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The Effects of Steaming on Color and Carotenoid Absorption Spectra of Orange-, Yellow- and Purple-Fleshed Sweet Potatoes (*Ipomoea batatas* (L.) Lamb.)

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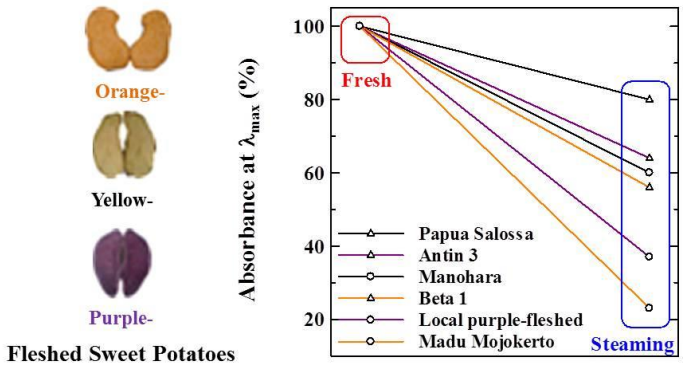
Abstract

Sweet potatoes, especially the orange and yellow-fleshed, are functional local foods because they contain carotenoids which serve as a pro-vitamin A. The processing of sweet potatoes into noodles, fermented cassava or "tape" and artificial rice is usually prepared through a steaming process. However, carotenoid is susceptible to degrade when it is subjected to high temperature, such as steaming. The objective of this research is to determine the effects of steaming on the color and carotenoid absorption spectra of local and excellent sweet potatoes which are correlated to the carotenoid content and to evaluate the difference of carotenoid spectral properties among sweet potatoes by principal component analysis (PCA). The steaming treatment decreased color values, such as lightness and redness, while yellowness was decreased in some sweet potato cultivars. In addition, this process also influenced the spectral properties of carotenoid extracts from sweet potatoes. Steaming decreased absorbance and resulted in hypsochromic and bathochromic shifts. Madu Mojokerto, Manohara, local purple fleshed, Beta 1, and Papua Solossa sweet potatoes experienced some decreases in absorbance and a hypsochromic shift of ± 77 % and ± 2 nm, ± 40 % and ± 21 nm, ± 63 % and ± 28 nm, ± 44 % and ± 2 nm, and ± 20 % and ± 23 nm, respectively; while Antin 3 sweet potatoes experienced some decrease in absorbance of ± 36 % and a bathochromic shift of ± 28 nm. The PCA results showed that there were four groups of sweet potatoes based on spectrum shape and absorbance value.



Short Description

Six varieties of sweet potatoes, namely Beta 1 and Madu Mojokerto (orange-fleshed), Papua Solossa and Manohara (yellow-fleshed), Antin 3 and local (purple-fleshed), were used to study the effect of steaming on the color and carotenoid absorbance spectra. The sweet potato of yellow-fleshed Papua Salossa had the higher stability of carotenoids after the steaming treatment with the lowest percentage of absorbance decrease (20%), while the carotenoids in orange-fleshed Madu Mojokerto was the most unstable among other sweet potatoes against the treatment.

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Keywords: Absorption spectra, carotenoid, color, PCA, steaming, sweet potato

INTRODUCTION

Carotenoid is a group of pigment which has yellow to red color. In photosynthesis process, carotenoid acts as light harvesting and photoprotector. Some carotenoids, i.e. *β*-carotene, *α*-carotene, *β*-cryptoxanthin, also serve functional benefit as pro-vitamin A. Carotenoids in vegetables and fruits provide more than 70 % of the needs of vitamin A per day [1]. The pro-vitamin A carotenoid, such as all-*trans* *β*-carotene has 100 % availability to be converted into vitamin A in human body [2]. According to the flesh color, orange- and yellow-fleshed sweet potatoes contain a high amount of carotenoids. Although the purple-fleshed sweet potato do not show a typical

color of carotenoid, it had a lower total carotenoid content (5.19 µg/g) compared to the orange (157.9 µg/g) and yellow (75.4 µg/g) varieties [3]. Maoka *et al*. (2007) found a series of *β*-end carotenoid with hydroxy and epoxide groups in yellow-fleshed sweet potato [4]. In addition, *β*-carotene was detected as a major carotenoid in orange-fleshed sweet potato [2].

Sweet potatoes (*Ipomoea batatas* (L.) Lamb.) are one of local functional foods with a great production in Indonesia. Sweet potatoes are usually processed as food products by steaming. Steaming process is commonly used for making of some products such as noodles, fermented cassava or "tape", and artificial rice. This process causes the decreasing carotenoid content because carotenoids have unstable characteristic at high temperature. Previous research by Yudha and Farida (2013) showed that steaming decreased the *β*-carotene content in orange-fleshed sweet potato from 55.7 to 40.7 µg/g [5]. The objective of this study is to determine the effects of steaming on the color values and spectral properties of sweet potato carotenoids and to evaluate the difference of these spectral properties using the principal component analysis (PCA).

EXPERIMENTAL

General

The local and excellent sweet potato varieties were harvested at 4.5 mo to 5.0 mo old. The excellent varieties of orange- (Beta 1), yellow- (Papua Solossa) and purple- (Antin 3) fleshed sweet potatoes were cultivated by Indonesian Legumes and Tuber Crops Research Institute in Tumpang (ILETRI, Malang, East Java). Madu Mojokerto cultivar (orange-fleshed) and Manohara cultivar (yellow-fleshed) of local sweet potatoes were harvested from Menganti village (Gresik) and Sumber Pasir village (Malang regency), respectively. While the local variety of purple-fleshed sweet potato was purchased from Karangploso market (Malang regency). Acetone, methanol and diethyl ether (DE) with pro-analysis grade were purchased from Merck (Darmstadt, Germany).

Sample Preparation

The sorted sweet potatoes with the high quality (15 cm to 20 cm in diameters and 500 g in the total weight) were washed by running water to remove the remaining clay. The sweet potatoes were steamed without being peeled for 30 min at 100 °C [6]. The raw and steamed sweet potatoes were peeled, cut into small pieces and then mashed in mortar.

Moisture Content, Colors and Chroma Analysis (Modified Method of Masuda and Jitoe (1994), [7])

The moisture content of each sample (0.3 g to 0.5 g) was measured using a Moisture Analyzer MOC63u (Shimadzu, Kyoto, Japan) at a range of ± 0.1 % (wet basis). The Hunter's coordinate of colors (L*, a*, b*), Chroma (C*) and °Hue of sample (2 g) was measured by Colorflex EZ (HunterLab, VA, USA). These measurements were repeated three times.

Carotenoid Extraction and Absorption Spectrum Measurement (Modified Methods of Rodriguez and Kimura (2004) [8])

Sample (0.5 g) was homogenized with acetone and methanol mixture (7:3, v/v) (for orange- and yellow-fleshed sweet potatoes) and 100 % acetone (for purple-fleshed sweet potato) for 15 min at 60 rpm (1 rpm = 1/60 Hz). The used extraction solvents for each sample were based on the experimental result of the optimal carotenoid extraction from previous study [9]. Carotenoid extract was filtered, and the obtained residue was re-extracted with the same solvent until the residue became colorless. The ratio between sample and solvent was 1 and 10 (g/mL). The carotenoid extracts were combined and concentrated using a rotary evaporator, and then dried with N_2. Absorption spectra of carotenoid extracts in DE were recorded by UV-1700 Spectrophotometer (Shimadzu) in the wavelength range of 300 nm to 600 nm.

Data Analysis

The effects of steaming on absorption spectra were determined using descriptive method. The spectral patterns were analyzed using Plot 32 and Microsoft Excel 2013. Statistical data were processed on Minitab 14 and PCA was analyzed using a PAST software 9. PC (principal component) 1 and 2 were obtained according to the PAST. PC 1 is considered to be correlated to the stability of carotenoids, while both PC 1 and PC 2 reflect similarities in spectral properties of sample.

RESULTS AND DISCUSSION

Moisture Content

Physical characteristics of local and excellent sweet potato varieties are shown in Table 1. The local and excellent sweet potatoes showed three different flesh colors such as orange, yellow, and purple. The excellent sweet potatoes had darker flesh colors than the local ones. The diameter, length, and weight of sweet potatoes used in this research were 15 cm to 20 cm, 20 cm to 30 cm, and 100 g to 500 g, respectively.

The average of moisture contents from raw flesh sweet potatoes was 72.79 ± 1.57 %, 65.05 ± 3.40 %, and 61.15 ± 1.21 % for Madu Mojokerto, Manohara, and purple-fleshed, respectively. Whereas it's content for excellent sweet potatoes was 75.13 ± 0.55 %, 68.37 ± 1.13 %, and 61.13 ± 2.63 % for Beta 1, Papua Solossa, and Antin 3, respectively. Directorate of Nutrition, Ministry of Health Republic of Indonesia 10 reported that the moisture content of orange-fleshed sweet potato was 79.28 %. The previous research by Salim and Putri (2014) showed that the moisture content of Manohara was 63.62 % [10], while Susanti (2010) stated that the moisture contents of purple-fleshed sweet potato cultivar Gunung Kawi and Beta 1 were 68.5 % and 75.2 %, respectively [11]. Other report by ILETRI (2012) suggested that Antin 3 had moisture content of 70.90 % [12]. The difference between these moisture content values may be correlated with different plantation time, harvesting age, and chemical composition. Antarlina (1997) classified the moisture content of sweet potato into two groups, i.e., a high moisture group if the content is more than 73.5 %, while if it is less than 65.6 %, it is grouped as low [13]. The moisture contents of orange-fleshed sweet potatoes (Madu Mojokerto and Beta 1 cultivars) were under the range of high value, while other sweet potatoes under low moisture content. The orange-fleshed sweet potatoes had higher moisture content than yellow- and purple-fleshed. Ishiguro *et al*. (2010) reported that orange-fleshed sweet potato contained more *β*-carotene than yellow- and purple-fleshed sweet potatoes [14]. The *β*-carotene content had a correlation with moisture content [15]. High *β*-carotene content in the sweet potato was accompanied by the high moisture content.

Table 1. Physical characteristics of local and excellent sweet

Parameters	Variety of Sweet Potato					
	Local			Excellent		
	Madu Mojokerto	Manohara	Purple-fleshed	Beta 1	Papua Solossa	Antin 3
Visual appearance						
Diameter (cm)	15 to 20	20 to 30	15 to 20	15 to 20	20 to 25	15 to 20
Length (cm)	15 to 20	15 to 20	15 to 20	15 to 20	20 to 30	20 to 30
Weight (g)	130 to 160	400 to 500	110 to 280	200 to 300	300 to 400	400 to 500

Based on the statistical analysis, it was known that the flesh colors gave significantly different results of moisture content ($p < 0.05$).

The percentages of moisture content of sweet potatoes decreased after the steaming. The order of moisture content decreasing is as follow: Madu Mojokerto (7.60 %) > Manohara (6.66 %) > Antin 3 (2.94 %) > Beta 1(1.58 %) > Papua Solossa (1.58 %) > purple-fleshed (1.24 %). It was reported that the amylose conducted a retrogradation by lowering its availability to bind the water and also released the water (syneresis) after steaming treatment [16]. The sweet potato varieties have different content of starch granule and its component affects the retrogradation. As a result, retrogradation causes the lower moisture content after steaming process.

Colors

The colors analysis was based on the Hunter's color coordinate with the L* (lightness), a* (redness), and b* (yellowness) as the color parameters. The results of L*, a*, b* analysis are shown in Table 2. The yellow-fleshed sweet potato cultivar Manohara had the highest lightness value before steaming, whereas the highest redness and yellowness values were in orange-fleshed sweet potato cultivar Beta 1. Steaming process caused the decrease in redness and lightness values while the yellowness values increased in all sweet potatoes. This result suggested that carotene degradation was caused by the steaming process. Increasing temperature lowered the redness value, indicating the decrease in carotenoid content and color darkening [17]. Kays and Kays (1998) reported that the flesh color of sweet potato was faded because of the oxidation and isomerization of trans to cis double bond [18]. Isomerization also caused the decrease in redness rate [19]. The negative value of b* in purple-fleshed sweet potato after steaming was due to the present of anthocyanin and phenolic compounds. This pigmentation results the increment of blue color value [20].

The color characteristic could be determined by chroma and °hue. The chroma (C*) (1) and °hue (2) values were calculated with following equations:

$$C^* = \sqrt{(a^*)^2 + (b^*)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$^\circ hue = arc\tan\frac{b^*}{a^*} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The results of chroma and °hue values are shown in Table 2. The flesh colors of Madu Mojokerto, Manohara, and Papua Solossa with respect to °hue value were yellow reddish, while Beta 1 was red, purple-fleshed and Antin 3 were red purplish. The flesh colors of Beta 1 and Antin 3 were changed to yellow reddish and purple, respectively after steaming. These changes could be correlated with their carotenoid content. Soegiarto (2015) reported that HPLC analysis showed the increase in carotenoid degradation products and the decrease in all-*trans* *β*-carotene after steaming [9]. The occurrence of carotenoid degradation products, caused by the steaming process, changes the biological activity of carotenoid and also decreases the color intensity [8].

Absorption Spectra

Absorbance could be used as the parameter of carotenoid content because it is linearly correlated with carotenoid concentration according to Lambert-Beer's equation [21]. The results of spectral patterns and the differences of absorbance spectra of carotenoid extracts are shown in Figure 1, while their spectral properties and decrease in percentage of the main peak absorption are summarized in Table 3. Absorption spectra of carotenoid extracts from the raw sweet potatoes have higher absorbance values at the main peaks compared to the steamed samples. The steaming process caused the carotenoid degradation which is indicated in the absorbance decrease in the main peak. The maximum absorption wavelengths (λ_{max}) of carotenoid extracts from sweet potatoes were in 427 nm to 428 nm, 444 nm to 451 nm and 472 nm to 476 nm. The spectral properties of orange-fleshed sweet potato cultivar Beta 1 in acetone (data not shown) had similar λ_{max} as well as the spectral shape compared to the *β*-carotene [22]. While absorption spectra of carotenoid extracts from other sweet potatoes showed different spectral shape and the band in 427 nm to 428 nm appeared as a peak instead of a shoulder. These phenomena indicate that *β*-carotene with other carotenoids posessing λ_{max} at 427 nm is included in these sweet potatoes.

The degradation products of carotenoid occurred during the steaming process were detected in the difference spectra (Figure 1). The degradation products of carotenoid from crude extract can be identified from the positive absorption in the differences of the spectra [23]. The difference of the spectra of orange-fleshed cultivar Madu Mojokerto and Beta 1, yellow-fleshed cultivar Manohara and Papua Solossa showed negative absorption.

Table 2. The average colors (L*, a*, b*), Chroma (C*) and °Hue values of local and excellent sweet potatoes before and after steaming

Treatment	Color Parameter (±SD)	Variety of Sweet Potato					
		Local			Excellent		
		Madu Mojokerto	Manohara	Purple-fleshed	Beta 1	Papua Solossa	Antin 3
Before Steaming	L*	61.60±0.29	84.66±0.32	27.15±0.27	65.87±1.57	80.50±0.32	25.39±2.40
	a*	27.47±0.69	3.40±0.36	21.23±0.23	34.91±1.06	9.74±2.83	11.84±0.35
	b*	**41.16±0.39**	**34.95±0.76**	**-1.35±0.34**	**44.64±1.06**	**41.16±0.07**	**-1.79±0.07**
	C*	49.49±0.70	35.12±0.73	21.28±0.25	56.67±1.49	41.42±0.09	11.64±0.35
	°hue	56.29±0.43	84.44±0.68	-0.06±0.02	51.98±0.20	83.69±1.88	-8.58±0.35
After Steaming	L*	57.39±0.54	65.63±0.25	22.71±0.47	41.98±1.42	54.96±0.20	13.61±1.73
	a*	17.82±0.70	2.13±0.15	15.62±0.20	18.62±0.77	4.55±0.79	10.30±2.06
	b*	**49.02±0.46**	**41.16±0.30**	**-13.05±0.16**	**38.38±0.52**	**39.77±0.58**	**-11.48±2.36**
	C*	52.16±0.67	41.66±0.31	20.35±0.26	42.67±0.21	41.01±0.91	15.43±3.12
	°hue	70.03±0.56	87.07±0.19	-0.69±0.00	64.11±1.22	76.28±3.83	-48.06±0.80

Table 3. Spectral properties and decrease in percentage of main peak absorption in carotenoid extracts from sweet potatoes

Variety of Sweet Potato	λ_{max}(nm) (Absorbance in AU)		% Absorbance Decrease at λ_{max}
	Before Steaming	After Steaming	
Orange-fleshed cultivar Madu Mojokerto	427 (0.556)	427 (0.115)	77
	450 (0.593)	448 (0.138)	
	475 (0.423)	475 (0.111)	
Yellow-fleshed cultivar Manohara	-	-	40
	-	403 (0.091)	
	427 (0.192)	427 (0.121)	
	448 (0.203)	447 (0.107)	
	472 (0.142)	475 (0.061)	
Local purple-fleshed	428 (0.053)	422 (0.022)	63
	450 (0.059)	442 (0.017)	
	475 (0.049)	477 (0.012)	
Orange-fleshed cultivar Beta 1	428 (1.031)	426 (0.580)	44
	451 (1.352)	449 (0.750)	
	476 (1.135)	474 (0.617)	
Yellow-fleshed cultivar Papua Solossa	-	405 (0.254)	20
	427 (0.403)	427 (0.340)	
	450 (0.426)	449 (0.287)	
	472 (0.272)	477 (0.151)	
Purple-fleshed cultivar Antin 3	420 (0.039)	419 (0.023)	36
	444 (0.042)	442 (0.024)	
	472 (0.034)	472 (0.027)	

It means that carotenoid degradation products of these samples have similar absorption spectra with the initial carotenoids. *β*-carotene 5,6-epoxide and *β*-cryptoxanthin 5',8'-epoxide, which have similar absorption spectra with all-*trans β*-carotene, were identified as the degradation products of carotenoid extracts [9]. On the other hand, purple-fleshed sweet potatoes had positive absorption peaks at 377 nm, 520 nm, 555 nm, and 558 nm. The absorption at 520 nm, 555 nm, and 558 nm indicated the increase in anthocyanin pigment after steaming. Yang & Gadi (2008) summarized their study that steaming increased the total anthocyanin due to inactivation of some enzymes, i.e. polyphenol oxidase, peroxidase, and glycosidase [20]. Degradation of crude pigment extract from red alga *Kappaphycus alvarezii* after 48 hour of heating process showed positive absorption peaks at 342 nm, 343 nm, 345 nm, 546 nm, 547 nm, 553 nm, 692 nm, 693 nm, and 696 nm [23]. Moreover, Limantara *et al*. (2006) described that the irradiation caused the oxidation of B ring in bacteriochlorin to form chlorin [24]. In addition, carotenoid extract from palm's fiber had a positive absorption at 363 nm after 1 h of steaming, which showed the formation of *cis* carotenoid [25].

In this study, steaming process caused the decrease in absorbance (hypochromic shift), shifting of λ_{max} to shorter wavelength (hypsochromic shift), and shifting of λ_{max} to longer wavelength (batochromic shift). The hypochromic and hypsochromic shifts were caused by isomerization of carotenoid from all-*trans* to *cis* forms. This was supported before that heating could cause carotenoid isomerization [26]. Hypochromic shift of orange-fleshed cultivar Madu Mojokerto was higher than other sweet potatoes, while yellow-fleshed cultivar Papua Solossa had lowest hypochromic shift. This result indicated that carotenoids in yellow-fleshed cultivar Papua Solossa showed higher stability against the steaming process. Sweet potatoes cultivar Madu Mojokerto, Manohara, local purple-fleshed, Beta 1, and Papua Solossa had hypsochromic shifts of ± 2 nm, ± 21 nm, ± 28 nm, ± 2 nm, ± 23 nm, respectively, whereas Antin 3 had batochromic shift of ± 28 nm (Figure 1 and Table 2). Kusumaningtyas & Limantara (2009) have investigated carotenoid isomerization in palm oil after sterilization process [27]. The decrease in absorbance at main peak around 10.4 % and hypsocromic shift around 3 nm indicated the formation of *cis* carotenoid.

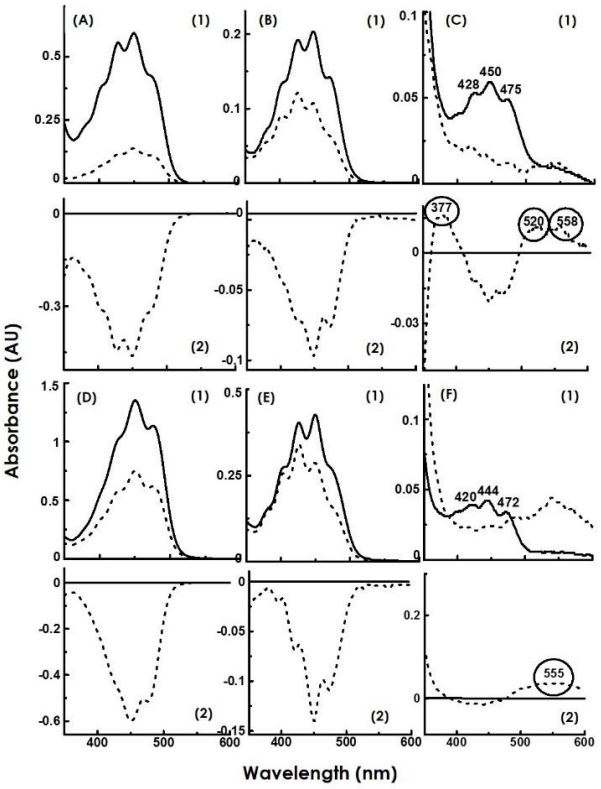

Figure 1. Spectral patterns (1) and the difference spectra (2) of carotenoid extracts obtained from local and excellent sweet potatoes before (—) and after steaming (---) (A) Madu Mojokerto, (B) Manohara, (C) Purpled-fleshed, (D) Beta 1, (E) Papua Solossa, (F) Antin 3. The difference spectra were obtained by subtraction of absorption spectra after steaming with those spectra before steaming as references.

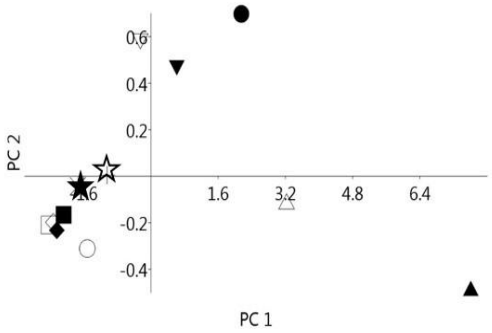

Figure 2. PC 1 vs PC 2 score plot from the results of PCA on analysis on carotenoid absorption spectra before (shaded) and after (unshaded) steaming in orange-fleshed cultivar Madu Mojokerto (circle), yellow-fleshed cultivar Manohara (star), local purple-fleshed (square), orange-fleshed cultivar Beta 1 (triangle), yellow-fleshed cultivar Papua Solossa (inv. triangle), purple-fleshed cultivar Antin 3 (diamond).

The larger hypsochromic shifts around 21 to 28 nm may be caused by a rapid degradation of carotenoids with the λ_{max} at 448 and 450 nm compared to the carotenoids having λ_{max} at 422 and 427 nm from the yellow-fleshed and local purple-fleshed cultivars.

Absorption spectra of carotenoid from local and excellent sweet potatoes before and after steaming can be grouped by PCA method. The PCA result of carotenoid absorption spectra from sweet potatoes before and after steaming is shown in Figure 2. In PCA, PC 1 and PC 2 were enough to extract the absorption spectra of sweet potatoes. Symbols which closely located had the similar spectral properties, i.e. spectra shape and absorbance value. PCA results in Figure 2 could be subsequently confirmed by spectral properties in Figure 1. At least there were four groups of sweet potatoes. First group was orange-fleshed cultivar Beta 1 before and after steaming. Second group was orange-fleshed cultivar Madu Mojokerto before steaming and yellow-fleshed cultivar Papua Solossa before and after steaming. Third group was yellow-fleshed cultivar Manohara before and after steaming. Fourth group was local purple-fleshed and Antin 3 before and after steaming, and orange-fleshed cultivar Madu Mojokerto after steaming. Each group was classified based on their spectral properties. In the present study, PC 1 value of the first group was higher than those of other group.

This fact expresses higher absorbance value of samples in the first group than other groups. In more detailed results of the first group, orange-fleshed cultivar Beta 1 before steaming has higher PC 1 value compared with its value after steaming. Correlation between PC 1 value and the grouping is in agreement with their absorbance values in Figure 1 and Table 3 that showed spectral properties and % decrease of main peak absorption in carotenoid extracts from sweet potatoes. After steaming, several samples had significantly changed their spectral properties. For example, orange-fleshed cultivar Madu Mojokerto before and after steaming has different spectral shape as well as absorbance value. These differences are due to the change of composition and content of carotenoid. As a result, this sweet potato before steaming was classified into the second group, whereas it after steaming belonged to the fourth group which had the similar spectra with purple-fleshed sweet potatoes.

Several spectra in sweet potatoes had not changed significantly, i.e. in local purple-fleshed and Antin 3. This was because the major pigment in purple-fleshed was not carotenoid and only contained a few carotenoid, accordingly the spectral pattern was not as clear as in orange- and yellow-fleshed. Moreover, the absorption spectra of carotenoid extracts from Beta 1, Papua Solossa, and Manohara before and after steaming were also significantly unchanged and were classified under the same group. Generally, the differences of fleshed color in sweet potatoes would result in difference of absorption spectra. This was because the fleshed colors would affect the λ_{max}. Orange-fleshed sweet potato had λ_{max} at longer wavelength than yellow-fleshed sweet potato. As the number of conjugated double bonds in carotenoid increases, it results in the change on colors from yellow to orange and then to red and of course the absorption is shifted to the longer λ_{max} [8].

CONCLUSION

Steaming process decreased the lightness, redness, and absorbance value, but the yellowness was fluctuated depend on the sweet potato cultivar. Steaming also caused the shift of spectra to shorter wavelength for all cultivars, except for longer shifted purple-fleshed cultivar Antin 3. Four groups of sweet potatoes before and after steaming were classified by PCA according to their spectral characteristics, i.e. spectrum shape and absorbance value. Moreover, the PC 1 value could be used for quantitatively determination of the relative carotenoid content of the sample.

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Abstrak

Ubi jalar, terutama daging umbi yang berwarna oranye dan kuning, merupakan makanan lokal yang fungsional karena mengandung karoten yang berfungsi sebagai pro-vitamin A. Pemrosesan ubi jalar menjadi mie, fermentasi singkong atau "tape" dan beras buatan, biasanya disiapkan melalui proses pengukusan. Namun, karotenoid rentan untuk terdegradasi ketika terkena suhu tinggi, seperti pada pengukusan. Tujuan dari penelitian ini adalah untuk mengetahui pengaruh pengukusan terhadap warna dan spektrum serapan karotenoid yang dihubungkan dengan kandungan karotenoid dari ubi jalar lokal dan unggul serta untuk mengevaluasi perbedaan sifat spektral karotenoid antar ubi jalar dengan analisis komponen utama (*principal component analysis* atau PCA). Hasil penelitian menunjukkan bahwa perlakuan pengukusan pada ubi jalar menurunkan nilai warna, seperti cahaya, kemerahan, sedangkan nilai kekuningan turun pada beberapa varietas ubi jalar. Selain itu, perlakuan ini juga mempengaruhi sifat spektral dari ekstrak karotenoid dari ubi jalar, dimana pengukusan menurunkan nilai absorbansi dan menghasilkan pergeseran hipsokromik dan batokromik. Madu Ubi jalar Mojokerto, Manohara, ubi ungu lokal, Beta 1, dan Papua Solossa mengalami penurunan nilai absorbansi dan pergeseran hipsokromik sebesar ± 77% dan ± 2 nm, ± 40% dan ± 21 nm, ± 63% dan ± 28 nm , ± 44% dan ± 2 nm, dan ± 20% dan ± 23 nm, secara berturut-turut, sedangkan ubi jalar Antin 3 mengalami penurunan nilai absorbansi ± 36% dan pergeseran batokromik ± 28 nm. Hasil PCA menunjukkan bahwa ada empat kelompok ubi jalar berdasarkan bentuk spektrum dan nilai absorbansi.

***Kata Kunci*:** Karotenoid, PCA, Pengukusan, Spektra Serapan, Ubi Jalar, Warna