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STABILITY OF ANTHOCYANIN CONTENT IN VARIOUS PROCESSED PURPLE SWEET POTATOES

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Abstract

People are becoming more conscious of the relationship between nutrition and health. Research has been conducted on the presence of anthocyanins in purple sweet potatoes, as this bioactive compound not only imparts the bright purple color to its flesh but also holds the potential for health benefits. Anthocyanins have activity as antioxidants, anti-inflammatories, and have the potential as phytoestrogens. This study aims to investigate the effect of processing methods on anthocyanin content in purple sweet potatoes.

The material used consisted of purple sweet potatoes of the Biang variety. The chemicals employed for analysis distilled included water, pH 1 buffer solution, and pH 4.5 buffer solution. Anthocyanins were determined using the pH differential method (AOAC Official Method 2005.02) measured with UV-VIS spectrophotometer.

The raw samples showed mean value of anthocyanin 49.58 (SD 16.59)mg/kg, the steamed samples displayed median value 67.29 (range 48.04–148.50) mg/kg, and the mean value of anthocyanin in the water extract was 130.70 (SD 13.17) mg/kg. The water extract method consistently produces highest anthocyanin content than the others. This study showed that heating and food processing will affect anthocyanin levels. To preserve optimal nutritional content, selection of food processing methods and specific anthocyanin source should be considered.

Keywords: Ipomoea batatas Lam, purple sweet potato, anthocyanins, heating, processing method

INTRODUCTION

With the increasing public awareness of health, there is also a growing interest in food quality. People are becoming more conscious of the relationship between nutrition and health. Therefore, many individuals are choosing foods that promote their well-being. Recent research has also focused significantly on the use of plant-based medicines. It is important to recognize that vegetables, tubers, and fruits also contain bioactive

compounds with medicinal properties. One example is the sweet potato, scientifically known as *Ipomoea batatas* (L.) Lam. The sweet potato belongs to the *Convolvulaceae* plant family and is an easily cultivated plant that is readily available in sufficient quantities in Indonesia (Adil, 2010). However, unfortunately, the utilization of purple sweet potatoes is still very limited.

Sweet potatoes come in a variety of skin and flesh colors, ranging from white, cream, yellow, and orange to pink, red, and purple (Alam *et al*., 2016, 2020). Among them, purple sweet potatoes hold a special significance. This highly nutritious vegetable provides various vitamins, amino acids, minerals, dietary fiber, phenolic acids, tocopherols, and anthocyanins (Teow *et al.*, 2007; Zhang *et al.*, 2014). Research has been conducted on the presence of anthocyanins in purple sweet potatoes, as this bioactive compound not only imparts the bright purple color to its flesh but also holds the potential for health benefits (de Pascual-Teresa and Sanchez-Ballesta, 2008; He and Giusti, 2010).

Anthocyanins, plant pigments that provide bright red, blue, and purple colors to plants, have been utilized as natural dyes. Anthocyanin pigments are used in various food and beverage products, including fermented beverages, juices, fruit extracts, and instant noodles (Mahmudatussa'adah *et al*., 2015). Anthocyanins have garnered attention due to their potential health benefits. Several studies have linked health-enhancing properties to anthocyanidins (Clifford, 2000), by demonstrating antioxidant and anti-inflammatory activities, as well as the potential as phytoestrogens (Alam, 2021; Schmitt and Stopper, 2001). Furthermore, anthocyanins are also associated with a lower risk of obesity (Lee *et al*., 2017), diabetes, and high cholesterol levels (Liu *et al*., 2016). Furthermore, anthocyanins also have the potential to enhance endothelial function, which in turn improves vascular vasomotor function and potentially reduces the risk of cardiovascular diseases, including stroke (Kimble *et al*., 2019; Manolescu *et al*., 2019).

A variety of purple sweet potato has been developed by Agung *et al.* in West Java, Indonesia. This variety is known as the 'Biang' variant of purple sweet potato, characterized by its deep purple color and smooth skin. The Biang purple sweet potato stands out as a superior cultivar with a high anthocyanin content, prominently reflected in its coloration. In addition to its high anthocyanin content, the Biang purple sweet potato also possesses a sweet flavor (Shukri, 2022). In a comparative study with other sweet potato varieties, the Biang purple sweet potato exhibited the highest anthocyanin content at 84.02 mg per 100 grams, followed by Ayamurasaki and Antin-3, with respective contents of 82.97 mg per 100 grams and 81.48 mg per 100 grams (Noerrizki *et al*., 2022).

Current studies indicate that high-temperature treatment generally has the potential to influence the anthocyanin content in fruit, vegetable, and tuber-based food products. Nonetheless, information regarding the temperature stability of anthocyanins derived from food sources remains limited, and conclusive results have yet to be obtained (Patras *et al*., 2010). Therefore, appropriate processing methods are required to preserve the nutrients and bioactivity within anthocyanins.

This study aims to investigate the effect of processing treatments on anthocyanin content in purple sweet potatoes compared to their raw state. It will involve the analysis of anthocyanin levels in processed purple sweet potato products, including steamed and water extracts. Additionally, the research seeks to provide insights into the comparative anthocyanin levels using the 'Biang' variety. Consequently, this study is expected to contribute to a better understanding of the nutritional potential of purple sweet potatoes and the impact of processing methods on anthocyanin content in their derived products.

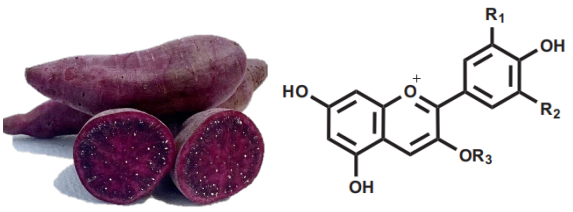
MATERIALS AND METHODS

This research was conducted at a private laboratory located in Bogor, Indonesia.

Materials

Purple sweet potatoes (*Ipomoea batatas* [L.] Lam) were sourced from a nearby plantation in Ciparenje, Sumedang, located in West Java, Indonesia. They were officially identified and registered as breeding varieties by the Faculty of Agriculture at Universitas Padjadjaran under registration number 733/PVHP/2019 (Fig. 1).

The chemicals employed for analysis included distilled water, pH 1 buffer solution, and pH 4.5 buffer solution. The equipment used included 25 mL volumetric flasks, 50 mL volumetric flasks, 50 mL Falcon tubes, a Vortex mixer, a sonicator, a homogenizer, a centrifuge, a water bath, and a UV-VIS spectrophotometer.



1: *Purple Sweet Potato 'Biang' Variety and Basic Structures of Cation Flavylium (Anthocyanidin)*

Sample Preparation

The material used consisted of purple sweet potatoes of the Biang variety, harvested from the Ciparenje plantation in Sumedang, West Java, Indonesia. These

Biang variety purple sweet potatoes had a growth period of 5 months from March to August. They were carefully packaged to prevent direct sunlight exposure. On the same day, the Biang sweet potatoes underwent processing according to predetermined treatments, and the following day, they were examined in the laboratory. The processed products were transported in a cool box during transit and were shielded from direct sunlight.

The purple sweet potatoes were processed according to the predetermined treatments, namely raw, steamed, and water extract. The following outlines the preparation methods for each of these products:

a) Raw: Purple sweet potatoes weighing approximately 200 grams were thoroughly washed in running water until clean, and then they were air-dried to remove any excess water.
b) Steamed: Initially, purple sweet potatoes weighing approximately 200 grams were washed thoroughly with clean water then allowed to air-dry. Subsequently, the cleaned purple sweet potatoes were steamed for 7 minutes once the water reached the boiling point (Mahmudatussa'adah *et al.*, 2015). Allow the steamed sweet potatoes to cool briefly and place them on a clean and dry surface.
c) Water extract: In the initial step, purple sweet potatoes were washed with clean water and peeled. Subsequently, the peeled purple sweet potatoes were sliced horizontally into pieces approximately 1–2 cm thick. These slices were then mixed with sterile water in a 1:1 ratio. The mixture was blended and subsequently strained through three layers of filter cloth. The liquid obtained from the straining process was then heated until it boiled and continued to be heated on the stove for 1 minute.

Total Monometric Anthocyanin Pigment Content

Anthocyanins were determined using the pH differential method (AOAC Official Method 2005.02).

a) Solid Sample

   Weigh solid samples from 1 to 5 grams (according to color concentration) into 50 mL Falcon tubes and 50 mg for the raw material. Add 25 mL of distilled water, vortex, and heat in a water bath at 60 °C for 20 minutes. Centrifuge the solution at a speed of 6000 rpm for 10 minutes. Pipette 5 mL of the clear filtrate into two 25 mL volumetric flasks. Dissolve the contents of the first flask in pH 1 buffer solution to the mark and homogenize. Dissolve the contents of the second flask in pH 4.5 buffer solution to the mark and homogenize. Measure the sample solution using a UV-VIS spectrophotometer at wavelengths of 520 nm and 700 nm. Rinse the remaining contents in the 50 mL Falcon tube with 10 mL of distilled water, sonicate for 1 hour, then bring to volume with distilled water and homogenize. Finally, use distilled water as a blank.

b) Liquid Sample

   Pipette 5 mL of the test portion into a 50 mL volumetric flask, add distilled water up to the mark, and homogenize it. Then, pipette 5 mL of the dissolved sample into two 25 mL volumetric flasks. Dissolve the contents of the first flask in pH 1 buffer solution up to the mark and homogenize it, while the contents of the second flask are dissolved in pH 4.5 buffer solution up to the mark and homogenized. Finally, measure the sample solution using a UV-VIS spectrophotometer at wavelengths of 520 nm and 700 nm, using distilled water as a blank.

The results were calculated as follows:

Anthocyanin Content (mg/kg; mg/L) =

$$= \frac{((Abs_{520nm} - Abs_{700nm})pH1 - (Abs_{520nm} - Abs_{700nm})pH4.5 \times MW \times 1000 \times Fp \times V}{\varepsilon \times 1 \times \text{test portion weight}}. \quad (1)$$

Explanation:

MW.....Molecular weight of cyanidin-3-glucoside (449.2 g/mol);
1 .....Cuvette path length (cm);
ε .....Molar absorptivity coefficient of cyanidin-3-glucoside (26900 L x mol^{-1} × cm^{-1});
Fp .....Dilution factor;
V.....Final volume;
1000....Conversion factor from g to mg.

Experimental Design and Statistical Analysis

In this study, the Randomized Block Design was employed to examine the anthocyanin content of purple sweet potatoes harvested from the Ciparenje plantation in Bogor, Indonesia. To ensure the reliability of the findings, the plantation was organized into distinct blocks to account for potential variations. Within these blocks, the three processing methods (raw, steamed, and water extract) were applied in a randomized manner. Data collection involved conducting laboratory analyses for each sample, with measurements taken twice, to enhance the accuracy and validity of the results. This approach was employed to ensure robust and consistent measurements.

Data analysis was carried out using the Statistical Package for the Social Sciences (SPSS) version 25.0 (IBM SPSS Statistics, USA). Normal distribution was assessed using the *Shapiro–Wilk* test. Data that followed a normal distribution were presented as Mean and Standard Deviation (SD), while data that did not conform to a normal distribution were presented as Median and Range.

RESULTS

Based on the data presented in Tab. I, this analysis provides valuable insights into the diverse anthocyanin content found in various purple

I: *Total Anthocyanin Content (mg/kg; mg/L)*

Type	N	Minimum	Maximum	Mean	SD
Raw	6	31.63	68.90	49.58	16.59
Steamed	6	48.04	148.50	67.29*	100.46**
Water Extract	6	115.22	145.34	130.70	13.17

*Median; **Range

sweet potato products. The raw samples showed mean value of anthocyanin 49.58 (SD 16.59) mg/kg, and exhibited notable variability among the six samples. Conversely, the Water Extract samples displayed highest and more consistent anthocyanin content, averaging around 130.70 (SD 13.17) mg/L. Meanwhile, the Steamed samples demonstrated a wide range of anthocyanin content, with a median value of 67.29 (range 48.04–148.50) mg/kg, indicating significant variability.

DISCUSSION

Purple sweet potatoes come in various cultivars, showcasing a wide spectrum of anthocyanin levels. For instance, the Ayamurasaki cultivar from Japan registers at 60 mg/100 g FW (Suda *et al*., 2003), while a cultivar from Peru boasts an impressive 243 mg/100 g FW (Ginting *et al*., 2020). In Indonesia, a comprehensive study involving 12 purple-fleshed sweet potato cultivars unveiled anthocyanin contents spanning from 1.86 mg to a substantial 123.92 mg/100 g FW (Ginting *et al*., 2020). While purple sweet potatoes naturally contain a significant number of anthocyanins, there has been concern that improper processing may reduce the anthocyanin content in their processed products (Patras *et al*., 2010). Based on the comparison of anthocyanin levels between raw purple sweet potatoes and their processed products (Tab. I), it is evident that there is an increase in anthocyanin content after heat treatment in both steamed and water extract products.

Prior studies have highlighted the concern of reduced anthocyanin levels due to heat processing, impacting anthocyanin yield (Ifadah *et al*., 2022). However, distinct heat processing methods yield varying anthocyanin outcomes (Mahmudatussa'adah *et al*., 2015). Mahmudatussa'adah *et al.* examined Ayamurasaki purple sweet potatoes at 5 months old in various forms: raw, steamed (7 minutes), and dried flakes (141.5 °C). Results showed the highest monomeric anthocyanin concentration in steamed (3.76 ± 0.01 mg CyE/gram db), followed by flakes (3.19 ± 0.12 mg CyE/gram db) and raw (1.45 ± 0.01 mg CyE/gram db) (Mahmudatussa'adah *et al*., 2015). These findings align with Truong *et al.*, who found that steaming purple sweet potatoes for 25 minutes increased anthocyanin concentration (Truong *et al*., 2009). Lachman *et al.* also reported significant increases in anthocyanins after baking, boiling, and steaming purple tubers (Jaromir Lachman *et al*., 2012). While concerns have been raised about the potential reduction in anthocyanin levels due to heat processing, it is worth emphasizing that different heat processing methods can yield varying anthocyanin outcomes. Notably, steaming, known for its gentle yet effective approach, has consistently demonstrated the greatest increase in anthocyanin content.

In contrast, a study conducted in Manhattan, Kansas, revealed that thermal treatment could diminish total anthocyanin content in purple sweet potatoes (Xu *et al*., 2015). This research used samples of the anthocyanin-rich purple sweet potato variant P40, with an average weight of 120–150 grams. Various cooking methods were employed, including conventional oven baking at 205 °C for 50 minutes, steaming with a rice cooker at 100 °C for 20 minutes, pressure-cooking at 121 °C with a pressure of 15 psi for 17 minutes, microwaving at 850 watts on 100% power for 5 minutes, and frying in a conventional fryer at 177 °C for 5 minutes. The results demonstrated that steaming, microwaving, pressure-cooking, and frying each reduced total anthocyanin content by 17.4%, 27.2%, 35.0%, and 21.7%, respectively (Xu *et al*., 2015). This discrepancy suggests that the intensity and duration of heat exposure during processing significantly impact anthocyanin content, with shorter and less intense heating, as in steaming, preserving more anthocyanins.

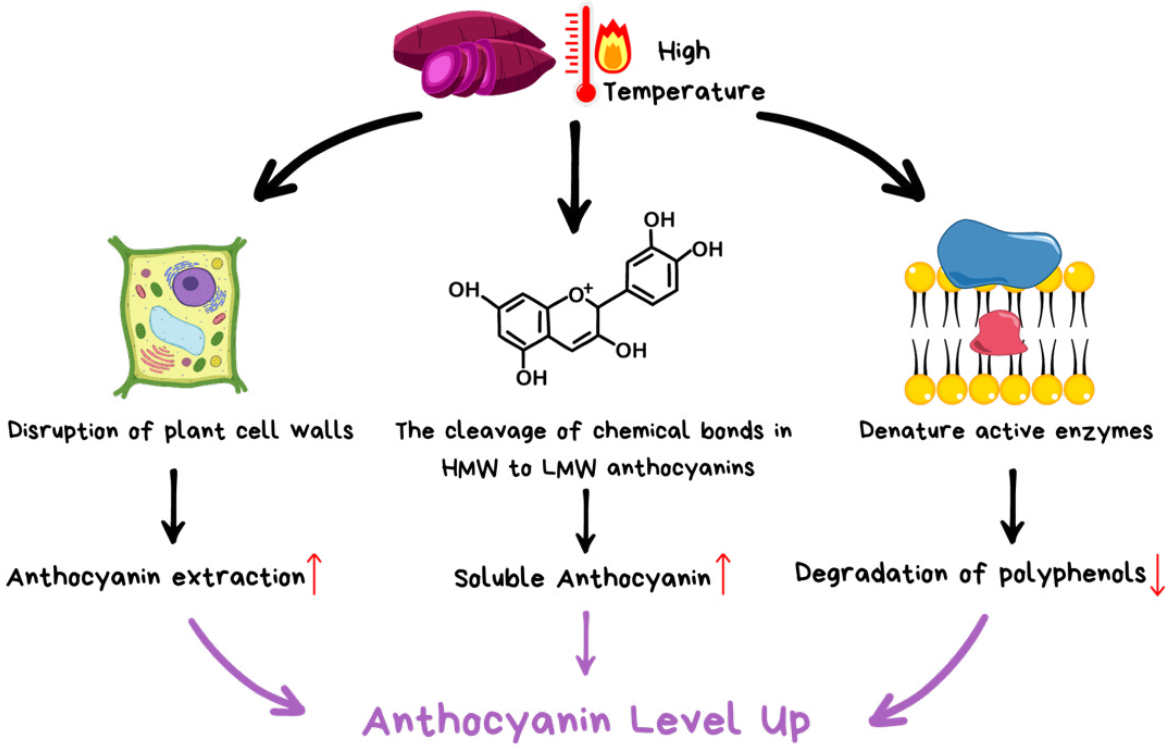
Additionally, Brown *et al.* conducted a study that produced intriguing findings, revealing that microwave cooking not only increased but also preserved the total anthocyanin content in three red and purple-fleshed potato varieties when compared to raw tubers. The authors also emphasized that both microwave cooking and boiling were more effective in preserving the total anthocyanin content as opposed to frying or baking (Brown *et al*., 2008). These results emphasize the significant influence of heat exposure, the specific method of heat processing, its duration, and the type and variety of anthocyanin sources on the levels of anthocyanins in the final product.

In another study by G. Dwijayanti *et al*., the impact of heat and heating duration on purple sweet potato juice production was investigated. Two critical variables were examined: heating temperature (70 °C, 80 °C, and 90 °C) and heating duration (5, 10, and 15 minutes). The results demonstrated a notable

influence of both temperature and heating duration on the total anthocyanin content. Higher temperatures, within the range of 70 °C to 90 °C, consistently led to a reduction in anthocyanin content, while prolonging the heating duration from 5 to 15 minutes further exacerbated this decline. The most effective preservation, with the highest recorded value at 215.08 mg/L, was achieved when the juice was heated at 70 °C for 5 minutes (Dwiyanti *et al.*, 2018). These findings underscore the heat sensitivity of anthocyanins and underscore the crucial role of precise temperature control during processing in preserving their content and potential health benefits.

The study by Patras *et al.* underscores the well-established phenomenon of anthocyanin content reduction upon exposure to heat. This susceptibility to thermal treatment has been documented not only in fruits like elderberries, blueberries, and raspberries but also during jam processing (Patras *et al.*, 2010). Significantly, Mulinacci *et al.* observed a modest decline (16–29%) in anthocyanin content following heating treatments in various pigmented tuber varieties, including boiling and microwave cooking (Mulinacci *et al.*, 2008). Interestingly, several studies have revealed variations in anthocyanin stability across different food types, with berries exhibiting lower stability compared to certain vegetables such as radish, red potatoes, red cabbage, and purple sweet potato (Giusti et Wrolstad, 2003; Lim *et al.*, 2013; Odake *et al.*, 1992). This variability can be attributed to the prevalence of acylated anthocyanins in purple sweet potatoes (Xu *et al.*, 2015). These acylated forms, resulting from acylation with various phenolic and aliphatic acids, demonstrate increased resistance to pH changes, light sensitivity, and the effects of heat exposure (Amoanimaa-Dede *et al.*, 2019; Shipp and Abdel-Aal, 2010).

Consistent with the preceding study (Fig. 2), the findings reveal dual effect on anthocyanin content after heat processing. The increase in anthocyanin content following the heating process is attributed to several factors: the disruption of plant cell walls, which aids in anthocyanin extraction; the cleavage of chemical bonds in high-molecular-weight anthocyanins; and the formation of low-molecular-weight anthocyanins that are soluble and undergo structural changes (interconversion) (Jaromír Lachman *et al.*, 2012). Additionally, heating can denature active enzymes within the tissues, including anthocyanase, polyphenol oxidase, and peroxidase. These enzymes are involved in the degradation of polyphenols, including anthocyanins, at room temperature (SHI *et al.*, 1992). The study conducted by Jang *et al.* successfully isolated polyphenol oxidase in purple-fleshed tubers and found that this enzyme is most active at room temperature but becomes denatured at temperatures above 70 °C (Jang *et al.*, 2005). These studies collectively support the research findings



2: *Mechanism of heating effect in anthocyanin*
High Molecular Weight (HMW) ; Low Molecular Weight (LMW)

that heating can increase anthocyanin levels in processed products.

In our analysis, we observed significant variations in anthocyanin content depending on the processing method employed. Raw sweet potatoes exhibited the lowest anthocyanin content, averaging approximately 49.58 mg/kg, which can be attributed to minimal processing. The minimal alteration of raw sweet potatoes likely accounts for their relatively lower anthocyanin levels. In contrast, steaming sweet potatoes before analysis resulted in a significant increase in anthocyanin content, with a median value of 67.29 mg/kg. This substantial rise suggests that the steaming process may facilitate the release or preservation of anthocyanins. The application of heat during steaming potentially disrupts cellular structures, making anthocyanins more accessible for analysis. The most remarkable increase in anthocyanin content was observed with the water extract method, averaging around 130.70 mg/L. This substantial enhancement, compared to raw and steamed sweet potatoes, underscores the remarkable efficacy of water extraction in maximizing anthocyanin yield. The aqueous extraction process efficiently liberates anthocyanins from the sweet potato matrix, resulting in significantly higher levels. These findings emphasize the pivotal role of processing methods in shaping anthocyanin content in purple sweet potatoes and, consequently, their potential health benefits.

It is worth noting that based on the data presented in Tab. I, some variability occurred, which might be attributed, in part, to the limited number of samples analyzed. The Raw samples exhibited notable variability among the six samples. Conversely, the Water Extract samples displayed more consistent anthocyanin content, suggesting a more robust and reliable outcome. Meanwhile, the Steamed samples demonstrated a wide range of anthocyanin content, indicating significant variability within this processing method. As such, it is essential to acknowledge that the observed variability in anthocyanin content could be influenced by factors beyond the processing method alone. Further research with a larger and more diverse sample pool may help elucidate the factors contributing to this variability more comprehensively.

CONCLUSION

The obtained results suggest that various sweet potato treatment methods exert distinct effects on anthocyanin levels, with the water extract method consistently emerging as the preferred choice for maximizing anthocyanin content due to its higher and more consistent yields. This conclusion underscores the significance of both heat processing techniques and the selection of anthocyanin sources. To preserve optimal nutritional value, it is crucial to carefully choose the appropriate processing method and consider the specific anthocyanin source in use.

However, it is important to acknowledge the limitations of this study, primarily the relatively small sample size. The number of samples used here represents only a fraction of the entire relevant population. For more accurate and representative results, future research will need a larger sample size. A larger sample size not only enables a better representation of various sweet potato varieties but also provides increased statistical power for result analysis and drawing conclusions. Consequently, the research findings will gain higher reliability and validity, making them more dependable for broader applications.

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Conflict of Interest

The authors declare that they have no conflict of interests.

REFERENCES

ADIL, W. H. 2010. Karakterisasi Plasma Nutfah Ubi Jalar Berdaging Umbi Predominan Ungu. *Buletin Plasma Nutfah*, 16(3): 85–89.

ALAM, M. K. 2021. A comprehensive review of sweet potato (*Ipomoea batatas* [L.] Lam): Revisiting the associated health benefits. *Trends in Food Science & Technology*, 115: 512–529.

ALAM, M. K., RANA, Z. H. and ISLAM, S. N. 2016. Comparison of the proximate composition, total carotenoids and total polyphenol content of nine orange-fleshed sweet potato varieties grown in Bangladesh. *Foods*, 5(3): 64.

ALAM, M. K., SAMS, S., RANA, Z. H., AKHTARUZZAMAN, M. and ISLAM, S. N. 2020. Minerals, vitamin C, and effect of thermal processing on carotenoids composition in nine varieties orange-fleshed sweet potato (*Ipomoea batatas* L.). *Journal of Food Composition and Analysis*, 92: 103582.

AMOANIMAA-DEDE, H., HONGBO, Z., KYEREKO, W. T., YEBOAH, A., AGYENIM-BOATENG, K. G., SAKYI, M. E. and ASIAMAH, C. A. 2019. Structure, functions and biosynthetic pathway of naturally occurring anthocyanin in sweet potato-a review. *J. Plant Biochem. Physiol*, 7(234): 10–35248.

BROWN, C. R., DURST, R. W., WROLSTAD, R. and DE JONG, W. 2008. Variability of phytonutrient content of potato in relation to growing location and cooking method. *Potato Research*, 51: 259–270.

CLIFFORD, M. N. 2000. Anthocyanins–nature, occurrence and dietary burden. *Journal of the Science of Food and Agriculture*, 80(7): 1063–1072.

DE PASCUAL-TERESA, S. and SANCHEZ-BALLESTA, M. T. 2008. Anthocyanins: from plant to health. *Phytochemistry Reviews*, 7: 281–299.

DWIYANTI, G., SISWANINGSIH, W. and FEBRIANTI, A. 2018. Production of purple sweet potato (*Ipomoea batatas* L.) juice having high anthocyanin content and antioxidant activity. *Journal of Physics: Conference Series*, 1013(1): 012194.

GINTING, E., YULIFIANTI, R. and INDRIANI, F. C. 2020. Selected purple-fleshed sweet potato genotypes with high anthocyanin contents. *IOP Conference Series: Earth and Environmental Science*, 456: 012023.

GIUSTI, M. M. and WROLSTAD, R. E. 2003. Acylated anthocyanins from edible sources and their applications in food systems. *Biochemical Engineering Journal*, 14(3): 217–225.

HE, J. and GIUSTI, M. M. 2010. Anthocyanins: natural colorants with health-promoting properties. *Annual Review of Food Science and Technology*, 1: 163–187.

IFADAH, R. A., WIRATARA, P. R. W. and AFGANI, C. A. 2022. Ulasan ilmiah: antosianin dan manfaatnya untuk kesehatan. *Jurnal Teknologi Pengolahan Pertanian*, 3(2): 11–21.

JANG, J.-W., MA, Y.-H., SHIN, J.-M. and SONG, K.-B. 2005. Characterization of polyphenoloxidase extracted from Solanum tuberosum Jasim. *Food Science and Biotechnology*, 14(1): 117–122.

KIMBLE, R., KEANE, K. M., LODGE, J. K. and HOWATSON, G. 2019. Dietary intake of anthocyanins and risk of cardiovascular disease: A systematic review and meta-analysis of prospective cohort studies. *Critical Reviews in Food Science and Nutrition*, 59(18): 3032–3043.

LACHMAN, JAROMIR, HAMOUZ, K., ORSÁK, M., PIVEC, V., HEJTMÁNKOVÁ, K., PAZDERŮ, K., DVOŘÁK, P. and ČEPL, J. 2012. Impact of selected factors – Cultivar, storage, cooking and baking on the content of anthocyanins in coloured-flesh potatoes. *Food Chemistry*, 133(4): 1107–1116.

LEE, Y.-M., YOON, Y., YOON, H., PARK, H.-M., SONG, S. and YEUM, K.-J. 2017. Dietary anthocyanins against obesity and inflammation. *Nutrients*, 9(10): 1089.

LIM, S., XU, J., KIM, J., CHEN, T., SU, X., STANDARD, J., CAREY, E., GRIFFIN, J., HERNDON, B. and KATZ, B. 2013. Role of anthocyanin-enriched purple-fleshed sweet potato p40 in colorectal cancer prevention. *Molecular Nutrition & Food Research*, 57(11): 1908–1917.

LIU, C., SUN, J., LU, Y. and BO, Y. 2016. Effects of anthocyanin on serum lipids in dyslipidemia patients: a systematic review and meta-analysis. *PLoS One*, 11(9): e0162089.

MAHMUDATUSSA'ADAH, A., FARDIAZ, D., ANDARWULAN, N. and KUSNANDAR, F. 2015. Efect of Heat Processing on Monomeric Anthocyanin of Purple Sweet Potato (*Ipomoea batatas* L)) [in Indonesian: Pengaruh Pengolahan Panas Terhadap Konsentrasi Antosianin Monomerik Ubi Jalar Ungu (*Ipomoea batatas* L)]. *Jurnal Agritech*, 35: 129.

MANOLESCU, B. N., OPREA, E., MITITELU, M., RUTA, L. L. and FARCASANU, I. C. 2019. Dietary anthocyanins and stroke: A review of pharmacokinetic and pharmacodynamic studies. *Nutrients*, 11(7): 1479.

MULINACCI, N., IERI, F., GIACCHERINI, C., INNOCENTI, M., ANDRENELLI, L., CANOVA, G., SARACCHI, M. and CASIRAGHI, M. C. 2008. Effect of cooking on the anthocyanins, phenolic acids, glycoalkaloids, and resistant starch content in two pigmented cultivars of Solanum tuberosum L. *Journal of Agricultural and Food Chemistry*, 56(24): 11830–11837.

NOERRIZKI, A. M., PRAYUDHA, H. N., USTARI, D., SUGANDA, T., CONCIBIDO, V. and KARUNIAWAN, A. 2022. Daya Hasil Dan Kandungan Antosianin Genotip Ubi Jalar Ungu (Purple-Fleshed Sweet Potato) Di Jatinangor, Jawa Barat. *Berita Biologi*, 21(3): 269–277.

ODAKE, K., TERAHARA, N., SAITO, N., TOKI, K. and HONDA, T. 1992. Chemical structures of two anthocyanins from purple sweet potato, Ipomoea batatas. *Phytochemistry*, 31(6): 2127–2130.

PATRAS, A., BRUNTON, N. P., O'DONNELL, C. and TIWARI, B. K. 2010. Effect of thermal processing on anthocyanin stability in foods; mechanisms and kinetics of degradation. *Trends in Food Science & Technology*, 21(1): 3–11.

SCHMITT, E. and STOPPER, H. 2001. Estrogenic activity of naturally occurring anthocyanidins. *Nutrition and Cancer*, 41(1–2): 145–149.

SHI, Z. U., BASSA, I. A., GABRIEL, S. L. and FRANCIS, F. J. 1992. Anthocyanin pigments of sweet potatoes–Ipomoea batatas. *Journal of Food Science*, 57(3): 755–757.
SHIPP, J. and ABDEL-AAL, E.-S. M. 2010. Food applications and physiological effects of anthocyanins as functional food ingredients. *The Open Food Science Journal*, 4(1): 7–22.
SHUKRI, I. 2022. Ini Keunggulan Ubi Jalar Biang dan Mencrang Titisan Cilembu. *Trubus* [online]. Available at: https://trubus.id/ini-keunggulan-ubi-jalar-biang-dan-mencrang-titisan-cilembu/ [accessed: 2023, November 15].
SUDA, I., OKI, T., MASUDA, M., KOBAYASHI, M., NISHIBA, Y. and FURUTA, S. 2003. Physiological functionality of purple-fleshed sweet potatoes containing anthocyanins and their utilization in foods. *Japan Agricultural Research Quarterly: JARQ*, 37(3): 167–173.
TEOW, C. C., TRUONG, V.-D., MCFEETERS, R. F., THOMPSON, R. L., PECOTA, K. V. and YENCHO, G. C. 2007. Antioxidant activities, phenolic and β-carotene contents of sweet potato genotypes with varying flesh colours. *Food Chemistry*, 103(3): 829–838.
TRUONG, V. D., DEIGHTON, N., THOMPSON, R., MCFEETERS, R., DEAN, L., PECOTA, K. and YENCHO, C. 2009. Characterization of anthocyamims and anthocyanidins in purple-fleshed sweetpotato by HPLC-DAD/ESI-MS/MS. *Journal of Agricultural and Food Chemistry*, 58: 404–410.
XU, J., SU, X., LIM, S., GRIFFIN, J., CAREY, E., KATZ, B., TOMICH, J., SMITH, J. S. and WANG, W. 2015. Characterisation and stability of anthocyanins in purple-fleshed sweet potato P40. *Food Chemistry*, 186: 90–96.
ZHANG, M., MU, T.-H. and SUN, M.-J. 2014. Purification and identification of antioxidant peptides from sweet potato protein hydrolysates by Alcalase. *Journal of Functional Foods*, 7: 191–200.

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