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Nutritional Profile of Fruit and Processed Products of Tongka Langit Banana in Maluku, Indonesia

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Abstract: The Tongka Langit banana (*Musa troglodytarum* L.) boasts the unique characteristics of its fruit inflorescences standing upright towards the sky and has the potential to be developed into food products that are rich in nutritional content. This study aims to reveal the nutrient profile of the basic ingredients and processed products using the HPLC method, proximate analysis, organoleptic testing, mineral analysis, and microbiological testing. The samples of long-fruited and short-fruited bananas were obtained from the Ambon Island and Kei Besar Island, Maluku Province. The results showed that these bananas have a very high content of β-carotene and vitamin A in long fruits (66.02 mg/100g; 954.72 IU) and a very low one in short fruits (37.12 mg/100g; 212.76 IU). The vitamin B levels obtained from the analyses ranged from 0.08 to 0.13 mg/100g, and the vitamin C levels ranged from 7.06 to 10.42 mg/100g. By contrast, vitamin D was not detected, and vitamin E was present in very low amounts, ranging from 0.08 to 0.14 mg/100g. As far as processed products are concerned, the palm sugar jam was found to contain β-carotene and vitamins A, B, C, and E in a larger amount than the one found in other processed products. The proximate analysis showed that the carbohydrate, protein, and fat contents vary considerably. The organoleptic test revealed that the processed products are suitable for consumption. The analysis of minerals in the juice and peel showed high potassium and calcium levels, while some other minerals were present at adequate levels. The microbiological test of processed fruit juice and peel products showed that they are suitable for direct consumption. In conclusion, the nutritional profile of and the “PISTA” processed products resulting from the Tongka Langit banana may indicate a potential for developing community food diversification and highlight the importance of conserving this endemic germplasm and revenue for people.

Keywords: banana nutrients, high nutritional value, processed banana fruit, fruit juice, peel juice.

印度尼西亚马鲁古的通卡·兰吉特香蕉水果和加工产品的营养成分

摘要：通卡·兰吉特香蕉（穴居鼠）具有其果实花序直立于天空的独特特征，并有可能被开发成营养成分丰富的食品。这项研究旨在通过高效液相色谱方法，近距离分析，感官测试，矿物质分析和微生物学测试来揭示基本成分和加工产品的营养成分。长果和短果香蕉的样品取自马鲁古省的安汶岛和京贝沙岛。结果表明，这些香蕉在长果实中含量非常高（β。胡萝卜素和维生素一种）(66.02 毫克/100g； 954.72 IU），在短果实中含量非常低（37.12 毫克/100g； 212.76 IU）。通过分析获得的维生素乙含量范围为 0.08 至 0.13 毫克/100g，维生素 C 含量范围为 7.06 至 10.42 毫克/100g。相比之下，未检测到维生素 D，并且维生素 E 的含量非常低，为 0.08 至 0.14 毫克/100g。就加工产品而言，发现棕榈糖果酱中的β-胡萝卜素和维生素一种，乙，C 和 E 的含量比其他加工产品中的含量高。最近的分析表明，碳水化合物，蛋白质和脂肪含量相差很大。感官测试表明加工后的产品适合食用。果汁和果皮中的矿物

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质分析显示钾和钙含量很高，而其他一些矿物质含量也很高。加工过的果汁和果皮产品的微生物学测试表明，它们适合直接食用。总之，由通卡·朗吉特香蕉制成的营养成分和“皮斯塔”加工产品的营养状况可能表明有发展社区食品多样化的潜力，并强调了保护这种地方种质和对人们收入的重要性。

关键词：香蕉营养成分，高营养价值，加工香蕉果实，果汁，果皮汁.

1. Introduction

The Tongka Langit banana (*Musa troglodytarum* L.) has long been known as an indigenous banana of Maluku, which is also found in Papua New Guinea and the Pacific Islands [1]. With its wide and endemic geographical distribution, with the synonym name as *Musafehi Bertero ex Vieill.* or commonly called Fe'i banana, this plant is characterized by a high level of flora diversity which can be used as a community food source. Similarly, the nutritional potential of this banana indicates that the fruit can be processed into alternative foods, thus continuing the cultivation and preservation of the endemic banana germplasm. The name of "Tongka Langit" pinned to this banana comes from a local term in Maluku, which means a pillar of the sky. It shows the taxonomic characteristics of fruit bunch inflorescence directed upright toward the sky, pointing the difference from other common bananas.

The Tongka Langit banana germplasm, which has a limited number of morphological forms, is characterized by many different properties, i.e., peduncle length (tall and short), flower position (upright and pendulous), fruit size (small and large), peel color (orange, yellow, yellowish-orange, reddish-orange, brownish-red and brownish-orange), and pulp color (orange and yellow) [2].

The differences concerning the color of the fruit peel and pulp indicate high levels of antioxidants present in various amounts and point to gene variations that may be a source of carotenoids and thus play a role in improving health [3]. Humans need carotenoids and vitamins to prevent damage to body cells. Carotenoids give foods a yellow, orange or red color. There are several types of carotenoids, including α-carotene, β-carotene, astaxanthin, lycopene, lutein, zeaxanthin, β-cryptoxanthin, and fucosantin [4-6]. Carotenoids are also known as anti-cancer agents and antioxidants that can prevent eye problems, skin diseases, heart diseases, and increase endurance. β-carotene is the active compound and the best source of vitamin A from plants. In the human body, β-carotene is converted to vitamin A by oxygenase, creating two molecules, unlike α-carotene, which releases only one molecule with vitamin A activity [7]. The *phytoene synthase* (PSY) gene regulates carotenoid metabolism at the major enzymatic step for the biosynthesis of lycopene, α-carotene, and β-carotene. In addition, it has many copies of the gene and acts as a carotenogenesis modulator [8].

Vitamins are essential chemical compounds that the human body needs – albeit in small amounts – as they are essential for maintaining health [9] and pregnancy [10, 11]. The content of β-carotene and vitamins in Tongka Langit fruits and banana peels is very high compared to carrots. This fact needs to be taken into account as part of the effort to diversify food and increase the level of community income and the regional food security system.

Food security is an obligation of local governments (Government Regulation No. 68 of 2002 concerning Food Security and Law No. 32 of 2004 concerning Regional Government), as it relates to basic services to regulate, promote, control, and monitor food availability through food diversification. In this context, the community plays an important role, serving as the production process organizer and consumer. Therefore, full support from Pattimura University is required to explore other natural resources to ensure a sustainable life for Maluku people. Currently, there is no HPLC data for Tongka Langit banana cultivars that have high β-carotene and vitamin content as a reference for the production of Tongka Langit banana consumption products that can be used as the superior consumption product of Maluku.

The analysis of β-carotene and vitamin contents in Tongka Langit bananas was carried out by a High-Performance Liquid Chromatography (HPLC). This separation method relies on physical properties that can be used for an identity test, purity test, and assay. The focus is on analyzing a compound that is non-volatile and unstable at high temperatures, which cannot be done by gas chromatography. HPLC is a chromatography that uses a liquid as the mobile phase, both polar and non-polar, and operates under high pressure. In liquid partition chromatography, both the stationary and mobile phases are in the form of a liquid, and the solvent used must be immiscible [12].

Based on the details presented, a study was carried out to determine the nutritional profile of the fruit and the processed products derived from Tongka Langit. This task is important and serves as a reference for product development for the community.

2. Materials and Methods

2.1. Time and Location of Research

The sampling and HPLC analysis were carried out in August 2019. Using a site survey, the Tongka Langit long fruits and short fruits banana were collected from Airlouw village lay at 3º46'15"S – 128º8'0"E (in Ambon island) and Fangamas forest reside at 5º40'28"S – 132º59'7"E (in Kei Besar Island, Southeast Maluku Regency), respectively. The HPLC analysis of the Tongka Langit banana peel and pulp samples was conducted at the testing laboratory of the Indonesian Agricultural Postharvest Research and Development Center in Bogor, Indonesia.

2.2. Beta-Carotene Analysis Procedure

A sample of as much as 10 g to 1 mL of NaCl was taken, then pyrogallol was added to 30 mL of ethanol, and the mixture was homogenized. 3 mL of KOH were added, after which the sample was incubated in a 56°C water bath for 20 minutes and transferred to a container filled with cold water plus ice. Also, 23 mL of 1% NaCl were added, followed by 6 mL of 2-propanol and ethyl acetate and 15 mL of n-hexane (1: 9) (replicated three times). The composition was stirred for 10 minutes, then centrifuged at 3000 rpm for 5 minutes. Afterward, the supernatant was transferred to a 100 mL evaporating flask (evaporated at 40°C) and rinsed with 99.5% ethanol. The sample was placed in a 5 mL volumetric flask containing 99.5% ethanol and then placed in the HPLC for 8 minutes at 20 μL. The output of the mixed separation was generated in the form of a chromatogram on the recorder.

2.3. Vitamin A Analysis Procedure

A sample of 5 g was mixed with 25 mL of ethanol, then dissolved in an ultrasonic bath. Afterward, 15 mL of reagent A were added as well. The composition was stirred until becoming homogenous and rinsed with a little distilled water. The result was then covered with parafilm and stored overnight in a dark room. Tera was then mixed with distilled water and stirred. Filtering with Whatman filter paper No. 41, the filtrate (25 mL) was taken with a 5-mL pipette, diluted with acetonitrile, and then shaken in an ultrasonic water bath for 40 minutes. The filtrate was added to the column containing glass wool and Al_2O_3, ready for injection into the HPLC. The output of the mixture was in the form of a chromatogram on the recorder.

2.4. Vitamin B Analysis Procedure

The samples were ground and sifted using 40 mesh sieves. Then 0.5-2 g of the sample were weighed and placed in a 100 mL volumetric flask. 60 mL of 2% acetic acid were added, then heated in a water bath for 20 minutes, followed by sonication for 5 minutes. After the composition cooled down, 25 mL of methanol were added to it, and the resulting solution was crushed with 2% acetic acid. The solution was then centrifuged, and the supernatant was separated to be injected into the HPLC. The output of the mixed separation was generated in the form of a chromatogram on the recorder.

2.5. Vitamin C Analysis Procedure

A sample of 10 g was mixed with ±60 ml of metaphosphoric acid 5% w/v and homogenized. The sample was placed in a 100 mL volumetric flask containing 5% (w/v) metaphosphoric acid and stored overnight in the refrigerator. Then 5 mL of the standard sample were taken, and 2-3 drops (constant color) of 0.2% (w/v) DCP (2,6 dichloroindophenol) were added. Besides, 0.2% (w/v) thiourea was added in 5 mL of 5% (w/v) metaphosphoric acid and then 2% (w/v) DNPH (dinitrophenylhydrazine) was added in 1 mL of 9 N sulfuric acid. This mixture was incubated in a water bath at 50°C for 90 minutes, then cooled. Afterward, 5 mL of acetic acid were added, stirred for 1 hour, and centrifuged at 3000 rpm for 5 minutes. Then 10 μL were injected into the HPLC for 5-6 minutes. The output of the mixed separation was generated in the form of a chromatogram on the recorder.

2.6. Vitamin D Analysis Procedure

The 100 g sample was mixed with 1 g ascorbic acid and 40 mL ethanol and stirred until evenly distributed. Also, 10 mL of 60% KOH were added and stirred for 30 minutes. Afterward, another 10 mL of ethanol were added. This mixture was kept in the dark place for one night. The solution was stirred again for 30 minutes while adding 50 mL of the petroleum ether: diethyl ether mixture (1:1). The sample solution was transferred to a separatory funnel and an Erlenmeyer flask, rinsed with distilled water, and stirred for 2 minutes. The solution was allowed to separate the supernatant in the container, and then we continued stirring. Again, 30 mL of the mixture of petroleum ether: diethyl ether (1:1) were added and stirred for 2 minutes; then, the supernatant was mixed with the sample. The sample solution was evaporated to dryness, then diluted with 2-5 mL propanol and injected into the HPLC. The output of the mixed separation was generated in the form of a chromatogram on the recorder.

2.7. Vitamin E Analysis Procedure

The sample of 10 g was added to a 200 mL volumetric flask. 400 mg of macatazine and 20 mL of 0.02% ammonia were added in an ultrasonic water bath for 20 minutes at 65°C. The mixture was cooled to room temperature. Afterward, 100 mL of ethanol were added, and the solution was placed back in the ultrasonic for 10 minutes. The solution was made up to 200 mL with ethanol and stirred. Then a portion of the solution was centrifuged. A sample of 5 mL of the clear solution was placed in a 50 mL volumetric flask and then injected into the HPLC. The result of the mixed separation was generated in the form of a chromatogram on the recorder.

2.8. Proximate Analysis, Mineral Analysis, and Bio-testing Procedure

Determination of protein content was done by using the Kjeldahl method [13]. Fat content analysis used the Soxhlet method, while the water content and ash content used the gravimetric method [14]. The mineral analysis was carried out by following the previous procedure described in [15]. As a biological test, we have conducted the organoleptic and microbiological analyses, respectively, reported in [16, 17], while total solids and total acidity were observed according to the standard method [13].

2.9. Process of the Consumption Product

We have expanded the four new processed products for consumption, i.e., cane sugar jam, palm sugar jam, pulp fruit juice, and peel fruit juice. The procedure for making jam includes crushing the pulp fruit, adding spices and sodium benzoate (0.3 g/kg), then boiling this mixture while mixing is performed. Sugarcane or palm sugar was added to produce cane sugar jam or palm sugar jam, respectively. Production of two other types of juice is based on the source of the basic ingredients, using the pulp or peel to produce pulp fruit juice or peel fruit juice, respectively. Each separated pulp fruit or peel fruit is washed and crushed using a blender. This mixture is added with water, special spices, sodium benzoate, and sugar, then boil it. This material is then filtered to obtain either pulp fruit juice or peel fruit juice.

Furthermore, all four products are packaged into 250 mL bottles and labeled as ready for the local market. Nutritional content testing is carried out using previously described methods. Some samples per production period were randomly stored for quality control from the expiration or deterioration of products. All products were applied for the halal certification and supplied with the national food production number and product logo registration.

3. Results and Discussion

The morphological characteristics of Tongka Langit bananas, which are closely related to the nutritional contents of β-carotene, are the color of the pulp and the peel of the fruit (Fig. 1). The yellowish color of the two characteristics indicates a high content of β-carotene. According to authors [18], plant parts with a red to yellow color contain carotenoids, e.g., β-carotene. This outcome is in line with the results of the analysis carried out using HPLC for the β-carotene content of long and short fruit pulp, which yielded values of 52.74 mg/100g and 37.12 mg/100g, respectively. Compared to the HPLC analysis results on the red banana, in this case, the β-carotene content is lower, i.e., 0.12 mg/100g [19], while the carrot powder only has 20.55 mg/100g β-carotene [20]. Therefore, the β-carotene content in Tongka Langit banana pulp is higher than that of red banana and carrot.

Fig. 1 Morphological variations of Tongka Langit banana with long fruit from Ambon island (a) and short fruit from Kei Besar island (b), showing differences in size

The β-carotene content of Tongka Langit banana peelsranges from 66.02 mg/100g in long fruit to 51.77 mg/100g in short fruit (Fig. 2). HPLC analysis results for red banana peel showed a β-carotene value of 0.24 mg/100g [19]. By contrast, Kepok banana peels have a higher β-carotene content than red bananas, i.e., 45 mg/100g [21]. Thus, the highest value ofβ-carotene present in the Tongka Langit banana is found in the long fruit peel, while the lowest value is found in the short fruit pulp.

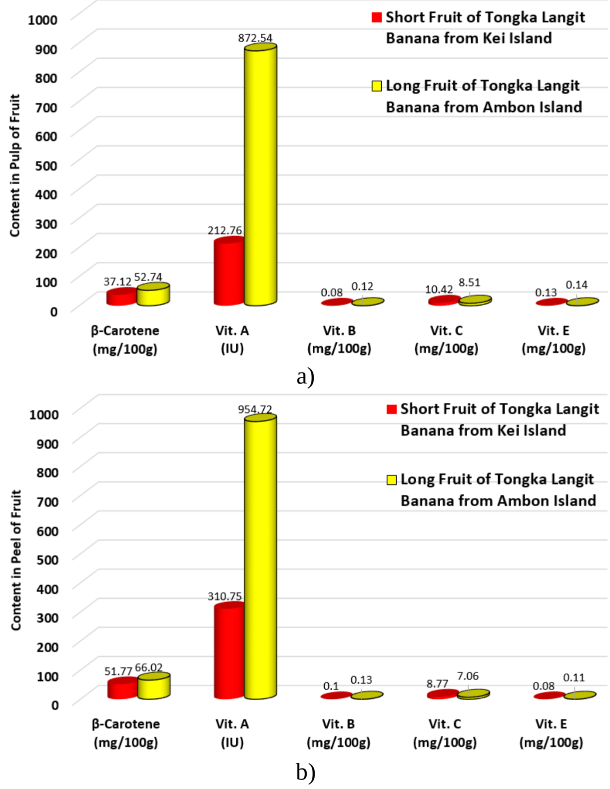

Fig. 2 The results of the analysis of beta carotene and vitamin content in the pulp (a) and peels (b) of two types of Tongka Langit bananas. Units of measurement were presented below the nutrients label

The vitamin content in Tongka Langit bananas consists of vitamins A, B, C, and E. Vitamin D is not found in this plant (Fig. 2). According to researchers

[22], the HPLC analysis of the bananas showed a very low vitamin D content of 0.009 mg/100g. This result proves that most banana cultivars do not contain vitamin D, and certain cultivars contain only a small amount. By comparison, vitamin A is found in very large amounts in the long fruit pulp of Tongka Langit bananas. More specifically, the value is almost three times higher than that in the short fruit, which is only 212.76 IU. The long fruit peel also contains more vitamin A than the short fruit peel. The vitamin B content in the pulp and peel of Tongka Langit banana fruits is very low, ranging only from 0.08 to 0.13 mg/100g. The highest value can be found in the long fruit peel, while the lowest can be found in the short fruit pulp. The Vitamin C content is higher in the short fruit than in the long fruit, with values ranging from 7.06 to 10.42 mg/100g. This value is lower than the vitamin C content in other banana cultivars analyzed employing HPLC, including the Cavendish banana, whose values range from 2.1 to 18.7 mg/100g [23], the Brazilian Dwarf banana (12.7 mg/100g), and the Williams banana (4.5 mg/100g) [24]. The vitamin E content in Tongka Langit bananas is very low, ranging from 0.08 to 0.14 mg/100g. The highest value is found in the long fruit pulp. Overall, the peel and pulp of Tongka Langit bananas have the lowest vitamin B and E contents, while the vitamin A content is the highest.

The nutritional value of Tongka Langit bananas differs from other banana cultivars and even from other types of fruits. The nutritional composition of fruit cultivars at harvest varies widely and is influenced by cultivar, fruit maturity, climate, soil type, and soil fertility [25, 26].

Based on the HPLC analysis results for the pulp and peels, we can conclude that the nutritional value of Tongka Langit bananas is very high. These fruits – especially the pulp and peels – must be properly utilized for consumer products. Although banana peels are considered organic waste, they lead to an accumulation of solid waste if they are not utilized optimally. Therefore, banana peels are currently used in a wide range of animal feed, manure, compost, food, and beverage ingredients.

The Tongka Langit banana from the Maluku Islands is used in four consumer products made from the pulp and peel of the fruit, i.e., cane sugar jam, palm sugar jam, fruit pulp juice, and fruit peel juice. Natural ingredients are used to manufacture these products, i.e., spices and auxiliary ingredients (sodium benzoate). The contents of β-carotene and vitamins A–E for edible products analyzed by HPLC showed a significant change in the raw material value. The highest value of β-carotene and vitamin A is found in palm sugar jam, whereas the lowest value is found in the pulp juice. The highest contents of vitamins B, C, and E is found in palm sugar jam products, while the lowest ones are revealed in fruit peel juice (Fig.3). The reduced nutritional value of consumer products is due to many factors, including temperature and cooking time. These result in degradation due to oxidation at high temperatures so that the structure of beta carotene becomes unstable [27]. During oxidation, volatile compounds are formed, and carotenoids decompose into low molecular weight aldehydes and ketones [28]. According to [29], carotene stability is related to double bonds and unsaturated bonds in the molecular structure of carotene. The double bonds in the hydrocarbon chain of carotene are in a transform. The carotene structure may undergo thermal isomerization to a cis form upon cooking. Carotene compounds in the cis form have less stability than trans, making them easily oxidized under heat treatment conditions. Carotene is the most unstable compared to other pigment groups such as chlorophyll and flavonoids.

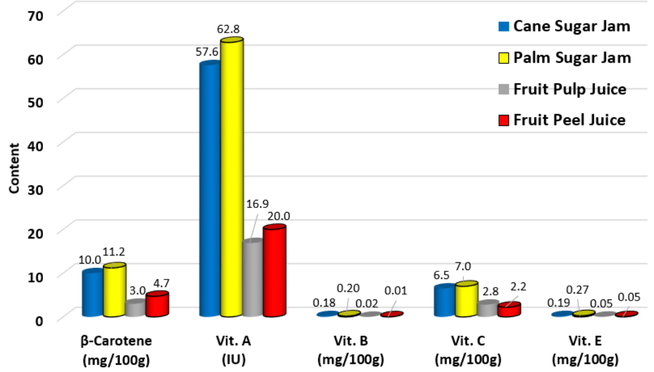

Fig. 3 The results of the analysis of the content of β-carotene and vitamin jam, fruit pulp juice, and fruit peel juice made from Tongka Langit banana, with high contents of β-carotene and Vitamin A

The proximate analysis was carried out on four samples of consumer products, i.e., cane sugar jam, palm sugar jam, fruit pulp, and peel juice, yielding different results. The highest carbohydrate content is found in palm sugar jam products, at 31.47%, while the lowest value is revealed in fruit peel juice (Fig. 4).

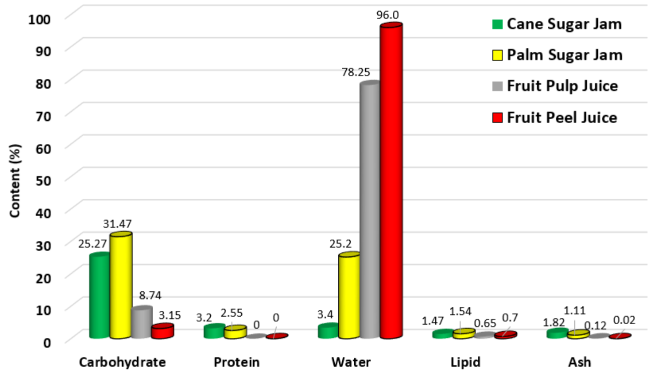

Fig. 4 The proximate analysis results of Tongka Langit jam, fruit pulp juice and fruit peel juice

Not all of the products were found to contain protein. Protein content was detected only in sugar jam, with the highest value of 3.2%, and palm sugar jam, with the lowest value of 2.55%. Fruit pulp juice and fruit peel juice do not contain protein. The highest water content was found in fruit peel juice at 96.0%, while the lowest was detected in cane sugar jam. Palm sugar jam had the highest fat content, i.e., 1.54%, while fruit pulp juice had only a 0.65% fat percentage. The highest ash content was found in the cane sugar jam at 1.82%, while the lowest was found in the fruit peel juice products amounting to just about 0.02%.

The organoleptic analysis results and the total sugar analysis performed for four products showed normal conditions for all organoleptic parameters (Table 1). The highest sugar content was found in fruit pulp juice, at 19%, and the lowest value (13.9%) was detected in cane sugar jam products. These organoleptic results show that all products are suitable for consumption, as the parameters smell, color and flavor are normal.

Table 1 Organoleptic analysis results and total sugars of Tongka Langit jam, fruit pulp juice and banana peel juice

No.	Product name	Smell	Color	Flavor	Total sugar (%)
1	Cane sugar jam	Normal	Normal	Normal	14.7
2	Palm sugar jam	Normal	Normal	Normal	13.9
3	Fruit pulp juice	Normal	Normal	Normal	19
4	Fruit peel juice	Normal	Normal	Normal	15

According to the Indonesian National Standard, the mineral analysis for fruit pulp and peel juice beverage products was conducted. According to this analysis, peel juice has a higher value of magnesium, iron, zinc, copper, sodium, calcium, phosphorus, and iodine parameters, while fruit pulp juice has a higher potassium value (Fig. 5).

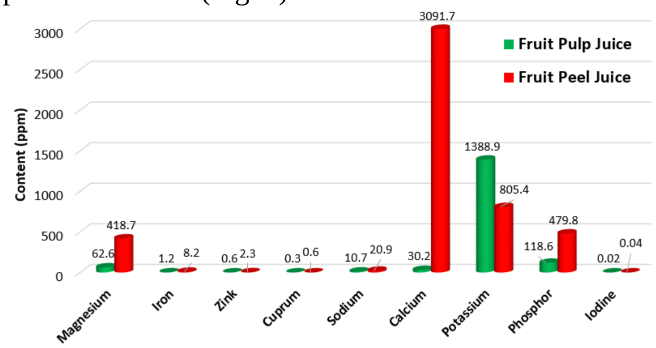

Fig. 5 Results of the mineral analysis of the fruit juice and banana peel of Tongka Langit revealing high potassium and calcium contents

Microbiological analysis results, total dissolved solids, and total acidity of the two beverage products showed that all microbiological parameters met the analytical requirements, as the total values for TPC, *Escherichia coli*, and MPN Coliform were below the established standards. No *Salmonella* was present (Table 2). The highest total solids content was found in the pulp juice at 16.0 Brix. By comparison, the peel juice only contained 10.6 Brix. The total acidity for the two products had insignificant values, as it amounted to 0.13% for fruit pulp juice and 0.12% for peel juice. These results indicate that these two consumable products meet the Indonesian National Standard for direct drinkable beverages.

Table 2 Results of microbiological analysis, total dissolved solids and total acid products of the Tongka Langit banana drink, which meet the requirement for consumption's products

No.	Parameter	Pulpfruit juice	Peel fruit juice
1	Total Plate Count (TPC)	$2x10^2$ cfu/mL	$3x10^2$ cfu/mL
2	*Escherichia coli*	Less than 10 mpn/mL	Less than 10 mpn/mL
3	MPN Coliform	Less than 3 mpn/mL	Less than 3 mpn/mL
4	*Salmonella*	Not detected	Not detected
5	Total solids	16.0 Brix	10.6 Brix
6	Total acidity	0.13%	0.12%

Currently, we have introduced four new processed products for consumption, i.e., cane sugar jam, palm sugar jam, pulp fruit juice, and peel fruit juice (Fig. 6). All consumption products have a national food production certificate, with the numbers for both cane sugar jam and palm sugar jam is 2088171010136-24, and for both pulp and peel fruit juice is 2138171020136-24. This product has received a halal certificate in 2019 from the Institution for the Assessment of Food, Drugs, and Cosmetics, Indonesian Muslim Council, Maluku Province, number 2016000289025. The logo engaged by this product uses the PISTA term (as a local acronym for “Pisang Tongka Langit”). It has a copyright registration letter obtained from the Ministry of Law and Human Rights, the Republic of Indonesia.

a) b) c) d)

Fig. 6 Photo of processed product from Tongka Langit in 250 mL bottle: (a) cane sugar jam, (b) palm sugar jam, (c) pulp fruit juice, and (d) peel fruit juice. These products can be expanded for consumption as a home industry food production

4. Conclusion

Tongka Langit banana, which is rarely cultivated and consumed by the people of Maluku, has a high nutritional profile, especially high in β-carotene and Vitamin A. The levels of β-carotene and Vitamin A are highest in the long fruit peel (66.02 mg/100g; 954.72 IU) and lowest in the short fruit pulp (37.12 mg/100g; 212.76 IU). The Vitamin B levels are highest in the long fruit peel (0.13 mg/100g) and lowest in the short fruit pulp (0.08 mg/100g). The highest vitamin C level was found in the short pulp (10.42 mg/100 g), and its lowest content was detected in the long fruit peel (7.06 mg/100g). Vitamin D was not detected in all of the samples tested. Vitamin E is present in very low amounts, ranging from 0.08 to 0.14 mg/100g. The nutritional profile for banana products derived from palm sugar jam shows a higher content of β-carotene, vitamins A, B, C, and E than that of the other products. Therefore, there is a need to cultivate this superior crop on a large scale and use the pulp and peel for a mixture of different consumer products so that the results can meet the daily nutritional needs and increase the Maluku people's income.

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