The Development of Flake Containing Provitamin A Carotenoids From Blend of Banana and Yellow-Fleshed Sweet Potato

Rosita Dwi Chandra, Chandra Ayu Siswa, Renny Indrawati, Heriyanto, and Tatas H.P. Brotosudarmo

INTRODUCTION

Vitamin A deficiency (VAD) remains a health problem faced by the majority of developing countries including Indonesia. It has been associated with the rising rates and severity of infections, and the main cause of childhood morbidity and mortality [1]. In addition, VAD has led to eye and vision problems [2,3]. Insufficient dietary intake of vitamin A has become an underlying cause of VAD. McLaren & Frigg reported that a number of trials to improve vitamin A status in some countries has resulted in the decrease of overall child mortality up to 23% [4]. The most common practice that has been conducted to alleviate VAD in many countries is through supplementation with vitamin A. In Indonesia, from 1970s to 1990s, providing high-dose vitamin A capsules as a nation-wide vitamin A intervention program to alleviate vitamin A deficiency was conducted twice a year to under-five children. As a result, around 0.33% clinical prevalence of VAD was successfully decreased in 1992, although 50% of children under-fives, at the sub-clinical level, was still suffered from a lack of serum retinol (<20 µg/dl) [5]. However, in some cases, the synthetic compounds such as retinyl palmitate or retinyl acetate are used for the fortification [6]. Therefore, some consideration has been made that food-based approaches such as consuming food sources of vitamin A including edible plants which contain

Abstract

As vitamin A deficiency (VAD) remains a health problem in Indonesia, fulfilling the requirement of vitamin A from the daily diet is of importance, especially for children. Consuming food sources rich in provitamin A carotenoids, such as bananas and yellow-fleshed sweet potatoes, is one alternative to reduce the number of VADs. Raw materials have been known for their short shelf life due to high moisture content. Therefore, processing them into dry products such as flakes can be one way to extend the shelf life of a product. The utilization of Agung Semeru banana and Papua Solossa yellow-fleshed sweet potato into flakes containing provitamin A carotenoids was conducted in this study. Through focus group evaluation, flake F2 that was made from blend of banana puree (BP), banana flour (BF), and sweet potato flour (SPF) with ratio 6:1:3 (w/w/w) was selected as the most preferred flake, and was liked by 77% of panelists in the following organoleptic appraisal. Comprising the total carotenoid by 1926.73 µg/100 g dw, vitamin A activity around 58.45 µg RAE/100 g dw, and high amount of carbohydrate, along with ash that represents minerals, this flake can be considered as a nutritional and energy food resource. However, this product is in short of meeting the recommendation of protein and fat given by Indonesian national standard, with slightly higher moisture content. Hence, it requires some improvement by serving it with milk and/or legumes, as well as selecting a proper packaging material and method.

Keywords: banana, carotenoid, flake, nutrition, yellow sweet potato

Flake Containing Provitamin A: Flake made from the mixture of banana and yellow-fleshed sweet potato was liked by 77% of panelists. Composing of total carotenoid, vitamin A activity, and proximate compositions (moisture, crude protein, crude fat, ash, crude fiber, and carbohydrate), this product can be considered as a nutritional and energy food resource for daily intake.

INTRODUCTION

Vitamin A deficiency (VAD) remains a health problem faced by the majority of developing countries including Indonesia. It has been associated with the rising rates and severity of infections, and the main cause of childhood morbidity and mortality [1]. In addition, VAD has led to eye and vision problems [2,3]. Insufficient dietary intake of vitamin A has become an underlying cause of VAD. McLaren & Frigg reported that a number of trials to improve vitamin A status in some countries has resulted in the decrease of overall child mortality up to 23% [4]. The most common practice that has been conducted to alleviate VAD in many countries is through supplementation with vitamin A. In Indonesia, from 1970s to 1990s, providing high-dose vitamin A capsules as a nation-wide vitamin A intervention program to alleviate vitamin A deficiency was conducted twice a year to under-five children. As a result, around 0.33% clinical prevalence of VAD was successfully decreased in 1992, although 50% of children under-fives, at the sub-clinical level, was still suffered from a lack of serum retinol (<20 µg/dl) [5]. However, in some cases, the synthetic compounds such as retinyl palmitate or retinyl acetate are used for the fortification [6]. Therefore, some consideration has been made that food-based approaches such as consuming food sources of vitamin A including edible plants which contain
provitamin A carotenoids are the most reliable and sustainable approaches to prevent VAD. Besides, it could also provide other advantages to simultaneously gaining several nutrients [7].

Bananas are tropical fruits that have become a popular fruit worldwide and are usually consumed as staple food in some developing countries including Indonesia. According to The Food and Agriculture Organization (FAO), bananas are considered as the fourth most important fruit in the world, following rice, wheat and maize [8]. Several banana cultivars have been identified to contain provitamin A carotenoids [8], thus, it becomes an advantage when the bananas are regularly consumed. Blades et al. [9] stated that carotenoids which can be categorized in provitamin A carotenoids are trans-α-carotene and trans-β-carotene. One banana variety that can be found in Indonesia is Agung Semeru banana (Musa paradisiaca L. AAB). According to Chandra et al. [10], the content of provitamin A carotenoids in this banana was significantly higher compared to Cavendish banana, in which α-carotene was in the range of 2509.88-3684.79 µg/100 g dw, while β-carotene ranged from 2238.94-3645.61 µg/100 g dw, depending on the ripening stages. These amount contributed in the level of vitamin A activity by 291.16-457.33 µg RAE/100 g dw. Therefore, Agung Semeru banana was chosen to be used in this study as it has promise as a fruit that is able to fulfil the daily requirements of vitamin A.

As bananas are climacteric fruits which generally have a fast ripening rate associated with a short shelf-life, it is necessary to process them into dry food products with a longer shelf life such as flakes. Cereal flakes are mostly made from corn, wheat and rice, and are commonly consumed for breakfast by wide range of age groups, especially children. It is usually provided in the form of brownish yellow thin sheets, and is generally served with milk although it could be directly consumed as snack [11]. However, due to heating process involved in the making of flakes, the reduction of provitamin A carotenoids tend to occur as pigments are very susceptible to some adverse environmental factors such as high temperature, light, and oxygen [12]. Thus, another source of provitamin A carotenoids is required to be added in order to cover the loss of the carotenoids.

Sweet potatoes are a tropical and subtropical crop that have nutritional advantages including proteins, carbohydrates, fiber, free sugars and vitamins [13]. Yellow-fleshed sweet potatoes have been known as a good source of carotenoids especially β-carotene, with total carotenoids around 75.4 µg/g [14,15]. Hence, yellow-fleshed sweet potatoes could be mixed with Agung Semeru banana into flakes containing provitamin A carotenoids. The objectives of this study were to investigate the total carotenoids and vitamin A activity in flakes made from blend of Agung Semeru banana and Papua Solossa yellow-fleshed sweet potato, to determine the most preferred flake based on focus group evaluation, followed by the acceptance evaluation through hedonic appraisal with school-age children as panelists, and to analyse the proximate compositions of the selected flake.

**EXPERIMENTAL**

**General**

Agung Semeru banana (Musa paradisiaca L. AAB) used for the development of flakes in this study was obtained from the Senduro banana plantation, Lumajang regency, East Java, Indonesia. Meanwhile, yellow-fleshed sweet potato (*Ipomoea batatas* (L.) Lam.), Papua Solossa variety, was purchased from a local market in Malang, East Java, Indonesia.

Methanol (MeOH) (≥ 99.9%), methyl tert-butyl ether (MTBE) (≥ 99.5%), water (H2O), acetone (≥ 99.5%), n-hexane (≥ 96%) and ethanol (EtOH) (≥ 99.9%) were purchased from Merck (Darmstadt, Germany). Standard carotenoids with purity ≥ 95% such as α-carotene and β-carotene were obtained from NATChrom (Malang, Indonesia).

**Flake Making**

Main materials used in the flake making were banana puree (BP), banana flour (BF) and sweet potato flour (SPF). BP was made by crushing ripe bananas (ripening stage 5) using a food processor as at this stage the bananas were reported to contain the highest total carotenoids [10]. Meanwhile, BF was made by drying unripe bananas (ripening stage 2) using an oven (100 °C, 3 h), and SPF was obtained through freeze drying process (−45 °C, 24 h). Ripening stage 2 was chosen for BF due to the low sugar content and high ratio of β-car presented at this stage [10]. There were three formulations of flakes developed in this study. The first flakes (F1) was made from the mixture of BP and SPF (6:4, w/w), while the second flakes (F2) was made from the mixture of BP with BF and SPF (6:1:3, w/w/w). The formulation of the third flakes (F3) was similar to that of F2, however, the ratio of the mixture was 6:3:1 (w/w/w). Baking powder was added by 0.5 % of the total weight of the mixture. After all of the materials were well mixed, the dough was steamed at 100 °C for 15 min and then rolled in order to flatten the dough. The flattened dough was cut into approximately 1.5 cm × 2 cm × 0.2 cm, followed by baking process at 100 °C for 13 min. The flakes were ready to be analyzed further.

**Determination of Total Carotenoid**

Total carotenoids (in µg carotenoid/100 g dw) were determined based on the pigment absorption spectrum measured with a spectrophotometer (UV-1700, Shimadzu) according to the following formulation (1) modified from Gross [12]:

\[
\text{Total Carotenoid} = \frac{A \times V \times 10^6}{A_{\lambda\text{max}}^1 \times 100} \times \frac{G \times 100 - \text{moisture content} \%}{(100 - \text{moisture content} \%)}
\]

where \(A\) is the absorbance at maximum absorption wavelength (\(\lambda_{\text{max}}\)), \(V\) is the volume of carotenoid extract (mL); \(G\) is the weight of sample (g); \(A_{\lambda\text{max}}^1\) is 2500 for a specific absorbance extinction of a mixture of carotenoids in acetone. The moisture content was determined using a Shimadzu MOC63u moisture analyser.

**Determination of Vitamin A Activity**

This analysis was carried out by following the previous method presented in the study of Chandra et al. [10]. Grounded flakes (0.2 g) and 1 mL extraction solvent consisted of EtOH:n-hexane (4:3, v/v) were homogenized on a vortex (IKA, Staufen, Germany) for 5 min at maximum speeds. The extraction process was conducted in a dark room and the extract was kept on ice bath. After centrifugation at 5000 rpm for 1 min at 5 °C, the supernatant was evaporated using a rotary evaporator (Heidolph, Schwabach, Germany). The residues were prepared for further analysis.

Prior to filtration using a filter membrane (PTFE, 0.22 µm), the residues were redissolved in 1 mL acetone. The sample (20 µL) was then subjected to HPLC analysis for the determination
of the carotenoid content with a Shimadzu high-performance liquid chromatograph (HPLC) on a YMC carotenoid C-30 reversed-phase column (150 × 4.6 mm I.D.) (Wilmington, MA, USA), equipped with a guard column and photodiode array detector, in H2O:MeOH:MTBE (4:81:15, v/v/v) at 0 min and (4:6:90, v/v/v) at 70 min. The flow rate was 1 mL/min and the column oven was 30 °C. The identification of pigments was performed according to the chromatography result of α-carotene and β-carotene standard pigments. The concentrations of each carotene (µg/100 g dw) were calculated based on peak area at λmax by using standard linear equations (2 and 3) shown in Chandra et al. [10]:

\[ \alpha - \text{car}: y = 232.04x - 47.906, R^2 = 0.9950 \]  
\[ \beta - \text{car}: y = 206.57x - 74.953, R^2 = 0.9982 \]  

Vitamin A activity was calculated by converting the concentrations of provitamin A carotenoids (α-carotene and β-carotene) into retinol activity equivalent (RAE) based on conversion factor for provitamin A carotenoids (\( \text{RAE}_x \)).

**Color Analysis**

Color of the flakes was measured using ColorFlex® EZ 0530 (HunterLab, USA) under the same light conditions and at room temperature. The results were represented in terms of L* (lightness), a* (redness), and b* (yellowness) according to Commission Internationale de l’Eclairage (CIELAB system). The hue angle (H°) is the relative amount of yellowness and redness or the angle between the hypotenuse and 0° on the a* (bluish-green/red-purple) axis [16]. It was calculated based on the following formula: 

\[ H° = \arctan \frac{\sqrt{a^2 + b^2}}{L°} \]

**Sensory Evaluation**

Hedonic evaluation was used to determine the degree of overall liking for the flakes. Prior to hedonic evaluation, focus group evaluation was conducted to observe the preference of consumer and to define the critical attributes of a product [17]. It was also aimed to select the most preferred formulation of a product that could be utilized for sensory preference. It usually involves small group of 8-12 panelists to respond to the products [18]. Small group of 8 consumers was used in this study, consisting of 6 females and 2 males. They were employed to obtain both positive and negative reactions towards the flakes. The responses of panelists were then observed. After this session, the flakes with the most preferred formulation were chosen for hedonic evaluation for consumer acceptance test which usually involves 50-100 panelists [19].

In this study, the panelists were comprised of 69 school-age children who were 4th and 5th grade students of two elementary schools in Malang, East Java, consisting of 43 females, 26 males of age 9 yrs (43 %), 10 yrs (48 %) and 11 yrs (9 %). This group was willing to participate in the evaluation and was in good health, with no allergic towards the milk and the flake compositions. The attributes that were required to be evaluated were aroma, color, taste and texture of the flakes. In addition, the quality of texture (crispness) and the taste (deliciousness) of the flakes were also evaluated, followed by the evaluation of taste of the flakes served in the milk. Fifteen pieces of flakes and 30 mL of milk were served with water and a questionnaire using a 5 point hedonic scale (1-dislike very much, 2-dislike moderately, 3-neutral (neither like nor dislike), 4-like moderately, 5-like very much) and 5-point scale for quality of hedonic evaluation (taste: 1-not very good, 2-not good moderately, 3-neutral (neither good nor not good), 4-good moderately, 5-very good; texture: 1-not very crispy, 2-not crispy moderately, 3-neutral (neither crispy nor not crispy), 4-crispy moderately, 5-very crispy). After short explanation, the panelists were instructed to rate the flakes, started from the flakes only and continued to put the rest of flakes in the milk.

**Proximate Analysis**

Proximate analysis was conducted based on the procedures of AOAC (Association of Official Analytical Chemists) to determine moisture, ash, crude fat, crude protein, crude fiber, and carbohydrate content of the flakes [20]. Moisture content and crude fiber were measured by gravimetric method. Soxhlet extraction method was used to determine crude fat while crude protein content was obtained from Kjeldahl method. Carbonization and incineration in muffle furnace at 550 °C were the method used to determine ash content. Total carbohydrate content was calculated by difference method in which 100 % was deducted by the total percentage of moisture, ash, crude protein, crude fat and crude fiber content.

**RESULTS AND DISCUSSION**

**Absorption Spectra**

The differences of spectral patterns and absorbance spectra of carotenoid extracts in the main materials and the flakes are presented in Figure 1. It can be seen that SPF, BP, and BF exhibited different absorption spectra of carotenoid extracts. SPF showed the maximum absorption wavelength (\( \lambda_{max} \)) at 405, 428, and 452 nm. According to Soegiarto et al. et al., the peak at 427-428 nm in sweet potatoes indicated the presence of β-carotene and other carotenoids [21]. Meanwhile, \( \lambda_{max} \) of BP and BF was exposed at 422, 450, and 477 nm, showing the presence of β-carotene as the major carotenoids, as it has maximum absorption wavelength at 450 nm [10,22,23]. Regarding the flakes, the ratios of the main materials were found to determine the absorption spectra of the flakes. Flake 1 (F1) and flake 2 (F2) which were formulated with the higher amount of SPF compared to flake 3 (F3) had the absorption spectra similar to that of sweet potato, while F3 presented that of banana.

![Absorption spectra and spectral patterns of carotenoid extracts of sweet potato flour (SPF), banana puree (BP), banana flour (BF), flake 1 (F1), flake 2 (F2) and flake 3 (F3)](image)
Total Carotenoid and Vitamin A Activity

The total carotenoid and vitamin A activity of BP, BF, SPF, F1, F2 and F3 are depicted in Figure 2. As shown in Figure 2, among the main materials, the highest concentration of total carotenoid was presented in SPF (7505.16 ± 751.79 µg/100 g dw) as the drying process was conducted by using freeze dryer so that there was no heat treatment applied. The second highest total carotenoid was provided by BP, which was mashed fresh bananas at ripening stage 5, with 6405.03 ± 217.06 µg/100 g dw. On the other hand, oven-dried BF obtained the total carotenoid about six times lower (926.05 ± 63.18 µg/100 g dw) than that of fresh bananas at ripening stage 2 (5774.95 ± 267.43 µg/100 g dw), which indicates that the heat treatment at 100 °C for 3 h impacted on the decrease of total carotenoid content in the banana flour by 84%. As a result, the amount of total carotenoid in F1 (2532.10 ± 136.56 µg/100 g dw) was the highest among the flake products as the highest addition of SPF was formulated in this flake, followed by F2 with 1926.73 ± 195.49 µg/100 g dw. It can be seen that the total carotenoid content increased significantly with the increase in the level of SPF in flakes, thus, F3 exhibited the lowest amount of total carotenoid, 1547.33 ± 254.88 µg/100 g dw.

![Figure 2. Total carotenoid and vitamin A activity in the flakes (F1, F2, and F3) and the forming materials (banana puree (BP), banana flour (BF), and sweet potato flour (SPF))](image)

The vitamin A activity was determined by converting the concentrations of provitamin A carotenoids, α-carotene and β-carotene, which were present in the samples. The highest retinol activity equivalent (RAE) was shown in F1 with 58.51 ± 9.75 µg RAE/100 g dw. Interestingly, this result was not significantly different from F2 which was 58.45 ± 8.41 µg RAE/100 g dw, which might be caused by the close ratio of sweet potato flour added in the formulation, 4/10 in F1 and 3/10 in F2. Meanwhile, F3 was the flake with the lowest amount of vitamin A activity with 31.61 ± 5.08 µg RAE/100 g dw. These results imply that heating processes which were carried out for twice in the flake making, i.e. steaming and baking process of the dough, impacted on the dramatic reduction of vitamin A activity, reaching by more than 80%, as compared to the initial vitamin A activity provided in SPF and BP, 386.94 ± 23.55 µg RAE/100 g dw and 430.96 ± 19.20 µg RAE/100 g dw, respectively. Therefore, optimization processes of flake making, particularly those involving heat applications, are still required in order to prevent the severe pigment degradation. Nevertheless, it could be suggested that by consuming 100 g of flake F1 or F2, a quarter of the average requirement of vitamin A can be fulfilled as the estimated average requirement (EAR) values of vitamin A for children range from 210-275 µg RAE/day [24]. Moreover, it could also be proposed to fulfill the remaining requirement of vitamin A from provitamin A carotenoid-rich vegetables or fruits.

Sensory Evaluation

The focus group evaluation resulted in the flake F2 that provided the highest preference in comparison to the flake F1 and F3. Taste and texture of F1 were perceived as grainy and hard (less crispy) which might be caused by the higher amount of crude fiber presented in sweet potatoes. The presence of carbohydrate, crude fiber and other compounds which contain hydroxyl groups provide an affinity to form hydrogen bonds with the molecules of water [25], increasing the hardness. Meanwhile, grainy perception is referred to the degree of uneven surface which in turn causing the roughness or graininess of particles on chewing and it could be perceived from sweet potatoes, showing negative response and lower score of preference testing [26]. Meanwhile, F3 was perceived as less sweet compared to F2 as the less amount of SPF added in the formulation of F3, and this might be less preferred by children. Therefore, F2 was selected for hedonic evaluation which involved a total of 69 school-age children as panelists.

Prior to fulfill the question of hedonic evaluation, the panelists were provided question about the intake frequency of flakes that are sold in the market. The responses to the questions are shown in Table 1. In addition, after conducting hedonic evaluation, panelists were instructed to fill the questions about consumption intent towards flake F2 (Table 2).

| Table 1. The responses of panelists to the question about the intake frequency of flakes that are sold on the market |
|-----------------|-----------------|
| Questions | Responses (%) |
| Have you ever consumed the flakes that are sold in the market? | Yes | No |
| Yes | 88 | 12 |
| Do you like the flakes that you have consumed? | Yes | No |
| Yes | 84 | 16 |
| How often do you consume the flakes in a week? | Often (≥ 6 times) | Sometimes (3-5 times) | Rarely (&lt; 2 times) |
| Often (≥ 6 times) | 33 | 7 | 59 |

| Table 2. The responses of panelists to consumption intent towards the flake F2 |
|-----------------|-----------------|
| Questions | Responses (%) |
| I will consume this flake for breakfast every day | 59 |
| I will consume this flake more than once a day | 62 |
| I will consume this flake when there is no other foods available | 65 |
| I will only consume this flake when forced to do so | 13 |
| I like this flake and will make it as a long-term intake | 77 |
| I do not like this flake but I will consume it sometimes | 26 |
| I do not like this flake and will never consume it | 12 |

As seen in Table 1, 88% of panelists had ever consumed the flakes that were sold in the market and 84% provided the preference towards the flakes that were consumed. Following this, according to data in Table 2 that depicts the responses of panelists after tasting the flake F2, despite the disliking shown by around 12% of panelists, more than 60% of panelists showed positive responses towards the flake, with 77% showing a willingness to make it as a long-term intake.
The results of hedonic evaluation which showed the preference of panelists for the flake F2 is presented in Figure 3 and Figure 4. The color of the flake was represented with hue value 75.16 ± 0.01, which was yellowish and it was liked moderately (4.43/5). According to Reyes & Cisneros-Zevallos, the hue angle in the range between 72° dan 90° is described as a product with yellowish tint [27]. In addition, the aroma and texture of the flake were also liked moderately by panelists as the score provided by each attribute was 4.42/5. Moreover, the taste of the flake as well as the flake mixed with milk were scored 4.55/5 and 4.59/5, respectively, which means that those were liked very much by panelists. To support the results, further investigation was conducted through quality of hedonic evaluation (Figure 4) and it was resulted that the taste of the flake was very good (4.62/5) and the texture was very crispy (4.71/5) although it was liked moderately. Despite the fact that this flake was made conventionally and relied on the natural components and properties of bananas and sweet potatoes, the acceptance expressed by panelists towards the flake suggests that this flake has quality to be further developed with some modification and optimization in the processes including heat exposure.

**Proximate Compositions**

Proximate compositions are necessary to be determined in order to evaluate the quality of food commodities whether it meets the standard regulated by a statutory authority in a country such as Indonesian National Standard (SNI) in Indonesia. Table 3 represents the proximate content of the most liked flake (F2) and the main materials used in the flake (BP, BF, and SPF). The proximate analysis of the flake showed the low amount of crude protein and crude fat, 3.07% and 0.17%, respectively, and this was caused by the low content of crude protein and crude fat in the main materials. The content of crude protein in SPF, BF and BP were 4.21%, 3.14% and 1.18%, respectively, while crude fat was presented around 0.24%, 0.26% and 0.35%, respectively. Moreover, the low level of protein might also be affected by the Maillard reaction between alkaline amino acids and reducing sugars that occurred during heat exposure [28]. According to SNI 01-4270-1996 which regulates the nutritional standard for flakes, the minimum protein and fat content that becomes the quality standard of nutrition in flakes are 5% and 7%, respectively [29]. Hence, these contents are still required to be improved and it could be achieved by serving or mixing it with milk or legumes.

Inspite of the low level of crude protein and fat, the flake provided the amount of carbohydrate and ash which met the quality standard of SNI 01-4270-1996. The minimum carbohydrate content that is regulated by SNI is 60.7% and F2 contained 89.19% of carbohydrate. Meanwhile, regarding ash content, the flake contained approximately 2.75% which was lower than the maximum level (4 %) regulated by SNI 01-4270-1996. These results show that the flake F2 could be used as an energy source due to the high amount of carbohydrate contained, completed with the presence of minerals in accordance to the availability of ash content.

The crude fiber presented in the flake F2 was found to be 1.09%, which was higher than the quality standard regulated by SNI 01-4270-1996 (maximum 0.7%). BF and BP contained lower amount of crude fiber compared to SPF, 0.78%, 0.93%, and 2.46%, respectively. It can be seen that the high level of crude fiber was resulted from SPF as it has been studied that the crude fiber in some sweet potato varieties ranged from 2.1-13.6% [30].

Besides the presence of crude protein, crude fat, carbohydrate, ash and crude fiber, moisture content which also plays an important role in maintaining the quality and shelf-life of food products is necessary to be analyzed. According to Ergun et al. [25] moisture content affects the texture and shelf-life of products. SNI 01-4270-1996 regulated that the flakes could meet the quality standard of flakes if the moisture content in the level of maximum 3%. In this study, the flake F2 provided moisture content which were slightly higher than the standard, which was 3.42 %. Roseliana found that the characteristics of flakes available in the market were ranging from 1-9% [31]. Hence, it could be suggested that the selection of packaging materials and processes should be well-considered in order to provide sufficient protection of the products from moisture in the surrounding environment.

**Table 3. Proximate compositions of the most liked flake (F2) and the main materials used for the flake (BP, BF, SPF)**

<table>
<thead>
<tr>
<th>Samples</th>
<th>Moisture (%)</th>
<th>Crude protein (%)</th>
<th>Ash (%)</th>
<th>Crude fat (%)</th>
<th>Carbohydrate</th>
<th>Crude fiber (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F2</td>
<td>3.42 ± 0.03</td>
<td>3.07 ± 0.19</td>
<td>2.75 ± 0.02</td>
<td>0.17 ± 0.01</td>
<td>89.19 ± 0.07</td>
<td>1.09 ± 0.04</td>
</tr>
<tr>
<td>BP</td>
<td>62.54 ± 0.40</td>
<td>1.18 ± 0.01</td>
<td>0.78 ± 0.07</td>
<td>0.35 ± 0.02</td>
<td>35.20 ± 0.12</td>
<td>0.93 ± 0.04</td>
</tr>
<tr>
<td>BF</td>
<td>7.67 ± 0.21</td>
<td>3.14 ± 0.04</td>
<td>1.99 ± 0.04</td>
<td>0.26 ± 0.01</td>
<td>86.90 ± 0.08</td>
<td>0.78 ± 0.03</td>
</tr>
<tr>
<td>SPF</td>
<td>6.27 ± 0.08</td>
<td>4.21 ± 0.25</td>
<td>2.85 ± 0.04</td>
<td>0.24 ± 0.02</td>
<td>83.98 ± 0.01</td>
<td>2.46 ± 0.10</td>
</tr>
</tbody>
</table>

*Chandra, et al. (2021).*

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CONCLUSION
The utilization of Agung Semeru banana and Papua Solossa yellow-fleshed sweet potato in the flake making was resulted in flake F2 as the most preferred in the focus group evaluation, followed by 77% of positive responses expressed by panelists in the hedonic test. This flake composed of 192.67 ± 195.49 \(\mu g/100\) g dw of total carotenoids and around 58 \(\mu g\) RAE/100 g dw of vitamin A activity. Thus, it could fulfill the quarter daily average requirement of vitamin A for children. However, this result implies that the method of flake development is still required to be properly optimized in order to prevent the severe degradation of pigments. In addition, this flake could be served with milk and legumes to fulfill the requirement of protein and fat, while the selective packaging materials and processes should also be put as concern to prevent the increase in moisture content of the flake.

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Abstrak
Kekurangan vitamin A (KVA) masih menjadi masalah kesehatan di Indonesia sehingga pemenuhan kebutuhan vitamin A dari makanan sehari-hari sangatlah penting, terutama untuk anak-anak. Mengkonsumsi sumber makanan kaya akan karotenoid provitamin A, seperti pisang dan ubi jalar kuning, merupakan salah satu alternatif untuk menurunkan angka KVA. Bahan baku segar telah diketahui memiliki umur simpan yang pendek karena tingginya kadar air. Oleh karena itu, mengolahnya menjadi produk kering seperti flake dapat menjadi salah satu cara untuk memperpanjang umur simpan suatu produk pangan. Pemanfaatan pisang Agung Semeru dan ubi jalar kuning Papua Solossa menjadi flake yang mengandung karotenoid provitamin A dilakukan dalam penelitian ini. Melalui uji kesukaan dalam focus group, flake F2 yang terbuat dari bubur pisang (BP), tepung pisang (BF), dan tepung ubi jalar (SPF) dengan rasio 6:1:3 (w/w/w) terpilih sebagai flake yang paling disukai, dan disukai oleh 77% panelis dalam penilaian organoleptik. Terdiri dari total karotenoid sebesar 1926.730 g/100 g bk, aktivitas vitamin A sekitar 58.445 g RAE/100 g bk, dan jumlah karbohidrat yang tinggi, serta abu yang mewakili tersedianya mineral, flake ini dapat dipertimbangkan sebagai sumber makanan benuutrisi dan berenergi. Namun, produk ini masih belum memenuhi kandungan protein dan lemak yang direkomendasikan standar nasional Indonesia, dengan kandungan air yang sedikit lebih tinggi. Oleh karena itu, perlu dilakukan beberapa perbaikan termasuk menyajikannya dengan susu dan/atau kacang-kacangan, serta memilih bahan dan metode pengemasan yang tepat.

Kata kunci: pisang, karotenoid, flake, nutrisi, ubi jalar kuning