biology and life sciences forum

Proceeding Paper

Effect of Drying Methods and Storage Conditions on Quality of Purple Sweet Potato Leaves †

Ngo Van Tai [1,*], Vo Thi Ngoc Tran [2] and Le Thi Kim Loan [3,*]

[1] School of Food Industry, King Mongkut's Insitute of Technology Ladkrabang, Bangkok 10520, Thailand
[2] Department of Food Technology, Can Tho University, Can Tho 94000, Vietnam; vongoctran02041999@gmail.com
[3] Faculty of Agriculture and Food Technology, Tien Giang University, My Tho 860000, Vietnam
* Correspondence: 64608035@kmitl.ac.th (N.V.T.); lethikimloan@tgu.edu.vn (L.T.K.L.)
† Presented at the 4th International Electronic Conference on Foods, 15–30 October 2023; Available online: https://foods2023.sciforum.net/.

Abstract: Purple sweet potato has been gradually increasing in terms of planting and consumption but, after harvesting, the leaves of the sweet potato are often discarded as waste or used for animal feed. The aim of this study was to determine the effect of drying methods on the quality of sweet potato leaf powder and its storage capacity. The nutritional and antioxidant properties of powder were analyzed. The results showed that hot air-drying could preserve the antioxidant properties more than the sun-drying method. Both methods could produce a product with high nutritional value, especially a high amount of protein and fiber. This could be considered as a supplementation ingredient for the food industry. Moreover, after storage at room temperature for 12 weeks, a slight increase in moisture content and decrease in antioxidant properties were found. Further, the application of this ingredient should be further investigated in food application to improve the income for local farmers as well as reduce the environmentally harmful waste.

Keywords: sweet potato; antioxidants; drying method; nutritional value; storage

check for updates

Citation: Van Tai, N.; Tran, V.T.N.; Loan, L.T.K. Effect of Drying Methods and Storage Conditions on Quality of Purple Sweet Potato Leaves. *Biol. Life Sci. Forum* **2023**, *26*, 44. https://doi.org/10.3390/Foods2023-15093

Academic Editor: Anet Režek Jambrak

Published: 14 October 2023

1. Introduction

Sweet potatoes are one of the five most important foods for developing countries. This food is considered a good source, supports health-related problems, and also contributes to food security [1]. Purple sweet potato contains many nutrients that are good for the body, such as starch, protein, amino acids, vitamins A, B, C, E, and more than 10 kinds of trace elements necessary for the body, such as calcium, zinc, iron, magnesium, potassium, sodium, phosphorus, etc. The production of sweet potato is increasing year by year and the leaves of sweet potato are a by-product after tuber harvest. Food waste has become a big consideration in recent years due to harm to the enviornment and economic conditions [2]. Purple sweet potato leaves also contain many beneficial nutrients and, at the same time, contain a certain amount of antioxidants that can help support a reduction in diseases. They also produce various kinds of foods, such as dried powder, soup, and other products [3]. Recent research has shown that, in addition to providing essential nutrients, antioxidants also support the immune system as well as health benefits like anticancer, antidiabetic, and antioxidant [4–6].

However, due to the characteristics of purple sweet potato leaves, they contain high moisture content. Sweet potato leaves' ability to retain their nutritional value during processing will be crucial for providing food ingredients. Due to its affordability, drying is a suistable method for preserving and producing many products from plants and waste materials [7]. In addition, sun drying is a natural drying method that has been used for a long time to preserve powder. However, during the wet season, it is challenging to sun dry. Therefore, the purpose of this study was to compare the effects of sun and oven drying on the nutritional, antioxidant properties, and preservation characteristics of sweet potato leaves.

2. Materials and Methods

2.1. Preparation of Sample and Drying Conditions

Purple sweet potato leaves were harvested at a local farm at Binh Tan district, Vinh Long province, and transported immediately to the laboratory for further processing. The leaves were then divided into two parts and dried under two different drying conditions (sun drying and oven drying). For the sun-drying method, the leaves were spread evenly on the tray and dried in direct sunlight (average temperature was about 31.8 ± 1.5 °C). The oven dryer machine (UN75, Memmert, Schwabach, Germany) was controlled at 60 °C, and air velocity was 0.5 m/s for the drying process of purple sweet potato leaves. The drying process was finished when purple sweet potato leaves reached moisture below 10%, which is the safe humidity for storage process [8]. The initial moisture content was analyzed, and the final moisture content was calculated based on the change in weight after drying. The drying time was also recorded. The leaves after drying were finely ground and sieved through a 100-mesh sieve. The nutritional composition and antioxidant properties of the two powders were analyzed and compared. At the same time, 500 g of purple sweet potato leaf powder was stored in polyamide packaging covered with aluminum film and 90% vacuum-sealed. Storage process was carried out at room temperature (25 ± 0.5 °C) and 70.8 ± 5.9% of humidity for 2, 4, 6, 8, 10, and 12 weeks. Samples were evaluated for antioxidant properties and moisture content every two weeks.

2.2. Proximate Analysis

The proximate composition was determined by using standard AOAC methods (AOAC, 2005).

2.3. Antioxidant Properties

Total phenolic content was determined by the Folin–Ciocalteu colorimetric method [9] and expressed as milligram gallic acid equivalents (mgGAE)/100 g on a dry weight basis (DW). Moreover, total flavonoid content was determined by the aluminum method [9] and expressed as milligram quercetin equivalents (mgQE)/ 100 g DW. 2,2-diphenyl-1-picrylhydrazyl (DPPH) was determined following the method established by Tai et al. [9] and expressed as percentage of inhibition of DPPH (%DPPH).

2.4. Data Analysis

All measurements were conducted in triplicate and presented as mean± STD (standard deviation). Statistical analyses were performed using Statgraphic Centurion XV.I (USA). One-way analysis of variance (ANOVA) was used to analyze the differences among data. Differences at $p < 0.05$ were significant.

3. Results and Discussions

Effect of Drying Method on the Nutritional and Antioxidant Properties of Sweet Potato Leaves

Table 1 summarizes the proximate composition of purple sweet potato leaf powders. The final moisture contents of the sun drying and hot air-drying methods were 8.97 ± 0.18% and 9.77 ± 0.27%, respectively. To reach this moisture content, the drying time of sun drying (13 h) was longer than the hot air-drying method (10 h). The contents of ash, crude protein, crude fiber, and crude fat and carbohydrate in dehydrated sweet potato leaves are also shown to be different. One-way ANOVA showed significant ($p < 0.05$) differences between the contents for dry samples. The results were similar to Sui et al. [10], who reported that different drying methods could lead to variation in nutritional properties. The study of Moguel-Ordóñez et al. [11] focused on *Stevia rebaudiana* (Bertoni) leaves, reporting that the sun-drying process could maintain a higher nutritional value than hot air drying. In addition, it can be seen that dried purple sweet potato powder has high amounts of crude protein and crude fiber, which could be considered a good source for supplementation to reduce the glycemic index or dietary fiber [12]. Further, this source of ingredients has high potential for use as a supplement to high-fiber, plant-based protein, or low-glycemic-index products.

Table 1. Effect of drying methods on the proximate composition and antioxidant properties of sweet potato leaf powder.

		Sun Drying	Hot Air Drying
Proximate compositions	Moisture	8.97 ^{b}	9.77 ^{a}
	Ash	10.9 ^{a}	9.87 ^{b}
	Protein	25.7 ^{a}	25.4 ^{b}
	Fiber	8.28 ^{a}	8.24 ^{b}
	Fat	3.25 ^{a}	3.28 ^{a}
	Carbohydrate	42.4 ^{a}	42.1 ^{a}
	Calories	301 ^{a}	296 ^{b}
Antioxidant properties	TPC (mgGAE/100 g DW)	6.04 ^{b}	6.35 ^{a}
	TFC (mgQE/100 g DW)	0.23 ^{b}	0.34 ^{a}
	DPPH (%)	60.1 ^{b}	65.3 ^{a}

Means values within the same row with different superscripts differ at $p < 0.05$.

When comparing the two drying methods, the process of drying purple sweet potato leaf powder with a drying device showed a higher ability to maintain the content of biological compounds when dried by the sun (Table 2). The prolonged drying time may be responsible for the decrease in the content of biological compounds. In this process, biological compounds can be decomposed by heat and direct sunlight. In addition, the DPPH assay is an excellent tool for determining the antioxidant activity of plant products [13]. The values of percentage of inhibition of DPPH were higher for the convection drying method. On the other hand, the values from the results of DPPH decreased in the sun-drying method. DPPH could be related to the number of pigments, and the loss of pigments could be explained by thermal oxidation and decomposition [14,15], which might be the main cause of the antioxidant activity decrease in leaf powders obtained by the sun-drying method. The nutritional profile of purple sweet potato leaf powder under two drying methods showed a slight change during storage. It could be seen that after 3 months of storage, the moisture content was slightly increased but still lower than 10%.

Table 2. Effect of drying methods and storage period on nutritional values of dried sweet potato leaves.

Drying Method	Storage (Week)	Protein (%)	Lipid (%)	Carbohydrate (%)	Moisture Content (%)
Sun drying	0	25.7 ^{a}	3.25 ^{a}	42.4 ^{a}	8.97 ^{a}
	2	25.7 ^{a}	3.25 ^{a}	42.4 ^{a}	8.97 ^{a}
	4	25.7 ^{a}	3.25 ^{a}	42.4 ^{a}	8.97 ^{a}
	6	25.6 ^{a}	3.24 ^{a}	42.4 ^{a}	9.00 ^{a}
	8	25.6 ^{a}	3.23 ^{a}	42.3 ^{a}	9.01 ^{ab}
	10	25.5 ^{a}	3.23 ^{a}	42.3 ^{a}	9.03 ^{a}
	12	25.5 ^{a}	3.22 ^{a}	42.3 ^{a}	9.09 ^{b}
Hot air drying	0	25.4 ^{a}	3.28 ^{a}	42.1 ^{a}	9.77 ^{a}
	2	25.4 ^{a}	3.28 ^{a}	42.1 ^{a}	9.77 ^{a}
	4	25.4 ^{a}	3.28 ^{a}	42.1 ^{a}	9.77 ^{a}
	6	25.3 ^{a}	3.28 ^{a}	42.1 ^{a}	9.80 ^{ab}
	8	25.3 ^{a}	3.27 ^{a}	42.0 ^{a}	9.81 ^{a}
	10	25.3 ^{a}	3.27 ^{a}	42.0 ^{a}	9.82 ^{b}
	12	25.2 ^{a}	3.27 ^{a}	42.0 ^{a}	9.84 ^{b}

Means values within the same row with different superscripts differ at $p < 0.05$.

The content of biological compounds and antioxidant activity of purple sweet potato leaf powder were also maintained after 12 weeks of storage at room temperature (Table 3). It can be seen that PA packaging with aluminum foil is effective in maintaining nutrients and biological compounds. Moreover, the 90% vacuum packaging condition mostly removed the air in the packaging, which helps prevent oxidation of the nutritional ingredients [16–18]. In addition, the aluminum film also has a light-blocking effect that helps reduce the transformation of light-sensitive compounds [19,20].

Table 3. Effect of drying methods and storage period on antioxidant properties of dried sweet potato leaves.

Drying Method	Storage (Week)	TPC (mgGAE/100 g)	TFC (mgQE/100 g)	DPPH (%)
Sun drying	0	6.04 ^{a}	0.23 ^{a}	60.1 ^{a}
	2	6.04 ^{a}	0.23 ^{a}	60.1 ^{a}
	4	6.03 ^{a}	0.23 ^{a}	60.1 ^{a}
	6	6.00 ^{a}	0.21 ^{a}	59.6 ^{a}
	8	6.00 ^{a}	0.20 ^{b}	59.3 ^{b}
	10	5.97 ^{a}	0.20 ^{b}	59.0 ^{b}
	12	5.92 ^{b}	0.19 ^{b}	58.8 ^{b}
Hot air drying	0	6.35 ^{a}	0.34 ^{a}	65.3 ^{a}
	2	6.35 ^{a}	0.34 ^{a}	65.3 ^{a}
	4	6.35 ^{a}	0.34 ^{a}	65.3 ^{a}
	6	6.33 ^{a}	0.33 ^{a}	65.0 ^{a}
	8	6.32 ^{a}	0.33 ^{a}	64.8 ^{b}
	10	6.30 ^{a}	0.31 ^{b}	64.7 ^{b}
	12	6.29 ^{a}	0.31 ^{b}	64.5 ^{b}

Means values within the same row with different superscripts differ at $p < 0.05$.

4. Conclusions

Both methods, including sun drying and hot air-drying, can maintain the nutrient content of purple sweet potato leaves. The sun-drying method is recommended because it uses natural energy sources and has little impact on the environment. However, it depends on the actual conditions that the appropriate method is used. The method of preservation in PA packaging with aluminum foil (90% vacuum) is recommended because the product quality can be maintained after 3 months of storage. Due to high antioxidant compounds, further studies should be considered on the application of purple sweet potato leaf powder, not only for livestock but also other food products in order to improve the usability of locally available raw materials and increasethe the income for sweet potato growers.

Author Contributions: Conceptualization, N.V.T. and L.T.K.L.; methodology, L.T.K.L. and N.V.T.; formal analysis, L.T.K.L.; investigation, L.T.K.L.; writing—original draft preparation, V.T.N.T. and N.V.T.; writing—review and editing, N.V.T. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data are contained within the article.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Oke, M.; Seyoum Workneh, T. A review on sweet potato postharvest processing and preservation technology. *Afr. J. Agric. Res.* **2013**, *8*, 4990–5003.
2. Van Tai, N.; Minh, V.Q.; Thuy, N.M. Food processing waste in Vietnam: Utilization and prospects in food industry for sustainability development. *J. Microbiol. Biotechnol. Food Sci.* **2023**, *13*, e9926. [CrossRef]
3. Li, G.; Lin, Z.; Zhang, H.; Liu, Z.; Xu, Y.; Xu, G.; Li, H.; Ji, R.; Luo, W.; Qiu, Y.; et al. Anthocyanin Accumulation in the Leaves of the Purple Sweet Potato (*Ipomoea batatas* L.) Cultivars. *Molecules.* **2019**, *24*, 3743. [CrossRef] [PubMed]
4. Carvalho APAd Conte-Junior, C.A. Health benefits of phytochemicals from Brazilian native foods and plants: Antioxidant, antimicrobial, anti-cancer, and risk factors of metabolic/endocrine disorders control. *Trends Food Sci. Technol.* **2021**, *111*, 534–548. [CrossRef]
5. Salehi, B.; Gültekin-Özgüven, M.; Kirkin, C.; Özçelik, B.; Morais-Braga, M.F.B.; Carneiro, J.N.P.; Bezerra, C.F.; da Silva, T.G.; Coutinho, H.D.M.; Amina, B. Antioxidant, Antimicrobial, and Anticancer Effects of Anacardium Plants: An Ethnopharmacological Perspective. *Front. Endocrinol.* **2020**, *11*, 295. [CrossRef] [PubMed]
6. Ngo, T.V.; Kusumawardani, S.; Kunyanee, K.; Luangsakul, N. Polyphenol-Modified Starches and Their Applications in the Food Industry: Recent Updates and Future Directions. *Foods* **2022**, *11*, 3384. [CrossRef] [PubMed]
7. Udomkun, P.; Romuli, S.; Schock, S.; Mahayothee, B.; Sartas, M.; Wossen, T.; Njukwe, E.; Vanlauwe, B.; Müller, J. Review of solar dryers for agricultural products in Asia and Africa: An innovation landscape approach. *J. Environ. Manage.* **2020**, *268*, 110730. [CrossRef] [PubMed]
8. Karataş, M.; Arslan, N. Moisture sorption isotherms and thermodynamic properties of cowpea (*Vigna unguiculate* L. Walp) stored in a chamber under controlled humidity and temperature. *J. Food Process Eng.* **2022**, *45*, e14101. [CrossRef]
9. Tai, N.V.; Linh, M.N.; Thuy, N.M. Optimization of extraction conditions of phytochemical compounds in "Xiem" banana peel powder using response surface methodology. *J. Appl. Biol. Biotechnol.* **2021**, *9*, 56–62. [CrossRef]
10. Sui, W.; Mu, T.; Sun, H.; Yang, H. Effects of different drying methods on nutritional composition, physicochemical and functional properties of sweet potato leaves. *J. Food Process. Preserv.* **2019**, *43*, e13884. [CrossRef]
11. Moguel-Ordóñez, Y.B.; Cabrera-Amaro, D.L.; Segura-Campos, M.R.; Ruiz-Ruiz, J.C. Studies on drying characteristic, nutritional composition, and antioxidant properties of Stevia rebaudiana (Bertoni) leaves. *Int. Agrophysics* **2015**, *29*, 323–331. [CrossRef]
12. Giuntini, E.B.; Sardá, F.A.H.; de Menezes, E.W. The Effects of Soluble Dietary Fibers on Glycemic Response: An Overview and Futures Perspectives. *Foods.* **2022**, *11*, 3934. [CrossRef] [PubMed]
13. Awika, J.M.; Rooney, L.W.; Wu, X.; Prior, R.L.; Cisneros-Zevallos, L. Screening Methods to Measure Antioxidant Activity of Sorghum (*Sorghum bicolor*) and Sorghum Products. *J. Agric. Food Chem.* **2003**, *51*, 6657–6662. [CrossRef] [PubMed]
14. Zhang, J.; Hou, X.; Ahmad, H.; Zhang, H.; Zhang, L.; Wang, T. Assessment of free radicals scavenging activity of seven natural pigments and protective effects in AAPH-challenged chicken erythrocytes. *Food Chem.* **2014**, *145*, 57–65. [CrossRef] [PubMed]
15. Enaru, B.; Dreţcanu, G.; Pop, T.D.; Stănilă, A.; Diaconeasa, Z. Anthocyanins: Factors Affecting Their Stability and Degradation. *Antioxidants.* **2021**, *10*, 1967. [CrossRef] [PubMed]
16. DeWitt, C.A.M.; Oliveira, A.C.M. Modified Atmosphere Systems and Shelf Life Extension of Fish and Fishery Products. *Foods.* **2016**, *5*, 48. [CrossRef] [PubMed]
17. Narasimha Rao, D.; Sachindra, N. Modified atmosphere and vacuum packaging of meat and poultry products. *Food Rev. Int.* **2002**, *18*, 263–293. [CrossRef]
18. Smith, J.P.; Ramaswamy, H.S.; Simpson, B.K. Developments in food packaging technology. Part II. Storage aspects. *Trends Food Sci. Technol.* **1990**, *1*, 111–118. [CrossRef]
19. Kwon, S.; Orsuwan, A.; Bumbudsanpharoke, N.; Yoon, C.; Choi, J.; Ko, S. A short review of light barrier materials for food and beverage packaging. *Korean J. Food Sci. Technol.* **2018**, *24*, 141–148. [CrossRef]
20. Lamberti, M.; Escher, F. Aluminium foil as a food packaging material in comparison with other materials. *Food Rev. Int.* **2007**, *23*, 407–433. [CrossRef]