# Effect of Various Drying Temperatures on Characteristics of Mustard Green Flour and Leaves During Drying

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**Abstract.** Vegetables can be extended their shelf life by processing them into vegetable flour. Flour processing technology is inseparable from the drying process which means removing water from a material until it reaches a certain moisture content. This study aims to determine the effect of various temperatures at various stages of drying on the characteristics of the material to become mustard green flour. Drying it using a cabinet dryer at temperatures of 45 ºC, 55 ºC, and 65 ºC. Observations were made at 0 h of drying (analysis of raw materials), 2 h, 4 h, and after turning into mustard green flour. The results showed that the drying temperature had an effect on the changes in the characteristics of the material during the drying process until it turned into mustard green flour. During the drying process, there was a decrease in moisture content, ash content, total chlorophyll, and physical color of the mustard green flour. Drying temperature has an effect on decreasing moisture content, ash content, total chlorophyll and physical color of mustard green flour, while drying time affects total chlorophyll and physical color of mustard green flour.

**Keywords:** *Brassica juncea* (L.) Czern., functional food, minimize dryer damage, vegetable mustard, vegetable flour.

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# 1 Introduction

Mustard green (*Brassica juncea* (L.) Czern.) or mustard brown, vegetable mustard, Indian mustard, Chinese mustard are a source of beneficial dietary fiber for the body. Fiber in food functions like increasing the volume of fecal bulk, devreasing the time of intstinal transit, control blood sugar levels, cardiovascular disease, obesity and cholesterol [1–3]. However, almost all types of vegetables have a limited shelf life. Vegetables can be extended their shelf life by processing them into vegetable flour. Vegetable flour processing can be done using simple technology that can easily be done by the community. In the form of flour, besides being easier in the distribution and trading process, vegetable flour is also a very flexible intermediate product to be processed into various food products [4, 5]. Flour processing technology cannot be separated from the drying process. Drying is a process of decreasing the moisture content of the material until it reaches a certain water content so that it can slow down the rate of product damage due to biological and chemical activities. The temperature setting and the length of time for drying are carried out by taking into account the contact between the dryer and the heating device (either hot air being flowed or other heating devices). Because most food ingredients are heat sensitive, the temperature and drying time used must be maximum, where the final moisture content of the dried material is achieved with a short drying time [4, 6–10]. Therefore, a study was conducted to determine the characteristics of mustard green flour at variations in temperature and drying time.

# 2 Materials and methods

Mustard green were obtained from Kejapanan, Gempol, Pasuruan, East Java, Indonesia. The vegetables were sorted and washed before cutting with a sharp knife to remove leave stalks and roots. The mustard green was cut into smaller sizes and blanched at 75 °C for 3 min. The blanched cutted leaves then dried with cabinet dryer at temperatures of 45 °C, 55 °C, and 65 °C for respectively. Flour were obtain by milling dried leaves and passing it through 80 mesh sieve. Observations were made at 0 h of drying (analysis of raw materials), 2 h, 4 h, and after turning into mustard green flour. Statistical analysis was performed using ANOVA followed by Tukey's HSD (honestly significant difference) test [11, 12].

# 3 Result and discussion

## 3.1 Characteristics of mustard green during drying

### *3.1.1 Total chlorophyll of mustard green during drying*

The results of the analysis of variety showed that there was no interaction between temperature and drying time on the total chlorophyll parameter, but the drying temperature had a significant effect on the total chlorophyll of mustard greens and the drying time had a very significant effect on the total chlorophyll of mustard greens. The mean total of mustard chlorophyll during the drying process is presented in Table 1.

**Table 1**. Total chlorophyll due to the effect of temperature and drying duration.

| Drying temperature (ºC) | Total chlorophyl (mg $g^{-1}$) |
|---|---|
| 45 | 18.963 |
| 55 | 18.510 b |
| 65 | 16.329 |
| HSD 5 % | 2.235 |
| Duration (h) | |
| 2 | 20.063 b |
| 4 | 15.804 a |
| HSD 5 % | 1.482 |

Note: Numbers followed by the same alphabet shows insignificant differences based on the 5 % HSD.

Table 1 shows that the higher the drying temperature and the longer the drying time, the lower the total chlorophyll. At the drying temperature of 65 ºC, there was a significant decrease with the drying temperature of 45 ºC and 55 ºC, while the total chlorophyll in the drying time of 4 h was significantly different from the drying time of 2 h. A decrease in total chlorophyll due to the influence of temperature and storage time has also been reported by Manolopoulou and Varzakas [13] which states that there is an interaction between temperature and storage time on chlorophyll degradation and changes in vegetable color. The results of these studies concluded that broccoli stored at high temperature (10 ºC to 20 ºC) showed wilting symptoms and chlorophyll degradation.

### *3.1.2 Mustard green color during drying*

The results of the analysis of variance showed that there was no significant interaction between temperature and drying time on the physical color parameters of the mustard greens, but the drying temperature had a significant effect on the lightness and yellowness parameters. The temperature and drying time had no significant effect on the greenness parameter. The average physical color of the mustard greens during the drying process is presented in Table 2.

Table 2 shows that the decrease in brightness of mustard greens at a temperature of 65 ºC was not significantly different from the treatment at 55 ºC but was significantly different from the treatment at 45 ºC. The yellowness variables of mustard greens at a temperature of 55 ºC was not significantly different from that of 65 ºC but was significantly different from the treatment at 45 ºC. The difference in the brightness level of the flour is thought to be influenced by the total chlorophyll content in the samples. This is consistent with the results of observations of total chlorophyll which show a decrease with increasing drying temperature. The redness parameter showed an insignificant difference in all treatments. Negative values for the redness parameter indicate a greenish color.

**Table 2**. Leaves colour due to the effect of temperature and drying duration.

| Drying temperature (ºC) | Lightness (L*) | Greenness (a*) | Yellowness (b*) |
|---|---|---|---|
| 45 | 54.958 b | 16.382 | 20.670 b |
| 55 | 52.112 ab | 13.465 | 14.587 a |
| 65 | 50.783 a | 13.855 | 15.547 ab |
| HSD 5 % | 3.103 | ns | 5.755 |
| Duration (h) | | | |
| 2 | 53.033 | 14.717 | 18.087 |
| 4 | 52.202 | 14.418 | 15.782 |
| HSD 5 % | ns | ns | ns |

Note: Numbers followed by the same alphabets in the same sub-column shows insignificant differences based on the 5 %.

## 3.2 Characteristics of mustard green flour

During the drying process, there is a decrease in water content accompanied by changes in the texture of the surface of the material. Drying time can be accelerated by increasing the drying temperature, but too high a temperature can cause serious damage to the product such as color, aroma, nutrition, and dry product rehydration capacity [14, 9, 10]. This is in line with research conducted by Yusufe *et al*. [15] on drying tomatoes. High temperature heating (70 ºC to 90 ºC) with a heating time of 7 h and 8 h can reduce pH, total dissolved solids, total acid and water activity (Aw) on tomato drying [15].

### *3.2.1 Water content of mustard green flour*

Water contents of mustard green flour are presented in Table 3. The water content of the mustard green flour at drying temperatures of 45 ºC, 55 ºC and 65 ºC decreased by 83.940 %, 86.661 %, and 89.339 %, respectively. The higher the drying temperature, the lower the water content of the mustard green flour. This is because higher temperatures cause more water to be evaporated, so that the samples become drier and lighter [16, 17].

**Table 3.** Moisture of mustard green flour on various drying temperature.

| Drying temperature (ºC) | Moisture (%) |
|---|---|
| 45 | 13.890 ± 0.581 |
| 55 | 11.537 ± 0.287 |
| 65 | 9.221 ± 0.670 |

### *3.2.2 Ash content of mustard green flour*

The results of the ash content analysis are presented in Table 4. Ash content of mustard flour at drying temperatures of 45 ºC, 55 ºC, and 65 ºC decreased by 7.038 %, 10.779 %, and 13.877 %, respectively. The higher the drying temperature, the lower the ash content of the mustard flour. This is due to the evaporation of several minerals at high temperatures [18].

**Table 4.** Ash content of mustard green flour on various drying temperatures.

| Drying temperature (ºC) | Ash content (%) |
|---|---|
| 45 | 11.518 ± 0.143 |
| 55 | 11.054 ± 0.301 |
| 65 | 10.671 ± 0.406 |

### *3.2.3 Total chlorophyll of mustard green flour*

The results of the analysis of total chlorophyll of mustard green flour are presented in Table 5. Total chlorophyll of mustard green flour at drying temperatures of 45 ºC, 55 ºC, and 65 ºC decreased by 45.792 %, 51.772 %, and 56.081 %, respectively from the initial total chlorophyll of. The higher the drying temperature, the lower the total chlorophyll of mustard flour. This is due to the degradation of chlorophyll due to the influence of heat from the drying temperature [19].

**Table 5.** Total chlorophyll of mustard green flour on various drying temperatures.

| Drying temperature (ºC) | Total chlorophyll (mg $g^{-1}$) |
|---|---|
| 45 | 16.660 ± 1.633 |
| 55 | 14.822 ± 0.782 |
| 65 | 13.497 ± 0.489 |

### *3.2.4 Color of mustard green flour*

The results of the physical color analysis of the mustard green flour are presented in Table 6. The higher the drying temperature, the lower the brightness of the mustard green flour produced. During the drying process chlorophyll degradation occurs due to the influence of heat from the drying temperature to brownish pheophytin [20]. This causes the greenness value to decrease, and the yellowness value shows a tendency to increase with increasing drying temperature used.

**Table 6.** Colour (L a b) of mustard green flour on various drying temperatures.

| Drying temperature (°C) | Lightness | Greenness | Yellowness |
|---|---|---|---|
| 45 | 52.163 ± 2.532 | 13.370 ± 0.047 | 19.243 ± 0.060 |
| 55 | 50.920 ± 0.582 | 12.957 ± 0.247 | 15.840 ± 0.282 |
| 65 | 50.177 ± 0.489 | 14.547 ± 0.936 | 21.843 ± 3.276 |

The further-research, with the aim of energy efficiency and minimization of environmental pollution, should research drying with renewable energy or hybrid as heating [20–25]

## 4 Conclusion

Various drying temperatures effected total chlorophyll and colour of cutted leaves during drying. The higher the temperature, the lower the total chlorophyll and lightness of cutted leaves during drying. Drying temperatures also tent to effect the characteristics of leaves flour. The higher the temperature, the lower the moisture, ash content, total chlorophyll, and lightness of leaves flour. Drying duration from 2 h to 4 h decreased total chlorophyll and lightness of cutted leaves during drying.

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## References

1. V. Abe- Inge, J. K. Agbenorhevi, F. M. Kpodo, O. A. Adzinyo, Food Res., **2**,4: 331–339 (2018) https://doi.org/10.26656/fr.2017.2(4).050
2. D. Dhingra, M. Michael, H. Rajput, R.T. Patil, J. Food Sci. Technol., **49**,3: 255–266 (2012) https://doi.org/10.1007%2Fs13197-011-0365-5
3. D. Damat, R. Anggriani, R.H. Setyobudi, P. Soni, Coffee Sci., **14**,4: 493–500 (2019) http://dx.doi.org/10.25186/cs.v14i4.1625
4. M. Muhtadi, R. Rauf, K. Harismah, S. Saifuddin, WARTA, **19**,1: 83–89 (2016) [in Bahasa Indonesia] http://dx.doi.org/10.23917/warta.v19i1.1987
5. M.D.J.C. Sandarani, D.C.M.C.K. Dasanayaka, C.V.L. Jayasinghe, J. Agric. Sci. Food Res., **9**,1: 1–6 (2018) https://www.longdom.org/open-access/strategies-used-to-prolong-the-shelf-life-of-fresh-commodities-17293.html
6. Kendall P., P. DiPersio, J. Sofos, *Drying Vegetables*. [Online] from https://foodsafety.ces.ncsu.edu/wp-content/uploads/2017/06/Drying-Vegetables-CSU-fact-sheet.pdf?fwd=no (2012).

7. D.G. Mercer, *A Basic Guide to Drying Fruits and Vegetables*, Department of Food Science, University of Guelph, Canada (2012). p.27. https://iufost.org/iufostftp/Guide%20to%20Drying-Full.pdf
8. V.R. Sager, P.S. Kumar, J. Food Sci. Technol., **47**: 15–26 (2010) https://doi.org/10.1007/s13197-010-0010-8
9. R.H. Setyobudi, E. Yandri, Y.A. Nugroho, M.S. Susanti, S.K. Wahono, W. Widodo, et al., Sarhad J. Agric., **37**,Special Issue 1: 171–183 (2021) https://dx.doi.org/10.17582/journal.sja/2022.37.s1.171.183
10. R.H Setyobudi, M.F.M. Atoum, D. Damat, E. Yandri, Y.A. Nugroho, M.S. Susanti, et al., Jordan J. Biol. Sci., **15**,3: 475–488 (2022) https://doi.org/10.54319/jjbs/150318
11. P.G. Adinurani, Perancangan dan Analisis Data Percobaan Agro: Manual and SPSS [Design and Analysis of Agrotrial Data: Manual and SPSS] (Plantaxia, Yogyakarta, 2016) [in Bahasa Indonesia] https://opac.perpusnas.go.id/DetailOpac.aspx?id=1159798#
12. P.G. Adinurani, Statistik Terapan Agroteknologi (disusun sesuai rencana pembelajaran semester) [Agrotechnology Applied Statistics (compiled according to the semester learning plan)] (Deepublish, Yogyakarta, 2022) [in Bahasa Indonesia] https://deepublishstore.com/shop/buku-statistika-terapan-3/
13. K. Ahmadi, T. Estiasih. *Teknologi Pengolahan Pangan.* [Food Processing Technology] Bumi Aksara, Jakarta (2009). [in Bahasa Indonesia]. https://opac.perpusnas.go.id/DetailOpac.aspx?id=1110601
14. A.F.K. Correia, A.C. Loro, S. Zanatta, M.H.F. Spoto, T.M.F.S. Vieira, Int. J. Food Sci., **2015**,970724: 1–7 (2015) http://dx.doi.org/10.1155/2015/970724
15. M. Yusufe, A. Mohammed, N. Satheesh, Acta Univ. Cibiniensis, Ser. E: Food Technol., **21**,1: 41–50 (2017) http://dx.doi.org/10.1515/aucft-2017-0005
16. E. Manolopoulou, T. Varzakas, Curr. Res. Nutr. Food Sci. J., **4**,2: 10–17 (2016) http://dx.doi.org/10.12944/CRNFSJ.4.Special-Issue-October.02
17. E. Sinurat, Murniyati, JPB Perikanan, **9**,2: 133–142 (2014). [in Bahasa Indonesia]. https://www.bbp4b.litbang.kkp.go.id/jurnal-jpbkp/index.php/jpbkp/article/download/106/72
18. Y.H. Diza, T. Wahyuningsih, S. Silfia, Jurnal Litbang Industri, **4**,2: 105–114 (2014). [in Bahasa Indonesia]. https://dx.doi.org/10.24960/jli.v4i2.635.105-114
19. A. Nuryanti, Indones. Natural Res. Pharm. J., **3**,2: 111–123 (2018) https://www.neliti.com/id/publications/341626/studi-kelayakan-kadar-air-abu-protein-dan-kadmium-cd-pada-sayuran-di-pasar-sunte#cite
20. K. Östbring, I. Sjöholm, M. Rayner, C. Erlanson-Albertsson, Foods, **9**: 1–15 (2020) https://doi.org/10.3390/foods9050669
21. S. Suherman, H. Widuri, S. Patricia, E.E. Susanto, R.J. Sutrisna, Int. J. Renew. Energy. Dev., **9**,1: 131–139 (2020) https://doi.org/10.14710/ijred.9.1.131-139
22. S. Suherman, M. Djaeni, D.H. Wardhani, M. Dzaki R, M.N. Bagas F., MATEC Web Conf., **156**,05008: 1–4 (2018) https://doi.org/10.1051/matecconf/201815605008
23. H. Susanto, R.H. Setyobudi, D. Sugiyanto, S.M. Nur, E. Yandri, H. Herianto, et al., E3S Web Conf., **188**,00010: 1–13 (2020) https://doi.org/10.1051/e3sconf/202018800010
24. K. Abdullah, A.S. Uyun, R. Soegeng, E. Suherman, H. Susanto, R.H. Setyobudi, et al., E3S Web Conf., **188**,00016: 1–8 (2020) https://doi.org/10.1051/e3sconf/202018800016
25. R.H. Setyobudi, E. Yandri, M.F.M. Atoum, S.M. Nur, I. Zekker, R. Idroes, et al., Jordan J. Bio. Sci., **14**,3: 613–620 (2021) https://doi.org/10.54319/jjbs/140331