POWDER PROCESSING FROM MANGO PEEL

Diep Dang Hung[12], Duong Thi Phuong Lien[1]

[1]Institute Of Food and Biotechnology, Can Tho University, Vietnam

[2]Graduate School, Nam Can Tho University, Vietnam

ABSTRACT

Processing powder from Keo mango peel created a semi-product with better value by utilizing the Keo mango peel by-product from the mango processing industry. The study's objectives were as follows: To develop a drying curve model for Keo mango peel powder dried by the hot air convection and to investigate the effects of pretreatment (freezing and not – freezing treatment; blanching at 90°C for two minutes and not – blanching) and drying techniques (heat pump drying at 28°C, freeze drying, and hot air convection at 50, 60, 70°C) on the powder's quality. The drying of Keo mango peel at 50, 60, and 70°C using hot air convection is well illustrated by the Lewis – Newtonian model. Drying blanched fresh raw materials by hot air convection at 60°C was the most effective method. The color values of L*, a*, b*, and water activity of the mango peel powder showed 70.97±0.32, 6.27±0.12, 39.67±0.35 and 0.47±0.01, respectively. Water absorption capacity, swelling power, and water-soluble solids were respectively 7.59±0.07 g/g, 6.78±0.27%, and 6.71±0.27%. The total polyphenol content was 28.84±0.34 mgGAE/g, and the free radical DPPH scavenging was 90.43±0,12%. Drying blanched fresh raw materials by hot air convection at 60°C can retain the best biological activity and is appropriate for the economic conditions of the Mekong Delta.

Keywords: *blanching, drying, freezing, mango peel, pre – treatment*

1. INTRODUCTION

Mango (*Mangifera indica* L.) is one of the most popular fruit trees grown in the world because it is easy to eat and grow. Mango contains glucid, protein, lipid, provitamin A, vitamin B, C, E and many minerals such as: carotene, calcium, iron, potassium, magnesium, etc. Mango pulp is produced into many different products such as: fresh fruit pulp, juice, nectar, puree, jam, etc. In the processing mango products, the peel is the main by-product. The peel contributes about 15 - 20% of the fruit composition (Beerh et al., 1976). Since the peel is not currently used for any commercial purpose, it is discarded as a waste and becomes a source of pollution (Ashoush & Gadallah, 2011). In mango peel, in addition to the main ingredient fiber , it is also rich in vitamins, polyphenols and carotenoids (Ajila et al., 2007; Abdul et al., 2012). Therefore, processing powder from mango peel is one of the effective ways to reuse mango peels. , The powder made from mang peelcan be used as value-added ingredients or for the extraction of bioactive compounds (pectin, polyphenols and carotenoids) and food preservatives (Yoong et al., 2018). Mango peel powder is considered to be rich in fiber and good antioxidants, which can be a useful ingredient for supplementing and developing new food products (Abdul et al., 2012). This is one of the ways to utilize seemingly unusable waste sources,increase the value of use as well as diversifying mango products and minimize the risk of environmental pollution.

2. MATERIALS AND METHODS

2.1 Materials

Mango peels were collected from Antesco factory waste and used the fruit flesh to conduct experiments on processing fruit flesh products. Mango peels that were not overripe, had no odor, and had no bruises showing signs of damage or pests were collected in packaging and brought to the laboratory. Mango peels were pre-washed to remove excess fruit flesh and impurities. The peels that met the requirements were washed and drained in preparation for the pretreatment.

2.2 Methods

2.2.1 Analysis method

The basic physical and chemical composition indicators of raw materials as well as final products are analyzed and measured according to prescribed standards.

- Water activity a_w : Use a portable water activity meter (WA-60A, China).

- Color: Use a handheld Spectrophometer (S60 Japan).

- Total Polyphenol content (mgGAE/g): Measured by the Folin-Cioateu method using a UV spectrophotometer (Singleton, Orthofer, & Lamuela- Raventós, 1999) .

- DPPH free radical scavenging ability (%): Method for determining free radicals with DPPH as standard, spectrophotometric measurement at 517 mm wavelength.

2.2.2 Data processing method

The experiment was randomly arranged with 3 replications. The selection result from the previous experiment was used as the fixed factor for the next experiment.

The recorded data were compiled and processed using Statgraphics Centurion XIX statistical software and Excel 2019 software. Analysis of variance (ANOVA) and LSD test were used to conclude the difference between the averages of the different treatments.

3. RESULTS AND DISCUSSION

3.1 Kinetics of moisture change in mango peels at different drying temperatures

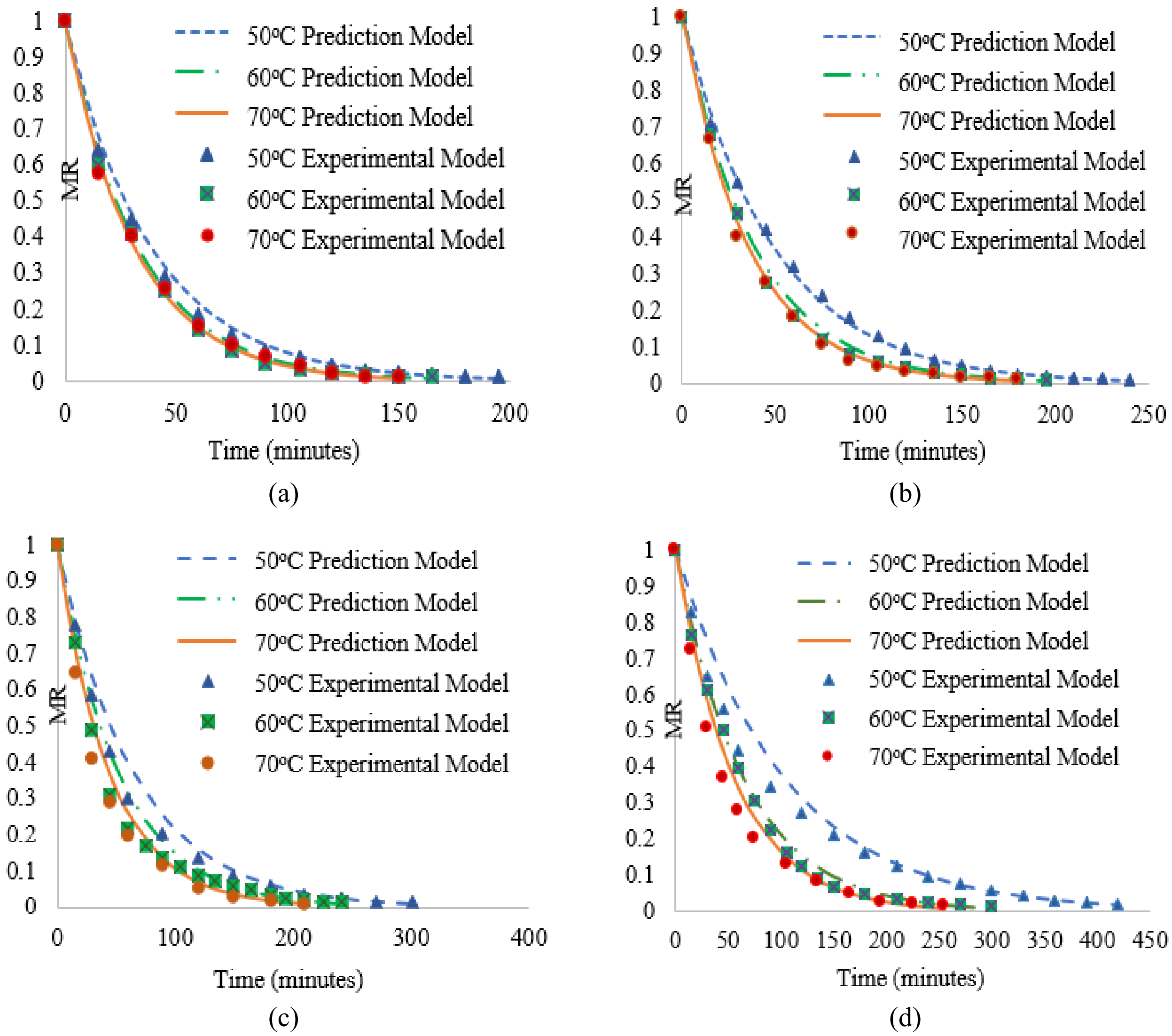

Figure 1. Degree of agreement of experimental and predicted drying curves at temperatures when freeze-dried – blanched (a); frozen (b); blanched (c); untreated (d)

The results in Figure 1 show that when the drying temperature increases from 50°C to 70°C, the time for the raw materials to reach a moisture content below 10% is shortened. When the drying temperature increases, the moisture on the surface of the raw materials will change phase from liquid to vapor phase, then separate from the raw materials as a result of the hot dry air source provided. The diffusion and phase change process ends when the vapor pressure of the environment (hot dry air) and the vapor pressure on the surface of the raw materials are saturated.

Along with the drying temperature, the pretreatment method affects the drying rate of the raw material. Figure 1 shows that when freeze-drying/blanching conditions are available, the drying time to a moisture content below 10% will be shortened. According to Figure 1, the raw material with freeze-drying combined with blanching has the shortest drying time, the raw material without freeze-drying and blanching has the longest drying time. Several studies have shown that drying time is significantly reduced when blanching with hot water for drying various fruits, vegetables and crops such as Kingsly et al. (2007) for tomatoes, Ertekin & Yaldiz, (2004) for eggplant.

3.2 Effect of raw material pretreatment method and drying method on the quality of Keo mango peel powder

Table 1. Effects of raw material pretreatment and drying methods on color and water activity of Keo mango peel powder

Pretreatment method	Drying method	L*	a*	b*	a_w
Freezing - Blanch	Convection 50°C	63,07±0,57^{i}	6,93±0,06^{d}	32,73±0,15^{h}	0,43±0,01^{def}
	Convection 60°C	66,67±0,45^{g}	6,83±0,06^{de}	33,13±0,21^{g}	0,44±0,01^{cde}
	Convection 70°C	61,57±0,35^{jk}	7,17±0,06^{c}	34,87±0,21^{e}	0,41±0,01^{g}
	Heat pump 28°C	66,47±0,38^{g}	6,77±0,06^{e}	32,57±0,15^{hi}	0,47±0,01^{a}
	Freeze	76,83±0,12^{b}	3,53±0,06^{i}	33,13±0,21^{g}	0,37±0,01^{i}
Freezing	Convection 50°C	61,23±0,50^{k}	7,53±0,06^{b}	32,37±0,15^{ij}	0,44±0,0^{1}
	Convection 60°C	65,83±0,31^{h}	7,53±0,06^{b}	32,20±0,26^{jk}	0,45±0,02^{bcd}
	Convection 70°C	58,97±0,21^{l}	7,83±0,06^{a}	32,43±0,15^{hij}	0,43±0,01^{ef}
	Heat pump 28°C	61,77±0,15^{j}	7,47±0,12^{b}	32,03±0,21^{l}	0,48±0,01^{a}
	Freeze	76,73±0,15^{b}	4,47±0,06^{h}	32,37±0,15^{ij}	0,39±0,01^{h}
Blanching	Convection 50°C	70,20±0,17^{e}	6,27±0,06^{f}	39,53±0,15^{b}	0,45±0,02^{bc}
	Convection 60°C	70,97±0,32^{d}	6,27±0,12^{f}	39,67±0,35^{b}	0,47±0,01^{a}
	Convection 70°C	67,90±0,26^{f}	6,33±0,15^{f}	40,63±0,21^{a}	0,43±0,01^{ef}
	Heat pump 28°C	72,27±0,21^{c}	5,33±0,06^{g}	39,73±0,15^{b}	0,48±0,01^{a}

	Freeze	80,97±0,12^{a}	3,17±0,06^{j}	33,67±0,15^{f}	0,42±0,01^{fg}
Untreated	Convection 50°C	70,17±0,25^{e}	4,53±0,06^{h}	39,20±0,26^{c}	0,46±0,01^{ab}
	Convection 60°C	70,37±0,15^{e}	4,53±0,06^{h}	37,37±0,25^{d}	0,47±0,01^{a}
	Convection 70°C	67,73±0,35^{f}	5,23±0,06^{g}	39,03±0,12^{c}	0,48±0,01^{a}
	Heat pump 28°C	70,63±0,15^{de}	4,47±0,06^{h}	39,03±0,15^{c}	0,48±0,01^{a}
	Freeze	80,67±0,15^{a}	6,93±0,06^{i}	32,17±0,15^{jk}	0,43±0,01^{def}

Note: Values are expressed as mean and standard deviation; numbers with different superscripts in the same column indicate statistically significant differences ($p<0.05$)

The results of Table 1 show that the drying method, brightness (L*) is highest when freeze-dried (76.73÷80.97) and lowest when dried with hot air (58.97÷70.97). From the analysis results, it can be seen that brightness (L*) tends to increase when the temperature increases from 50°C to 60°C and tends to decrease when increasing from 60°C to 70°C. This result may be due to the fact that drying at low temperature for a long time will cause non-enzymatic browning reactions, thereby leading to a decrease in the brightness of the powder. In addition, drying with hot air at high temperature (70°C) will create favorable conditions for the Maillard reaction and release phenolic compounds that cause browning of the product. The values of a*, b* has a decreasing trende while brightness (L*) increases, similar to the report of Azizpour et al. (2016) on shrimp powder products, when increasing the drying temperature and drying time, the L* value decreases and a*, b* will increase. Similar to the a* value, the yellow hue of the b* value increases, however, this value increases rapidly for samples dried in hot air (drying at 70°C).

a_w value ranges from 0.37 to 0.48, the freezing and blanching treatments also significantly affect the change of a_w. The reason may be that the freezing and blanching processes have damaged the cells of the raw materials, leading to faster and easier evaporation. However, the a_w values of the powder is relatively low ($p<0.05$), so it can be seen that the pretreatment and drying methods have insignificant effects on the water activity of the product.

Table 2. Effects of raw material pretreatment and drying methods on water-soluble, swelling capacity and water absorption capacity of Keo mango peel powder

Pretreatment method	Drying method	Water absorption capacity (g/g)	Water-soluble (%)	Swelling capacity (%)
Freezing - Blanch	Convection 50°C	7,61±0,6^{de}	5,32±0,11^{g}	8,65±0,11^{b}
	Convection 60°C	8,23±0,18^{b}	5,24±0,12^{g}	8,72±0,12^{b}
	Convection 70°C	8,72±0,09^{a}	4,92±0,21^{h}	9,02±0,20^{a}
	Heat pump 28°C	7,14±0,02^{fg}	5,36±0,23^{g}	8,60±0,22^{b}
	Freeze	6,87±0,21^{h}	5,47±0,18^{g}	8,50±0,17^{b}
Freezing	Convection 50°C	7,21±0,16^{fg}	5,85±0,18^{f}	8,13±0,17^{c}
	Convection 60°C	7,37±0,10^{ef}	5,50±0,19^{g}	8,47±0,18^{b}
	Convection 70°C	8,09±0,14^{bc}	5,38±0,13^{g}	8,58±0,12^{b}
	Heat pump 28°C	6,74±0,03^{hij}	6,31±0,18^{e}	7,68±0,17^{d}
	Freeze	6,59±0,17^{ij}	6,44±0,10^{de}	7,55±0,10^{d}
Blanching	Convection 50°C	7,55±0,24^{e}	6,92±0,21^{c}	7,07±0,21^{e}
	Convection 60°C	7,59±0,07^{de}	6,71±0,27^{cd}	6,78±0,27^{f}
	Convection 70°C	7,83±0,33^{cd}	6,45±0,20^{de}	7,54±0,20^{d}
	Heat pump 28°C	6,99±0,06^{gh}	6,95±0,02^{c}	7,04±0,02^{ef}
	Freeze	6,82±0,11^{hi}	7,74±0,41^{b}	5,91±0,13^{h}
Untreated	Convection 50°C	6,51±0,26^{jk}	7,78±0,15^{b}	6,21±0,15^{g}
	Convection 60°C	6,55±0,11^{j}	7,75±0,12^{b}	6,24±0,12^{g}
	Convection 70°C	6,58±0,19^{ij}	7,64±0,22^{b}	6,35±0,22^{g}
	Heat pump 28°C	6,50±0,10^{jk}	8,28±0,15^{a}	5,69±0,15^{h}
	Freeze	6,27±0,16^{k}	8,31±0,09^{a}	5,67±0,10^{h}

Note: Values are expressed as mean and standard deviation; numbers with different superscripts in the same column indicate statistically significant differences ($p<0.05$)

The statistical results showed that the water-soluble of Keo mango peel powder ranged from 4.92 to 8.31% and was affected by the pretreatment method, while the drying method had insignificant effect. The results in Table 2 showed that the water-soluble of the powder was highest without pretreatment and lowest when freeze-dried or blanched. According to thereport of Sogi et al. (2013), the water-soluble of mango peel powder was highest when freeze-dried and lower when dried with hot air (the difference was not statistically significant).

The swelling capacity of mango peel powder ranged from 5.67 to 9.02%. It was affected by pretreatment and drying methods similar to the water absorption capacity. The swelling capacity of the powder was high when freeze-dried/blanched and low when no pretreatment was performed. The data obtained after the experiment showed that the swelling capacity of the sample when dried in hot air had the highest value and was lower when freeze-dried (28ºC) and sublimated (the differences between the treatments were not statistically significant). The low swelling capacity was due to the presence of a large number of crystals, which increased the stability of the granules, thereby reducing the swelling degree of the granules (Liu et al., 2003) . When starch is gelatinized at a certain temperature, the molecular organization inside the granules is broken and the interaction between starch and water increases, leading to a significant increase in swelling (Liu et al., 2003).

Table 3. Effects of raw material pretreatment and drying methods on the biological activity of Keo mango peel powder

Pretreatment method	**Drying method**	**TPC (mgGAE/g)**	**DPPH (%)**
Freezing-blanch	Convection 50ºC	$24,19 \pm 0,29^{h}$	$88,42 \pm 0,16^{hi}$
	Convection 60ºC	$24,89 \pm 0,70^{g}$	$89,20 \pm 0,25^{ef}$
	Convection 70ºC	$21,65 \pm 0,27^{j}$	$87,12 \pm 0,07^{j}$
	Heat pump 28ºC	$24,82 \pm 0,14^{g}$	$89,23 \pm 0,27^{def}$
	Freeze	$28,87 \pm 0,35^{b}$	$89,57 \pm 0,18^{cde}$
Freezing	Convection 50ºC	$21,73 \pm 0,24^{j}$	$88,20 \pm 0,51^{i}$
	Convection 60ºC	$23,73 \pm 0,18^{hi}$	$88,54 \pm 0,26^{ghi}$
	Convection 70ºC	$18,52 \pm 0,31^{l}$	$86,36 \pm 0,30^{k}$
	Heat pump 28ºC	$23,19 \pm 0,46^{i}$	$88,84 \pm 0,29^{fgh}$
	Freeze	$27,51 \pm 0,41^{e}$	$89,14 \pm 0,13^{efg}$
Blanching	Convection 50ºC	$27,89 \pm 0,39^{de}$	$89,48 \pm 0,52^{de}$
	Convection 60ºC	$29,47 \pm 0,36^{a}$	$90,43 \pm 0,12^{ab}$
	Convection 70ºC	$23,34 \pm 0,15^{i}$	$88,69 \pm 0,25^{fghi}$
	Heat pump 28ºC	$28,61 \pm 0,45^{bc}$	$89,69 \pm 0,21^{cde}$
	Freeze	$29,84 \pm 0,45^{a}$	$90,55 \pm 0,28^{a}$

Untreated	Convection 50^{o}C	$26,92\pm0,32^{f}$	$89,24\pm0,27^{def}$
	Convection 60^{o}C	$28,24\pm0,13^{cd}$	$89,83\pm0,32^{bcd}$
	Convection 70^{o}C	$19,75\pm0,18^{k}$	$86,63\pm1,16^{jk}$
	Heat pump 28^{o}C	$28,11\pm0,35^{cd}$	$90,17\pm0,13^{abc}$
	Freeze	$29,49\pm0,39^{a}$	$90,14\pm0,23^{abc}$

Note: Values are expressed as mean and standard deviation; numbers with different superscripts in the same column indicate statistically significant differences ($p<0.05$)

The experimental results of phenolic content in Table 3 illustrates that the TPC value of mango peel powder ranges from 18.52 to 29.84 mgGAE/g. This result is higher than the report of Ashoush & Gadallah, (2011), the phenolic content of mango peel powder is about 19.06±0.30 mgGAE/g. It can clearly be seen thatthe phenolic content of mango peel powder is highest when blanched (29.84±0.45 mgGAE/g) and lowest when frozen (18.52±0.31 mgGAE/g). The highest phenolic content (lowest phenolic loss) of freeze-dried samples (27.51÷29.84 mgGAE/g) and the highest freeze-dried treatment were not significantly different from the treatment blanched and dried at 60^{o}C. The lowest phenolic content (highest phenolic loss) was obtained when drying with convective hot air at 70^{o}C (18.52÷23.34 mgGAE/g). For the convective hot air drying method, the phenolic content tended to increase when the drying temperature increased from 50^{o}C to 60^{o}C and tended to decrease when the drying temperature increased from 60^{o}C to 70^{o}C. Therefore, the increase in drying temperature (60^{o}C to 70^{o}C) resulted in an increase in phenolic content loss. However, if drying at too low a temperature (50^{o}C), the drying time is prolonged, leading to faster oxidation of polyphenol compounds by air, and the loss of phenolic content also increases.

The free radical DPPH scavenging ranged from 86.36 to 90.55%. The results were lower than the study of Ashoush & Gadallah, (2011) on the DPPH free radical scavenging ability of mango peel powder (about 93.89±0.20%). As can be seen from the Table 3, the DPPH free radical scavenging ability was highest when blanched (90.55±0.28%) and lowest when freeze-dried (86.36±0.30%). The highest DPPH free radical scavenging ability was in freeze-dried samples (89.14 to 90.55%) and the highest freeze-dried treatment was not statistically different from the treatment blanched and dried at 60^{o}C. The lowest DPPH free radical scavenging ability was when dried with convection hot air at 70^{o}C (86.36 to 88.69%). The data in Table 3 also show that , the DPPH free radical scavenging ability of mango peel powder when dried at 50ºC and 60ºC was higher than that at 70ºC when using the convective hot air drying method.

In summary, the freeze-drying treatments retain the best biological activity (phenolic content and DPPH free radical scavenging ability). In addition, the biological activities of the treatments blanched and dried with convection hot air at 60ºC were proven to be better than other treatments (the difference was not statistically significant with the freeze-drying treatment). This is a drying condition that retains biological activity well and is less expensive than freeze-drying and freeze-drying in terms of environment and economy.

4. CONCLUSION

The Lewis – Newton model is suitable to describe the process of drying Keo mango peel by convection hot air at temperatures of 50, 60 and 70ºC. The convection hot air drying method at 60ºC applied to fresh raw materials blanched before drying is the most effective. Accordingly, the finished mango peel powder has the color values L*, a*, b* and water activity of 70.97±0.32; 6.27±0.12; 39.67±0.35 and 0.47±0.01 respectively, the water absorption capacity, swelling capacity and water-soluble have the values of 7.59±0.07 g/g; 6.78±0.27% and 6.71±0.27% respectively. Phenolic content 28.84±0.34 mgGAE/g and DPPH free radical scavenging ability 90.43±0.12%.

REFERENCES

1. Beerh, O. ., Raghuramaiah, B., Krishnamurthy, G. V., & Giridhar, N. (1976). Utilization of Mango Waste: Recovery of Juice from Waste Pulp and Peel. *Journal of Food Science and Technology*, *3*(13), 138–141.

2. Ashoush, I. S., & Gadallah, M. G. E. (2011). Utilization of Mango Peels and Seed Kernels Powders as Sources of Phytochemicals in Biscuit. *World Journal of Dairy & Food Sciences*, *6*(1), 35–42.

3. Ajila, C. M., Bhat, S. G., & Prasada Rao, U. J. S. (2007). Valuable components of raw and ripe peels from two Indian mango varieties. *Food Chemistry*, *102*(4), 1006–1011. https://doi.org/10.1016/j.foodchem.2006.06.036

4. Abdul Aziz, N. A., Wong, L. M., Bhat, R., & Cheng, L. H. (2012). Evaluation of processed green and ripe mango peel and pulp flours (Mangifera indica var. Chokanan) in terms of chemical composition, antioxidant compounds and functional properties. *Journal of the Science of Food and Agriculture*, *92*(3), 557–563. https://doi.org/10.1002/jsfa.4606

5. Yoong Cheok, C., Mohd Adzahan, N., Abdul Rahman, R., Hanani Zainal Abedin, N.,

Hussain, N., Sulaiman, R., & Hean Chong, G. (2018). Critical Reviews in Food Science and Nutrition Current trends of tropical fruit waste utilization Current trends of tropical fruit waste utilization. *Taylor & Francis*, *58*(3), 335–361.

6. Singleton, V. L., Orthofer, R., & Lamuela-Raventós, R. M. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent. In *Methods in enzymology* (Vol. 299, pp. 152–178). Elsevier.

7. Kingsly, A. R. P., Singh, R., Goyal, R. K., & Singh, D. B. (2007). Thin-layer drying behaviour of organically produced tomato. *American Journal of Food Technology*, *2*(2), 71–78. https://doi.org/10.3923/ajft.2007.71.78

8. Ertekin, C., & Yaldiz, O. (2004). Drying of eggplant and selection of a suitable thin layer drying model. *Journal of Food Engineering*, *63*(3), 349–359.

9. Azizpour, M., Mohebbi, M., & Khodaparast, M. H. H. (2016). Effects of foam-mat drying temperature on physico-chemical and microstructural properties of shrimp powder. *Innovative Food Science and Emerging Technologies*, *34*, 122–126. https://doi.org/10.1016/j.ifset.2016.01.002

10. Sogi, D. S., Siddiq, M., Greiby, I., & Dolan, K. D. (2013). Total phenolics, antioxidant activity, and functional properties of "Tommy Atkins" mango peel and kernel as affected by drying methods. *Food Chemistry*, *141*(3), 2649–2655. https://doi.org/10.1016/j.foodchem.2013.05.053

11. Liu, Q., Weber, E., Currie, V., & Yada, R. (2003). Physicochemical properties of starches during potato growth. *Carbohydrate Polymers*, *51*(2), 213–221. https://doi.org/10.1016/S0144-8617(02)00138-8