Poltekita: Jurnal Ilmu Kesehatan
http://jurnal.poltekkespalu.ac.id/index.php/JIK

Vol.17 No.2 August 2023: Hal. 301-308
p-ISSN: 1907-459X e-ISSN: 2527-7170

Original Article

Phytochemicals, Nutrient Levels and Antioxidants of Various Types of Sweet Potatoes (Ipomoea batatas L.)

Nurdin Rahman[1*], Nurhanifah Muthmainnah Nurdin[1]

[1] Nutrition Study Program, Faculty of Public Health, Tadulako University, Palu, Indonesia

(Correspondence author's: nurdinrahman.untad@gmail.com)

ABSTRACT

This study aims to identify the phytochemical compounds, including flavonoids, tannins, phenols, beta-carotene, anthocyanins, and fiber, as well as the antioxidant capacity of various types of sweet potatoes. Method: The research followed a descriptive observational design with laboratory-based testing. The identification of phytochemical compounds utilized specific reagents. One Way ANOVA was employed to assess the differences in average levels of phytochemicals, nutrients, and antioxidant capacity (IC50) among the different types of sweet potatoes with normally distributed data. The determination of flavonoid, tannin, phenol, beta-carotene, and anthocyanin levels was carried out using UV/Vis Spectrophotometry at specific wavelengths. Crude fiber content was determined using the gravimetric method, while the antioxidant capacity was measured using the DPPH (2,2-Diphenyl-1-Picrylhydrazyl) method. Results: The findings indicated that all types of sweet potatoes contain alkaloids, while some lack steroids. Purple sweet potatoes showed the highest levels of flavonoids, tannins, and phenols at 627.27, 1727.27, and 1507.14 mg/100 g, significantly differing from other types of sweet potatoes (p = 0.00). Besides, purple sweet potatoes exhibited the highest anthocyanin content (18.35 mg/100 g) compared to other types, showing a significant difference (p = 0.00). Orange sweet potatoes exhibited the highest levels of beta-carotene and fiber, at 15.49 and 5.63 mg/100 g, respectively, although the difference was not statistically significant (p = 0.83). The antioxidant capacity (IC50) of purple, orange, white, and yellow sweet potatoes were 45.13, 266.59, 190.01, and 210.73 ppm, respectively. Conclusion: Different varieties of sweet potatoes exhibit variations in phytochemical composition and antioxidant capacity. Purple sweet potatoes are rich in flavonoids, tannins, phenols, and anthocyanins, with significant antioxidant potential. Orange sweet potatoes show high levels of beta-carotene and fiber but have comparable antioxidant activity to white and yellow varieties.

.

Keywords: Phytochemical, Sweet Potatoes, Flavonoids, Antioxidant Capacity, Purple Sweet Potatoes.

https://doi.org/10.33860/jik.v17i2.2701

© 2023 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY SA) license (https://creativecommons.org/licenses/by-sa/4.0/).

INTRODUCTION

Antioxidants are found in many plants, fruits, vegetables, and herbs. One of the plants that contains many antioxidants is sweet potato (Ipomoea batatas L.). Research results from Safari et al. (2019) [1] showed that purple sweet potato extract has a strong antioxidant with an IC50 value of 41.1±7.3 ppm. Research results from Surya (2017) [2], the antioxidant activity of yellow sweet potato was obtained with an IC50 value of 158.6726 µg/mL.

Sweet potato also has high non-digestible oligosaccharides (NDOS) carbohydrates (poly- and oligosaccharides [NDOS]) in the host tract. However, it has a beneficial effect on the host because it selectively stimulates the growth of bacteria in the colon to improve host health, so sweet tubers function as prebiotics [3]. Nutrients that are abundant in sweet potatoes are water, energy, protein, fat, starch, dietary fiber, glucose, and several vitamins found in sweet potatoes, including vitamin A (found in the form of β-carotene), vitamin B6 (pyridoxine). and vitamin C where these nutrients play an important role in immunity [4,5]. The mineral content in sweet potatoes, such as phosphorus, calcium, iron, and soluble fiber, absorbs excess fat or cholesterol in the blood. These natural fibers are oligosaccharides mainly consisting of raffinose, stachyose, and verbacose [6].

This study aimed to identify the phytochemicals present in purple, white, yellow, and orange sweet potatoes as well as quantitative tests (flavonoids, tannins, phenolics, beta-carotene, anthocyanins, crude fiber) and their antioxidant.

METHOD

This type of research was a laboratory test-based descriptive observational research. This research was carried out in September 2021 at the Chemistry Laboratory, Faculty of Mathematics and Natural Sciences, Tadulako University.

The tools used were a knife, oven, beaker (250 ml; 500 ml), Erlenmeyer, pipette, digital scale, bowl, baking dish, blender, measuring cup (5 ml; 10 ml; 500 ml), glass stirrer, funnel Buchner, rotary evaporator, spray bottle, petri dish, test tube, tube rack, UV-Vis Spectrophotometer, 5 ml volumetric flask, spatula, and fume hood. The materials used were purple, orange, white, and yellow sweet potatoes, tissue, distilled water, ethanol, aluminum foil, filter paper, concentrated H_2SO_4 solution, metal powder, 5% $FeCl_3$ solution, Dragendorff, HNO_3, chloroform, acetone anhydride, concentrated HCl, and DPPH solution.

The sweet potato samples were removed from the skin until clean, cut into pieces, then heated in an oven at 50 °C for 3×24 hours. After baking, grind it using a blender to make it into flour/powder. Sweet potato samples (flour) were macerated at a certain ratio with ethanol solvent three times 24 hours. After that, the mixture was filtered to separate the filtrate obtained; then, the solvent was evaporated using a rotary evaporator. The extract obtained was freeze-dried using a freeze-dryer.

The phytochemical screening was the flavonoid test [7], saponin test [7], Polyphenol and Tannin Test [7], alkaloid test [7], and Steroids test [7]. Then, the quantitative test of phytochemical substances, namely the determination of total flavonoid levels by the colorimetric method, refers to the procedure [8,9] with some modifications with quercetin (QE) as standard. Phenol analysis was carried out spectrophotometrically using the Folin-Ciocalteu method [10,11], and as a comparison used, gallic acid. The total phenolic content in the extract was expressed in gallic acid equivalent (GAE). Total Tannin Test with the Folin–Ciocalteu Method. Monomeric anthocyanin analysis refers to the method [12], on the method used by [13]. This method was based on the differences in anthocyanin structures at pH 1 and pH 4.5. Determination of beta-carotene levels carried out in this study followed the procedure [14]. Analysis of Antioxidant Activity Power using the DPPH Method.

Quantitative data such as assay results and antioxidant activity tests would be tested for normality first to see whether the data were normally distributed. If the data were normally distributed, use the One Way Anova test if there were differences followed by the Post Hoc test, namely the LSD (Least Significance Different) test, but if the data were not normally distributed, then use the Kruskal Wallis test. This test was a non-parametric test from the one-way ANOVA test, while qualitative data such as phytochemical profiles were analyzed descriptively.

RESULTS

Phytochemical Screening of Various Types of Sweet Potatoes

Table 1 shows that the purple and white sweet potato samples contained flavonoid compounds except for yellow and orange sweet potato. All types of sweet potatoes contain alkaloids. Purple and yellow sweet potatoes contain polyphenol and tannin compounds, saponin compounds are only found in yellow sweet potatoes, and all sweet potatoes do not contain steroid compounds.

Table 1. Results of Phytochemical Screening of Various Types of Sweet Potatoes

Type of Sweet Potato (flesh color)	Phytochemical Substances				
	Flavonoid	Alkaloid	Saponin	Steroid	Polyphenols & Tannin
Purple	+	+	-	-	+

Orange	-	+	-	-	-
White	+	+	-	-	-
Yellow	-	+	+	-	+

Note: (+) contained in the sample, (-) not contained in the sample

Table 2. Results of Phytochemical Levels, Nutrients, and Antioxidant Activities

Types of Sweet Potatoes	**Level (mg/100g)**					
	Flavonoid	**Tannin**	**Phenolic**	**Anthocyanin**	**Beta-caroten**	**Fiber (%)**
Purple	627.27 ± 19.28^{a}	1727.27±77.13^{a}	1507.14±40.41^{a}	18.35±0.46^{a}	15.49±0.39^{a}	5.63 ± 0.11^{a}
Orange	270.45 ± 16.07^{c}	1254.54±12.86^{b}	1089.28±25.25^{b}	11.76±0.34^{a}	402.09±9.06^{a}	5.84 ± 0.05^{a}
White	243.18 ± 3.21^{c}	950.00±32.14^{c}	871.42±101.02^{c}	3.80±0.23^{a}	18.49±0.17^{a}	4.09 ± 0.01^{a}
Yellow	450.00 ± 30.30^{b}	877.25±19.30^{c}	753.57±5.05^{c}	3.33±0.34^{a}	21.31±0.22^{a}	4.34 ± 0.07^{a}
p-value	0.00	0.00	0.01	0.83	0.83	0.83

Note: Different letter notation in the same column indicates a significant difference in the Post Hoc test, and the same letter notation in the same column indicates no significant difference

Table 2 shows differences in flavonoids, tannins, and total phenol ($\alpha<0.05$). Purple sweet potato contained the highest flavonoids, tannins, total phenols, and anthocyanins of 627.27, 1727.27, 1507.14, and 18.35 mg/100g, respectively.

Table 3. Results of Antioxidant Power of various types of Sweet Potatoes

Type of Sweet Potatoes	**IC_{50} (ppm)**	**Note**
Purple	45.13±0.26^{a}	Very strong
Orange	266.59±1.64^{a}	Very weak
White	190.01±1.60^{a}	Weak
Yellow	210.73±1.61^{a}	Very weak
p-value	0.83	

Note: Notation of the same letter in the same column indicates no significant difference

Table 3 shows no significant difference p = 0.83 (> 0.05), but the strongest antioxidant power was a purple sweet potato with an IC50 of 45.13 ppm.

DISCUSSION

Qualitative chemical (food) analysis tests aim to identify the types of secondary metabolite compounds using certain reagents which the presence of a precipitate or a change in the color of the solution can mark. Secondary metabolites are chemical compounds that are found in almost all plants. This compound is also an active chemical compound that provides physiological and pharmacological effects for the health sector. The most common compounds found in plants are alkaloids, flavonoids, saponins, tannins, phenols, and steroids [15].

Table 1 shows that after the phytochemical screening on purple, orange, white, and yellow sweet potato extracts, there were flavonoids, alkaloids, saponins, polyphenols, and tannins, but all sweet potato extracts did not contain steroid compounds.

Purple sweet potato contained the highest tannin content, about 1727.27 mg/100 g, and was significantly different from other types of sweet potato p = 0.00 (<0.05); there was a difference in tannin levels between sweet potato groups with p = 0.000 (<0.05). If we compare the tannin content between the two groups, the tannin content of purple sweet potato was significantly different from that of orange sweet potato p = 0.000 (<0.05), white sweet potato p = 0.000 (<0.05), and yellow sweet potato p = 0.000 (<0.05). The orange sweet potato was significantly different from the white sweet potato p = 0.002 (<0.05) and yellow sweet potato p = 0.001 (<0.05), while the white sweet potato was not significantly different from the yellow sweet potato p = 0.169 (>0.05). The results of this study are not in line with Satiti, (2015) [16], which stated that these four sweet potatoes did not contain tannin active compounds after being tested by Thin Layer Chromatography (TLC). Chronic treatment with tannic acid can reduce blood glucose levels in rats forced into diabetes [17].

Purple sweet potato contained the highest flavonoids, about 627.27 mg/100g, and was significantly different from other types of sweet potato, p = 0.00 (<0.05). When comparing the levels of flavonoids between the two groups, it can be described as follows: purple sweet potato flavonoid levels were significantly different from orange sweet potatoes p = 0.000 (<0.05), white sweet potatoes p = 0.00 (<0.05), and white sweet potatoes yellow creeper p = 0.001 (<0.05). However, orange sweet potato was not significantly different from white sweet potato p = 0.239 (> 0.05), orange sweet potato was significantly different from yellow sweet potato p = 0.001 (<0.05), while white sweet potato was significantly different from yellow sweet potato p = 0.000 (<0.05). Calculating flavonoid levels (mg/100g) in various types of sweet potato extract using the linear regression equation obtained was y = 0.0227x - 0.0872 with a correlation coefficient (R) of 0.998. The results of this study are relevant to [18], which states that purple sweet potato contains the highest flavonoid content compared to white, yellow, and orange sweet potatoes. The content of flavonoids in purple sweet potato is 13 times higher than in orange or yellow sweet potato [19].

Purple sweet potato contained the highest phenolic content, namely 1507.14 mg/100 g, and there was a difference in phenolic levels between the sweet potato groups (p = 0.001 <0.05). When comparing the phenolic levels between the two groups, it is described as follows: yellow p = 0.00 (<0.05). The orange sweet potato was significantly different from the white sweet potato p = 0.018 (<0.05) and yellow sweet potato p = 0.004 (<0.05), while the white sweet potato was not significantly different from the yellow sweet potato p = 0.103 (>0.05). This is under the research of Teow et al., (2006) [20], who stated that those containing the highest phenolics were sweet potatoes with purple flesh and sweet potatoes with white flesh containing the lowest phenolics, while in this study, yellow sweet potatoes contained the lowest levels of phenolics. The nature of easily oxidized phenol can be the reason for the reduced phenol content in the sample. When the sweet potato sample interacts with air, phenol will easily oxidize. Oxidation results are indicated by a change in color to brown. This oxidation can reduce the total phenol content in sweet potato samples [21].

The results of the beta-carotene analysis for various types of sweet potatoes can be seen in Table 3. Based on this, it shows that orange sweet potatoes have the highest levels of beta-carotene, namely 402.09 mg/100g, then yellow sweet potatoes at 21.31 mg/100g, then sweet potatoes white sweet potatoes at 18.49 mg/100g, and purple sweet potato has the lowest beta-carotene level, namely 15.49 mg/100g. This seems relevant to the research of Kemal et al. (2013) [22], orange sweet potato has the highest beta-carotene content, and purple sweet potato has the lowest beta-carotene content. According to Sabulantika & Ayustaningwarno (2014) [23], the purple sweet potato snack bar mixed with black soybeans contained a higher beta-carotene content than the yellow sweet potato snack bar mixed with black soybeans. Beta-carotene is a provitamin A that gives plants a yellow to orange color and can act as an antioxidant that protects cells from damage caused by free radicals. The content of beta-carotene has the benefit of preventing cancer, various cardiovascular diseases, and cataracts (Rahayu et al., 2012). The use of non-polar n-hexane aims to maximize the beta-carotene extraction process. Beta-carotene is a non-polar compound that will be easily attracted when dissolved in a non-polar solvent. This is based on the principle of like dissolves like, where compounds will dissolve in solvents with similar properties [21].

The highest anthocyanin content was purple sweet potato, namely 18.35 mg/100 g, while the lowest anthocyanin level was yellow sweet potato, about 3.33 mg/100 g, but not significantly different from other types of sweet potato, p = 0.83 (> 0.05). The anthocyanin content of sweet potato depends on the color intensity of the tuber. The more purple the color of the tubers, the higher the anthocyanin content [25]. This is following the research of Sabaluntika & Ayustaningwarno, (2014) [23], which states that the anthocyanin content of purple sweet potato is higher than red sweet potato, but yellow sweet potato does not contain anthocyanin or is relatively small. Purple sweet potato is due to the presence of anthocyanin pigments. The anthocyanin content of purple sweet potatoes is higher than white, yellow, and orange sweet potatoes. This is relevant to the results of Suprapta's research (2016) [26] that the anthocyanin content in white sweet potato was 0.06 mg/100 g, yellow sweet potato was 4.56 mg/100 g, and purple sweet potato was 110.51 mg/100 g. The high anthocyanin content in sweet potatoes can provide good benefits for health because it can function as an antioxidant.

Comparison of purple, orange, white, and yellow sweet potatoes was not significantly different (p = 0.83) (>0.05) related to fiber content. Orange sweet potato has the highest fiber content (5.84%); after that, purple sweet potato (5.63%), then yellow sweet potato (4.34%), and yellow sweet potato has the lowest crude fiber content (4.09%)). The presence of fiber in the ingredients can impact the health of the human body such as preventing coronary heart disease, and colon cancer, lowering cholesterol levels, controlling weight, and facilitating the digestive process [27]. Fiber can retain water and make a thick liquid in the digestive tract, so there will be a reduction in the absorption of food nutrients in the proximal part. This mechanism causes a decrease in the process (absorption) of amino acids, fatty acids, and other nutrients so that the formation of glucose is also inhibited [27].

Based on Table 3 it shows that purple sweet potato has the lowest IC50 (45.13 ppm). This means that purple sweet potato has a very strong antioxidant power compared to other types of sweet potato based on classification [28]. The lower the IC50 value, the more effective the compound inhibits free radical activity (DPPH) by 50%. Thus the order of the effectiveness of the four types of sweet potatoes in inhibiting free radicals (DPPH) is based on the IC50 value from the most effective in inhibiting to the least effective, such as purple, white, yellow, and orange sweet potatoes.

Antioxidant levels can be affected by the color of the type of sweet potato contained in it. The various colors in all types of plants, especially sweet potatoes, are caused by the presence of flavonoid compounds, especially anthocyanins, which are plant pigments that play an important role after chlorophyll and carotene [25]. Based on the research results, purple sweet potato has the highest antioxidant value compared to other sweet potatoes. This shows that the purple pigment in sweet potatoes affects antioxidant power, which means that the darker the color of the tubers, the higher the antioxidant power contained. This is the same as research from Sabulutika & Ayustaningwarno, (2014) [23] that purple sweet potato and black soybean snack bars had the highest antioxidant activity compared to yellow and red sweet potato snacks.

CONCLUSION

All types of sweet potatoes contain alkaloids but do not contain steroids. Purple sweet potato contains flavonoids, alkaloids, and polyphenols/tannins and does not contain saponins and steroids. Orange sweet potato contains alkaloids and does not contain flavonoids, saponins, steroids, and polyphenols/tannins. White sweet potato contains flavonoids, alkaloids and does not contain flavonoids, saponins, steroids, and polyphenols/tannins. Yellow sweet potato contains alkaloids, saponins, and polyphenols/tannins and does not contain flavonoids and steroids. Purple sweet potato contains the highest flavonoids, tannins, phenolics, and anthocyanins at 627.27; 1727,27; 1507.14; 18.35 mg/100 g. However, the anthocyanin levels were not significantly different from other sweet potatoes (p = 0.083). Orange sweet potato contains the highest ß-carotene and fiber, respectively: 15.49 and 5.63%. The strongest antioxidant power was purple sweet potato extract, with the lowest IC50 of 45.13 ppm, but not significantly different from other sweet potatoes (p = 0.83).

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

REFERENCE

1. Safari A, Rahayu SD, Fadhlillah M, Saadah, Rachman, Nenden I, et al. Ekstraksi dan Penentuan Aktivitas Antioksidan Ubi Jalar Ungu (Ipomoea batatas L). Al-Kimia : Universitas Padjajaran. 2019;6 No. 2:46–51.
2. Surya A. Uji Aktivitas Antioksidan pada Ubi Jalar Kuning (Ipomoea batatas L.) dengan Metode DPPH (1,1-Difenil-2-Pikrilhidrazil). Akademi Analis Kesehatan : Pekanbaru. 2017;

3. Lesmanawati W, Widanarni, Sukenda, Purbiantoro W. Potensi Ekstrak Oligosakarida Ubi Jalar Sebagai Prebiotik Bakteri Probiotik Akuakultur. Institut Pertanian Bogor. 2013;3 (1):16–20.
4. K'osambo LM, Carey EE, Misra AK, Wilkes J, Hagenimana V. Influence of Age, Farming Site, and Boiling on Pro-Vitamin A Content in Sweet Potato (Ipomoea batatas (L.) Lam.) Storage Roots. J Food Tech Afr. 1999;4(3).
5. Meludu NT. Proximate Analysis of Sweet Potato Toasted Granules. Afr J Biomed Res. 2010;13:89–91.
6. Nurdjanah S, Yuliana N. Ubi Jalar Teknologi Produksi Dan Karakteristik Tepung Ubi Jalar Ungu Termodifikasi. 2019;85.
7. Harborne JB. Metode Fitokimia, Penuntun Cara Modern Menganalisis Tumbuhan terjemahan K. Padmawinata dan Soediro, I. Edisi II. Bandung: Institut Pertanian Bogor; 1987.
8. Ahmad A, Waode A. Study of Antioxidant Activity and Determination of phenol and Flavonoid Content of Pepino's Leaf Extract (Solanum muricatum Aiton). International Journal of PharmTech. 2014;600-606.
9. Chang C, Yang M, Wen Hand CJ. Estimation of Total Flavonoid Content in Propolis by Two Complementary Colorimetric Method. J Food Drug Anal. 2002;
10. Mu'nisa A, Wresdiyati T, Kusumorini N, Manalu. Aktivitas Antioksidan Ekstrak Daun Cengkeh. Jurnal Veteriner. 2012;13(3):272–7.
11. Nurhayati SK, Harjono. Pengaruh Konsentrasi Natrium Benzoat dan Lama Penyimpanan pada Kadar Fenolat Total Pasta Tomat. Indonesian Journal of Chemistry Science. 2012;1(2):158–63.
12. Jie L, Xiao-ding L, Yun Z, Zheng-dong Z, Zhi-ya O, Meng L, et al. Identification and thermal stability of purple-fleshed sweet potato anthocyanins in aqueous solutions with various pH values dan fruit juices. Food Chemistry. 2013;136:1429–34.
13. Lee J, Durst W, Wrolstad RE. Determination of total monomeric anthicyanin pigment content of fruit juices, beverages, natural colorants, and wines by the pH differential method. Collaborative study Journal of AOAC International. 2005;88:1269–78.
14. Ritter ED, Purcell AE. Carotenoids Analytical Methods. Academic Inc London. 2009;
15. Herbert RB. Biosintesis Metabolit Sekunder. Semarang: IKIP Press; 1995.
16. Satiti W. Uji Aktivitas Antioksidan dan Skrining Fitokimia Ekstrak Metanol Empat Variasi Umbi Jalar (Ipmoea batatas (L.) Lam) dengan Metode DPPH (2,2-Diphenyl-1-Picrylhydrazyl) [Skripsi]. [Surakarta]: Program Studi Biologi, Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Sebelas Maret; 2015.
17. Babby A, Elanchezhiyan C, Suhasini S, Chandirasegaran G. Antihyperglycemic Effect Of Tannic Acid In Streptozotocin Induced Diabetic Rats. International Journal Current Research. 2014 Mar;6(03):5386–98.
18. Wang A, Li R, Ren L, Gao X, Zhang Y, Ma Z, et al. A comparative metabolomics study of flavonoids in sweet potato with different flesh colors (Ipomoea batatas(L.) Lam. Food Chemistry. 2018;260:124–34.
19. Grace MH, Yousef GG, Gustafson SJ, Truong VD, Yencho GC, Lila MA. Phytochemical changes in phenolics, anthocyanins, ascorbic acid, and carotenoids associated with sweetpotato storage and impacts on bioactive properties. Food Chemistry. 2014;145 (4):714–24.
20. Teow CC, Truong VD, McFeeters RF, Thompson RL, Pecota K, Craig Yencho G. Antioxidant activities, phenolic and b-carotene contents of sweet potato genotypes with varying flesh colours. Food Chemistry. 2006;103 (2007):828–38.
21. Sriarumtias FF. Pengukuran Kadar Betakaroten Dan Fenol Total Buah Pepino Kuning (Solanum muricatum Aiton) Pada Tingkat Kematangan Yang Berbeda. Jurnal Farmako Bahari. 2016;7 No. 2:12–21.
22. Kemal NN, Karim A, Asmawati,

Seniwati. Analisis Kandungan B-Karoten Dan Vitamin C Dari Berbagai Varietas Ubi Jalar (Ipomoea batatas). Indonesia Chimica Acta, Jurusan Kimia FMIPA, Universitas Hasanudin. 2013;

23. Sabuluntika N, Ayustaningwarno F. Pengaruh variasi pemberian Snack bar ubi jalar kedelai hitam terhadap Kadar uperoksida Dismutase (SOD) darah. Jurnal Gizi Indonesia. 2014 Desember;3 Nomor 1:20–5.
24. Rahayu P, Fathonah S, Meddiati F. Daya Terima dan Kandungan Gizi Makanan Berbahan Dasar Ubi Jalar Ungu. FSCE. 2012;1(1):2252–6587.
25. Winarno FG. Kimia Pangan dan Zat Gizi. Jakarta: Gramedia Pustaka Utama; 2004.
26. Suprapta DN. Aqueous extract of purple sweet potato increased sod-2, and sod-3 expression on human umbilical vein endothelial cells in vitro. Journal of Biology, Agriculture and Healthcare. 2016;6 (2):103–10.
27. Muchtadi D, Astawan M, Palupi NS. Metabolisme Zat Gizi Pangan. Tangerang: Universitas Terbuka; 2016.
28. Blois MS. Antioxidant determination by the use of stable free radical. Nature. 2005;181:1191–200.