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Fresh-like and higher antioxidant activity of okra (*Abelmoschus esculentus*) powder by microwave vacuum drying

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Research Highlights

This research aims to improve the quality of dried okra powder using microwave vacuum drying (MVD)

- Microwave vacuum drying (MVD) reduced the drying time by 75% compared to Hot air drying (HD)
- The Modified Henderson & Pabis model was the best for explaining the drying characteristic of okra.
- Pretreatment by blanching resulted in a reduced drying rate due to water diffusion being obstructed by mucilage from okra.
- Microwave vacuum drying of okra could be improves the quality of okra powder with better color and antioxidant value than drying with hot air dryer.

Methodology

Okra (*Abelmoschus esculentus*)

Unblanched — Blanched

Drying

Microwave Vacuum Drying (MVD)
at 3 W/g, -600 mmHg

Hot air Drying (HD)
At 70 ˚C

Analysis method

- Drying Characteristic
- Color of okra powder
- Water holding capacity (WHC) and swelling power (SC)
- Total phenolic compound (TPC) and antioxidant activity (DPPH)

Results

Drying characteristics

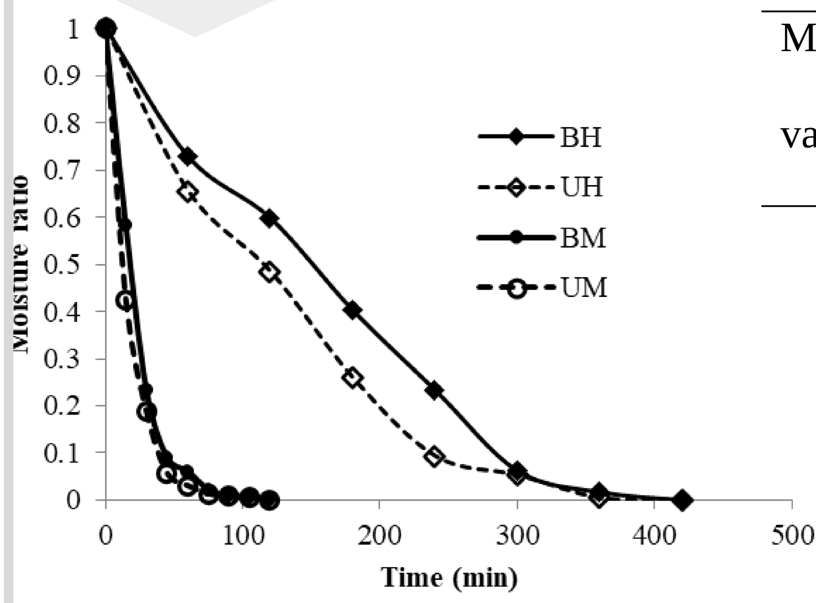

Figure 1 Moisture ratio of okra during drying with different condition;
BH- Blanching and hot air drying,
UH- Unblanched and hot air drying,
BM- Blanching and microwave vacuum drying,
UM- Unblanched and microwave vacuum drying

Table 1 Effective moisture diffusivity of okra during drying.

Drying method	Pretreatment	D_{eff} ($m^2 \cdot s^{-1}$)
Hot air drying	Blanching	0.1822×10^{-8}
	Unblanched	0.2369×10^{-8}
Microwave vacuum drying	Blanching	1.0729×10^{-8}
	Unblanched	1.1913×10^{-8}

The effective moisture diffusivity of the okra could be improved by using microwave vacuum drying, compared with hot air drying.
This was possible due to the reduction of pressure in the dryer chamber, resulting in an increased vapor pressure difference between the product and chamber. Therefore, mass diffusion was enhanced (Therdthai and Northongkom, 2011).

Table 2 Model parameters and performance of the thin layer models of okra (r=the goodness of correlation coefficient, RMSE=root mean square error and χ2 = chi square)

Drying condition		Model	Parameter	RMSE	r	χ^2
Microwave	Blanch	Lewis	k= 0.0499	0.0174	0.9887	0.0003
		Page	k= 0.0638, n= 0.9427	0.0112	0.9993	0.0001
		Henderson & Pabis	k = 0.0491, a= 0.9403	0.0230	0.9984	0.0006
		Mod. Henderson & Pabis	k= 0.4771, a= 10.1654, b=-10.3096, c= 1.1442, g= 0.3125, h=-0.0535	0.0061	0.9997	0.0001
		Logarithmic	k= 0.0532, a= 0.9889, c= 0.0054	0.0123	0.9990	0.0002
		Two-Term model	k= 0.0523, a= 0.4965, c= 0.4965,g= 0.0523	0.0127	0.9990	0.0002
		Wang & Singh	a= -0.0260, b= 0.0001	0.0967	0.9583	0.0114
	Unblanch	Lewis	k = 0.0551	0.0494	0.9903	0.0027
		Page	k= 0.0277, n= 1.1668	0.0286	0.9965	0.0010
		Henderson & Pabis	k = 0.0543, a= 0.9441	0.0586	0.9908	0.0044
		Mod. Henderson & Pabis	k= 0.3203, a= 10.1801, b=-10.6883, c= 1.5082, g= 0.3963, h=0.070	0.0040	0.9999	0.00003
		Logarithmic	k= 0.0467, a=1.0447, c= -0.0207	0.0353	0.9930	0.0017
		Two-Term model	k= 0.0495, a= 0.5135, c= 0.5135, g= 0.0495	0.0372	0.9926	0.0021
		Wang & Singh	a= -0.0262, b= 0.0001	0.0808	0.9692	0.0079

The Modified Henderson & Pabis was superior to the other models, having the lowest RMSE and χ2 and the highest correlation coefficient (r).

Physicochemical properties of okra powder

Table 3 Physicochemical properties (mean±standard error) of okra powder

Drying method	Pretreatment	*L**	a*	b*	WHC (g water/g sample)	Swelling capacity (mg/g)	TPC (mg GAE/100 g sample)	DDPH (IC_{50}) mg/ml
Hot air drying	Blanching	$66.83^{c}\pm0.11$	$-2.58^{a}\pm0.06$	$20.57^{c}\pm0.16$	$4.52^{a}\pm0.18$	$35.62^{a}\pm0.88$	$341.05^{d}\pm5.06$	$0.68^{a}\pm0.11$
	Unblanching	$68.26^{b}\pm0.12$	$-2.33^{a}\pm0.22$	$18.81^{d}\pm0.16$	$4.51^{a}\pm0.19$	$36.92^{a}\pm0.68$	$361.20^{c}\pm6.04$	$0.53^{a}\pm0.05$
Microwave vacuum drying	Blanching	$69.91^{a}\pm0.22$	$-11.57^{c}\pm0.23$	$24.91^{a}\pm0.07$	$4.63^{a}\pm0.21$	$38.13^{a}\pm2.20$	$421.69^{b}\pm13.46$	$0.22^{b}\pm0.06$
	Unblanching	$69.89^{a}\pm0.52$	$-4.98^{b}\pm0.11$	$23.37^{b}\pm0.13$	$4.53^{a}\pm0.13$	$39.70^{a}\pm2.68$	$452.40^{a}\pm8.02$	$0.19^{b}\pm0.03$

$^{a-c}$ = significant ($p<0.05$) difference within the same column.

- After the microwave vacuum drying, lightness and yellowness were increased, whereas redness was decreased ($p<0.05$).
- The Total phenolic compound (TPC) of okra dried by microwave vacuum drying was significantly ($p<0.05$) higher than that of hot air drying.
- The microwave vacuum dried okras have the lower IC50 values, implying a high radical scavenging power on the DPPH assay while the hot air dried okra have the higher IC50 value, implying the low radical scavenging power on the DPPH assay.

Conclusion

The thin layer models were used to describe the drying kinetics of okra. The Modified Henderson and Pabis model provided the best fit. The microwave vacuum drying had higher drying rate constant. Effective moisture diffusion coefficients of okra in microwave vacuum drying were higher than those in the hot air drying. Therefore, drying time could be decreased. After drying, microwave vacuum dried okra powder obtained the light green color and higher total phenolic compound and antioxidant activity than that of hot air dried okra powder. Pretreatment with blanching resulted in decrease moisture diffusivity during drying and also decreased the TPC. Therefore unblanching prior dried by microwave vacuum drying were able to improve the okra powder quality.

Acknowledgement

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References

Therdthai, N. and Northongkom, H. 2011. Characterization of hot air drying and microwave vacuum drying of gingerroot (Boesenbergia pandurate). International Journal of Food Science & Technology. 46, 601-607.