

Nutritional profiles of *Baccaurea macrocarpa* fruit¹Masriani and ^{2,*}Fadly, D.¹Department of Chemistry Education, Faculty of Teacher Training and Education, Universitas Tanjungpura, Pontianak 78124, Indonesia²Department of Food Technology, Faculty of Agriculture, Universitas Tanjungpura, Pontianak 78124, Indonesia**Article history:**

Received: 18 April 2021

Received in revised form: 24 May 2021

Accepted: 17 July 2021

Available Online: 24 March 2022

Keywords:

Amino acids,

Baccaurea macrocarpa,

Minerals,

Proximate

DOI:[https://doi.org/10.26656/fr.2017.6\(2\).273](https://doi.org/10.26656/fr.2017.6(2).273)**Abstract**

Some edible forest plants have been recognised as nutritional sources and may support human health. *Baccaurea macrocarpa* is a forest fruit with limited nutritional information. The nutritional value by determining proximates, minerals, and amino acid profile of skin, flesh, and the seed of *B. macrocarpa* was investigated through this study. Determination of the proximate composition was executed based on the AOAC. Estimation of energy content in kilocalories (kcal/100 g) was calculated by summing the multiplication of each protein, fat, and total carbohydrate. HPLC determined minerals and amino acids. The results showed that *B. macrocarpa* fruit contained low levels of ash (0.32 ± 0.03 - $1.64 \pm 0.05\%$), fat (0.24 ± 0.03 - $5.98 \pm 0.21\%$), protein (0.44 ± 0.51 - $2.73 \pm 0.11\%$) but a high level of water (61.99 ± 8.33 - $84.84 \pm 7.23\%$), fibre (7.91 ± 2.31 - $18.83 \pm 1.03\%$), and carbohydrates (13.40 ± 0.32 - $27.66 \pm 3.13\%$). The consumption of 100 g of this fruit may provide energy intake around 2.9% to 8.8% of the 2000 kcal daily energy requirement. It was rich in macro minerals P (60.88 ± 5.71 - 720.95 ± 54.67 $\mu\text{g/g}$), Ca (149.94 ± 13.73 - 515.32 ± 23.33 $\mu\text{g/g}$), and Mg (137.98 ± 14.76 - 315.18 ± 24.51 $\mu\text{g/g}$), and a sufficient amount of micro mineral Zn (6.68 ± 1.32 - 15.29 ± 3.10 $\mu\text{g/g}$), Fe (0.02 ± 0.00 - 20.97 ± 17.32 $\mu\text{g/g}$), Cu (0.75 ± 0.00 - 4.94 ± 0.11 $\mu\text{g/g}$), dan Mn (0.22 ± 0.00 - 2.42 ± 0.01 $\mu\text{g/g}$). This fruit contained an adequate amount of essential amino acids and an abundance of nonessential amino acids ($\Sigma\text{TAAE}/\Sigma\text{TAA} = 1.02$ - 1.64%). In conclusion, the results indicated that this forest fruit is potentially a good source of nutrition.

1. Introduction

Baccaurea macrocarpa, commonly called *Tampoi* or *Tampui*, is a fruit plant with thicker skin. *B. macrocarpa* plant is an Euphorbiaceae family along with rambai fruit. It is one of the most popular kinds of forest fruit in Kalimantan/Borneo due to its sweet and sour taste with smooth skin texture (Verheij and Coronel, 1992).

It is important to understand the nutritional components, including macro and micronutrients, such as water, ash, carbohydrate, protein, fat, minerals, and amino acids in a plant. Water is an essential nutrient foodstuff that may influence the materials' appearance, taste, and texture. Besides, the water content in the foodstuffs also affects the freshness, durability, and acceptability of the food (Winarno, 2008). Ash represents the total mineral found in food. High levels of fibre in plant-based foods may prevent the occurrence of

heart disease and various types of digestive disorders (Kendall *et al.*, 2010). Carbohydrates, protein, and fats are known well as macronutrients to support activity, growth, and health (Conlon and Bird, 2014). Besides these nutrients, there are minerals needed for the body, microminerals, and macrominerals. Calcium, potassium, magnesium, sodium, and phosphorus are included in the microminerals category, while manganese, copper, zinc, and Iron are included in the macrominerals category.

Minerals are inorganic compounds that the human body cannot synthesise, therefore food supplies the mineral needs. Although the requirement of minerals is relatively lower than protein, carbohydrate, and fats, its presence is required to carry out normal metabolic processes. Minerals have an essential role in maintaining metabolism by maintaining acid-base equilibrium and activating and inhibiting the enzyme-catalysed reactions, controlling body water balance, and bond formation

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(haemoglobin formation) (Ersoy and Çelik, 2010). Therefore, availability in the body requires serious attention because the deficiency or excess of these minerals may cause health problems. Furthermore, free amino acids are known as essential nutrients for health.

The free amino acids in food would naturally determine the aroma, taste, or quality (Kabelová *et al.*, 2008). Some edible forest plants have been known in developing countries as carbohydrates, protein, fat, minerals, and vitamin sources. Food Agriculture Organization (FAO) reported that around one million people benefitted from edible materials from forests as their source of food (Vunchi *et al.*, 2011). Some studies showed the value of forest fruit for nutritional and medicinal needs and found that the types and quantities of minerals, organic acid, and crude fibre are the essential factors determining whether forest vegetables or fruit are potentially healthy food sources (Magaia *et al.*, 2013).

Even though this exotic fruit is popular and edible, the information about its nutrient content is limited. The information about it is limited only to the proximate composition of the flesh, whereas the mineral composition and the amino acid profile have not been investigated yet. Therefore, this study aims to determine the relative values, mineral contents, and amino acid profiles of the skin, flesh, and seeds of *B. macrocarpa* fruit. The results of this study are intended to give valuable information about the nutrient composition to help people choose alternative nutritious food.

2. Materials and methods

2.1 Sample collection and preparation

B. macrocarpa fruit was collected and selected from Pontianak, West Kalimantan, Indonesia. The fruit samples were then analysed on their proximate, minerals, and amino acids in Gadjah Mada University's Integrated Testing and Research Laboratory, Yogyakarta, Indonesia.

2.2 Proximate and energy analysis

The determination of water, ash, protein, fibre, and fat of the samples was carried out based on methods from AOAC (2000). Meanwhile, the carbohydrate was determined using the 'by difference' method by Winarno (2008). The estimation of energy content in kilocalories (kcal/100 g) was calculated by summing up the multiplication of each protein, fat, and total carbohydrate (Winarno, 2008).

2.3 Mineral analysis

The analysis of mineral contents such as magnesium

(Mg), calcium (Ca), sodium (Na), copper (Cu), manganese (Mn), Iron (Fe), and zinc (Zn) in the skin, seeds, and flesh of the fruit referred to the procedure of AOAC 2012 (AOAC, 2012).

2.4 Amino acid analysis

The amino acid profiles of the skin, flesh, and seeds of *B. macrocarpa* fruit were determined by High-Performance Liquid Chromatography (González and Herrador, 2007). Initially, about 5 mL samples were hydrolysed with 20 mL of 6 N HCl in a 110°C autoclave for 12 hrs. The hydrolyzate obtained was cooled at room temperature then neutralised with 6 N NaOH. The sample solution was added to 2.5 mL of 40% acetate Pb and 1 mL of 15% oxalic acid. Then, it was placed into a 100 mL measuring flask and tasted using aquadest. About 3 mL of samples were filtered with a 0.45 µm millex filter. In a clean container, about 50 µL of sample/standard and 100 µL of OPA were poured and left for 3 mins. The sample and standard were reacted with OPA for 3 mins (50 µL sample/standard + 100 µL OPA). A total of 5 µL of derivatised samples were injected into the HPLC and then waited until the separation of all amino acids was completed.

2.5 Data analysis

All analyses except the amino acids were performed by triplicate. The data were managed using Microsoft Excel 360 for Windows.

3. Results

3.1 Proximate composition

The composition of proximate matter among various parts beyond *B. macrocarpa* fruit can be seen in Table 1. The table shows that all parts of the fruit contained high water content (>10%). The water content of skin, flesh, and seeds were 84.84±7.23%, 77.56±8.21%, and 61.99±8.33%, respectively. The ash content in various parts of the fruit was from 0.32±0.03% to 1.64±0.05%. The highest ash content was found in the seeds, while the lowest ash content was identified in the flesh. Meanwhile, the fat content in various fruit was from 0.24±0.03% to 5.98±0.21% dry weight. Seeds contained the highest fat while the skin was the lowest.

The data showed that various *B. macrocarpa* fruit protein content varied from 0.44±0.51% to 2.73±0.11% dry weight. The highest protein level was found in seeds, while the lowest levels were obtained from the flesh. The fruit contained fibre, which was relatively high in seeds and skin (>18%), and the flesh was >8% fibre. Afterwards, carbohydrate levels in the skin, flesh, and seeds were 13.40±0.32%, 21.09±3.33%, and

27.66±3.13%, respectively. These high carbohydrate contents, particularly in seeds, was proven to be the energy food source claimed.

The calories in each fruit part could be determined by conversion factors, such as 4 kcal/g for carbohydrate and protein and 9 kcal/g for fat (Coimbra and Jorge, 2011). The computation showed that the energy contributions of 100 g each *B. macrocarpa* fruit parts were low (Table 1). The calories in skin, flesh, and seeds were about 57.56±7.21 kcal, 91.43±8.53 kcal, and 175.38±12.04 kcal. The consumption of 100 g of this fruit may provide energy intake around 2.9% to 8.8% of the 2000 kcal daily energy requirement.

Table 1. Proximate composition and energy of *B. macrocarpa* fruit

Parameters	Skin	Flesh	Seed
Water (%)	84.84±7.23	77.56±8.21	61.99±8.33
Ash (%)	0.71±0.07	0.32±0.03	1.64±0.05
Fat (%)	0.24±0.03	0.59±0.02	5.98±0.21
Protein (%)	0.81±0.07	0.44±0.51	2.73±0.11
Fibre (%)	18.77±0.31	7.91±2.31	18.83±1.03
Carbohydrate (%)	13.40±0.32	21.09±3.33	27.66±3.13
Energy (kcal/100 g)	57.56±7.21	91.43±8.53	175.38±12.04

3.2 Mineral composition

The mineral composition, such as magnesium (Mg), calcium (Ca), sodium (Na), copper (Cu), manganese (Mn), Iron (Fe), and zinc (Zn) in various parts of the *B. macrocarpa* fruit, is shown in Table 2. The mineral composition varied among the various parts of the fruit. Calcium was the most abundant macromineral in the fruit's skin (515.32±23.33), while phosphorus was the most abundant in seeds (720.95±54.67 µg/g). Iron was the most abundant micro mineral in the skin of the fruit (20.97±17.32 µg/g), while Zn was the most abundant in seeds (15.29±3.10 µg/g). Phosphorus was the highest

Table 2. Mineral composition of *B. macrocarpa* fruit

Parameters	Skin	Flesh	Seed
Macromineral (µg/g)			
Ca	515.32±23.33	149.94±13.73	185.03±16.91
K	ND	73.12±4.72	100.90±12.73
Mg	258.15±18.31	137.98±14.76	315.18±24.51
Na	27.73±2.85	26.90±3.43	30.57±2.32
P	60.88±5.71	78.77±4.34	720.95±54.67
Ca/P	8.46±0.21	1.90±0.33	0.26±0.01
Na/K	ND	0.37±0.01	0.30±0.01
Micromineral (µg/g)			
Mn	2.42±0.01	0.22±0.00	1.75±0.03
Cu	0.75±0.00	2.56±0.01	4.94±0.11
Zn	6.68±1.32	10.36±0.52	15.29±3.10
Fe	20.97±17.32	12.61±1.72	0.02±0.00

ND = Not detected

mineral in all parts of the fruit. The sequence of macromineral compositions of skin, flesh, and seed were Ca> Mg> P> Na; Ca> Mg> P> K> Na; and P> Mg> Ca> K>Na, respectively. Judging from the order of micro-mineral composition in various parts of the fruit, Fe> Zn> Mn> Cu in the skin, Fe> Zn> Cu> Mn in the flesh, and Zn> Cu> Mn> Fe in seeds.

3.3 Amino acid profiles

Table 3 shows the amino acid profiles of various parts of *B. macrocarpa* fruit. Phenylalanine was the most significant essential amino acid in the fruit. It was followed by leucine, isoleucine, valine, threonine, histidine, lysine, and methionine. The highest level of the essential amino acids was in the seeds (1085.72 mg/g), which was followed by the flesh (315.47 mg/g) and skin (233.58 mg/g). Glutamic acid, aspartic acid, and tyrosine were three nonessential amino acids abundant in all fruit parts. All essential amino acids were found in the fruit, except lysine was not detected on the skin and flesh. Tryptophan was not determined in this study. The seeds contain the most nonessential amino acids (1074.39 mg/g), while the flesh was 312.24 mg/g and skin was 229.74 mg/g. Based on the nature of amino acids, all amino acid groups showed the highest levels in the seeds. The acidic amino acid group had the highest levels, followed by the polar amino acid group, hydrophobic, and alkaline.

4. Discussion

Baccaurea macrocarpa, known as *tampui/tampoi*, is an endemic plant of tropical forests, especially in Sumatra and Kalimantan. This fruit tree is close to extinction. The fruit produced by the tree has white flesh with a sweet and slightly sour taste. This fruit has a thick and hard skin, which is brown and has seeds. People generally consume the pulp when it is ripe as the sweet taste dominates over the sour taste. However, the skin and seeds have not been used by the community until now. Based on this research, it was known that three parts of the fruit have the potential for a relatively good nutritional content, both macronutrients, which are calculated as proximate, and micronutrients such as minerals and amino acids compositions.

Proximate composition, consisting of water, ash, fat, protein, and carbohydrate, plays the primary role in health. The water content of a food component will determine the stability and shelf life of food. The high water content will accelerate the destruction and decay due to microorganisms and chemical reactions (Bell, 2020). It would also indicate that *B. macrocarpa* fruit has low stability and shelf-life. Thus, the fruit should be immediately consumed when obtained. Ash is a residue left after all components, the water, fat, protein,

Table 3. Amino acid profile of *B. macrocarpa* fruit

Parameters	Content in fruit parts (mg/g d/w)			FAO/WHO/UNU ^a		
	Skin	Flesh	Seed	Infant (1-2 years)	Toddler (2-5 years)	Adult
Essential Amino Acid (EAA)						
L-Histidine	0.08	0.2	0.65	18	19	16
L-Threonine	0.24	0.3	0.97	27	34	9
L-Valine	0.32	0.41	1.2	41	35	15
L-Methionine	0.05	0.24	0.24	25 (Met+Cys)	27	17
L- Phenylalanine	2.4	1.23	4.52	46 (Phe+Tyr)	63	19
L- Isoleucine	0.36	0.39	1.19	31	28	13
L- Leusine	0.38	0.45	1.71	63	66	19
L- Lysine	ND	ND	0.86	52	58	16
Total of Essential Amino Acid (TEAA)	3.84	3.22	11.33			
Nonessential Amino Acid (NEAA)						
L-Tyrosine	61.4	69.5	93.6			
L-Alanine	18.45	24.09	106.04			
L- Aspartate	39.4	63.62	215.52			
L- Glutamate	40.94	58.26	292.33			
L- Asparagine	15.03	26.04	18.08			
L- Serine	23.85	32.41	115.05			
L-Glycine	8.46	7.48	94.43			
L- Arginine	22.22	30.85	139.34			
Total Non-Essential Amino Acid (TNEAA)	229.74	312.24	1074.39			
Total Amino Acid (TAA)	233.58	315.47	1085.72			
Σ TAAE/ Σ TAA (%)	1.64	1.02	1.04			
Percentage of amino acids by their nature^b						
Base/alkaline	22.3	31.05	140.85			
Acid	80.34	121.88	507.85			
Hydrophobic	30.42	33.88	208.14			
Polar uncharged	100.52	128.26	227.7			

^aFAO/WHO/UNU (2007): Daily needs for children and adults

^bBase/alkaline: L- Lysine, L-arginine, L- Histidine; Acid: L-aspartic, L- glutamic; Hydrophobic: L-Alanine, L-Isoleucine, L- Leucine, L-Methionine, L- Phenylalanine, L-Valine; Polar: L-Glycine, L-Serine, L-Threonine, L-Tyrosine, L-Cysteine.

carbohydrates, organic acids, are removed. Therefore, ash indicates crude total mineral content and provides ideas for determining essential minerals in food (Akpabio and Ikpe, 2013). As fat may improve food taste, seeds may be a good source since they contain several essential oils vital for the body (Saidu and Jideobi, 2009). Protein represents the number of nitrogen (Sofiana *et al.*, 2020). According to this research, *B. macrocarpa* seed contains relatively high protein, and it may be a complementary low protein food source such as grains. The fibre content in food can indicate undigested carbohydrate and lignin levels (Akpabio and Ikpe, 2013). Fibre induces the proliferation of beneficial microorganisms in the intestine (Slavin, 2013). The consumption of high fibre fruit may prevent non-communicable diseases (Edem and Miranda, 2011). However, the fibre content in the food also harms the absorption of essential minerals such as Iron (Adamma *et al.*, 2014). Carbohydrates function as a primary energy source and help the digestion and assimilation processes

of other food substances. The low energy levels from *B. macrocarpa* fruit can be used in weight management programs. According to the finding on proximate matter, *B. macrocarpa* fruit is categorised as a good source of fibre and carbohydrates with the highest potential found in the seed.

Besides the proximate profiles, understanding the balance of minerals, including Ca, P, K, Na, Fe, Zn, Mg, Mn, and Cu, is significantly required due to those irreplaceable roles in the metabolism mechanism (Emkey and Emkey, 2012). Ca and P are necessary for bones and teeth formation as well as their maintenance. They are also required for blood clotting and muscle contraction (Wardlaw *et al.*, 2004). Ca is essential in overcoming heart attack, high blood pressure, premenstrual syndrome, and others. (Senga *et al.*, 2013). P is an essential substance of nucleoproteins and nucleic acids, responsible for reproduction and lineage continuation (World Health Organization and Food and Agriculture Organization of the United Nations, 2004). Along with

Ca, P may strengthen teeth and bones. Foodstuffs are thought to have an excellent condition when the ratio is Ca:P > 1 and bad if the value is <0.5, and the absorption in the small intestine increases in animals when the Ca:P ratio is above 2 (Adeyeye and Aye, 2005). In addition to the high levels of Ca and P, it was revealed that the Ca:P ratio of this fruit was more than one, indicating a good source of both minerals.

Another mineral, K, effectively regulates the heart rhythm, nerve transmission, and water balance in the body (Alinnor and Oze, 2011). High K intake may reduce blood pressure, and low intake may increase blood pressure in animals and humans (Haddy *et al.*, 2006). Furthermore, a mineral called Na is one of the primary positive ions placed in the extracellular fluid as a critical factor in maintaining body fluids. It facilitates the absorption of nutrients such as glucose, amino acids, pyrimidines, and bile salts in the small intestine (Soetan *et al.*, 2009). Together with K, the transmission of nerve impulses and muscle contraction can occur through the formation of electric potential. However, high Na levels contribute to high blood pressure (Wardlaw *et al.*, 2004). The results show that Na:K ratio in the body is an essential factor in preventing and managing high blood pressure. The ratio of sodium to potassium is less than 1 ($\text{Na}^+/\text{K}^+ < 1$) can reduce high blood pressure (Aremu *et al.*, 2007). Therefore, the ratio of $\text{Na}^+:\text{K}^+$ in the range of 0.30 - 0.37 indicated that the *B. macrocarpa* fruit could be good food for hypertensive patients.

Other than those been described above, Iron is one of the crucial microminerals that work for general function, cognitive development, heat regulation, and energy metabolism (Wardlaw *et al.*, 2004). This mineral is also needed for haemoglobin synthesis and myoglobin, and the deficiency causes anaemia. Therefore, Fe is an essential nutrient for pregnant and nursing mothers, children, and adults to prevent anaemia and other related diseases; also, the need is increased during growth and menstruation (Ooi *et al.*, 2012). *Baccaurea macrocarpa* fruit can be an excellent food choice in fulfilling iron needs since its high iron content. *Baccaurea macrocarpa* also contains Zn, which is beneficial in healthy growth (MLitan *et al.*, 2014). It was also significant in carbohydrate and protein metabolism (Jabeen *et al.*, 2010), required to support more than 200 enzymes to function, and essential for the sexual growth and development in men (Kawade, 2012). The deficiency of this mineral is related to Chron's disease, hypothyroidism, and some viral infections.

The following minerals contained in this fruit are Mg, Mn, and Cu. Mg is needed by more than 300 enzymes that use adenosine triphosphate. It prevents

abnormal heart rhythms (Wardlaw *et al.*, 2004), improves beta-cell function and thus prevents diabetes and hypertension (Haq and Ullah, 2011), support healthy bones and teeth (Kartika *et al.*, 2011). The deficiency of this mineral in animals causes irritability, convulsions, and even death. Meanwhile, Mn becomes a catalyst and cofactor in various enzymatic processes, including mucopolysaccharides and glycoproteins (Shomar, 2012). Moreover, Cu is actively involved in the erythropoiesis mechanism to support the erythrocytes regulation. High concentrations may cause diarrhoea, epigastric pain, liver damage, blood in urine, hypotension, and vomiting (Lieberman *et al.*, 2005).

Besides proximate profiles and minerals, amino acids are also revealed in this fruit. The functions of amino acids have been widely studied. For example, Saiga *et al.* (2003) reported that glutamate and aspartate had antioxidant properties (Saiga *et al.*, 2003). In addition, hydrophobic amino acids have higher free radical scavenging capabilities (Ren *et al.*, 2008). *B. macrocarpa* fruit contained very high levels of glutamate, aspartate, phenylalanine, and average levels of valine, leucine, and isoleucine, which are potent antioxidants. The high intake of glutamate, histidine, leucine, and lysine may reduce the bodyweight of mice given high-fat feed through increasing energy expenditure (Kobayashi *et al.*, 2009).

According to these results, the flesh, a fruit part commonly consumed by communities, may contribute to the nutritional intake. The rest of the fruit, such as skin and seed, also showed quite good potential nutritional benefits, especially the seeds, which contained high micronutrients, including minerals, essential amino acids, and high nonessential. The present study verifies that the nutritional value of the potential *B. macrocarpa* fruit is beneficial to support community nutrition improvement.

5. Conclusion

The composition of the proximate, mineral and amino acid of the skin, flesh, and seed of the tampui fruit have been identified. It has been demonstrated that the nutritional value of this fruit to be used as a beneficial foodstuff to support community nutrition improvement.

Conflict of interest

The authors declare that no competing financial interests or personal relationships may influence the work reported in this paper.

Acknowledgments

We are most thankful to FKIP - Universitas Tanjungpura that has fully supported the project from which this paper grew.

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