Modeling the drying and sorption behaviour of yam (*Dioscoreaceae rotundata*)

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3rd International Conference and Exhibition on Food Processing and Technology, Las Vegas, USA

July 21-23, 2014

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Drying of yam

- Yam is an important food crop for many people in the yam zone of West Africa
- MC: about 70%
- Uses: when boiled, roasted or fried
- Losses: 10-50%
- Production: Ghana is a main producer (third to Nigeria)
- Export: Ghana is leading in West Africa

Yam as a food product

- Nutrition:
  - 4 times more protein as in cassava
  - the only root crop that exceeds rice in protein
  - overall rating of essential amino acids relatively high and superior to sweet potato

- Drying into powders may increase its variability of uses
  - In soups
  - composite products
  - baby foods

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Drying properties

- Moisture fits: Classical empirical/black-box models are often used
    - High R-square values
- The challenge: To understand moisture transport

- Is a mass driven equation an option?

Sorption isotherms

- Indicates equilibrium conditions of a food product under varying conditions of RH and temperature
  - useful for optimization
  - design of drying equipment
  - predictions of quality parameters
  - shelf-life study
  - storage investigations.

- How is it affected by temperature?

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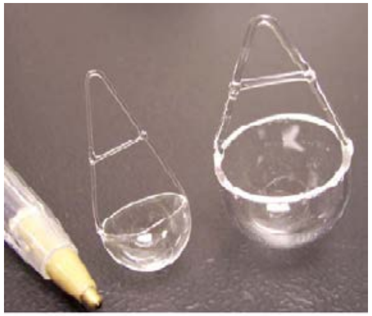
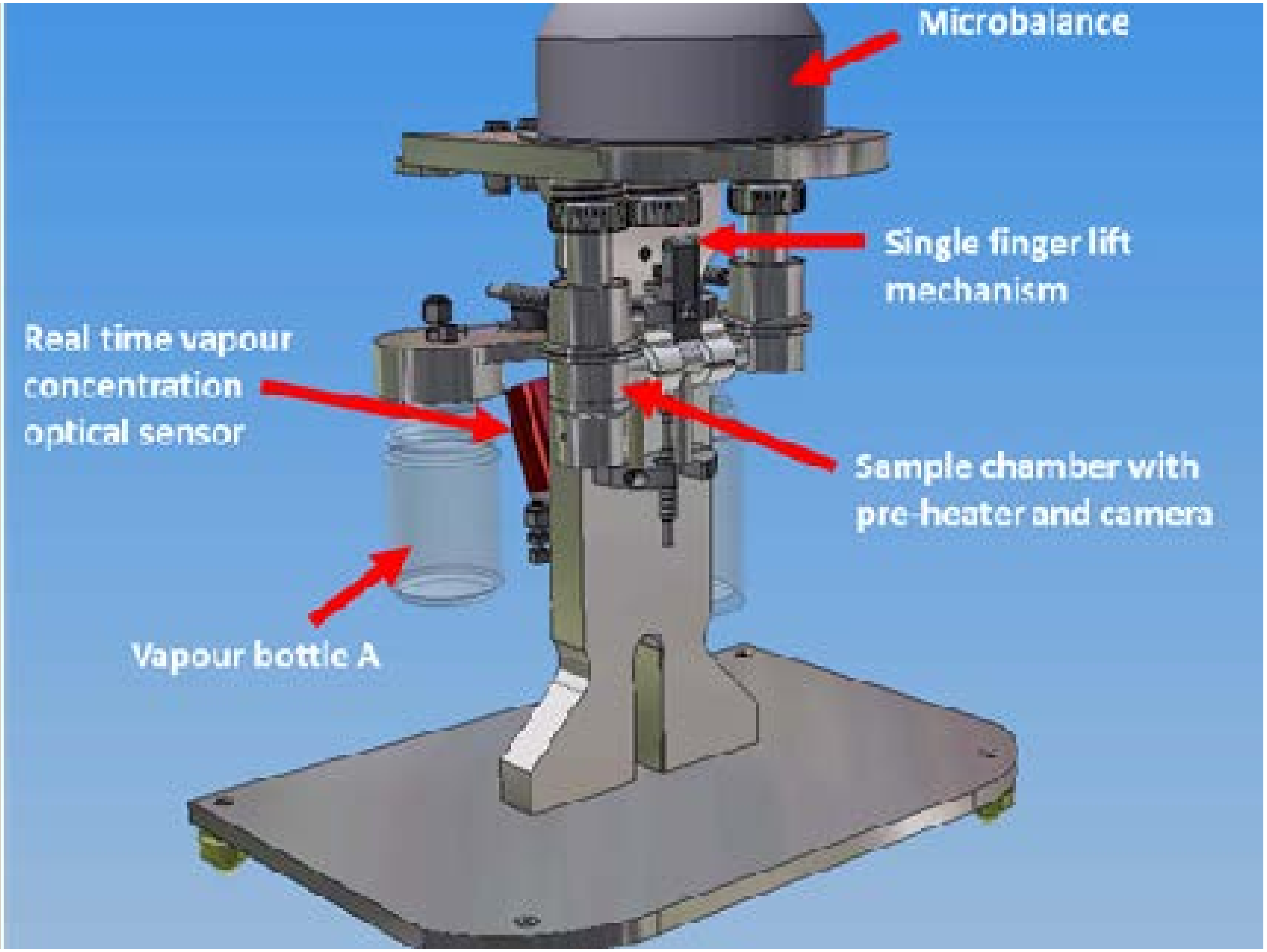
Dynamic Vapour Sorption analyser (DVS)





Sorption model

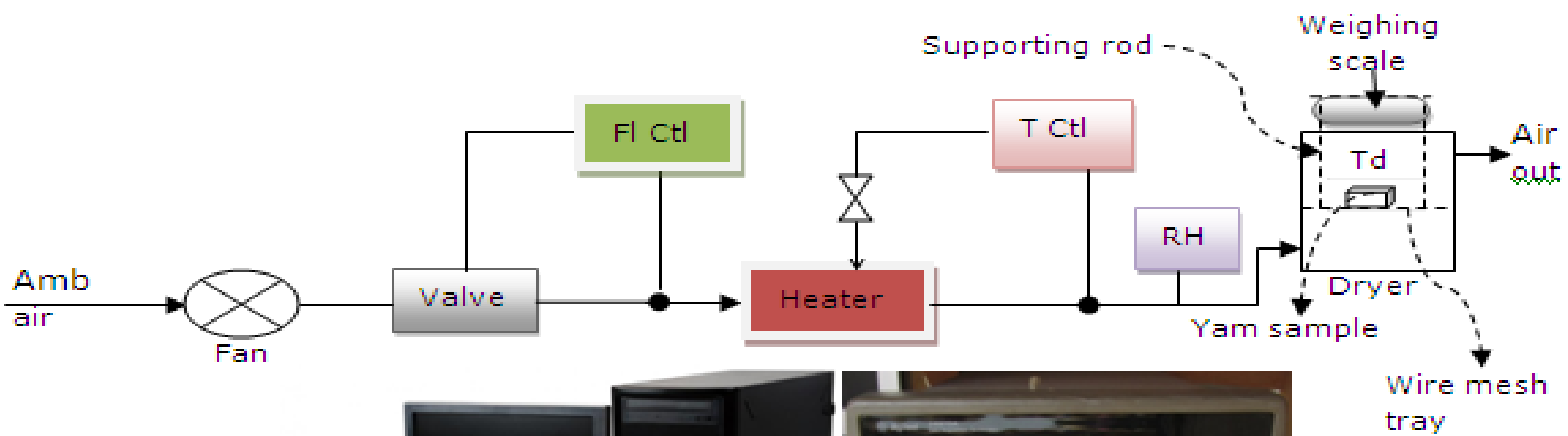
- *Sorption*
  - Henderson, Halsey, Oswin and GAB equations

  - *The GAB equation is*

$$\mathrm{X_e} = C_1 C_2 C_3 RH[(1 - C_2 RH)(1 - C_2 RH + C_2 C_3 RH)\,]^{-1}$$

Drying rate measurements

- Yam variety and cultivar: *D. rotundata, Dente*
    - *Cut size: 3x3x1 cm*
- *Drying procedure/ equipment*



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Drying model

Diffusion

$$\frac{dX}{dt} = D\frac{d^2X}{dx^2}$$

Approximated by

$$MR = \frac{X - X_e}{X_0 - X_e} = \frac{8}{\pi^2}\exp\left(-\frac{\pi^2}{L^2}Dt\right)$$

Specifying the drying rate as

$$drying\ rate = \frac{dX}{dt} = -k(X - Xe)$$

Gives

$$\frac{X - X_e}{X_0 - X_e} = \exp(-kt)$$

Then $k \approx \frac{\pi^2}{L^2}D$

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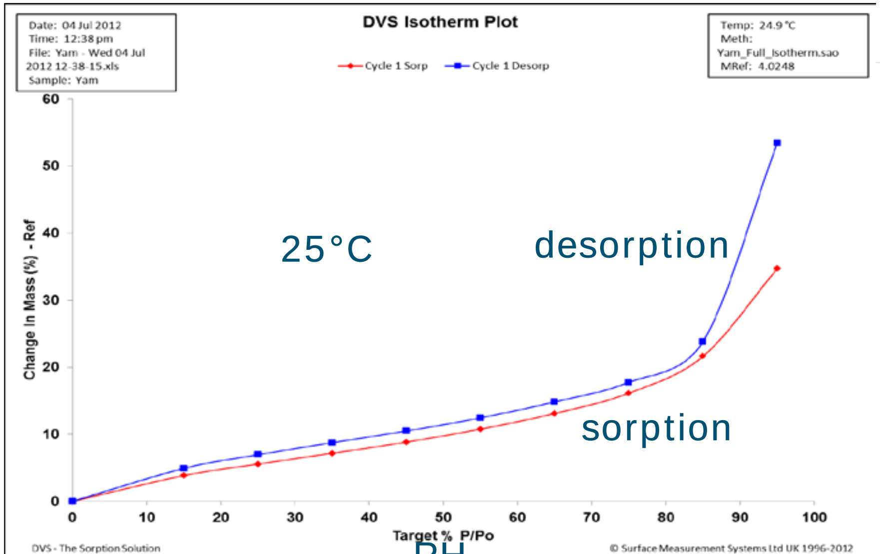
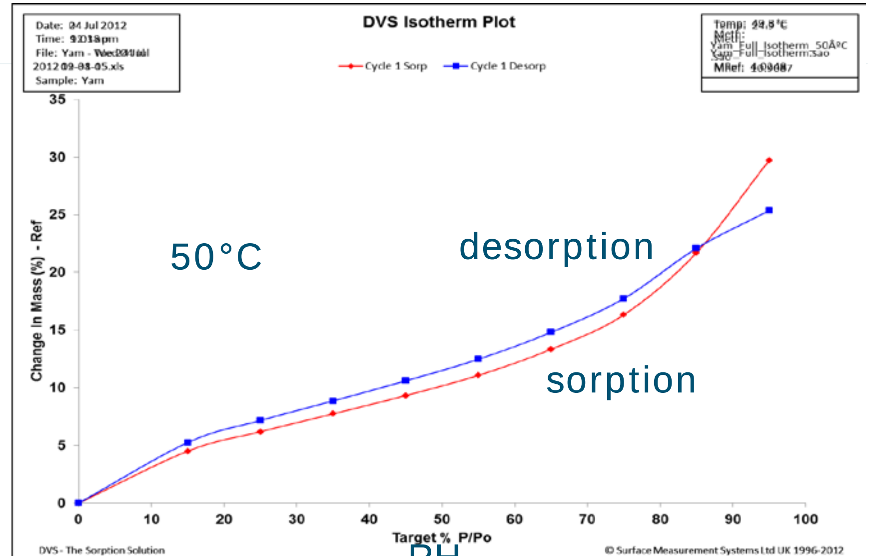
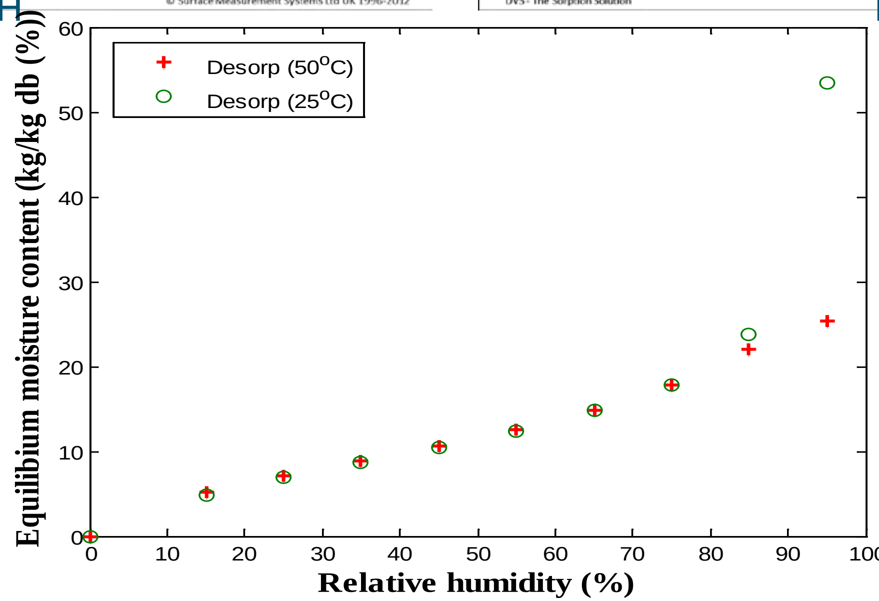
Results on sorption isotherms







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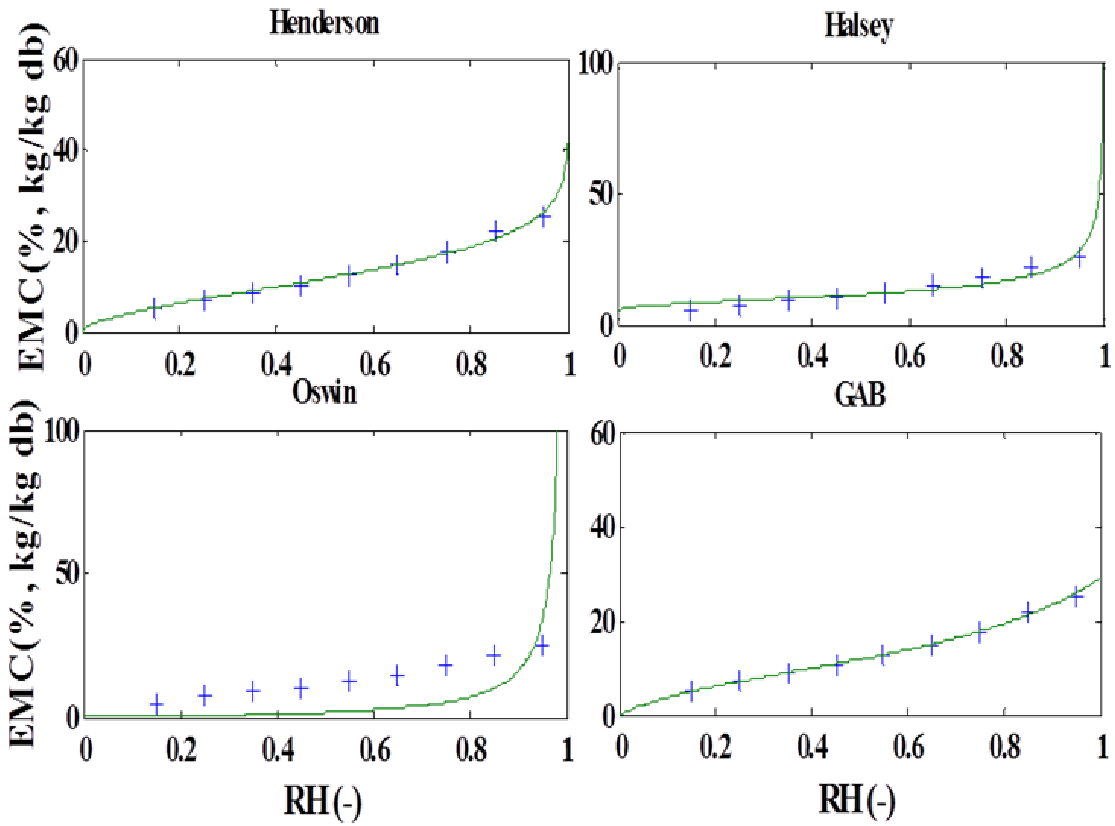
Sorption curve model



At 50°C	C_1	C_2	C_3	K	n	MSe
GAB	8.28	0.76	10.14	-	-	0.0027
Henderson	-	-	-	0.012	1.65	0.09

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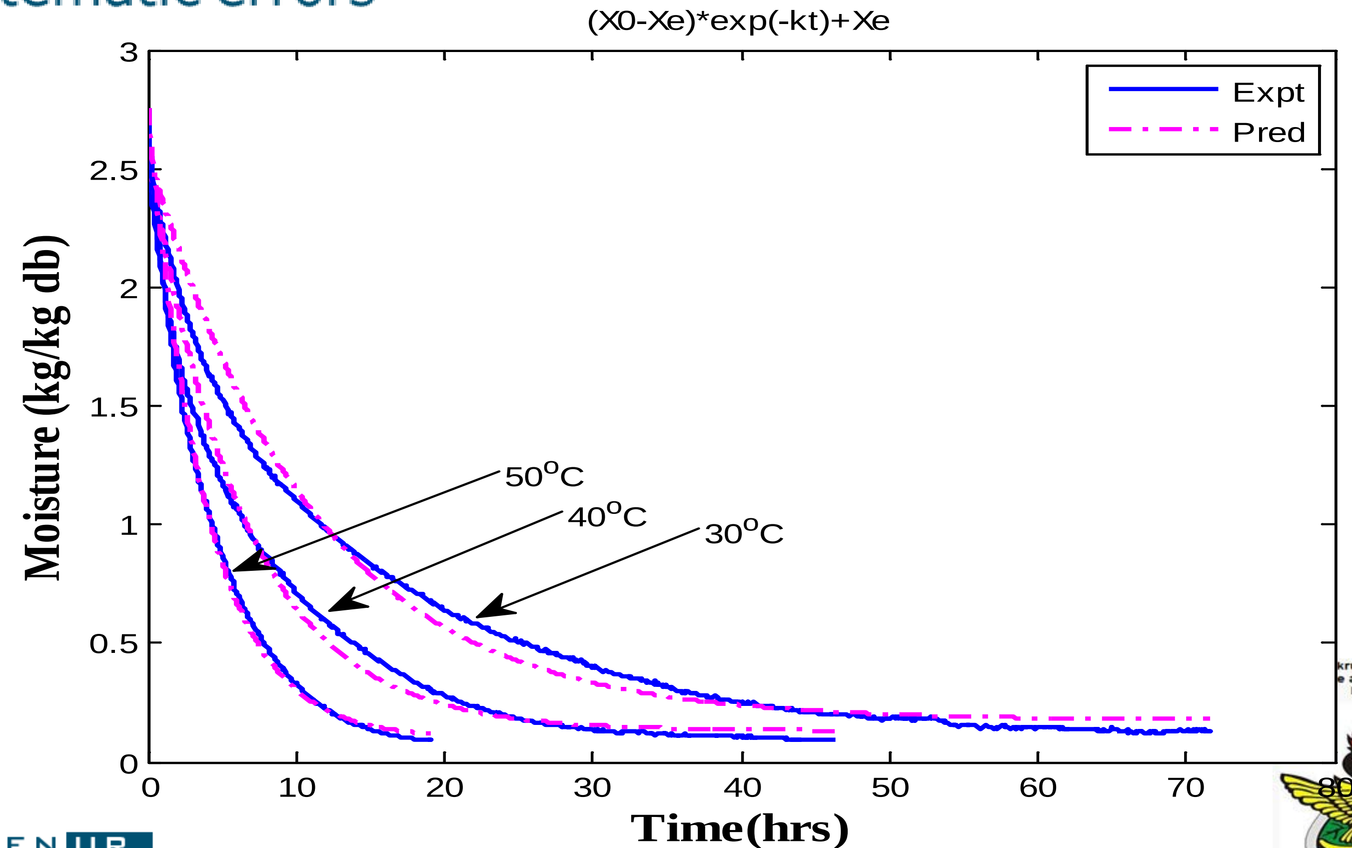
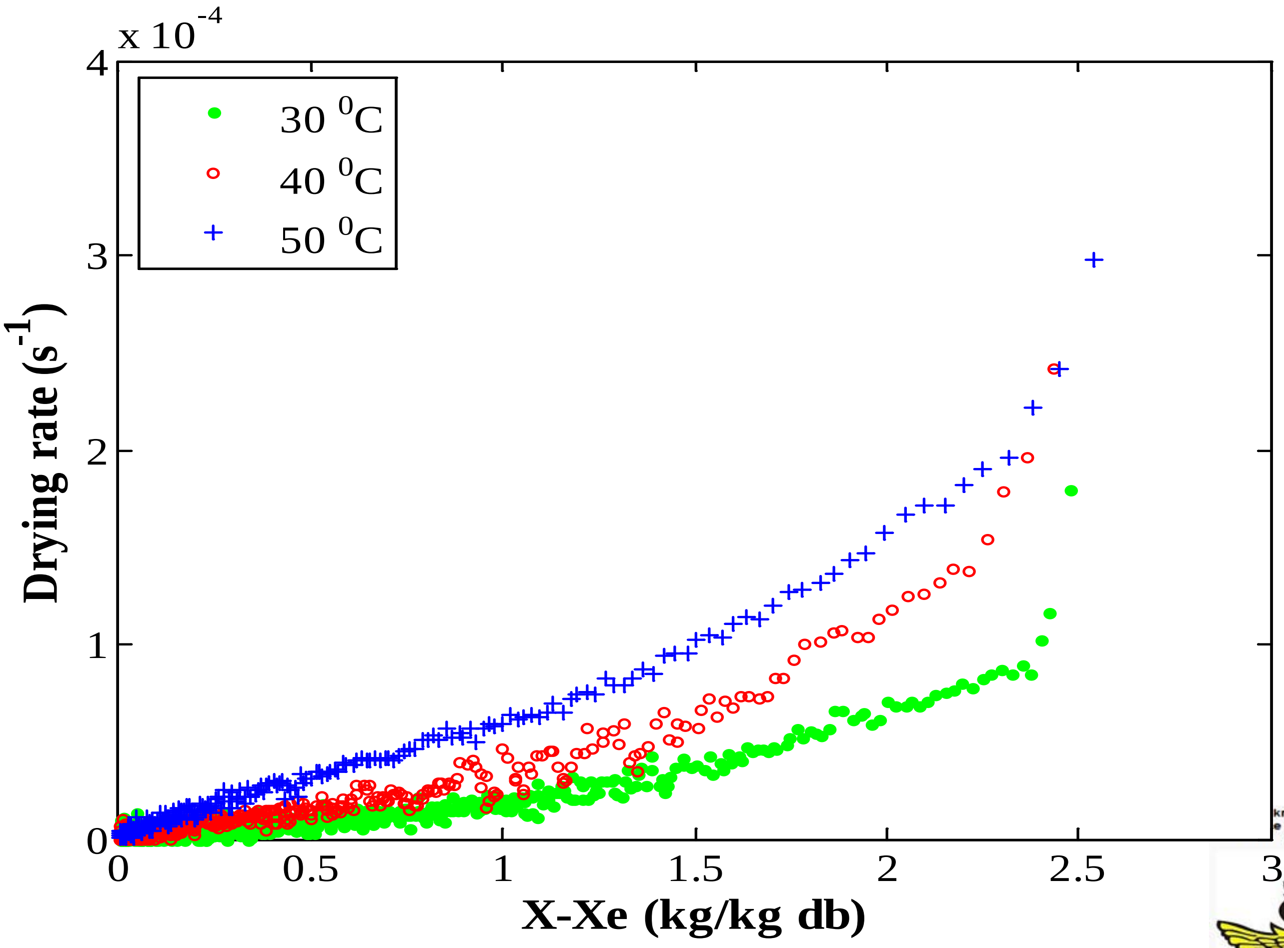
Drying model

- Using $$\frac{X - X_e}{X_0 - X_e} = \exp(-kt)$$
- R-square values ≈ 0.995 are good…
- … but systematic errors



Drying rate Vs moisture

$$\frac{dX}{dt} = rate = -k(X - Xe)$$



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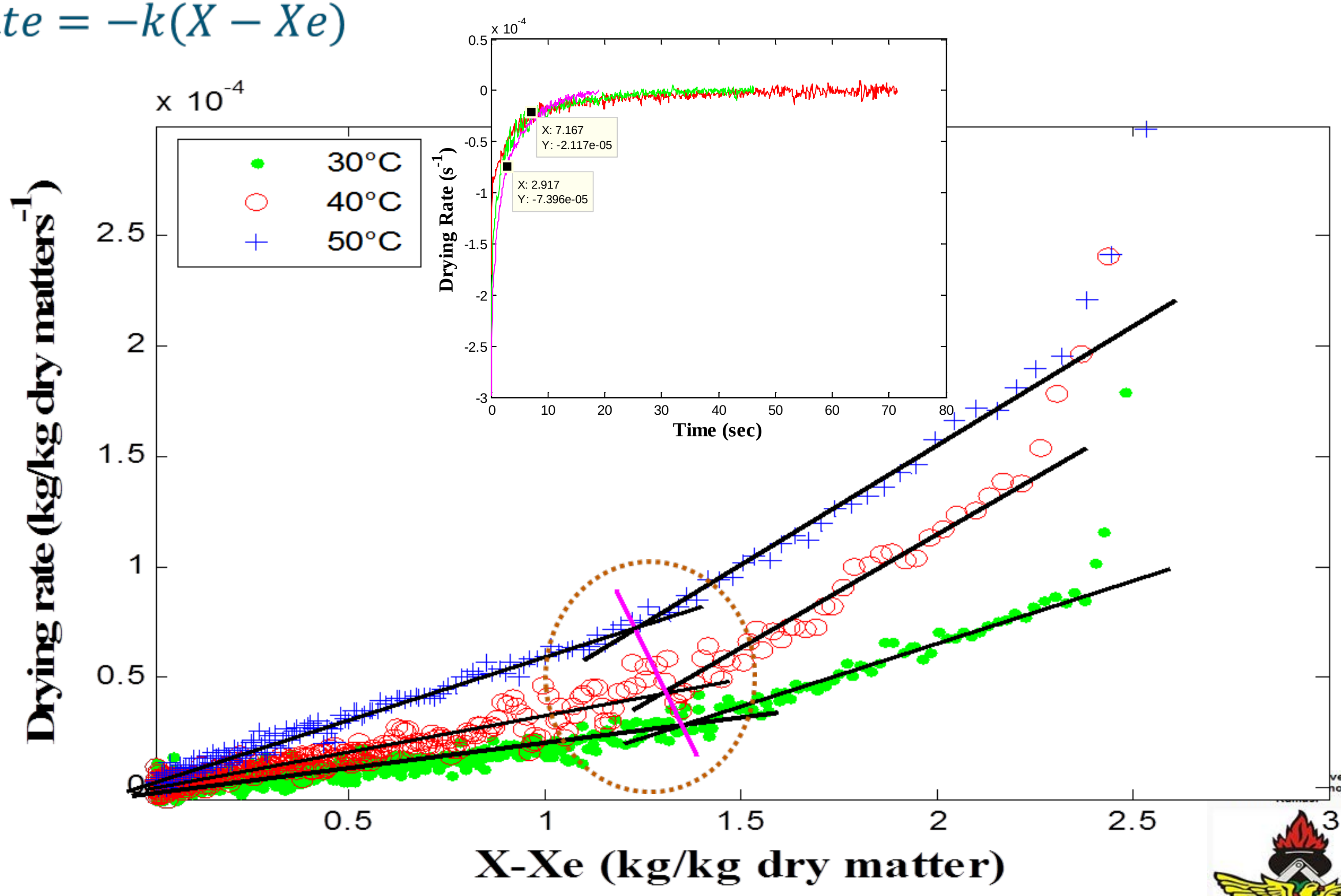

Cont. drying rate

- Rate, k is not constant
- This behaviour could not be detected by the empirical models
- Region of phase transition is well defined
- Probably may be the glass transition region coupled with shrinkage
- There is progressive increase in temp with decreased moisture content

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Conclusion

The present work reveals that:

- Both drying rate and diffusion approximation models exhibit two drying phases with a shift between 1.2-1.3 kg water/kg dry matter.
- This can be explained from shrinkage behavior of yam during drying
- There was no shift in EMC at different temperatures as reported in literature.
- The GAB model fitted well the sorption isotherms

Thanks for your attention

This work is sponsored by Wageningen University Research Center (WUR), The Netherlands and in colaboration with Kwame Nkrumah University of Science and Technology (KNUST), Ghana

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