**B I O D I V E R S I T A S**
Volume 10, Number 1, January 2009
Pages: 6-11

ISSN: 1412-033X (printed edition)
ISSN: 2085-4722 (electronic)
DOI: 10.13057/biodiv/d100102

# Selection of Indonesia Cassava (*Manihot esculenta* Crantz) Genotype as Source of β-Carotene

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Received: 16th September 2008. Accepted: 20th November 2008.

## ABSTRACT

Fourteen genotypes of Indonesia cassava (*Manihot esculenta* Crantz) of two generations were evaluated for β-carotene content. The β-carotene content of tubers and leaves were determined by spectrophotometry method. Other parameters such as water and ash contents were also evaluated. Results showed that β-carotene content of tubers of fourth generation (planted in 2006-2007) was higher than that of first generation (planted in 2002-2003), with the exception of Apuy, Iding and Sarewen genotypes. β-carotene content of tubers was lower than that in their leaves of fourth generation plants and that there was no correlation between both organs in terms of β-carotene content of tubers and their leaves except for Tim-Tim 40 genotype. β-carotene content of tubers in several genotypes i.e. Kalbar III (1.13 ppm), Local Muneng (1.03 ppm), Tim-Tim 29 (1.61 ppm) was higher than 1 ppm, and the highest value was found in Tim-Tim 40 (16.83 ppm) which was significantly different (5%) with other genotypes. Meanwhile the lowest content was found in Sarewen genotype as it could not be detected. Water and ash contents of the tubers were between 54 and 69% and between 0.20 and 0.79% respectively. As β-carotene is the precursor of vitamin A, consuming high β-carotene tubers are sufficient for daily requirements of vitamin A, although further study is needed.



**Key words:** cassava, *Manihot esculenta*, genotype, selection, β-carotene, tubers, leaves.

## INTRODUCTION

Cassava (*Manihot esculenta* Crantz.) is a very important crop in the tropics and is a staple food for over 800 millions people (Nassar et al., 2007). In the past, cassava is the main food, especially in the lack of food period (paceklik) in Indonesia. Nowadays, cassava is used as an alternative food in food diversity program to reduce on rice dependence. Cassava is one of the options are profitable because of the price is relatively cheaper (Setiawan, 1992).

Cassava is drought tolerant plant and they could be grown easily in land with low soil fertility. Therefore, they could be found in marginal areas (Sudarmonowati et al., 2002). Cassava originating from the South America, precisely in Brazil and they were spreading to almost all the world, including: Africa, Madagascar, India and China. Cassava is growing rapidly in agricultural countries and introduced to Indonesia in 1852 (Bappenas, 2007).

Caroten found in all green parts of the plant and most of them found in the yellow parts (Mutschler, 1991). Green or yellow vegetables and fruits usually have high content of caroten. There is a direct relationship between degree of greenness vegetables with their caroten content. The most green leaf containing higher content of caroten (Budiyanto, 2002). β-caroten is the most important provitamin, the two molecules of that provitamin can be formed vitamin A. Only up to 50% β-caroten were used to produce vitamin A. Carotenoid is a precursor of vitamin A, which is needed by the human body for growth, to establish immunity against the disease and to clarify the vision. β-carotene dosage for adults each day according to the WHO standard is 2.4 mg to 3.5 mg (Agbaje et al., 2007). In addition, maternal mortality will be dramatically reduced when pregnant women receive vitamin A or β-carotene supplements (Anderson et al., 2003). There are known 600 types of carotenoids, of which approximately 50 play important roles in the human diet (Lusty et al., 2006).

The objective of this research is to select Indonesian cassava genotype which have high β-caroten content mainly on tubers as a source of low-cost β-carotene for the community.

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## MATERIALS AND METHODS

*Source of materials and research location*

Materials used in this research were the root and leaves of cassava plants obtained from the Plant and Animal Germplasm Garden, Research and Development Center for Biotechnology-LIPI Cibinong. Analysis of β-carotene was conducted in Laboratory of Natural Material Chemistry, Research Center for Biotechnology-LIPI, Cibinong. This study was conducted from August to October 2007.

*Sample preparation*

Fresh cassava tubers were peeled and washed until clean. The clean tubers were sliced by using blender machine and washed with aquadest twice, and then filtered. After the sample separated into starch and pulp, the starch were then dried in the oven at a temperature of 50°C for 2 days. Leaf sample taken from fresh leaves were cut and dried in the oven at a temperature of 50° C for 1 day. The sample were then grinded to obtain leaves powder.

*Determination of water content*

Determination of water content was done according to Sudarmadji et al. (1984). Empty bowls and their lids were firstly dried in the oven with a temperature of 105° C for 30 minutes and cooled in desiccator, and then ± 5 gram of sample quickly weighed. Open cup, its contents and lid were dried in an oven at a temperature of 105 °C for 3-4 hours carefully to avoid contact between the cups with oven wall. The cups were then moved into desiccator, close the cover with the cup lid, and let it cool down for further weighing up again after cooling down.. The samples were then redried to obtain a constant weight.

*Determination of ash content*

Determination of ash content was done according to Sudarmadji et al. (1984). Approximately 5 grams of sample were put into a porcelain cup that has been known its weight, then heat up in a furnace at a temperature of 550°C until grayish color (charcoal-out), cooled and then weight up to obtain a constant weight. The calculation was done based on the dry powder weight.

*Determination of β-carotene content in spectrophotometer*

Spectrophotometry is a method of analysis based on measurements of the interaction between electro-magnetic radiation and molecule of a chemical substance. The term of spectrophotometry means measurement of light energy absorption by a chemical system as a function of long wave radiation. If the light monochromatic or heterochromatic fell in a homogenous medium, some of them will be reflected, partly absorbed in the medium and the rest will be forwarded (Underwood, 1992).

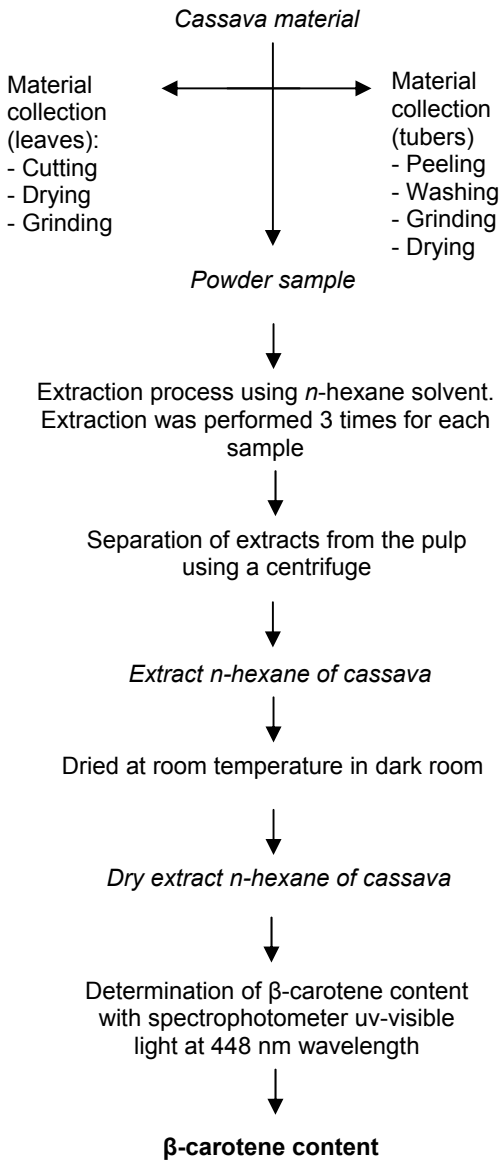


**Figure 1**. Flow chart of determination of β-carotene content of cassava tubers and leaves.

To analyse the content of β-carotene in cassava tubers and leaves, samples were extracted using the solvent of *n*-hexane. The extract were then dried up. The extracts were dissolved with technical methanol, and then measured with spectrophotometer (*Beckman DU650*) 448 nm wavelength. Extraction was performed 3 times. Solvent used for extraction was 5 ml of *n*-hexane (first extraction), while for the next extraction was 1 ml of *n*-hexane. Summary of the research procedures is presented in Figure 1.

*Research design and statistical analysis*

Research was arranged in the Complete Random Design with two replications. Data were analyzed using analysis of variance (ANOVA) and followed with Duncan's Multiple Range Test (DMRT) using SPSS 11.0.0. (2001).

## RESULTS AND DISCUSSION

*Tuber morphology*

Morphological observation of 14 cassava genotypes after harvesting the tubers are presented in Table 1 and Figure 2. Some cassava genotypes have a brown and light brown skin color, while the rind color consists of cream and dark cream color. Among the 14 cassava genotypes tested, most of them have white color and only 3 genotypes that having yellow flesh tubers.

**Table 1.** Results of tuber morphological observation of 14 Indonesia cassava genotypes

| Genotype | Skin Color | Rind Color | Flesh Color |
|---|---|---|---|
| Adira I | Light brown | Cream | Yellow |
| Adira IV | Brown | Cream | White |
| Apuy | Brown | Dark Cream | White |
| Gebang | Light brown | Cream | White |
| Iding | Brown | Cream | White |
| Kalbar III | Light brown | Dark Cream | White |
| Lelen | Brown | Cream | White |
| Local Muneng | Light brown | Dark Cream | White |
| Menti | Brown | Dark Cream | White |
| Parelek | Brown | Cream | White |
| Rawi | Brown | Dark Cream | White |
| Sarewen | Light brown | Cream | White |
| Tim-Tim 29 | Light brown | Dark Cream | Yellow |
| Tim-Tim 40 | Light brown | Cream | Yellow |

*β-carotene content*

**Tuber**

The results of β-carotene determination indicated that the carotene content of some tuber were higher than 1 ppm, i.e. genotype Kalbar III (1.13 ppm), Local Muneng (1.03 ppm), Tim-Tim 29 (1.65 ppm) and Tim-Tim 40 (6.83 ppm) consecutively. The highest content of β-carotene found in this research was Tim-Tim 40, and it was indicated by its color in which more yellowy compared with Local Muneng. Extract produced from the Tim-Tim 40 has a color close to standard. Based on the results of organoleptic study, tubers of genotype Tim-Tim 40 have nice taste after being cooked (Priadi et al*.,* 2004). Red and yellow color of steamed flesh tuber indicated that there is high content of β-carotene (Nassar et al., 2007).

Tubers that have β-carotene content less than 1 ppm were Adira IV (0.41 ppm), Adira I (0.35 ppm), Gebang (0.32 ppm), Parelek (0.33 ppm), Menti ( 0.23 ppm), Apuy (0.13 ppm), Rawi (0.12 ppm), Lelen (0.09 ppm), Iding (0.03 ppm) genotypes, while the lowest β-carotene content was of Sarewen (0.00 ppm) genotype. The Sarewen that having lowest content of β-carotene was indicated by white color of its extract. Due to the very low content of β-carotene in Sarewen genotype, the method used were unable to determine it.

In general in each genotype, β-carotene content of leaf was much higher than that of the tuber. For example, the genotype Sarewen tubers has very small content of β-carotene, even zero, however, their leaves have higher content of β-carotene. The results of the determination of water, ash and β-carotene content of tubers is presented in Table 2.

**Table 2.** Results of the determination of water, ash and β-carotene content of tubers of 14 Indonesia cassava genotype

| Genotype | Water content (%) | Ash content (%) | β-carotene (ppm) |
|---|---|---|---|
| Adira I | 61.3350$^{e}$ | 0.5900$^{b}$ | 0.3515$^{b}$ |
| Adira IV | 61.2350$^{e}$ | 0.5900$^{b}$ | 0.4125$^{b}$ |
| Apuy | 63.0150$^{d}$ | 0.3950$^{c}$ | 0.1255$^{b}$ |
| Gebang | 56.2600$^{g}$ | 0.1950$^{d}$ | 0.3170$^{b}$ |
| Iding | 62.4000$^{de}$ | 0.5900$^{b}$ | 0.0310$^{b}$ |
| Kalbar III | 58.1600$^{f}$ | 0.7850$^{a}$ | 1.1305$^{b}$ |
| Lelen | 54.1750$^{h}$ | 0.6000$^{b}$ | 0.0920$^{b}$ |
| Lokal Muneng | 57.5250$^{f}$ | 0.7900$^{a}$ | 1.0260$^{b}$ |
| Menti | 67.2300$^{b}$ | 0.4000$^{c}$ | 0.2260$^{b}$ |
| Parelek | 68.8750$^{a}$ | 0.5900$^{b}$ | 0.3305$^{b}$ |
| Rawi | 54.6100$^{h}$ | 0.3950$^{c}$ | 0.1160$^{b}$ |
| Sarewen | 62.6200$^{d}$ | 0.5950$^{b}$ | 0.0000$^{b}$ |
| Tim-Tim 29 | 68.0100$^{ab}$ | 0.2000$^{d}$ | 1.6050$^{b}$ |
| Tim-Tim 40 | 66.0050$^{c}$ | 0.3950$^{c}$ | 16.8255$^{a}$ |

Note: Means followed by different letters in a column are significantly different (*P<0.05*) according to DMRT.

In tuber, the water content ranges from 54 to 69%. The highest water content was in the Parelek genotype, while the lowest one was in Lelen genotype. Ash content ranges from 0.20 to 0.79%. The highest ash content was in Kalbar III genotype, while the lowest one was in Tim-Tim 29 genotype. According to Adupa (1994), characteristic of edible cassava tubers contain 62-65% water and 0.3-1.3% ash content respectively. Therefore the genotype of Tim-Tim 40 which have highest β-carotene content is the most feasible to be consumed as a source of vitamin A.

**Leaves**

Results of β-carotene determination in the leaves sample was higher than those of tubers. The lowest content of β-carotene was 298.95 ppm (Local Muneng), and the highest one was 517.72 ppm (Tim-Tim 40). The complete results of water, ash and β-carotene content of leaves were presented in Table 2. In general, the content of β-carotene in the leaf was higher than i tuber. For the measurement of absorbance, leaf samples were diluted 10 times due to too large reading of absorbance.

Tables 2 and 3 show that there is no relationship between the content of β-carotene in the tubers an in the leaves, with exception in genotype of Tim-Tim 40 which has the highest β-carotene content both in the tuber and leaf. Nassar et al. (2007) reported that there was relationship between the content of β-carotene in tubers and leaves of local cassava of Brazil genotype.

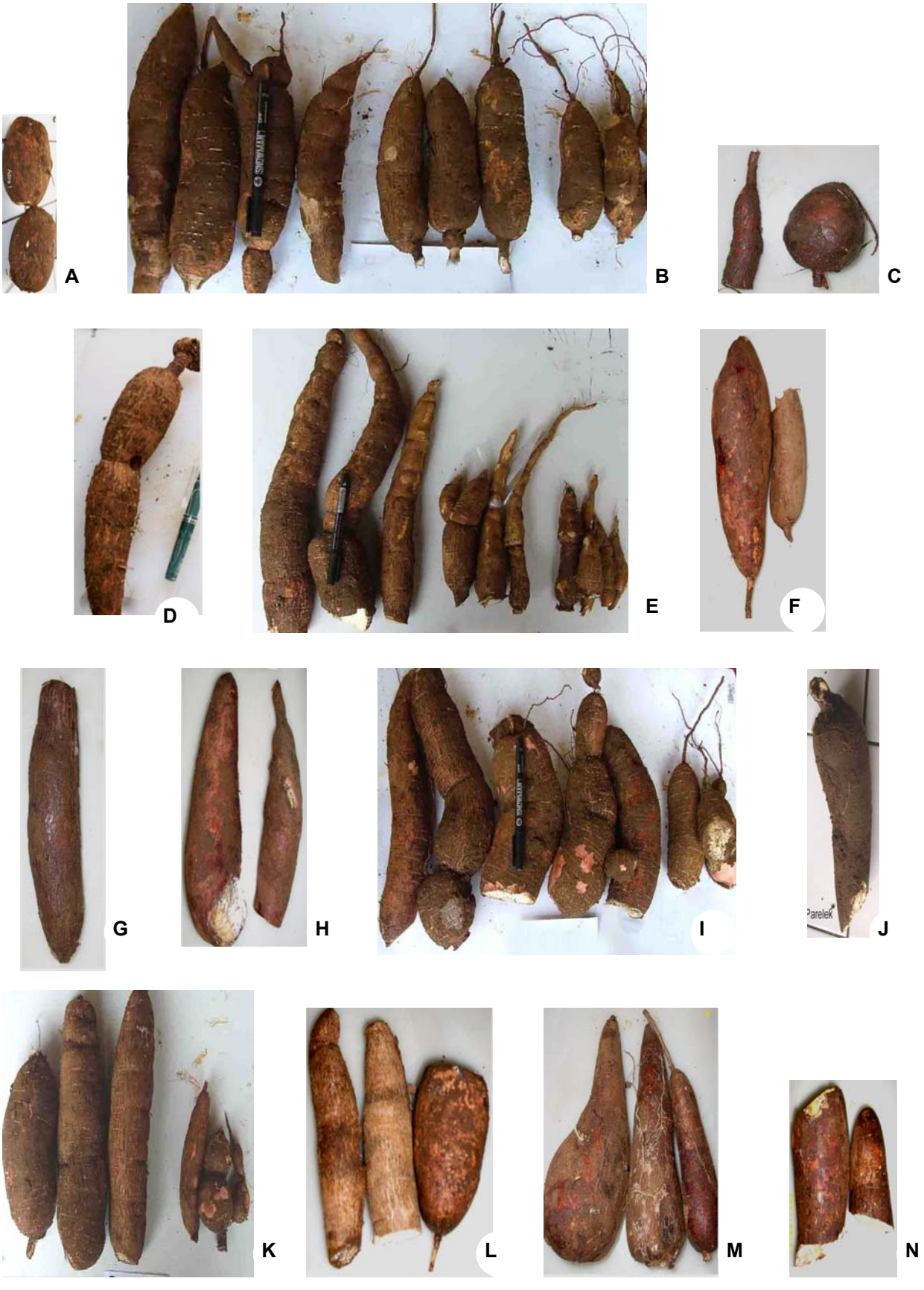


**Figure 2.** Morphology of 14 tubers of Indonesia cassava genotype. A. Adira I, B. Adira IV, C. Apuy, D. Gebang, E. Iding, F. Kalbar III, G. Lelen, H. Local Muneng, I. Menti, J. Parelek, K. Rawi, L. Sarewen, M. Tim-Tim 29, N. Tim-Tim 40. Bar = ± 10 cm.

Due to the low interest of consuming cassava, especially in Jakarta or other big cities in Indonesia, this study is expected to increase awareness of community about the importance of cassava as a source of low cost and easily obtained β-carotene. Beside of consuming the tubers, the leaves of cassava are also very potential for vitamin A intake in human consumption

**Table 3**. Results of the determination of water, ash and β-carotene content of leaves of 14 Indonesia cassava genotype.

| Genotype | Water content (%) | Ash content (%) | β-carotene (ppm) |
|---|---|---|---|
| Adira I | 68.6500$^{bc}$ | 1.6800$^{fg}$ | 323.4460$^{gh}$ |
| Adira IV | 69.0000$^{bc}$ | 1.7500$^{ef}$ | 474.3310$^{b}$ |
| Apuy | 67.4300$^{cd}$ | 2.3850$^{b}$ | 469.2595$^{bc}$ |
| Gebang | 68.7650$^{bc}$ | 1.4850$^{gh}$ | 388.1410$^{e}$ |
| Iding | 68.2950$^{bcd}$ | 2.4800$^{b}$ | 449.1345$^{cd}$ |
| Kalbar III | 66.8650$^{de}$ | 2.0000$^{de}$ | 354.6840$^{f}$ |
| Lelen | 64.9700$^{f}$ | 2.3950$^{b}$ | 305.1705$^{hi}$ |
| Lokal Muneng | 69.1050$^{ab}$ | 2.9000$^{a}$ | 298.9470$^{i}$ |
| Menti | 69.6650$^{ab}$ | 1.9900$^{de}$ | 467.7035$^{bc}$ |
| Parelek | 65.7750$^{ef}$ | 1.5950$^{fgh}$ | 350.7780$^{f}$ |
| Rawi | 67.0000$^{de}$ | 1.4000$^{h}$ | 446.3705$^{d}$ |
| Sarewen | 69.8300$^{ab}$ | 2.0900$^{cd}$ | 305.4100$^{hi}$ |
| Tim-Tim 29 | 69.1600$^{ab}$ | 2.3000$^{bc}$ | 334.2685$^{fg}$ |
| Tim-Tim 40 | 70.6250$^{a}$ | 1.0900$^{i}$ | 517.7195$^{a}$ |

Note: Means followed by different letters in a column are significantly different (*P<0.05*) according to DMRT.

*Comparison between β-carotene on a different generation*

Results of study indicated that the β-carotene content in the fourth generation which is growing in the 2006-2007 was higher than the first generation planted in 2002-2003, with exception in the genotype Apuy, Iding and Sarewen (Figure 2). β-carotene content difference between those generations is likely caused by the level of maturity in the tubers at harvesting time, because the fourth generation cassava was harvested in a mature age (12 months), while the first generation was harvested in a shorter period (8 months) due to the consideration of dry season. The carotenoid composition of foods are affected by factors like cultivar or variety, part of the plant consumed, stage of maturity, climate or geographic site of production, harvesting and post harvest handling, processing and storage (Rodriguez-Amaya, 2001).

Further research for examining protein and minerals content of tubers is required to increase value-added of Indonesia cassava genotypes.

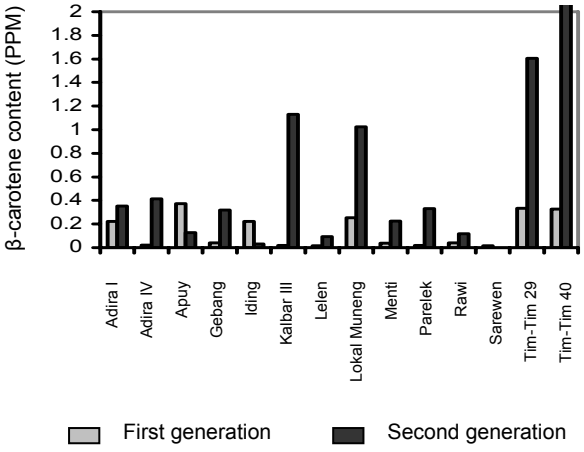


**Figure 3.** Comparison of β-carotene content in cassava tubers between first and fourth generation.

## CONCLUSIONS

Range of β-carotene content in cassava tubers tested was 0,00-16,8 ppm. Cassava genotypes which have β-carotene content in tubers more than 1 ppm i.e. Kalbar III (1.13 ppm), Local Muneng (1.03 ppm), Tim-Tim 29 (1.60 ppm), and the highest one is in the genotype of Tim-Tim 40 (16.83 ppm), while the lowest (0.00 ppm) one was the genotype of Sarewen. β-carotene content in the leaf was higher than in their tubers. Tim-Tim 40 genotype is a potential genotype to be developed further as a source of β-carotene. Although some Indonesian cassava genotypes containing high β-carotene, further research is still needed for selecting genotypes that having higher β-carotene content that can be used to provide low cost β-carotene for the community.

## ACKNOWLEDGMENTS

Authors would like to thank to Nanang Taryana Rustama and Nawawi as Technician of Plant and Animal Germplasm Garden, Research and Development Centre for Biotechnology-LIPI for their valuable assistance during this research.

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