The Effect of Different Drying Methods and Slice Thickness on The Quality of Porang (*Amorphophallus Muelleri*) Chips

Bambang Sigit Amanto[1], Hanun O. Chairunisa[1], Sigit Prabawa[1], Kawiji[1], Bara Yudhistira[1]*

[1] Program Studi Ilmu Teknologi Pangan, Fakultas Pertanian, Universitas Sebelas Maret, Surakarta, Indonesia.
Email*): barayudhistira@staff.uns.ac.id

Received:
18 March 2023

Revised:
10 August 2023

Accepted:
10 September 2023

Published:
27 September 2023

Abstract: Porang (Amorphophallus muelleri) is a type of tuber that has a high glucomannan content. The purpose of this study was to determine the effect of slice thickness on the quality of porang tuber chips using the Green House Effect (GHE) method by pretreatment with 0.15% sodium metabisulfite solution immersion. The slice thickness treatment was carried out at three levels, including 4 mm, 6 mm, and 8 mm, while the drying treatment was carried out with two types, which are the GHE drying method and the conventional drying method using sunlight. The results of the research on porang chips on brightness, moisture content, glucomannan content, ash content, and calcium oxalate content showed that the thickness of the slices had an effect on the quality of the chips. The thicker the slices of the porang chips, the darker the color of the porang chips. The thicker the slices of the porang chips, the higher the water content of the chips. The amount of glucomannan (%) in porang chips goes down as the slices get bigger.

Keyword: drying; green-house effect; porang chips; sodium metabisulfite

DOI:
10.29303/jrpb.v11i2.276

ISSN 2301-8119
e-ISSN 2443-1354

Available at
http://jrpb.unram.ac.id/

INTRODUCTION

Background

Porang (*Amorphophallus muelleri*) is a type of tuber plant (Sari and Suhartati, 2009). The benefits of porang tubers are mainly in the industrial and health fields, because of the glucomannan content in the tuber flour. Porang has several benefits, such as being used as a basic ingredient for noodles that are able to control cholesterol levels, overcome constipation, and prevent diabetes (Alifianto et al., 2013; Bo et al., 2013).

Porang tubers can be used as chips (porang flakes) to increase their selling value. Porang chips are thin slices of porang tubers that are then dried with the help of sunlight or artificial tools (machines) to reduce the water content so that the material can last a long time. Conventional drying using sunlight until now continues to be used because its operation does not require special skills and the costs incurred are more affordable. Drying in the sun takes a long time (6 days), depends on the weather, is not able to control the temperature, humidity, and drying time in real time, and exposes the chips to dust, pollution, and mold, which cause the chips to not meet the standards. One type of simple solar dryer is the *Green House Effect* (GHE) type dryer. In general, some of the added values of using GHE-type dryers are protection from weather conditions, cheap operation, especially when using only solar energy radiation, and, no contact with the outside environment, which can improve the cleanliness of the porang chip products produced (Zamharir et al., 2016).

During drying, the dried material may change its quality. Therefore, it is necessary to do pretreatment before the material is dried. Pretreatment is an attempt to increase the effectiveness of drying, improve appearance, and increase consumer preferences (Muhandri et al., 2017). Pretreatment can be done in various ways, such as chopping, steaming, fermenting, soaking, and so on (Amalia and Yuliana, 2013). One of the pretreatments in tuber processing is soaking. Materials that can be used for soaking include sodium chloride (NaCl) solution, lime solution ($Ca(OH)_2$), baking powder solution (sodium bicarbonate), and citric acid solution (Amalia and Yuliana, 2013; Nurvia et al., 2016; Wardani and Handrianto, 2019). Another soaking agent that is often used for flour products is bleach. The bleaching agent that is often used in the flour bleaching process is sulfite bleach (Haryani et al., 2016).

Sodium metabisulfite ($Na_2S_2O_5$) was chosen as the immersion agent because, according to research conducted by Reny and Indriaty (2015), immersion in a solution of sodium metabisulfite produces a brighter color of Goroho banana flour compared to the results of immersion in a solution of NaCl and citric acid. In addition, sodium metabisulfite was chosen because sodium metabisulfite has been widely used to improve the color of various types of flour, such as sweet potato flour, corn flour, cassava flour (Angelia and Hasan, 2018), pumpkin flour (Purwanto et al., 2013), walur flour (Sukri et al., 2014), and so on. Sodium metabisulfite can protect the material from oxidation, which causes a browning reaction (Padmadiningrum and Utomo, 2009). Soaking with sodium metabisulfite can also accelerate the decrease in water content during drying (Darmawan et al., 2019). Sodium metabisulfite has been used in some fruits and vegetables to keep them from turning brown (Wardhani et al., 2016).

There are several factors that need to be considered to obtain the maximum drying speed, such as (a) the surface area of the material, (b) temperature, (c) air velocity, (d) humidity (RH), (e) atmospheric pressure and vacuum, and (f) time (Yando and Paramita, 2017). The thickness of the porang chip slices is an analytical study in this study because the surface area of the material, which is influenced by the thickness of the chip slices, is a factor that must be controlled during the drying process. Slice thicknesses of 0.5 cm, 1 cm, and 1.5 cm were used by Amalia and Yuliana (2013) in a study of the effect of the soaking and boiling process on the calcium oxalate content of senthe tubers (*Alocasia macrorrhiza* L. Schott). Slice thicknesses of 1 mm, 2 mm, 3 mm, 4 mm, and 5 mm were used by Yando and Paramita (2017) in a study of the effect of temperature and slice thickness on moisture content, drying rate, and physical characteristics of cassava and sweet potato. Based on these studies, slice thickness will affect the properties of the dried material, which include calcium oxalate content, moisture content, drying rate, and physical properties, so the thickness of the slices that will be used as the treatment level in this study is 4 mm, 6 mm, and 8 mm.

Purposes

The objectives of this research activity are to determine the effect of slice thickness on the quality of porang (*Amorphophallus muelleri*) tuber chips by soaking in 0.15% sodium metabisulfite solution in Green House Effect drying and conventional drying and to determine the slice thickness and drying method that produces the best quality of porang tuber chips.

RESEARCH METHODS

Equipments and Materials

This study used spektrofotometer, titration analysis equipment and colormeter. Thi study also used porang (*Amorphophallus muelleri*), Sodium metabisulfite powder, 3.5 DNS reagent, formic acid (CH_2O_2) and sodium hydroxide (NaOH).

Methods

Preparation of samples

Sodium metabisulfite powder was dissolved in water at a concentration of 0.15%. The use of 0.15 % sodium metabisulfite is the same as the use of 1500 ppm sodium metabisulfite, or 1.5 g/liter of immersion solution. Then, the solution was stirred (Dwiyono and Djauhari, 2019).

Chips production

Porang tubers were sorted and selected if they were not deformed, and there were no foreign bodies involved. The porang tubers were peeled, washed with running water, and then sliced into thicknesses of 4 mm, 6 mm, and 8 mm using a knife and a porang tuber cutting machine. Porang chips were drained and divided into two treatments, consist of drying using the GHE method and drying using sunlight. Porang chips are arranged on a drying rack, then dried using a GHE dryer at a temperature of around 50 to 60 °C for 3–4 days, depending on weather conditions during the drying process. Other porang chips were arranged on a wire base and dried in direct sunlight for 3–4 days (Pramudita et al., 2020).

Physco-chemical analysis

The experimental design used a completely randomized design with three replicates of samples and analysis. The analyses carried out in this study included brightness analysis (Handayani et al., 2020), moisture content analysis (AOAC, 2005), glucomannan content analysis (Widjanarko and Megawati, 2015), ash content analysis (Handayani et al., 2020), and analysis of calcium oxalate levels (Maulina et al., 2012). Brightness analysis used a sample of porang tuber chips photographed on a white background in the open. The photos are then sent to the Paint software (Handayani et al., 2020).

The analysis of glucomannan levels in this study used the colorimetric assay method, which refers to the research of Widjanarko and Megawati (2015) and Wardani et al. (2021). This analysis consisted of making 3.5 dinitro salisilic acid (DNS)reagent, buffer solution, standard glucose solution, standard glucose curve, glucomannan extract, glucomannan hydrolyzate, and measuring the absorbance of the sample. Preparation of 3.5-DNS reagent by mixing solutions A and B. Solution A was prepared by mixing phenol (0.70 g), 10% (w/w) sodium hydroxide (1.50 mL), distilled water (5 mL), and sodium bisulfite (0.70 g). Solution B was prepared by mixing sodium potassium tartrate (22.50 g), 10% sodium hydroxide (30 ml), and 1% (w/w) 3.5-DNS (88 mL). A buffer solution of formic acid (CH_2O_2) and 0.1 M sodium hydroxide (NaOH) was prepared by mixing 1 mL of formic acid (CH_2O_2) with 60 ml of distilled water in a 250-mL measuring flask. Weigh 0.25 g of sodium hydroxide (NaOH) and dissolve it in 50 mL of aquadest. The resulting NaOH solution was then put into the volumetric flask and diluted to 250 mL. A standard glucose solution of 1 mg/mL was prepared by weighing 0.1 g of analytical-grade glucose, which had previously been dried to a constant weight at 105°C, and then diluted in 100 mL of distilled water.

The analysis of calcium levels in this study used the permanganometric titration method, which refers to the study (Maulina et al., 2012). The principle of this method is the oxidation-reduction reaction. The secondary standard solution used in this titration method is potassium permanganate ($KMnO_4$), where $KMnO_4$ is a strong oxidizing agent. The permanganometric titration method does not require an indicator because the secondary standard solution can act as an indicator (Mursyidi and Rohman, 2006). Analysis of calcium oxalate levels with this method consists of 2 stages, which are heating and permanganate titration. In the heating stage, 2 g of the mashed porang chip sample were suspended in 190 mL of distilled water, which was put into a 250-mL Erlenmeyer, and then 10 mL of a 6-M HCl solution was added. The suspension was heated at 100 °C for 1 hour, followed by cooling, and then 250 mL of water was added before it was filtered. Then, the titration stage begins with the amount of filtrate resulting from the heating stage being diluted to 300 mL, and then 125 mL is taken to be heated to almost boiling, then titrated with a 0.05 M $KMnO_4$ solution until it changes color to a pink color that almost disappears, which lasts for 30 s.

Data analysis

The study used a completely randomized design (CRD) with 2 treatment factors that were different drying methods and slice thickness. The data obtained were analyzed by SPSS version 16.0 using One Way ANOVA if there were significant differences between treatments followed by the DMRT test (Duncan Multiple Range Test) with a significance level of 0,05.

RESULTS AND DISCUSSION

Analysis of the physical and chemical properties of dried porang bulb chips under the GHE and under normal conditions

In the results of the brightness analysis, all treatments were significantly different (Table 1). Conventionally dried porang chips are darker because of the low drying temperature (Dwiyono and Djauhari, 2019). In the results of the water content analysis, the conventionally dried porang chips had a higher water content than the porang chips dried using GHE. The moisture content of the porang chip samples between the thicknesses of the slices in the conventional drying treatment was not significantly different. The GHE dryer dries the chip samples at a higher and more stable temperature. GHE drying is an artificial drying technique that utilizes a closed building whose walls and roof are made of transparent material that functions as an insulating material so that the incoming heat energy can increase the temperature in the drying room building (Wijayanti and Hariani, 2019). In the results of the analysis of glucomannan content, samples of porang chips with a thickness of 4 mm and 8 mm dried in GHE were not significantly different from samples of porang chips with a thickness of 6 mm dried in conventional methods. This is presumably because the glucomannan in GHE drying has been damaged because the drying temperature is above 60 °C (Zeng et al., 2020). In the analysis of ash content, all samples of porang chips were significantly different. In thin slices of chips, drying occurs faster because the thin slices reduce the distance that heat must travel to reach the center of the food, and the drying temperature becomes higher. The higher the drying temperature, the higher the ash content. The ash content increases because the water content that comes out of the material is getting bigger (Amirrudin, 2013). In the analysis of calcium oxalate levels, all samples of porang chips dried on GHE did not differ significantly. This is presumably due to the lack of immersion time in the pretreatment and the lack of heating treatment. Calcium oxalate has hydrothermal ability, so it can be removed by heating. Heating can be done by drying, boiling, soaking in warm water, or roasting (Amalia and Yuliana, 2013; Lewu et al., 2010).

Table 1. Determination of the Best Treatment for Porang Bulb Chips

Parameter	G4	G6	G8	K4	K6	K8
Brightness	502±27^{d}	425±11^{b}	333±13^{a}	559±11^{e}	457±20^{c}	356±33^{a}
Brightness (%)	66	56	44	73	60	46
Water content (%)	9.92±0.03^{a}	10.46±0.24^{b}	10.89±0.37^{c}	12.84±0.06^{e}	12.55±0.08^{d}	12.80±0.03^{de}
Glucoman an content (%)	42.00±6.99^{bc}	30.20±6.57^{a}	46.18±3.87^{cd}	58.95±2.18^{e}	48.98±1.25^{d}	39.25±3.06^{b}
Ash content (%)	6.31±0.36^{d}	6.67±0.31^{e}	5.63±0.18^{b}	6.30±0.12^{d}	5.15±0.07^{a}	5.96±0.14^{c}
Calsium Oxalate content (%)	532.72±85.31^{d}	587.45±32.16^{e}	557.90±43.99^{de}	360.94±1.54^{a}	369.13±1.99^{a}	476.69±3.57^{b}

Note: Different letter notations in one type of analysis (one line) indicate a significant difference at the significance level = 0.05. G4: GHE drying, porang thickness 4 mm; G6: GHE drying, porang thickness 6 mm; G8: GHE drying, porang thickness 8 mm; K4: conventional drying, porang thickness 4 mm; K6: conventional drying, porang thickness 6 mm; K8: conventional drying, porang thickness 8 mm.

Brightness of Porang Chips

In the Green House Effect, drying causes the brightness of the porang tuber chips to decrease after the drying process. The percentage is obtained from the calculation of brightness at maximum brightness. The maximum brightness in RGB imaging is 765 (Table 1). The brightness of a good porang tuber chip is more than 61% (Dwiyono et al., 2014). Therefore, good chips are porang chips with a slice thickness of 4 mm. Then, the brightness of all samples of chips was thought to be caused by immersion in a sodium metabisulfite solution. The sulfite in sodium metabisulfite is a strong inhibitor that is effective in inhibiting browning and has long been used as a solution to prevent browning of fruits and vegetables (Wardhani et al., 2016). In non-enzymatic browning, sodium metabisulfite can interact with the carbonyl group, the result of this reaction can bind melanoidin so as to prevent brown color. Meanwhile, in enzymatic browning, sodium metabisulfite will reduce disulfide bonds in the PPO enzyme so that the PPO enzyme cannot catalyze the oxidation of phenolic compounds that cause browning. Porang tubers contain PPO enzymes and tannins, which are phenolic compounds that cause browning (Zhao et al., 2010). The results of the statistical analysis showed that the thickness of the porang tuber chip slices had a significant effect on chip brightness ($p<0.05$). The thicker the slices of the porang chips, the darker the color of the chips. One of the factors that affects the drying process is the surface area of the material being dried. The surface area of the chips is affected by the thickness of the chip slices. Chips that are too thick will take longer to dry, causing an increase in the contact time between the chips and ambient oxygen. This can make oxidative browning happen more often and make the light less bright (Zeng et al., 2020).

In conventional drying, the highest brightness was obtained in samples of porang chips with a thickness of 4 mm (73%), and the lowest brightness at a thickness of 8 mm (46%). The thicker the chips, the lower the brightness. Drying in the sun produces a higher brightness than the GHE method of drying. This is because the heat of drying using the sun is unstable because it is affected by weather and environmental conditions. The sun's drying temperature range is relatively lower than the GHE method's drying temperature range. The drying temperature using sunlight ranges from 28 to 33 °C, while the drying temperature for the GHE method ranges from 26 to 36 °C. Heat in solar drying cannot be collected as well as heat in the GHE drying method, where the heat accumulates in greenhouse buildings (Dharma et al., 2020; Dwiyono and Djauhari, 2019).

Glucomannan content

Based on the results of the statistical analysis, the thickness of the slices of porang tuber chips dried using the GHE method had a significant effect on the levels of glucomannan in the chips ($p<0.05$). The lowest glucomannan content was found in the 6 mm slice thickness treatment sample. The highest glucomannan content was found in the 8 mm-thick treatment sample. The content of glucomannan is influenced by the thickness of the porang chips. The thinner the slices of porang chips, the lower the glucomannan content. The low glucomannan is caused by the breakdown of glucomannan when the drying temperature is above 60 °C and is thought to be due to the temperature instability in the GHE dryer (Zeng et al., 2020). So the thinner the thickness of the porang, the greater the potential for glucomannan to break down during drying.

The content of glucomannan in samples of porang chips that were dried in a vacuum dryer in the study by Zeng et al. (2020) reached its lowest value when the chip thickness was above 4 mm and the drying temperature was above 60 °C. Then, the highest glucomannan content was found in porang chips with a thickness of 4 mm and a drying temperature of 50 °C. However, in the porang chip sample, the 8-mm slice thickness treatment that resulted from this study had the highest glucomannan content, which should have been the lowest. This is caused by the drying temperature that cannot be controlled on the Green House Effect dryer used, and drying is carried out in the rainy season so that when the air in the environment decreases, the drying temperature also decreases. This is in accordance with the statement by Putra et al. (2014) that the temperature during the day fluctuates from time to time following the pattern of environmental temperature and the intensity of solar radiation. The average temperature at night is lower than during the day. In addition, the GHE dryer needs a way to control the temperature and the temperature outside the dryer can be changed to keep the drying temperature stable.

In conventional drying, the thickness of the chip slices affects the glucomannan content. The thicker the slices of porang chips, the lower the glucomannan content. The low glucomannan is thought to be caused by the breakdown of glucomannan when the drying temperature is above 60 °C. Thin slices increase sample contact with sodium metabisulfite immersion solution so that impurities are easily removed and glucomannan levels increase (Zeng et al., 2020). Based on SNI 7939:2020 regarding the quality standard of porang chips, all samples of chips are included in quality I with a glucomannan content criterion of 35%. Based on the results of the statistical analysis, the thickness of the slices of porang tuber chips dried using the conventional method using sunlight had a significant effect on the levels of glucomannan in the chips ($p<0.05$).

Calcium Oxalate Content

All levels of calcium oxalate contained in the sample of porang chips did not meet the permitted levels of calcium oxalate in tubers because the levels exceeded 71 mg/100 g. The 4 mm slice thickness treatment sample experienced a greater reduction in calcium oxalate than the 6 mm and 8 mm slice thickness treatment samples. The thinner the slices, the shorter the distance for the diffusion of water into the tuber pores, the rate of diffusion will be greater. The water pressure will increase so that the needle-shaped calcium oxalate crystals will be pushed out easily (Amalia and Yuliana, 2013). Based on statistical analysis, the thickness of the porang tuber chips dried using the GHE method did not significantly affect the calcium oxalate chip content ($p>0.05$). This is presumably due to the lack of immersion time and the unstable drying temperature. Calcium oxalate has hydrothermal ability, it can be removed by heating. Heating can be done by drying, boiling, soaking in warm water, or roasting (Amalia and Yuliana, 2013; Lewu et al., 2010).

Calcium oxalate levels in the sample chips can be reduced by immersing them in a solution of sodium metabisulfite. Then, the levels of calcium oxalate in the treatment samples with a thickness of 4 mm, 6 mm, and 8 mm were not significantly different. This is in accordance with the results of research from Hermianti and Firdausni (2013), including that soaking taro blocks in a 0.1% sodium metabisulfite solution can reduce the calcium oxalate content by 0.05%. However, this reduction is less significant than the 1% salt solution, which can reduce the calcium oxalate content by 0.094%. This is likely because there wasn't enough time spent in water during the pretreatment, and there wasn't any heating (Amalia and Yuliana, 2013). In conventional drying, the thicker the slices of porang chips, the higher the calcium oxalate content. This is in line with Ni'maturohmah's research (2019), which found that calcium oxalate levels increased quadratically with an increase in chip weight and drying time. This is thought to be caused by the reduced water content in the material during drying, which affects the increase in other components of the chips such as calcium oxalate. Calcium oxalate levels are also influenced by many factors. Environmental factors related to the oxalate content of porang tubers are temperature, rainfall, percentage of weed cover, soil pH, availability of calcium in the soil, and cation exchange capacity (CEC) (Ni'maturohmah, 2019). Based on the results of the statistical analysis, the thickness of the slices of porang tuber chips dried using the conventional method using sunlight significantly affected the levels of calcium oxalate chips ($p<0.05$).

Table 2. Results of the Analysis of Determining the Best Treatment for Porang Chips

Parameter	Treatment						Value
	G4	G6	G8	K4	K6	K8	
Brightness	5	3	1	6	4	2	0.65
Water content	6	5	4	1	3	2	1.00
Glucomanan content	3	1	4	6	5	2	0.81
Ash content	5	6	2	4	1	3	0.36
Clacium oxalate content	3	2	1	6	5	4	0.67
Total	15.50	11.28	9.27	15.20	13.33	8.67	
Ranking	1	4	5	2	3	6	

Determination of the Best Treatment for Porang Bulb Chips

The highest score on porang chips with a slice thickness of 4 mm is 15.50 (Table 2). So that it can be seen that the best treatment on porang chips is the treatment of 4 mm slice thickness with the Green House Effect drying method. The results of determining the best treatment differ from the results of determining the best treatment in the study of Zeng et al. (2020), porang chips with a slice thickness of 2 mm. This is due to differences in drying methods and differences in parameters used in determining the best treatment. In this study, samples of porang chips were dried using a vacuum drying method where the temperature and vacuum pressure could be controlled. The optimal temperature and degree of vacuum produced in the study by Zeng et al. (2020) are 60 °C and 0.06 MPa. The thickness of the slices, temperature, and degree of vacuum produced a glucomannan content of 61.96% and a whiteness of 82 degrees with a drying time of 5 hours.

In the research of Dwiyono and Djauhari (2019), the recommended slice thickness is 4-6 mm to get good quality porang chips. If the porang chips are too thin, they can crumble and stick to the dryer. If the slices of porang chips are too thick, then drying can take longer and trigger the growth of microbes on the chips. Therefore, porang chips with a slice thickness of 4 mm were still feasible to use as the best treatment. The results of the best treatment is the treatment of slice thickness, were dominated by the highest weight value on the parameters of water content and glucomannan content. The water content in porang chips greatly affects their quality and shelf life. High water content in foodstuffs can cause some damage, including microbial growth, browning reactions, and fat hydrolysis (De Man, 1997). The compound glucomannan is likely to be in porang chips because it is a biomaterial that can be used in many ways (Wigoeno et al., 2013)

CONCLUSION AND SUGGESTIONS

Conclusion

The quality of porang chips soaked in 0.15% sodium metabisulfite solution is influenced by the drying method (Green House Effect or conventional drying) and the thickness of the slices. The thicker the slices of the porang chips, the lower the brightness of the chips. The thicker the slices of the porang chips, the higher the water content of the chips. The thicker the slices of the porang chips, the lower the glucomannan content of the porang chips. The thicker the slices of the porang chips, the lower the ash content of the chips. The thicker the slices of porang chips, the higher the calcium oxalate content of the chips. The treatment of slice thickness by immersion in a 0.15% sodium metabisulfite solution gave the best results on the quality of porang chips (4 mm slice thickness by the Green House Effect method). The thicker slices of porang chips have an effect on the quality of the chips, especially on the water content and glucomannan content

Suggestions

Based on the research "Effect of Slice Thickness on the Quality of Porang Tuber Chips (Amorphophallus muelleri) by Soaking in 0.15% Sodium Metabisulfite Solution in Green House Effect Drying and Conventional Drying", suggestions for further research are to conduct research on the quality of porang chips using a Green House Effect (GHE) type dryer equipped with temperature control facilities so that the temperature in the GHE dryer can be controlled as needed, research needs to be done on the effect of variations in pretreatment using other types of solutions that can dissolve non-glucomannan components in order to obtain a higher glucomannan content. It is necessary to conduct research on the effect of pretreatment variations using other types of solutions that can reduce calcium oxalate levels so that calcium oxalate levels can meet the permitted standards. It is necessary to conduct research on other tests related to other chemical characteristics, such as dietary fiber content, fat content, protein content, starch content, and Total Plate Count as additional information that can be used as supporting data on the use of porang chips.

ACKNOWLEDGMENTS

Thank you to Universitas Sebelas Maret (UNS) Surakarta and the Institute for Research and Community Service (LPPM) Universitas Sebelas Maret for funding this research through the Research Group Grant (HGR-UNS Research) A.

FUNDING

This research is funded by Universitas Sebelas Maret (UNS) Surakarta and the Institute for Research and Community Service (LPPM) Universitas Sebelas Maret through the Research Group Grant (HGR-UNS Research) A.

CONFLICT OF INTEREST
All authors declare that there is no conflict of interest.

REFERENCES

Ajinegoro, R. (2021). Analisis Perpindahan Panas Pada Oven Pengering Berbahan Bakar LPG Untuk Proses Pengeringan Umbi Porang. Surabaya: Institut Teknlogi Sepuluh November, Thesis. [In Bahasa Indonesia].

Alifianto, F., Azrianingsih, R., Rahardi Jurusan Biologi, B. and Faldy Alifianto, M. (2013). Peta Persebaran Porang (Amorphophallus muelleri Blume) Berdasarkan Topografi Wilayah di Malang Raya. Jurnal Biotropika, 1(2), 75-80. [In Bahasa Indonesia].

Amalia, R. and Yuliana, R. (2013a). Studi Pengaruh Proses Perendaman dan Perebusan terhadap Kandungan Kalsium Oksalat pada Umbi Senthe (Alocasia macrorrhiza (L) Schott). Teknologi Kimia dan Industri, 2(3), 17–23. [In Bahasa Indonesia].

Amalia, R.and Yuliana, R. (2013b). Studi Pengaruh Proses Perendaman dan Perebusan terhadap Kandungan Kalsium Oksalat pada Umbi Senthe (Alocasia macrorrhiza (L) Schott). Teknologi Kimia dan Industri, 2(3), 17–23. [In Bahasa Indonesia].

Amer, B. M. A., Hossain, M. A. and Gottschalk, K. (2010). Design and Performance Evaluation of A New Hybrid Solar Dryer for B anana. Energy Conversion and Management, 51(4), 813–820. https://doi.org/10.1016/j.enconman.2009.11.016

Amirrudin. (2013). Pembuatan Tepung Wortel (Daucus carrota L.) dengan Variasi Suhu Pengering. Makassar: Universitas Hasanuddin, Thesis. [In Bahasa Indonesia].

Angelia, I. O. and Hasan, A. A. (2018). Pengaruh Variasi Lama Perendaman dan Konsentrasi Natrium Metabisulfit dalam Pembuatan Tepung Ubi Jalar, Tepung Jagung dan Tepung Singkong. Prosiding Seminar Hasil Penelitian (SNP2M), 2018, 149–154. [In Bahasa Indonesia].

AOAC (Association of Official Anallitycal Chemist). (2005). Official Methods of Analysis of Association of Official Anallitycal Chemist. AOAC, Inc.

Arun, S., Balaji, S. S.and Selvan, P. (2014). Experimental Studies on Drying Characteristics of Coconuts in a Solar Tunnel Greenhouse Dryer Coupled with Biomass Backup Heater. International Journal of Innovative Technology and Exploring Engineering, 4(5), 56–60.

Bo, S., Muschin, T., Kanamoto, T., Nakashima, H. and Yoshida, T. (2013). Sulfation and biological activities of konjac glucomannan. Carbohydrate Polymers, 94(2), 899–903. https://doi.org/10.1016/j.carbpol.2013.01.049

Darmawan, K. A., Wartini, N. M. and Wrasiati, L. P. (2019). Pengaruh Konsentrasi Natrium Metabisulfit dan Lama Perendaman terhadap Karakteristik Bubuk Bunga Kenikir (Tagetes erecta L.). Jurnal Rekayasa Dan Manajemen Agroindustri, 7(1), 81-89. https://doi.org/10.24843/jrma.2019.v07.i01.p09. [In Bahasa Indonesia].

De Man, J. M. (1997). Kimia Makanan. Bandung, Indonesia: Institut Teknologi Bandung.

Dharma, M. A., Nocianitri, K. A. and Yusasrini, N. L. A. (2020). Pengaruh Metode Pengeringan Simplisia Terhadap Kapasitas Antioksidan Wedang Uwuh. Jurnal Ilmu dan Teknologi Pangan (ITEPA), 9(1), 88. https://doi.org/10.24843/itepa.2020.v09.i01.p11. [In Bahasa Indonesia].

Dwiyono, K. and Djauhari, M. A. (2019). The Quality Improvement of Indonesian Konjac Chips (Amorphophallus Muelleri Blume) through Drying Methods and Sodium Metabisulphite Soaking. Modern Applied Science, 13(9), 107-118. https://doi.org/10.5539/mas.v13n9p107

Dwiyono, K., Sunarti, T. C., Suparno, O. and Haditjaroko, L. (2014). Penanganan Pascapanen Umbi Iles-Iles (Amorphophallus muelleri Blume) Studi Kasus di Madium, Jawa Timur. Jurnal Teknologi Industri Pertanian, 24(3), 179–188. [In Bahasa Indonesia].

Hamidi, N. (2017). Pengaruh Frekuensi Ultrasonik terhadap Karakteristik Pengering dengan Metode Novel Ultrasonic Chill. Saintek Ii, 155–159. [In Bahasa Indonesia].

Handayani, T., Aziz, Y. S. and Herlinasari, D. (2020). Pembuatan dan Uji Mutu Tepung Umbi Porang (Amorphophallus oncophyllus Prain) di Kecamatan Ngrayun. MEDFARM: Jurnal Farmasi dan Kesehatan, 9(1), 13–21. https://doi.org/10.48191/medfarm.v9i1.27

Haryani, K., Suharto, S., Suryanto, S., Sarana, S. and Santosa, T. B. (2016). Pemutihan Tepung Porang (Amorphophallus Onchophyllus) Menggunakan Natrium Metabisulfit Dan Vitamin C. Conference Series: Seminar Nasional Terapan Riset Inovatif, 01, 15-16. http://proceeding.sentrinov.org/index.php/sentrinov/article/view/105. [In Bahasa Indonesia].

Hendroatmojo. (1999). Identifikasi Kendala dan Konsideran dalam Pemberdayaan Bahan Pangan Komplemen Beras di Indonesia. Balai Penelitian Tanaman Aneka Kacang dan Umbi. [In Bahasa Indonesia].

Hermianti, W. and Firdausni, F. (2013). Pengaruh Natrium Metabisulfit dan Proses Mekanik Terhadap Kualitas Talas Blok. Jurnal Litbang Industri, 3(1), 31-43. https://doi.org/10.24960/jli.v3i1.618.31-38. [In Bahasa Indonesia].

Islami, A., Murad. and Priyati, A. (2017). Karakteristik Pengeringan Bawang Merah (Alium Ascalonicum. L) Menggunakan Alat Pengering ERK (Greenhouse). Jurnal Ilmiah Rekayasa Pertanian dan Biosistem, 5(1), 330–338. [In Bahasa Indonesia].

Koswara, S. (2013). Teknologi Pengolahan Umbi-Umbian Bagian 5: Pengolahan Ubi Jalar. Modul.

Lastari, A. N., Anandito, R. B. K. and Siswanti. (2016). Pengaruh Konsentrasi Natrium Metabisulfit (Na2S2O5) dan Lama Perendaman terhadap Karakteristik Tepung Kecambah Kedelai. Jurnal Teknosains Pangan, 5(2), 1-8. [In Bahasa Indonesia].

Lewu, M. N., Adebola, P. O. and Afolayan, A. J. (2010). Effect of Cooking on the Mineral Contents and Anti-nutritional Factors in Seven Accessions of Colocasia esculenta (L.) Schott Growing in South Africa. Journal of Food Composition and Analysis, 23(5), 389–393. https://doi.org/10.1016/j.jfca.2010.02.006

Matondang, S. (1989). Pengeringan Biji-bijian Hasil Pertanian. Medan, Indonesia: Universitas Sumatera Utara. [In Bahasa Indonesia].

Maulina, F. D. A., Lestari, I. M. and Retnowati, D. S. (2012). Pengurangan Kadar Kalsium Oksalat pada Umbi Talas Menggunakan NaHCO3: Sebagai Bahan Dasar Tepung. Jurnal Teknologi Kimia dan Industri, 1(1), 277–283. [In Bahasa Indonesia].

Michael, J. M. (2004). Termodinamika Teknik. Jakarta, Indonesia: Erlangga. [In Bahasa Indonesia].

Muhandri, T., Yulianti, S. D. and Herliyana, E. N. (2017). Karakteristik Pengeringan Jamur Tiram (Pleurotus ostreatus var. florida) Menggunakan Pengering Tipe Fluidized Bed Drier. Agritech, 37(4), 420–427. [In Bahasa Indonesia].

Mulyono, E. (2010). Peningkatan Mutu Tepung Iles-Iles (Amorphophallus Oncophillus) sebagai Bahan Pengelastis Mie dan Pengental melalui Teknologi Pencucian Bertingkat dan Enzimatis pada Kapasitas Produksi 250 kh Umbi/Hari. Jakarta, Indonesia: Balai Besar Penelitian dan Pengembangan Pasca Panen Pertanian. [In Bahasa Indonesia].

Mursyidi, A. and Rohman, A. (2006). Pengantar Kimia Farmasi Analisis Volumetri dan Gravimetri. Yogyakarta, Indonesia: Gadjah Mada University Press. [In Bahasa Indonesia].

Mutmaidah, S. and Rozi, F. (2015). Peluang Peningkatan Pendapatan Masyarakat Tepi Hutan Melalui Usahatani Porang. Conference Series: Seminar Hasil Penelitian Tanaman Aneka Kacang dan Umbi, 709–716. [In Bahasa Indonesia].

Ni'maturohmah, E. (2019). Optimasi Pengeringan Chips Porang (Amorphophallus muelleri Blume) Skala Pilot Plant Menggunakan Rotary Oven Tray. Malang: Universitas Brawijaya, Thesis. [In Bahasa Indonesia].

Nurvia, E., Yustina, I. and Yuniarti. (2016). Pengaruh Perlakuan Perendaman Ubi Talas Terhadap Sifat Kimia Dan Sensoris Keripik. Conference Series: Seminar Hasil Penelitian Tanaman Aneka Kacang dan Umbi, 810–816. [In Bahasa Indonesia].

Padmadiningrum, R. T. and Utomo, M. P. (2009). Perubahan Warna Dan Kadar - Karoten Dalam Tepung Ubi Jalar Akibat Pemutihan. Conference Series: Seminar Nasional Penelitian, 379–386.

Pramudita, B. A., Aprillia, B. S. and Rizal, A. (2020). Rancang Bangun Sistem Pengering Gaplek Tipe Hibrida Kombinasi antara Sistem Efek Rumah Kaca dan Tungku Biomassa. Jurnal Elektro dan Mesin Terapan, 6(2), 1–9. https://jurnal.pcr.ac.id/index.php/elementer/article/view/4423. [In Bahasa Indonesia].

Pratama, M. Z., Agustina, R. and Munawar, A. A. (2020). Kajian Pengeringan Porang (Amorphophallus oncophyllus) berdasarkan Variasi Ketebalan Lapisan Menggunakan Tray Dryer. Jurnal Ilmiah Mahasiswa Pertanian, 5(1), 351–360. [In Bahasa Indonesia].

Purbarani, K. (2017). Kualitas Fisik Tepung Glukomanan Yang Dikeringkan Menggunakan Vacuum Dryer Tipe Rak Dengan Variasi Suhu Pengering. Skripsi. http://etd.repository.ugm.ac.id/penelitian/detail/130486. [In Bahasa Indonesia].

Purwanto, C. C., Ishartani, D. and Rahadian, D. (2013). Kajian Sifat Fisik dan Kimia Tepung Labu Kuning dengan Perlakuan Blanching dan Perendaman Na Metabisulfit. Teknosains Pangan, 2(2), 41–48. [In Bahasa Indonesia].

Putra, G. M. D., Sutoyo, E. and Hartini, S. (2014). Uji Kinerja Alat Pengering Efek Rumah Kaca (ERK) Hybrid dengan Tungku Biomassa sebagai Sistem Pemanas Tambahan untuk Pengeringan Biji Pala (Myristica sp.). Jurnal Teknik Pertanian Lampung, 3(2), 183–194. [In Bahasa Indonesia].

Putri, F. M., Suedy, S. W. A. and Darmanti, S. (2017). Pengaruh Pupuk Nanosilika Terhadap Jumlah Stomata, Kandungan Klorofil dan Pertumbuhan Padi Hitam (Oryza sativa L. cv. japonica). Buletin Anatomi dan Fisiologi, 2(1), 72–79. [In Bahasa Indonesia].

Ramli, I. A., Jamaluddin P, J. P. and Yanto, S. (2018). Laju Pengeringan Gabah Menggunakan Pengering Tipe Efek Rumah Kaca (Erk). Jurnal Pendidikan Teknologi Pertanian, 3, 158. https://doi.org/10.26858/jptp.v3i0.5715. [In Bahasa Indonesia].

Rangana. (1970). Manual of Analysis Fruit and Vegetable Product. Mc. Graw-Hill Pub.Co. Ltd.

Ratti, C. (2001). Hot Air and Freeze-Drying of High-Value Foods: A Review. Journal of Food Engineering, 49(4), 311–319. https://doi.org/10.1016/S0260- 8774(00)00228-4

Rauf, R. F. (2021). Pemodelan Kinetika Pengeringan Rumput Laut Eucheuma cottonii Menggunakan Pengering Surya Efek Rumah Kaca. Jurnal Pendidikan Teknologi Pertanian, 7, 139–152. [In Bahasa Indonesia].

Reny, S. and Indriaty, F. (2015). Pengaruh Bahan Perendam pada Proses Pembuatan Tepung Pisang Goroho. Teknologi Industri, 7(2), 61–68. [In Bahasa Indonesia].

Rohanah, A. (2006). Teknik Pengeringan (TEP421). Medan, Indonesia:Universitas Sumatra Utara. [In Bahasa Indonesia].

Sari, R. and Suhartati. (2009). Tumbuhan Porang : Prospek Budidaya Sebagai Salah Satu Sistem Agroforestry. Info Teknis Eboni, 12(2), 97–110. [In Bahasa Indonesia].

Sitompul, M. R., Suryana, F. S., Mahfud, M. and Bhuana, D. S. (2018). Ekstraksi Asam Oksalat Pada Umbi Porang (Amorphophallus Oncophyllus) dengan Metode Mechanical Separation. Jurnal Teknik ITS, 7(1), 1–4. https://doi.org/10.12962/j23373539.v7i1.28831. [In Bahasa Indonesia].

Sudarmadji, S., Haryono, B. and Suhardi. (1997). Prosedur Analisis untuk Bahan Makanan dan Pertanian. Jakarta, Indonesia: Liberty.

Sukri, N., Kusnandar, F., Purnomo, E. H. and Risfaheri. (2014). Pengaruh Penambahan Natrium Metabisulfit terhadap Karakteristik Tepung Walur (Amorphophallus campanulatus var. Sylvetris). Teknotan, 8(3), 1275–1281. [In Bahasa Indonesia].

Tan, T. C., Cheng, L. H., Bhat, R., Rusul, G. and Easa, A. M. (2015). Effectiveness of Ascorbic Acid and Sodium Metabisulfite as Anti-Browning Agent and Antioxidant on Green Coconut Water (Cocos nucifera) Subjected to Elevated Thermal Processing. International Food Research Journal, 22(2), 631–637.

Wardani, N. E., Subaidah, W. A. and Muliasari, H. (2021). Ekstraksi dan Penetapan Kadar Glukomanan dari Umbi Porang (Amorphophallus muelleri Blume) Menggunakan Metode DNS. Jurnal Sains dan Kesehatan, 3(3), 383–391. https://doi.org/10.25026/jsk.v3i3.574. [In Bahasa Indonesia].

Wardani, R. K. and Handrianto, P. (2019). Pengaruh Perendaman Umbi dan Tepung Porang Dalam Sari Buah Belimbing Wuluh Terhadap Sifat Fisik dan Kadar Kalsium Oksalat. Journal of Pharmacy and Science, 4(2), 105–109. https://doi.org/10.53342/pharmasci.v4i2.148. [In Bahasa Indonesia].

Wardhani, D., Yuliana, A. E. and Dewi, A. S. (2016). Natrium Metabisulfit Sebagai Anti-Browning Agent Pada Pencoklatan Enzimatik Rebung Ori (Bambusa Arundinacea). Jurnal Aplikasi Teknologi Pangan, 5(4), 140–145. https://doi.org/10.17728/jatp.202. [In Bahasa Indonesia].

Widjanarko, S. B. and Megawati, J. (2015). Analisis Metode Kolorimetri dan Gravimetri Pengukuran Kadar Glukomanan pada Konjak (Amorphophallus konjac). Jurnal Pangan dan Agroindustri, 3(4), 1584–1588. [In Bahasa Indonesia].

Wigoeno, Y. A., Azrianingsih, R. and Roosdiana, A. (2013). Analisis Kadar Glukomanan pada Umbi Porang. Jurnal Biotropika, 1(5), 231–235. [In Bahasa Indonesia].

Wijayanti, F. and Hariani, S. (2019). Pengaruh Pengeringan Biji Kopi dengan Metode Rumah Kaca dan Penyinaran Sinar Matahari Terhadap Kadar Air Biji Kopi Robusta (Coffea Robusta). Prosiding Seminar Nasional Sains Dan Teknologi,2(1), 1–6. [In Bahasa Indonesia].

Wulandani, D. (2013). Analisis Pengeringan Sawut Ubi Jalar (Impomoea batatas L.) Menggunakan Pengering Efek Rumah Kaca (ERK). Journal Keteknikan Pertanian, 1(1), 151–158. https://doi.org/10.19028/jtep.01.1.151-158. [In Bahasa Indonesia].

Yando, A. M. and Paramita, V. (2017). Studi Pengaruh Suhu Dan Ketebalan Irisan Terhadap Kadar Air, Laju Pengeringan Dan Karakteristik Fisik Ubi Kayu Dan Ubi Jalar. Metana, 13(1), 23. https://doi.org/10.14710/metana.v13i1.17514. [In Bahasa Indonesia].

Zakaria, M., Hendrawan, Y. and Djojowasito, G. (2017). Modelling of Turmeric (Curcuma Domestica Val.) Drying Using Machine Vision and Artificial Neural Network. Agricultural Technology journal, 18(1), 11–20.

Zamharir, Sukmawaty. and Priyati, A. (2016). Analisis Pemanfaatan Panas padaPengeringan Bawang Merah (Allium ascalonicum L.) dengan Menggunakan Alat Pengering Efek Rumah Kaca (ERK). Jurnal Ilmiah Rekayasa Pertanian dan Biosistem, 4(2), 264–274. [In Bahasa Indonesia].

Zeng, Z., Chen, M., Wang, X., Wu, W., Zheng, Z., Hu, Z. and Ma, B. (2020). Modeling and Optimization for Konjac Vacuum Drying Based on Response Surface Methodology (RSM) and Artificial Neural Network (ANN). Processes, 8(11), 1–17. https://doi.org/10.3390/pr8111430

Zhao, J., Zhang, D., Srzednicki, G., Kanlayanarat, S. and Borompichaichartkul, C. (2010). Development of a Low-Cost Two-Stage Technique for Production of Low-Sulphur Purified Konjac Flour. International Food Research Journal, 17(4), 1113–1124.