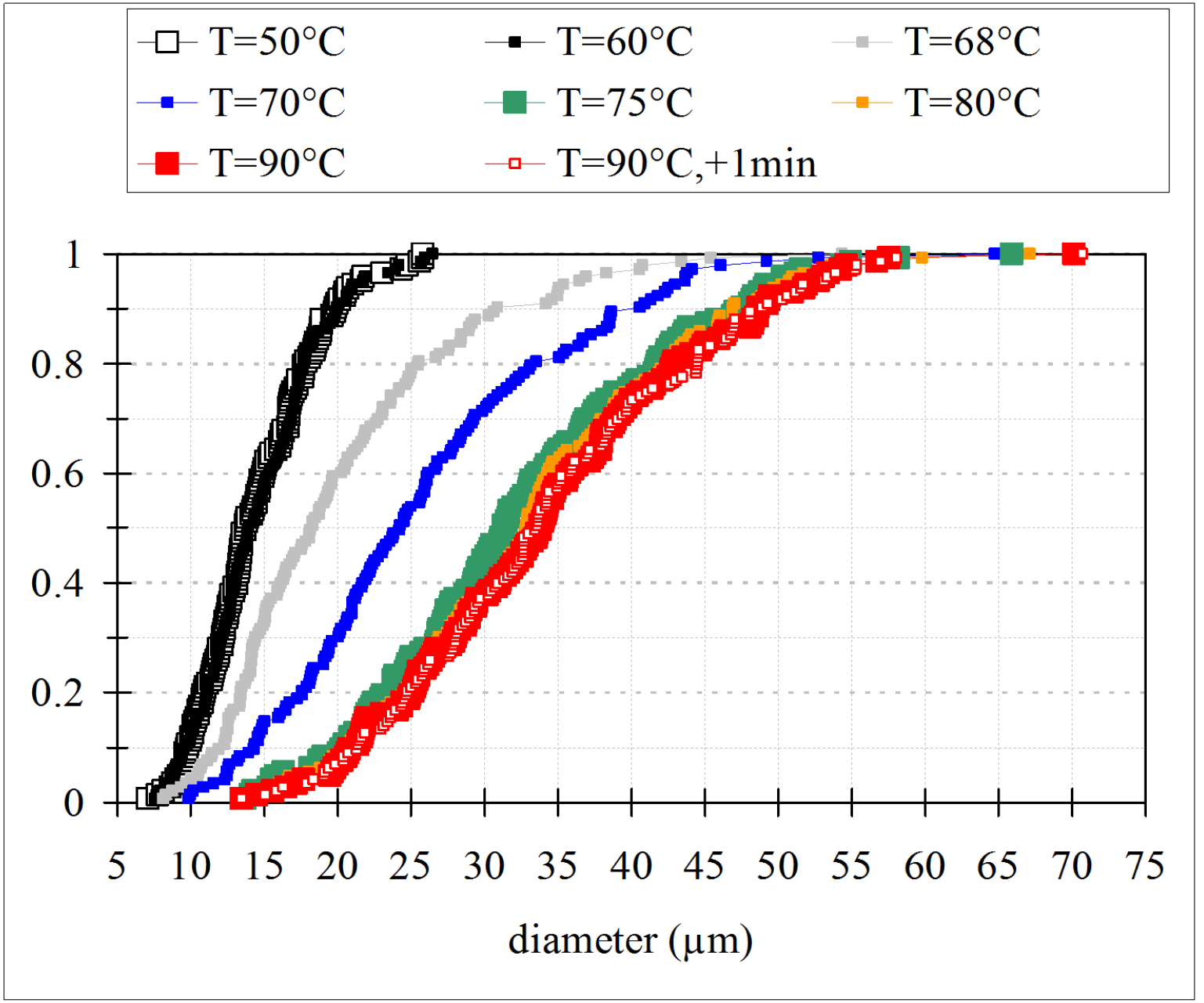
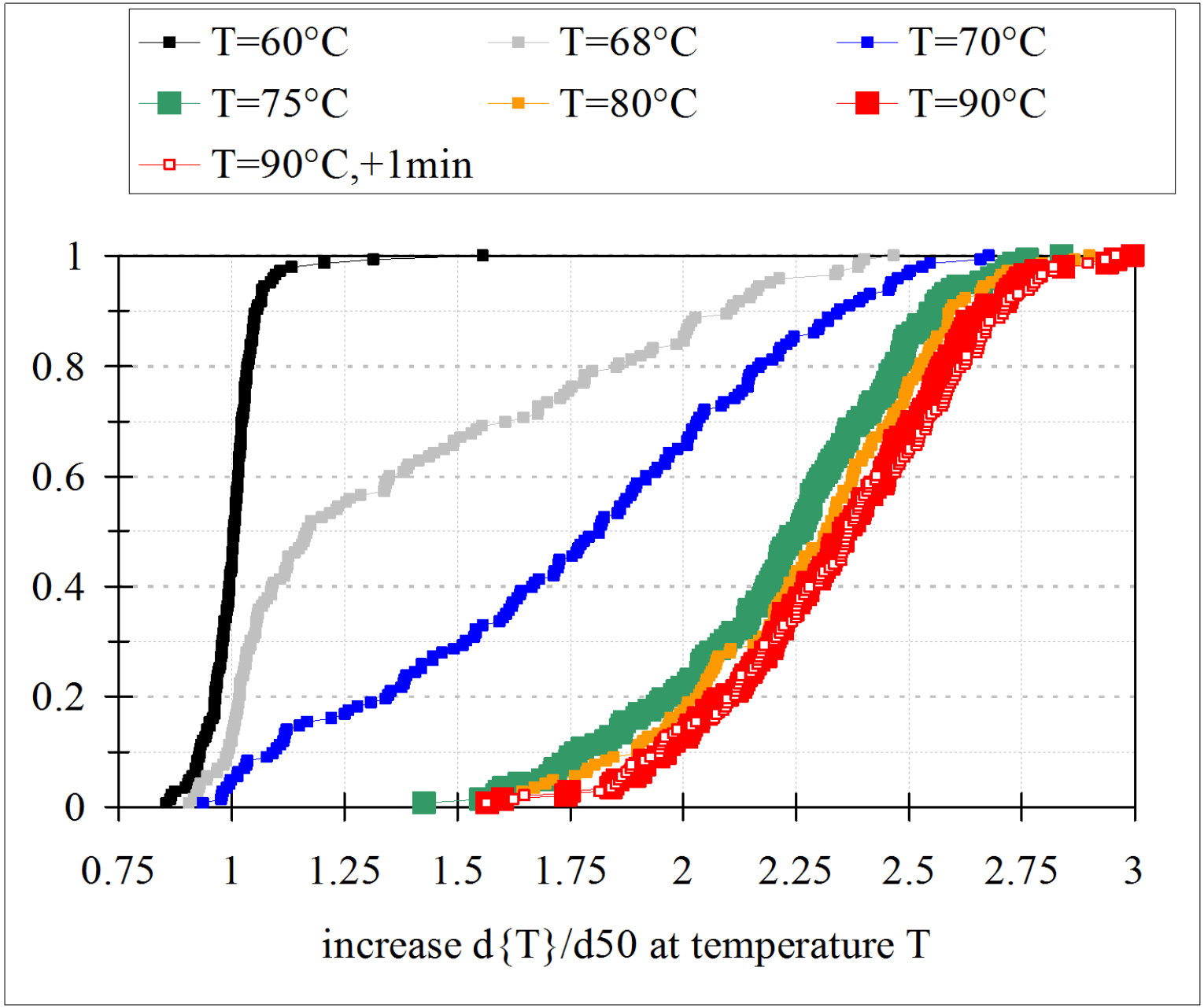
swelling and granule size



swelling and granule size increase



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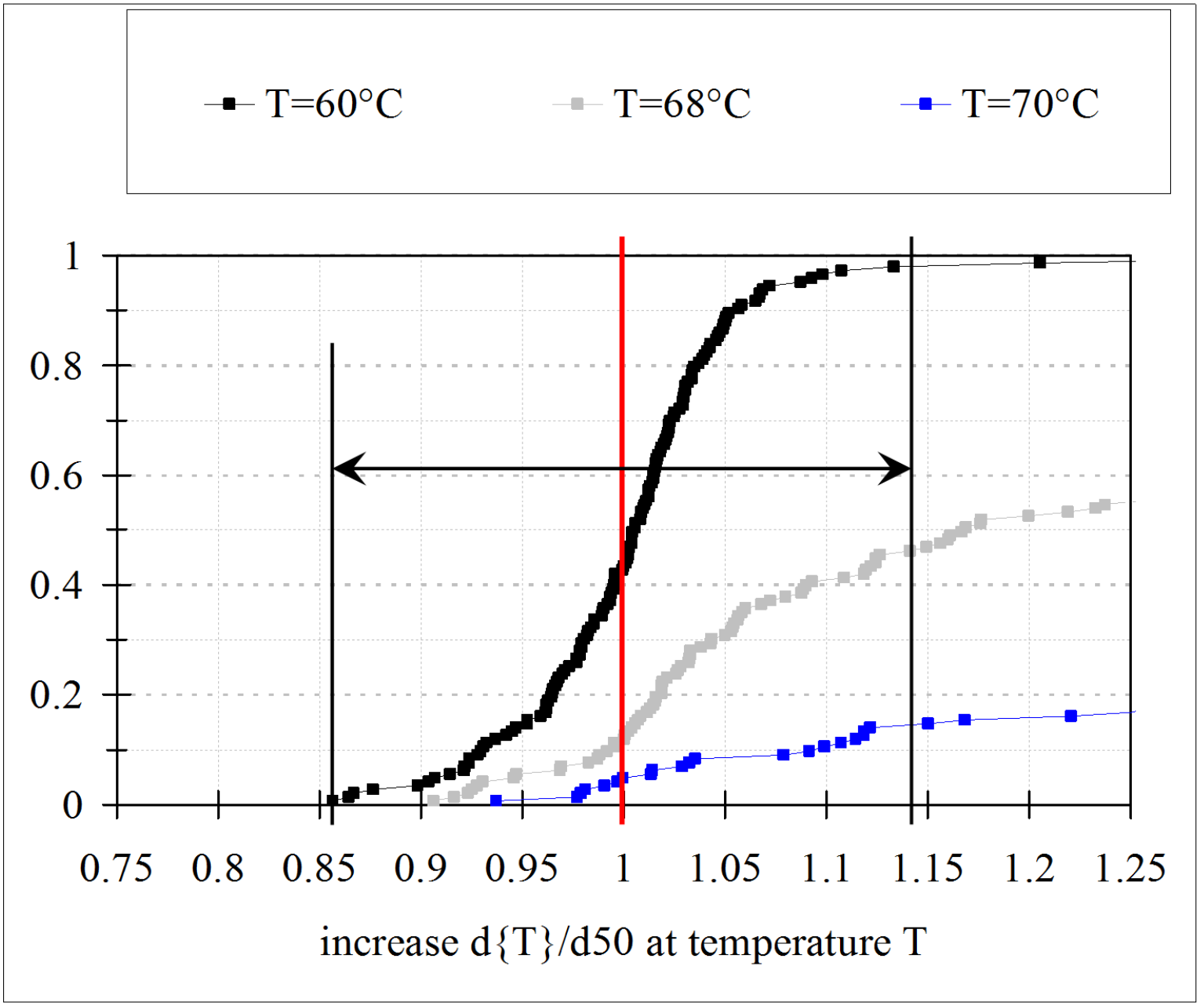
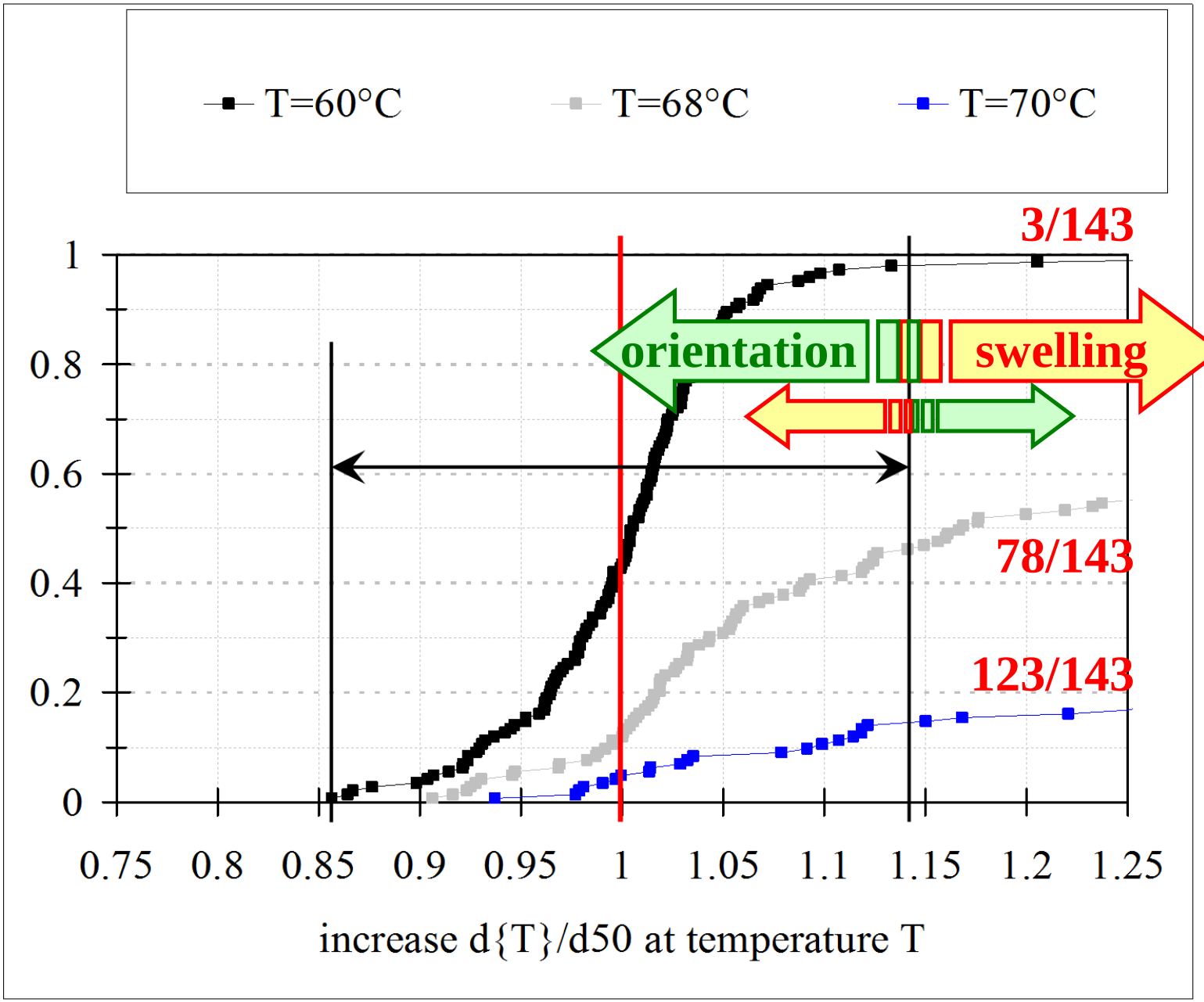
swelling and granule size increase



influence of granule orientation (...!!!)

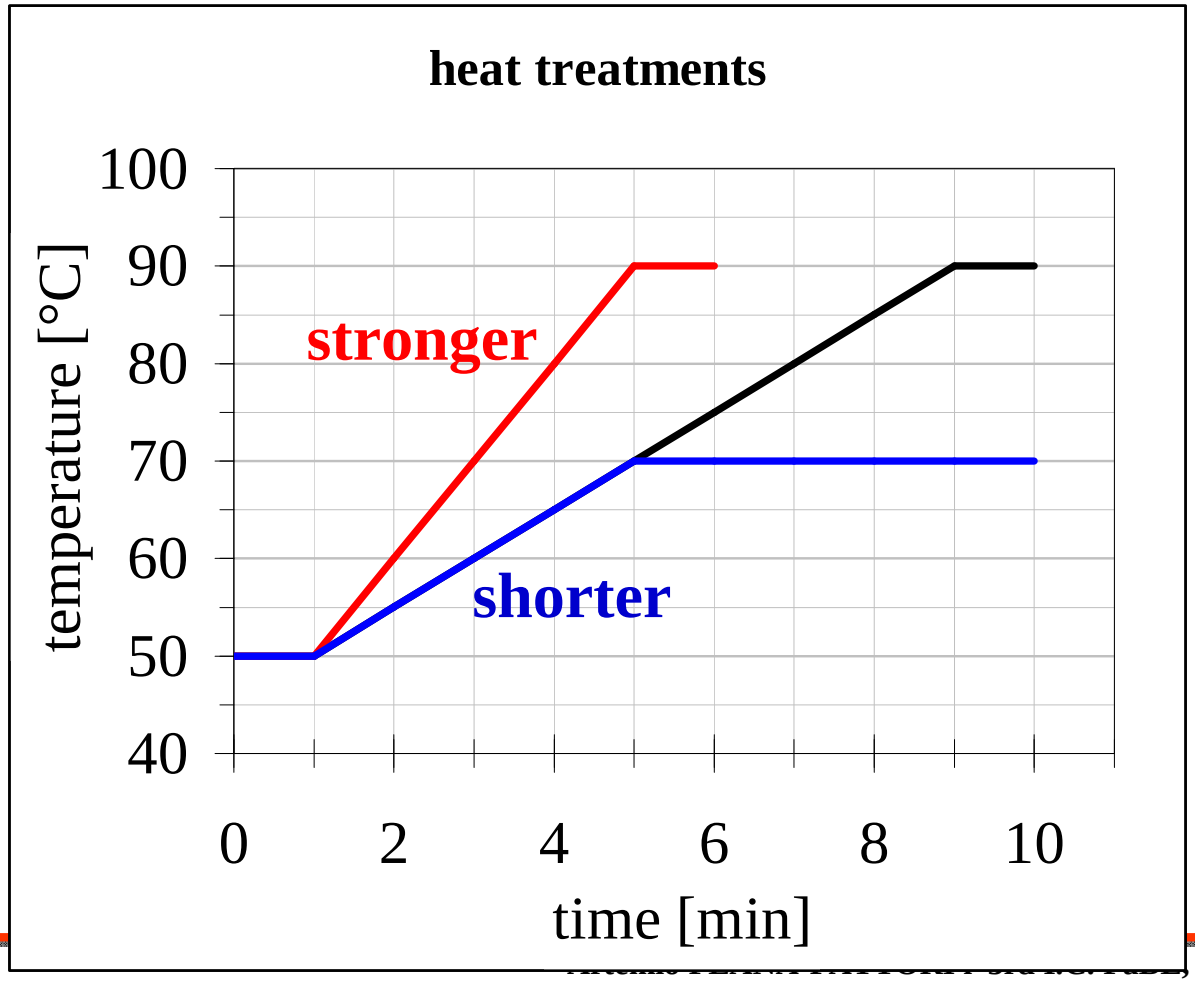


summary and future work

- summary:
- changes in the starch swelling state were relatively weak below 60 ºC and above 80 ºC (as expected)
- occurrence of uncooked and swollen granules at intermediate temperatures, simultaneously
- no relationship was found between initial granule diameter and swelling onset temperature

❑ future work:

✓ to assess the influence of heating rate and duration



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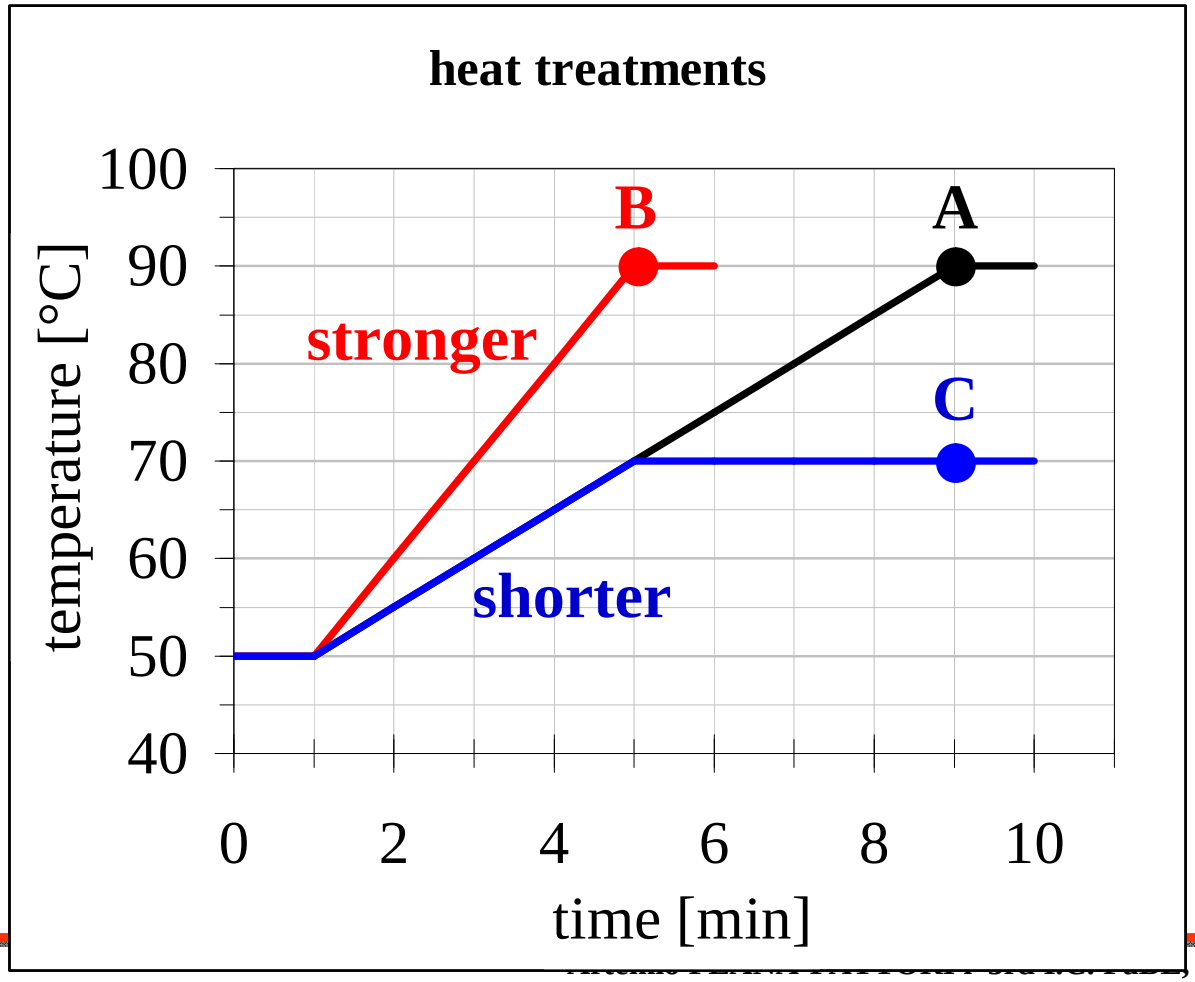

❑ future work:

- ✓ to assess the influence of heating rate and duration
- ✓ to model the influence of granule orientation on observations