Factorial experimental design for optimizing the roasting condition of banana peel (Musa paradisiaca var Semeru): characteristics and antioxidant activity

by Lannie Hadisoewignyo

Submission date: 17-Jul-2025 03:06PM (UTC+0700)
Submission ID: 2716278502
File name: design_for_optimizing_the_roasting_condition_of_banana_peel.pdf (494.17K)
Word count: 3893
Character count: 20168

Food Research 7 (6) : 48 - 53 (December 2023)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

RESEARCH PAPER

Factorial experimental design for optimizing the roasting condition of banana peel (*Musa paradisiaca* var Semeru): characteristics and antioxidant activity

*Hadisoewignyo, L., Foe, K. and Prasetyo, J.

Faculty of Pharmacy Widya Mandala Catholic University Surabaya, Jl. Raya Kalisari Selatan No. 1, Pakuwon City, Surabaya 60112, Indonesia

Article history:
Received: 2 September 2022
Received in revised form: 15 October 2022
Accepted: 21 October 2022
Available Online: 29 November 2023

Keywords:
Banana peel,
Factorial design,
Roasting condition,
Antioxidant,
Antidepressant

DOI:
https://doi.org/10.26656/fr.2017.7(6).462

Abstract

Banana peel is an organic waste that has not been widely used. The rich content of vitamins, minerals, antioxidants and tryptophan is the background for research utilizing organic waste for something useful. This study aimed to use a factorial design to find the optimum conditions for the banana peel roasting process. The variables analyzed were roasting temperature (180°C and 200°C) and roasting time (15 and 20 mins). Responses to determine the optimum conditions were water content, color similarity with local coffee products and antioxidant activity (IC_{50}). Antioxidant activity was measured using the 2,2-diphenyl-1-picrylhydrazyl method. The characteristics of banana peel powder and roasted banana peel powder showed the presence of beneficial substances and even richness in vitamins and minerals, as well as the presence of tryptophan. The scavenging activity of roasted banana peel powder was higher at high temperatures and longer during roasting. The lowest water content was at 200°C and 20 mins of roasting conditions. A brownish color resembling ground coffee was obtained with a roasting temperature of 200°C. The interaction between temperature and roasting time affects the moisture content and color similarity, while the roasting time dominantly affects IC_{50}. The optimum conditions selected were 200°C roasting conditions; 20 mins will produce a water content of 2.00%, color similarity 11.80 and IC_{50} 1979.2 (ppm). In addition, the presence of tryptophan in banana peel powder has the opportunity to be used as an antidepressant compound.

1. Introduction

Banana peel from *Musa paradisiaca* L. var. Semeru is an organic waste produced from the processing of bananas. Banana peel is a third part of the banana fruit, with various nutritious substances, including carbohydrates, fats, proteins, vitamins, minerals, polyphenolic compounds, and tryptophan. Polyphenol compounds can be used as natural antioxidant, anti-bacterial, and anti-inflammatory compounds, while tryptophan is a compound with mood-improving effects (Someya *et al.*, 2002; Khawas and Deka, 2016).

During the roasting process, heat transfer occurs from the roaster into the material and water mass is transferred, affecting the moisture content of the roasted powder. The length of the roasting time will affect the water content in the roasted powder. In addition to the water content, the roasting process will also affect the color of the roasted material. The higher the roasting temperature and the longer the roasting time, the darker the material's color.

Free radicals are unstable, reactive molecules or atoms that can cause the degradation of body cells. Those radicals participate in the aging and pathogenesis of diseases (Halliwell, 2012). Our body needs antioxidants to catch those radicals through catalyzing the destruction of free radicals (binding free radicals), acting as a primary antioxidant (donates hydrogen protons), reducing agent (donates electrons), reducing the formation of singlet oxygen ($^1O_2$) and binds metals (metal chelators) (Sharma *et al.*, 2018).

Banana peel has been made into a coffee analog drink through roasting, but the optimum roasting condition has not been determined yet (Mentari *et al.*, 2019; Sofa *et al.*, 2019). A previous study showed that cocoa bean shells roasted at temperatures of 110°C, 140°C and 190°C produced higher antioxidant activity than those not roasted (room temperature, 25°C). The optimum antioxidant activity was reached by roasting at 140°C, not at the highest temperature. Moreover, the temperature and roasting time greatly influence sensory properties. This study will determine the optimum

*Corresponding author.
Email: *lannie@ukwms.ac.id*

eISSN: 2550-2166 / © 2023 The Authors.
Published by Rynnye Lyan Resources

roasting temperature of Agung banana peel (Utami *et al.*, 2017).

To date, the utilization of banana peel waste still has low economic value. One previous study made starch from banana peels (Hadisoewignyo *et al*., 2017). This study used banana peels as an ingredient that works as a source of antioxidants and antidepressants. Banana peel is made into powder and roasted. The roasting process can affect the air content, color, and antioxidant activity of the ingredients, it is necessary to determine the optimal conditions of the roasting process. This study aimed to optimize the conditions for roasting agung banana peels with high antioxidant activity.

2. Materials and methods

2.1 Materials

The raw material used is Agung banana peel from Lumajang, East Java, Indonesia. The chemicals used were of analytical grade, including DPPH reagent pa (Merck), methanol pa (Merck), and distilled water. The equipment used is a roaster, chopper, oven, analytical balance, spectrophotometer (UV-Vis Thermo Scientific, Genesys 10S UV), magnetic stirrer, colorimeter Linshang LS171, Ohaus moisture analyzer MB25, vortex Dlab MX-S, micropipette, and glassware.

2.2 Characteristics of banana peel powder and roasted banana peel powder

The characteristics of banana peel powder and roasted banana peel powder were carried out at the Center of Agro-Based Industry, Ministry of Industry of the Republic of Indonesia, including microbiological testing.

2.3 Optimization of banana peel powder processing with factorial design

The roasting process was optimized using the factorial design method with two factors and two levels. The factors used are the temperature of the roaster and the roasting time. The temperature levels were 180°C and 200°C and the roasting time was 15 mins and 20 mins. Water content, powder color, and antioxidant activity (IC_{50}) were the observed responses to obtain the optimum process. The optimum condition was analyzed using Design Expert software ver 10.0.1.

Banana peels are washed, chopped (1×1 cm), dried, ground and sieved with 80 mesh. Banana peel powder is roasted at a roasting temperature of 180 and 200°C for 15 and 20 mins, as mentioned in Table 1.

Table 1. Factorial design for the roasting condition.

	Factors	Selected levels	
		-1	+1
A	Roasting temperature (°C)	180	200
B	Roasting time (min)	15	20

2.4. Moisture content analysis

The moisture content of the banana powder was determined after the roasting process using a moisture balance analyzer.

2.5 Color analysis

The color of roasted banana peel powder was measured using a colorimeter. L*, a*, b* values obtained represent three dimentions:1. L* represents the light-dark spectrum with a range from 0 to 100 d(black to white), 2. a* value represents the green-re spectrum with a range from -60 to +60 (green to red), 3. b* value represents the blue-yellow spectrum with a range from -60 to +60 (blue to yellow). The L*, a*, and b* values were then converted into ΔE^*_{ab} values using equation 1.

$$\Delta E^*_{ab} = \sqrt{(L^*_2 - L^*_1)^2 + (a^*_2 - a^*_1)^2 + (b^*_2 - b^*_2)^2} \quad (1)$$

L*a*b* Color Difference Compare with Local Coffee Product

2.6 DPPH radical scavenging activity

The DPPH radical scavenging activity (DPPH-RSA) test was carried out using the Burda and Oleszek (2001) method. A weight of 12.5 mg of the sample was dissolved in 25 mL of methanol. Then 1 mL of the solution was pipetted, and 2 mL of 0.1 mM DPPH solution was added. Then it was incubated in a dark room for 30 mins at room temperature, and then the absorbance was measured using a UV-Vis spectrophotometer at a wavelength (λ) of 517 nm. Antioxidant activity as a free radical scavenger was expressed as IC_{50} (μg/mL), which indicates the sample's concentration that can inhibit free radicals by 50%.

3. Results and discussion

3.1 Characteristics of banana peel powder and roasted banana peel powder

The characteristics of banana peel powder and roasted banana peel powder (Figure 1) were determined by several parameters, as shown in Table 2. Banana peels contain high amounts of minerals, especially sodium, potassium, calcium, magnesium, iron and zinc. In addition, there are also several vitamins, including vitamin C and beta-carotene, in a reasonably high amount. Dietary and insoluble dietary fiber is available in relatively high quantities in roasted and non-roasted banana peel powder. The insoluble dietary fiber in banana peels was high enough to benefit the body, especially the digestive system. In addition, heavy metal

https://doi.org/10.26656/fr.2017.7(6).462 © 2023 The Authors. Published by Rynnye Lyan Resources

contamination is determined for roasted and non-roasted banana peel powder. The content of lead, cadmium, copper, tin, and mercury does not exceed the required provisions.

Figure 1.Roasted banana peel powder.

Table 2. Characteristics of non-roasted and roasted banana peel powder.

Parameter	Banana Peel Powder	Roasted Banana Peel Powder
Water content (%)	4.42	2.38
Ash content (%)	10.24	10.59
Acid insoluble ash (%)	0.07	0.09
Protein (%)	6.98	7.12
Fat (%)	3.37	3.04
Carbohydrate (%)	74.99	76.87
Sugar content (%)	3.48	1.83
Reducing sugar (%)	0.90	0.73
Dietary fiber (%)	28.39	30.07
Insoluble dietary fiber (%)	27.40	28.01
Amylose (%)	14.89	15.51
Amylopectin (%)	27.46	25.77
pH	6.74	6.58
Density (g/mL)	0.7308	0.6903
Caffeine (mg/Kg)	<1.20	<1.20
Sodium (mg/Kg)	1099	1066
Potassium (mg/Kg)	113585	135073
Calcium (mg/Kg)	973	1174
Magnesium (mg/Kg)	1420	1544
Iron (mg/Kg)	30.09	34.80
Zinc (mg/Kg)	20.69	22.18
Vitamin A (IU/100 g)	<0.50	<0.50
Betacarotene	76.5	60.7
Vitamin B1 (mg/Kg)	< 0.25	< 0.25
Vitamin B2 (mg/Kg)	<0.25	<0.25
Vitamin B6 (mg/Kg)	<0.20	<0.20
Vitamin C (mg/Kg)	75.5	69.3
Vitamin D (mg/100g)	11.3	3.69
Vitamin E (mg/100g)	3.88	6.20
Folic acid (mg/Kg)	<0.25	<0.25
Tryptophan (%)	0.1	0.01
Acrylamide (mg/g)	0.127	0.475

The test on microbial contamination (Table 3) showed that the total plate count and the number of yeast molds were lower in the roasted banana peel powder. That was related to the use of high temperatures in the roasting process.

The presence of high carbohydrate content in banana peel powder and the heat during processing allows the formation of acrylamide, which is formed through various reactions, one of which is the Millard reaction (reaction between amino acids and reducing sugars). In the roasting process, the temperature used was 200ºC, where high temperatures can increase the formation of acrylamide, so the acrylamide content is higher in roasted banana peel powder (0.475 µg/g).

Table 3. Microbial contamination on non-roasted and roasted banana peel powder.

Parameter	Banana Peel Powder	Roasted Banana Peel Powder
Total plate count (CFU/g)	7.2×10^{-6}	3.0×10^{-4}
Escherichia coli (CFU/g)	<3	<3
Staphylococcus aureus (CFU/g)*	0	0
Bacillus cereus (CFU/g)**	0	0
Pseudomonas aeruginosa (CFU/g)*	0	0
Salmonella sp. (per 25 g)	Negative	Negative
Mold (CFU/g)	7	<10
Yeast (CFU/g)	17	<10

The presence of tryptophan in banana peels can relieve symptoms of depression and mood disorders. Tryptophan turns into serotonin when it breaks down, which can improve mood. The presence of tryptophan in banana peels can be used as an antidepressant. The tryptophan content in unroasted banana peel powder was higher than that of roasted banana peel powder, 0.1% and 0.01% (w/w), respectively. The roasting process can reduce the tryptophan content because tryptophan is unstable at high temperatures.

3.2 Moisture content and color determination

The moisture content of the roasted banana peel was determined using a moisture content analyzer (Table 4). The moisture content is lowest in the fourth roasting condition (200ºC, 20 mins). Controlling moisture content was essential for optimal process control, maintaining high product quality, and compliance with regulations (Wernecke and Wernecke, 2014). Although roasting can kill microbe's toxins and deactivate enzymes, the process can affect the nutrition status. A roasting process can influence color, aroma, taste and antioxidant properties (Sruthi *et al.*, 2021).

The brownish color resembling ground coffee is achieved with 200 degrees of roasting (Table 4, Figure 2). The visual appearance of the color could be an indicator of the roasting degrees and play as an indicator to stop the roasting process. During roasting, some important reactions are the Maillard reaction which induces aroma, the caramelization that creates the color,

https://doi.org/10.26656/fr.2017.7(6).462
© 2023 The Authors. Published by Rynnye Lyan Resources

Table 4. Color space, moisture content after roasted, and antioxidant activity after roasting.

Roasting condition	Color Similarity	Moisture Content After Roasted (%)	IC_{50} (ppm)
180°C, 15 mins	13.47±4.41	1.96±0.06	2450±919.24
180°C, 20 mins	12.32±3.91	3.00±0.68	2250±495.98
200°C, 15 mins	11.18±3.82	1.99±1.03	2050±354.55
200°C, 20 mins	11.81±0.49	1.93±0.18	1950±70.71

and pyrolysis, which creates a signature aroma and taste (Tarigan *et al.*, 2022). Maillard reaction has melanoidins as the end product with reducing properties, absorbing oxygen, and metal chelating capacity. Color can be an index of the antioxidant properties of food (Pokorný and Schmidt, 2003).

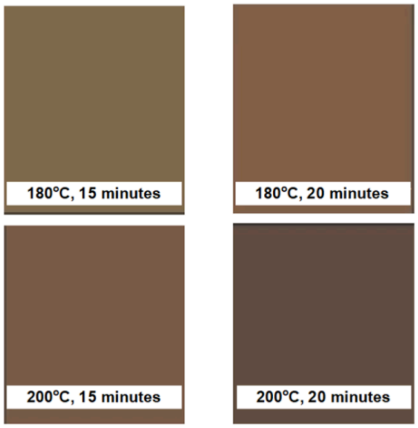

Figure 2. Color of banana peel after roasting.

3.2 Antioxidant activity

The scavenging activity of roasted banana peel powder was higher in high temperatures and more prolonged during the duration of roasting (Table 4). This result was in agreement with a previous study, which reported a lower IC_{50} value with a longer drying time for banana peel (Mentari *et al.*, 2019). Some compounds with antioxidant properties can get lost during roasting, but new compounds with antioxidant activity were created during the Maillard reaction. Maillard reaction is also responsible for forming volatile compounds that contribute to the aroma of the food (Diaz-de-Cerio *et al.*, 2019).

Some antioxidant molecules are formed during the roasting process, such as phenylalanine and heterocyclic compounds (Poncet *et al.*, 2021). Phenolic compounds were considered one of the quality markers of the roasting process (Diaz-de-Cerio *et al.,* 2019). Although enzymatic or chemical oxidation of polyphenols can reduce the antioxidant capacity, higher antioxidant activity is shown by partially oxidized polyphenols (Pokorný and Schmidt, 2003). A previous study reported that the maximum antioxidant activity was in medium-roasted coffee and dark-roasted coffee has a lower antioxidant value (Nicoli *et al.*, 1997; del Castillo *et al.*, 2002). Other studies reported the highest antioxidant capacity in lightly roasted coffee (Duarte *et al.*, 2005).

3.3 Optimization of the roasting condition using factorial design

Roasting temperature and time will significantly affect several parameters of the roasted powder, such as the resulting color and antioxidant content. The roasting conditions must be optimal per the standard criteria to produce the roasted powder. Therefore, optimizing the roasting process will provide optimal conditions to make the desired roasted powder. Optimization is carried out using a factorial design with two factors and two levels. The temperature and time of the roasting optimization condition were analyzed using the factorial design method using the software Design Expert ver. 10.0.1. Polynomial equations (Table 5) were built based on the moisture content, color similarity and IC_{50} value. Y is the response, and X is the value of the level of concentration. Roasting time and temperature influenced color similarity, moisture content and IC_{50} value. A longer roasting time resulted in lower moisture content.

Based on the polynomial equation, it can be seen that the interaction between temperature and roasting time dominantly affects the moisture content and color similarity, while the roasting time dominantly affects IC_{50}. The color change of the roasted powder depends on the length of the roasting time. The longer the roasting time, the darker color will appear, in this case, giving a darker brown color. The contour plot of moisture

Table 5. Polynomial equation

Response	Polynomial Equation
Moisture Content after roasted (%)	$Y = 2.22 – 0.26(X_a) + 0.25(X_b) – 0.28 (X_a)(X_b)$
Color Similarity	$Y = 12.20 – 0.70(X_a) – 0.13(X_b) + 0.44 (X_a)(X_b)$
IC_{50} (ppm)	$Y = 2175 - 175(X_a) - 75(X_b) + 25 (X_a)(X_b)$

X_a: level value for temperature, X_b: level value for time

© 2023 The Authors. Published by Rynnye Lyan Resources

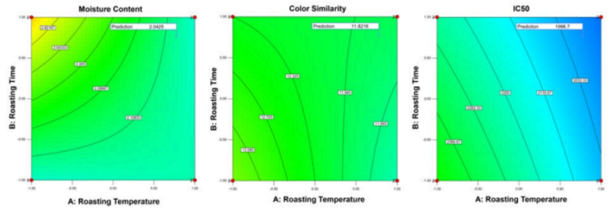

Figure 3. Contour plot of moisture content (A), color similarity (B), and IC_{50} (C) of roasting conditions (roasting time and roasting temperature).

content, color similarity and IC_{50} have been established based on polynomial equations (Figure 3).

In Figure 4, the yellow area on the superimposed contour plot depicts the optimum area. The optimum condition chosen was 200°C for 20 mins of roasting temperature. The optimum condition will result in moisture content of 2.00%, color similarity of 11.80 and IC_{50} of 1979.2 ppm. The previous hedonic test study showed that panelists prefer a darker color, a more pungent aroma and a bitter coffee analog from the banana peel (Hasbullah *et al.*, 2021). Hence, it is probable that panelists will also prefer this optimum condition of the Agung banana peel coffee analog.

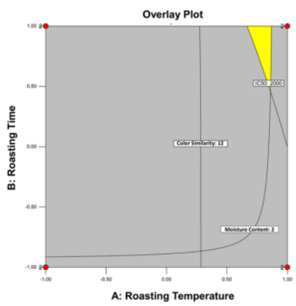

Figure 4. The superimposed contour plot of roasting condition.

4. Conclusion

Roasted banana peel can be considered a food raw material that has antioxidant and antidepressant activity. The optimum conditions selected based on the factorial design were 200°C; 20 mins. The presence of tryptophan in banana peel powder can be used as an antidepressant compound. It is recommended that further study should be carried out on a hedonic test for the taste and aroma of Agung banana peel coffee analog.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgments

The research was funded by Ministry of Education, Culture, Research, and Technology of Indonesia under the National Competition Scheme (PDKN, 2022).

References

del Castillo, M.D., Ames, J.M. and Gordon, M.H. (2002). Effect of Roasting on the Antioxidant Activity of Coffee Brews. *Journal of Agricultural and Food Chemistry*, 50(13), 3698–3703. https://doi.org/10.1021/jf011702q

Diaz-de-Cerio, E., Guerra-Hernandez, E., Garcia-Estepa, R., Garcia-Villanova, B. and Verardo, V. (2019) Analytical Approaches in Coffee Quality Control. In Grumezescu, A.M. and Holban, A.M. (Eds.). Caffeinated and Cocoa Based Beverages, Volume 8: The Science of Beverages, p. 315. Duxford, United Kingdom: Woodhead Publishing. https://doi.org/10.1016/B978-0-12-815864-7.00009-X

Duarte, S.M.D., Abreu, C.M.P.D., Menezes, H.C.D., Santos, M.H.D. and Gouvêa, C.M.C.P. (2005). Effect of processing and roasting on the antioxidant activity of coffee brews. *Food Science and Technology*, 25(2), 387–393. https://doi.org/10.1590/S0101-20612005000200035

Hadisoewignyo, L., Foe, K. and Tjandrawinata, R. (2017). Isolation and characterization of Agung banana peel starch from East Java Indonesia. *International Food Research Journal*, 24(3), 1324-1330.

Halliwell, B. (2012). Free radicals and antioxidants: Updating a personal view. *Nutrition Reviews*, 70(5), 257–265. https://doi.org/10.1111/j.1753-4887.2012.00476.x

Hasbullah, U., Mentari, A., Kholisoh, S. and Hidayat, T. (2021). Sensory Properties of Analog Coffee from Banana Peels. *Agrointek*, 15(2), 497–506. https://doi.org/10.21107/agrointek.v15i2.6219

Khawas, P. and Deka, S.C. (2016). Comparative Nutritional, Functional, Morphological, and Diffractogram Study on Culinary Banana (Musa

© 2023 The Authors. Published by Rynnye Lyan Resources

RESEARCH PAPER

ABB) Peel at Various Stages of Development. *International Journal of Food Properties*, 19(12), 2832–2853. https://doi.org/10.1080/10942912.2016.1141296

Mentari, A.B., Kholisoh, S.N., Hidayat, T.N. and Hasbullah, U.H.A. (2019). Pembuatan Kopi dari Kulit Pisang Kepok (*Musa paradisiaca* Linn) dan Aktivitas Antioksidannya. *Jurnal Ilmu Pangan dan Hasil Pertanian*, 3(1), 94-106. https://doi.org/10.26877/jiphp.v3i1.3872 [In Bahasa Indonesia].

Nicoli, M.C., Anese, M., Manzocco, L. and Lerici, C.R. (1997). Antioxidant Properties of Coffee Brews in Relation to the Roasting Degree. *LWT - Food Science and Technology*, 30(3), 292–297. https://doi.org/10.1006/fstl.1996.0181

Burda, S. and Oleszek W. (2001). Antioxidant and antiradical activities of flavonoids. *Journal of Agriculture and Food Chemistry*, 49(6), 2774-2779. https://doi.org/10.1021/jf001413m

Pokorný, J. and Schmidt, Š. (2003). The impact of food processing in phytochemicals: the case of antioxidants. In Johnson, I. and Williamson, G. (Eds). Phytochemical Functional Foods, p. 304. Cambridge, United Kingdom: Woodhead Publishing Ltd. https://doi.org/10.1533/9781855736986.2.298

Poncet, G., Castañeda, J., Llaha, F., Gil-Lespinard, M. and Zamora-Ros, R. (2021). In Prenzler, P.D., Ryan, D. and Robards, K. (Eds). Handbook of Antioxidant Methodology Approaches to Activity Determination, p.186. United Kingdom: Royal Society of Chemistry.

Sharma, G.N., Gupta, G. and Sharma, P. (2018). A Comprehensive Review of Free Radicals, Antioxidants, and Their Relationship with Human Ailments. *Critical Reviews in Eukaryotic Gene Expression*, 28(2), 139–154. https://doi.org/10.1615/CritRevEukaryotGeneExpr.2018022258

Sofa, A.D., Nurdyansyah, F. and Hasbullah, U.H.A. (2019). Physical Characteristics of Analog Coffee from Kepok Banana Skin (*Musa paradisiaca*) Fermented with *Lactobacillus plantarum*. *International Journal of Advance Tropical Food*, 1 (1), 37–41. https://doi.org/10.26877/ijatf.v1i1.4934

Someya, S., Yoshiki, Y. and Okubo, K. (2002). Antioxidant compounds from bananas (*Musa cavendish*). *Food Chemistry*, 79(3), 351–354. https://doi.org/10.1016/S0308-8146(02)00186-3

Sruthi, N.U., Premjit, Y., Pandiselvam, R., Kothakota, A. and Ramesh, S.V. (2021). An overview of conventional and emerging techniques of roasting: Effect on food bioactive signatures. *Food Chemistry*, 348, 129088. https://doi.org/10.1016/J.FOODCHEM.2021.129088

Tarigan, E.B., Wardiana, E., Hilmi, Y.S. and Komarudin, N.A. (2022). The changes in chemical properties of coffee during roasting: A review. *IOP Conference Series: Earth and Environmental Science*, 974(1), 012115. https://doi.org/10.1088/1755-1315/974/1/012115

Utami, R.R., Supriyanto, S., Rahardjo, S. and Armunanto, R. (2017). Aktivitas Antioksidan Kulit Biji Kakao dari Hasil Penyangraian Biji Kakao Kering pada Derajat Ringan, Sedang dan Berat. *AgriTECH*, 37(1), 89–95. https://doi.org/10.22146/AGRITECH.10454

Wernecke, R. and Wernecke, J. (2014). Industrial Moisture and Humidity Measurement: A Practical Guide. United Kingdom: Wiley-VCH. https://doi.org/10.1002/9783527652419

 © 2023 The Authors. Published by Rynnye Lyan Resources

Factorial experimental design for optimizing the roasting condition of banana peel (Musa paradisiaca var Semeru): characteristics and antioxidant activity

ORIGINALITY REPORT

7%	1%	5%	4%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Universiti Malaysia Sabah Student Paper	2%
2	Submitted to Institut Pertanian Bogor Student Paper	1%
3	SRINIVASA RAO PAVULURI, , and Ravi Kumar M. "DEVELOPMENT OF SORGHUM (Sorghum Bicolor) AND RAGI (Eleusine Coracana) BASED READY-TO-EAT SNACKS USING TWIN SCREW EXTRUDER", 2010 Pittsburgh Pennsylvania June 20 - June 23 2010, 2010. Publication	1%
4	Submitted to Baylor University Student Paper	1%
5	Skerget, M.. "Phenols, proanthocyanidins, flavones and flavonols in some plant materials and their antioxidant activities", Food Chemistry, 200502 Publication	1%
6	Novoselova, E.G., S.M. Lunin, M.O. Khrenov, S.B. Parfenyuk, T.V. Novoselova, B.S. Shenkman, and E.E. Fesenko. "Changes in immune cell signalling, apoptosis and stress response functions in mice returned from the BION-M1 mission in space", Immunobiology, 2015. Publication	1%

7	Jennifer A. Wood, Edmund J. Knights, Grant M. Campbell, Steven Harden, Mingan Choct. "Enzyme pre-milling treatments improved milling performance of chickpeas by targeting mechanisms of seed coat and cotyledon adhesion with various effects on dhal quality", Journal of the Science of Food and Agriculture, 2021 Publication	1%

Exclude quotes	On	Exclude matches	< 1%
Exclude bibliography	On		