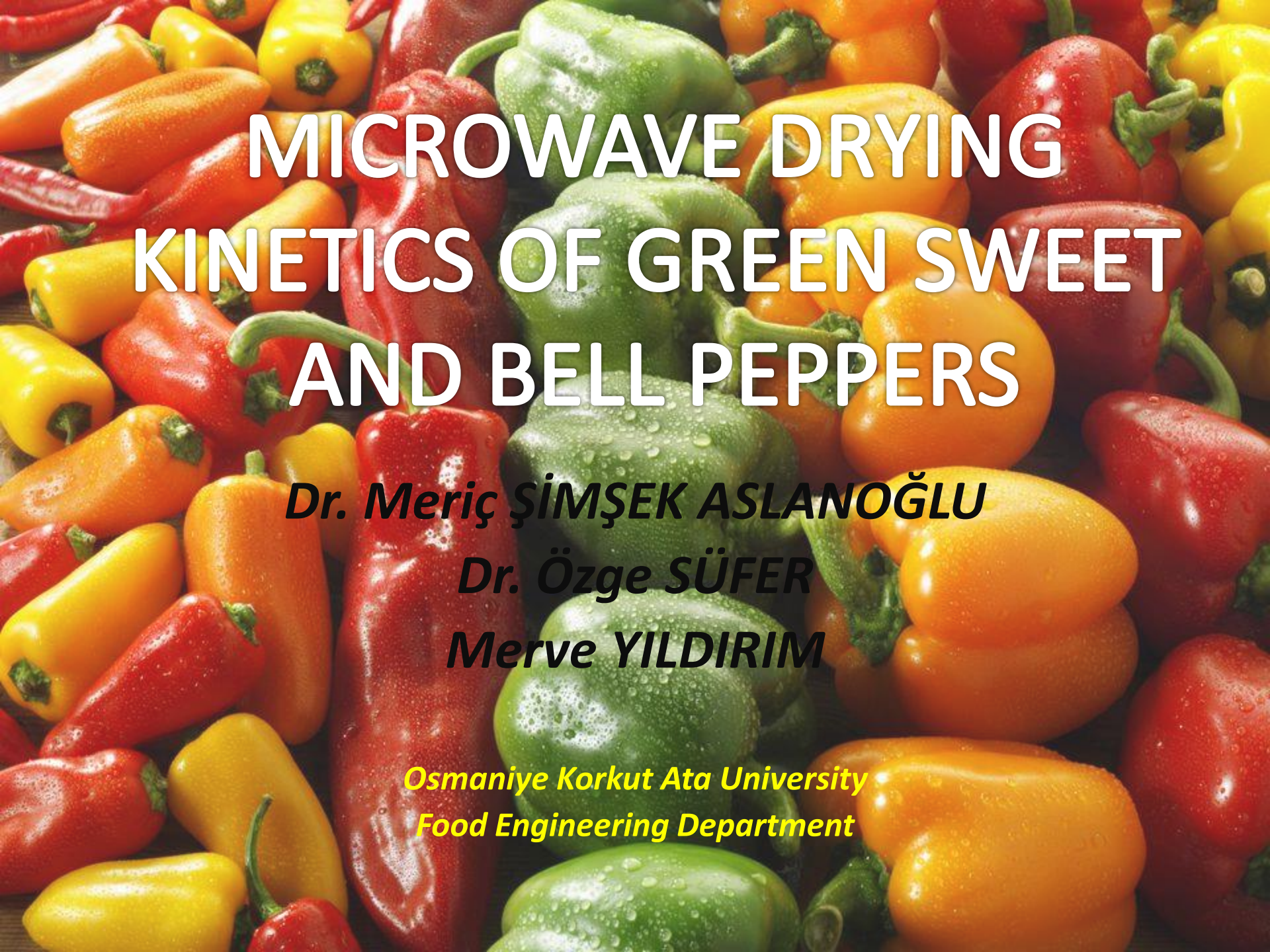


MICROWAVE DRYING KINETICS OF GREEN SWEET AND BELL PEPPERS

Dr. Meriç ŞİMŞEK ASLANOĞLU

Dr. Özge SÜFER

Merve YILDIRIM

Osmaniye Korkut Ata University

Food Engineering Department

CONTENT

- **Introduction**

✓Pepper (*Capsicum annuum* L.)

✓Microwave drying

✓Thin layer drying and semi-emprical equations

- **Objectives**
- **Material and Method**

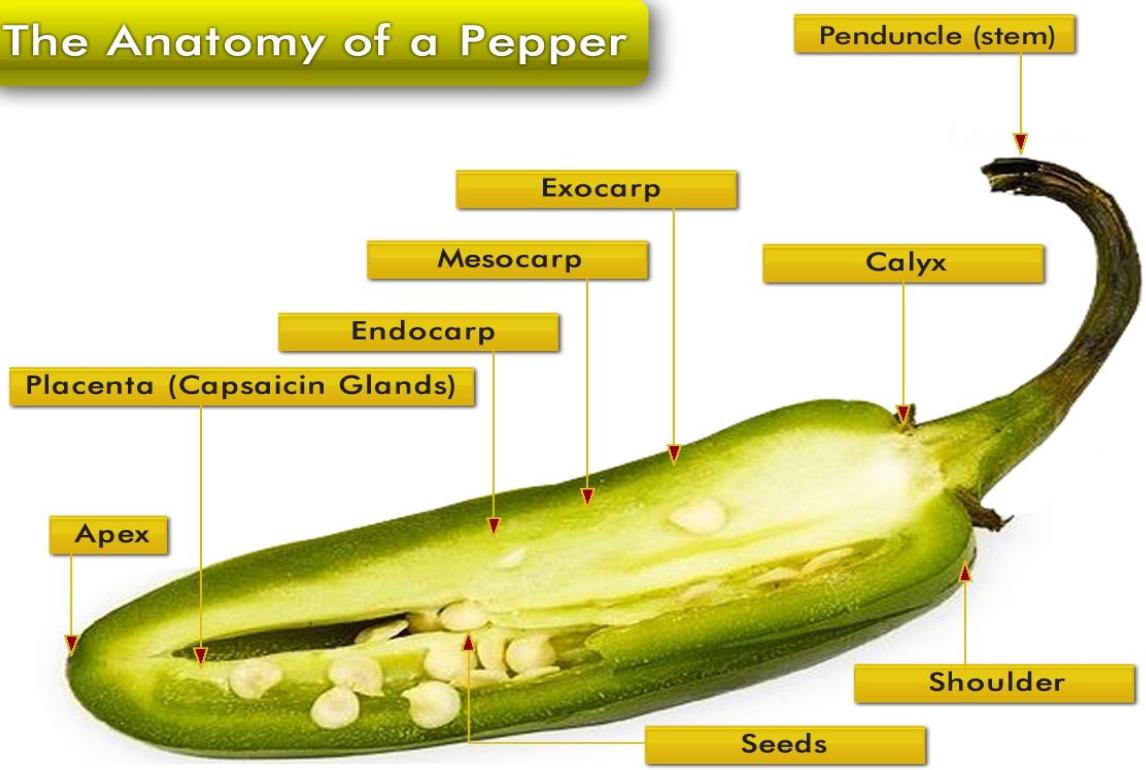
✓Material

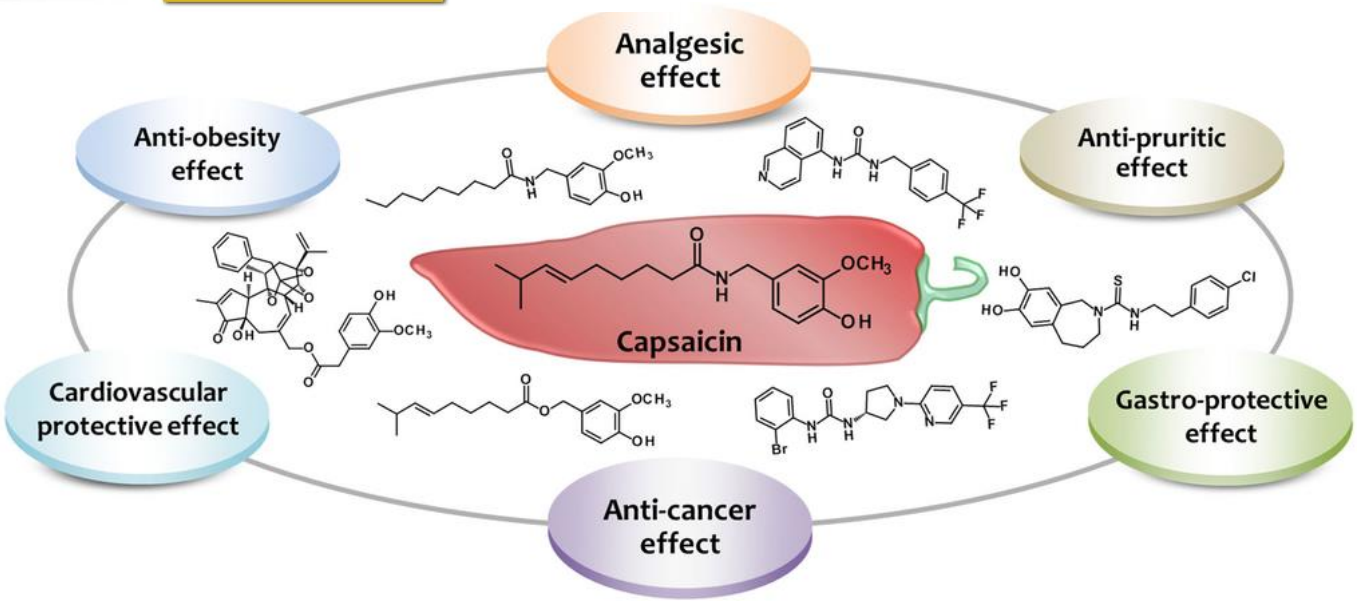
✓Drying procedure

✓Fitted mathematical expressions

- **Results and Discussion**
- **Further Studies**

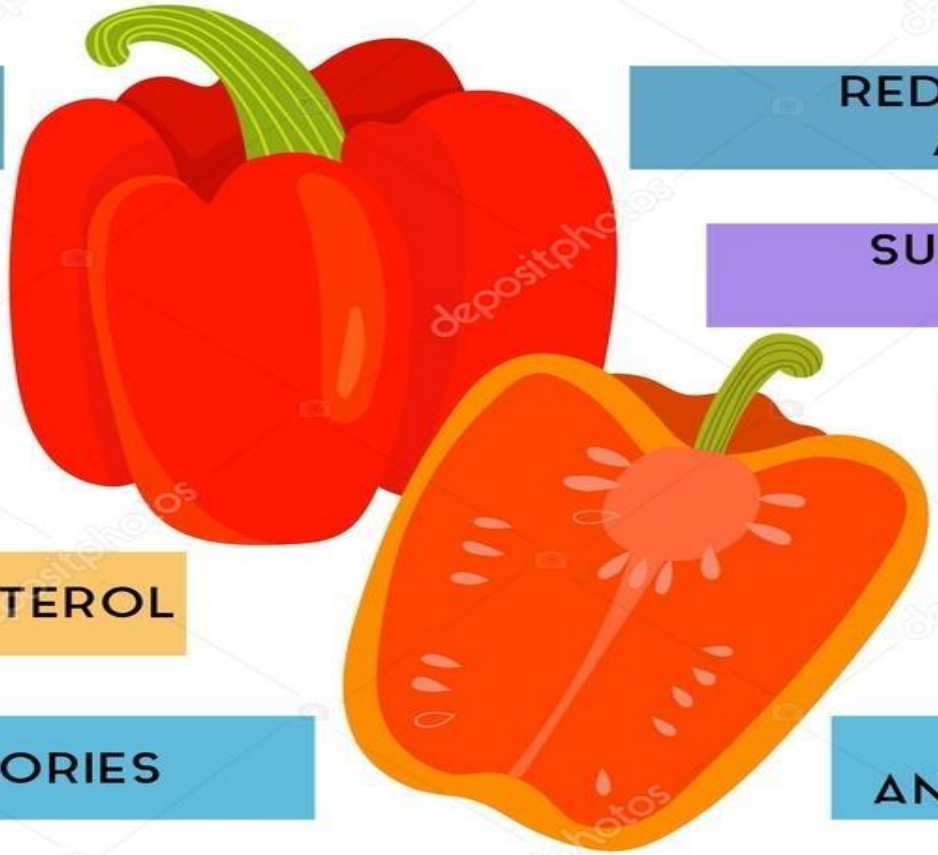
The Anatomy of a Pepper





10 HEALTH BENEFITS

BELL PEPPERS



- BOOSTS IMMUNITY
- REDUCE REDNESS AND SWELLING
- GOOD FOR EYES
- SUPPORT BLOOD CIRCULATION
- HEART HEALTHY
- CURES ANEMIA
- LOWERS CHOLESTEROL
- ANTI-CANCER
- BURN MORE CALORIES
- FUNCTION AS AN ANTI-OXIDANT

VITAMIN C	VITAMIN B6	VITAMIN A	FIBER	FOLATE
157%	16%	16%	7%	11%


Melis
Yakan Biber
Turşusu
Acı

Turkey


yonca
"daima mutfağımda"
Yakan Biber
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back to NATURE
Cracked Black Pepper Harvest Whole Wheat
CRACKERS


GARLICKY GREENGO
HATCHANERO
EVIL OOZE
GHOST PEPPER SAUCE
SCORCHING SCORPION


Braswell's
Peppery Sweet • Perfect Heat
Green Pepper Jelly
Net Wt. 10.5 OZ. (297g)


Green Pepper Powder
Green Pepper Powder
Healthy Canning

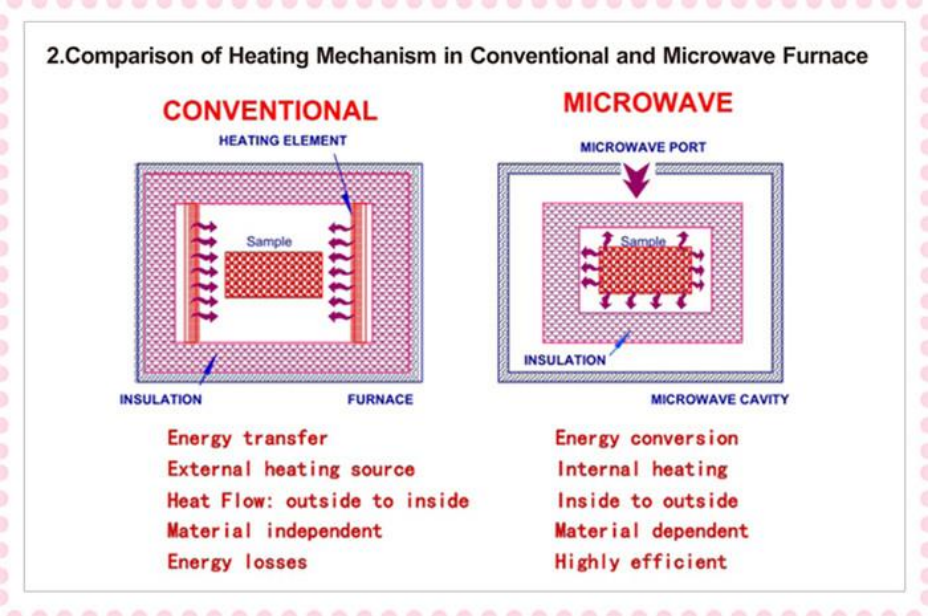

McILHENNY CO.
TABASCO
BRAND
GREEN PEPPER SAUCE

World


PEPPERLANE
Sneaky "Hippie"
JALAPEÑO PRESERVES
NET WT 11 OZ / 306 grams

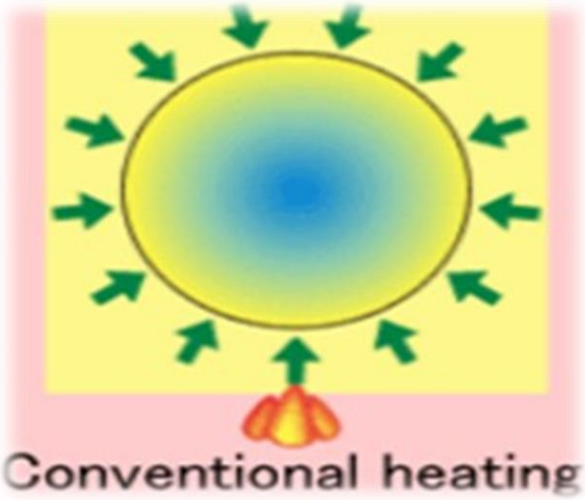
MECHANISM OF MICROWAVES

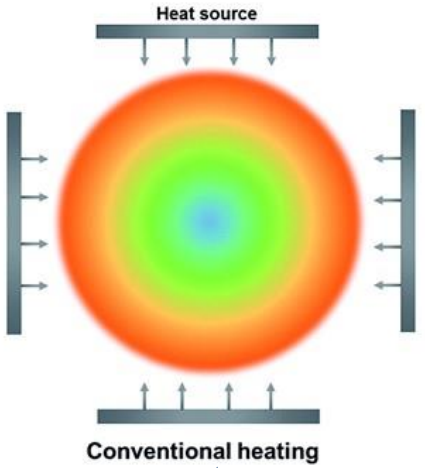
- The microwave energy is absorbed by liquid water
- After absorption, some water get evaporated
- Internal heating and evaporation generate significant pressure
- Moisture is pumped to the surface

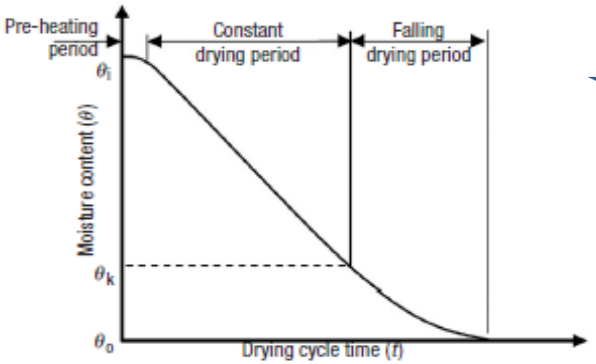


DRYING TECHNIQUES

Sun | *Smoke* | *Hot air* | *Refractance Window*







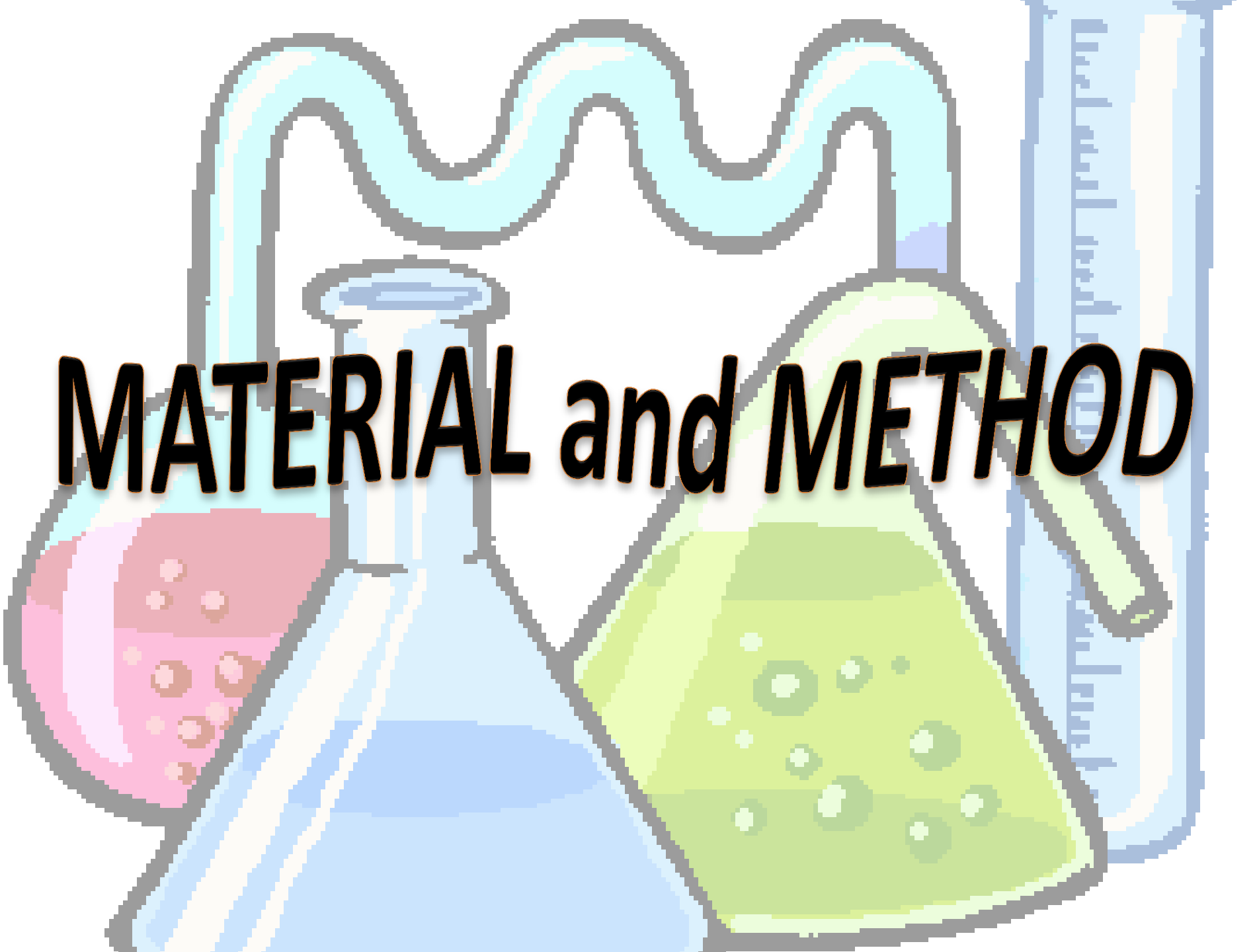
Freeze drying,
MWV drying

MATHEMATICAL MODELING

Drying contains a series of transfer phenomenas like heat and mass and is a complicated process. When defining the parameters of this, mathematical models could help to solve complexities. Mathematical models are able to be **emphirical**, **semi-emphirical** and **theoretical**. In most drying studies, semi-emphirical models were used called as **Page, Modified Page, Henderson and Pabis** and so on.

PURPOSE

- To decrease moisture content below 10% in order to prevent microbial growth and extend shelf life,
- To investigate the effects of power application on peppers,
- To create a new product with a high quality,
- To help designers and researchers with the aid of mathematical models.


MATERIAL and METHOD

Material

Trials




Conditions

90 W **90+180 W** **180 W**



Model Name	Equation
Lewis	$MR = \exp(-kt)$
Page	$MR = \exp(-kt^n)$
Modified Page	$MR = \exp(-kt)^n$
Logarithmic	$MR = a \exp(-kt) + c$
Midilli et al.	$MR = a \exp(-kt^n) + bt$
Wang and Singh	$MR = 1 + at + bt^2$
Parabolic	$MR = a + bt + ct^2$
Sigmoid	$MR = a + \frac{b}{1+ e^{k(t-c)}}$
Thompson	$t = a \ln(MR) + b [\ln (MR)^2]$
Rational	$MR = \frac{a+bt}{1+ct+dt^2}$

R^2

χ^2

RMSE

Mathematical Modeling – Drying

Correlation coefficient (R^2), root mean square error (RMSE) (1st equation) **and reduced chi square (χ2)** (2nd equation) were important parameters to choose the superior model. The highest R^2 and the lowest RMSE and χ2 demonstrated the goodness of the fit.

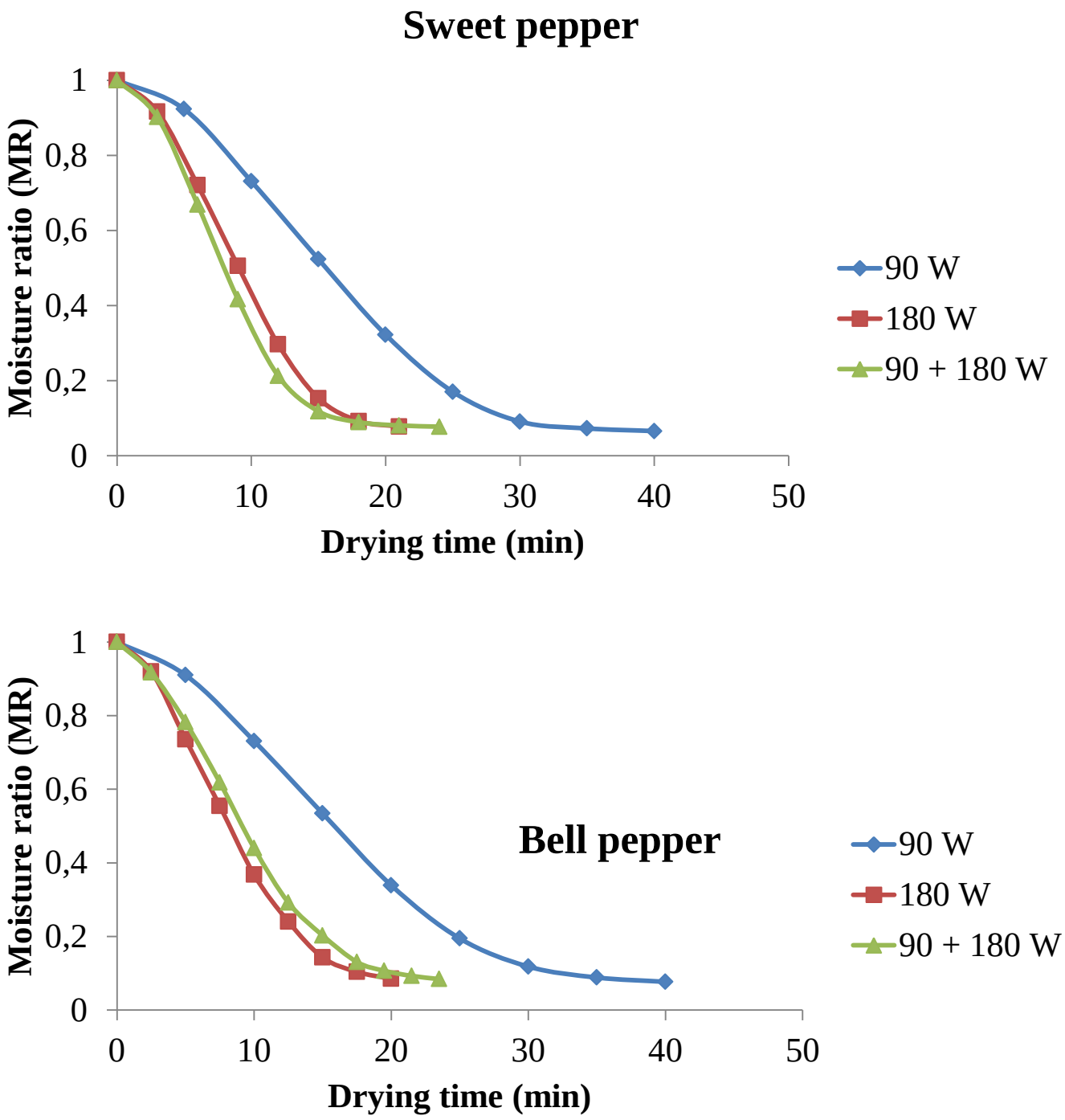
$$RMSE = \left[\frac{1}{N}\sum_{i=1}^{N}(MR_{exp,i} - MR_{pre,i})^2\right]^{1/2}$$

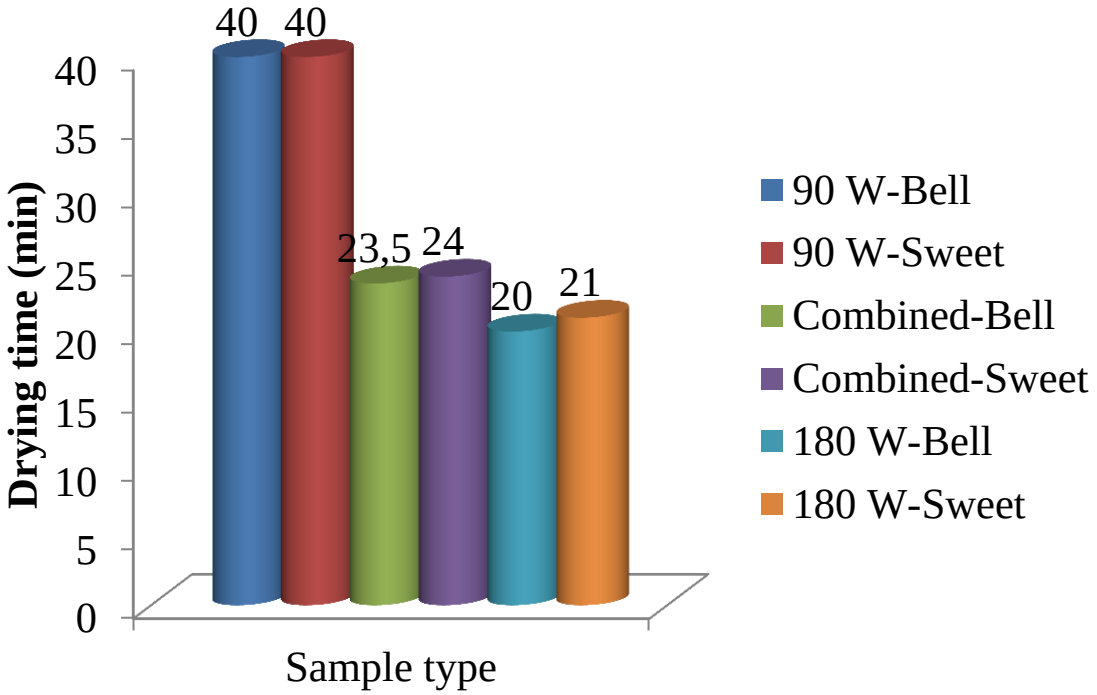
$$\chi^2 = \frac{\sum_{i=1}^{N}(MR_{exp,i} - NO_{pre,i})2}{N-z}$$

$$MR = \frac{6}{\pi^2}\exp\left(-\pi^2\frac{D_{eff}t}{r^2}\right)$$

where, N is the number of experimental data, y is the number of constant in model, MR_{exp},i is the experimental moisture ratio at i, MR_{pre},i is the predicted moisture ratio at i. Also, D_{eff} is the effective diffusivity (m^2/s), r is the radius of sample (m), and t is time.


RESULTS and DISCUSSION


Sweet pepper
Moisture ratio (MR)
1
0,8
0,6
0,4
0,2
0
0
10
20
30
40
50
Drying time (min)
90 W
180 W
90 + 180 W
Bell pepper
Moisture ratio (MR)
1
0,8
0,6
0,4
0,2
0
0
10
20
30
40
50
Drying time (min)
90 W
180 W
90 + 180 W



	Sweet pepper		Bell pepper	
Power level (W)	**Effective Diffusivity (D_{eff}) (m^2/s)**	**R^2**	**Effective Diffusivity (D_{eff}) (m^2/s)**	**R^2**
90	(1.0813×10^{-7})	0.9637	(8.2328×10^{-8})	0.9730
180	(1.8681×10^{-7})	0.9634	(1.5428×10^{-7})	0.9772
90+180	(1.7249×10^{-7})	0.9494	(1.3523×10^{-7})	0.9797



Sweet Green Pepper



Bell Pepper

Model	90 W			90+180 W			180 W		
	R^2	χ^2	RMSE	R^2	χ^2	RMSE	R^2	χ^2	RMSE
Sigmoid Model	0.99943	0.00009	0.00815	0.99980	0.00002	0.00435	0.99953	0.00008	0.00752
Midilli et al. Model	0.99951	0.00082	0.00755	0.99776	0.00028	0.01456	0.99959	0.00078	0.00705

Sigmoid model

$y = a/(1 + \exp(-k*(x-xc)))+b$

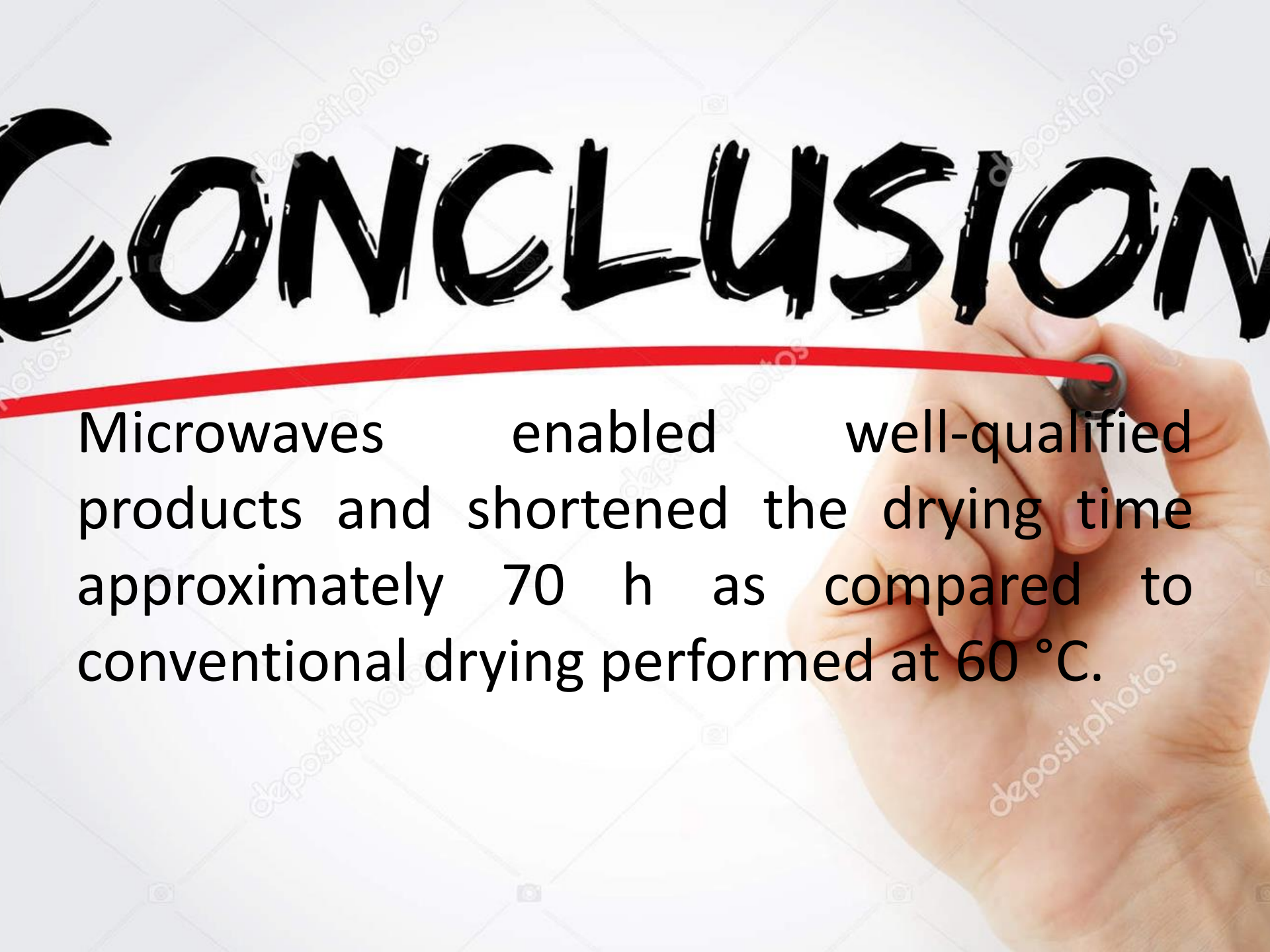
Midilli et al.

$y = a*\exp(-k*x^n)+ (b*x)$

Model	90 W			90+180 W			180 W		
	R^2	χ^2	RMSE	R^2	χ^2	RMSE	R^2	χ^2	RMSE
Sigmoid Model	0.99978	0.00004	0.00500	0.99992	0.00001	0.00288	0.99953	0.00006	0.00659
Midilli et al. Model	0.99946	0.00009	0.00773	0.99935	0.00008	0.00808	0.99972	0.00005	0.00557

Pal et al. 2008
Heat pump drying of bell pepper
30-35-40-45°C
Page model

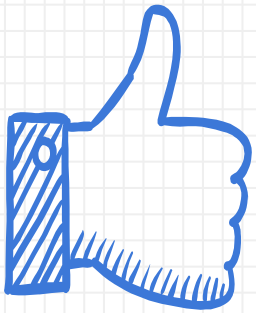
CONCLUSION



Microwaves enabled well-qualified products and shortened the drying time approximately 70 h as compared to conventional drying performed at 60 °C.

FURTHER STUDIES

- Colour kinetics
- Rehydration kinetics
- Bioactive compounds
- Microstructure



THANKS!

Any questions?

- mericsimsek@osmaniye.edu.tr
- ozgesufer@osmaniye.edu.tr
- yildirimmerve_393@hotmail.com