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Changes in physicomechanical, nutritional, and sensory indicators of taro tubers at different harvest times

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Abstract

Taro tuber, which has the scientific name of Colocasia esculenta, is grown in Vietnam. The nutritional compositions of taro tuber are mostly starch, vitamin, protein, lipid, cellulose, and mineral. The purpose of this study was to determine the changes in physicomechanical, nutritional, and sensory indicators of taro tubers at different harvest times. The physicomechanical, nutritional, and sensory indicators of taro tubers were determined at three harvesting stages of 280, 300, and 320 days. As a result, the right time to harvest taro tubers is 300 days or more because taro tubers have fully developed in terms of size, weight, nutritional composition, and sensory indicators by this time. Specifically, at 300 days, taro tubers had a diameter of 5.6 cm and a weight of 71 g, with 69.83% water, 26.17% glucid, 2.82% protein, and 0.32% lipid. At the time of harvest of 300 days, 14 amino acids were identified, including 7 essential amino acids, namely, leucine, isoleucine, lysine, methionine, valine, phenylalanine, and histidine. Through the analysis of sensory indicators such as color, smell, taste, and texture of taro tubers, choosing the time to harvest taro tubers at 300 days for processing and storage is appropriate.

Keywords: harvest times; nutritional; physicomechanical; sensory indicators; taro tubers.

Pratical Application: Using analysis results as a basis for choosing methods of preserving or processing products from taro materials.

1. Introduction

Taro tuber, which has the scientific name of *Colocasia esculenta*, is grown in Vietnam provinces such as Bac Kan, Thai Nguyen, Bac Giang, Bac Ninh, Vinh Phuc, Hung Yen, and Hai Duong. In Bac Kan, taro tuber is grown in the district as Ba Be, Bach Thong, Cho Don, Cho Moi, Na Ri, Ngan Son, and Pac Nam. The nutritional compositions of taro tuber are mostly starch, vitamin, protein, lipid, cellulose, and mineral. Starch is an important type of glucid found in taro tubers, whose content often changes with the growth and development of taro tubers (Rashmi et al., 2018; Wills et al., 1983). In the nutritional composition of taro tuber, protein occupies an important position with about 14 amino acids (Wills et al., 1983). Ever in our country, studies have usually paid more attention to productivity or changes in the form of the taro tuber harvest and less attention to internal quality, especially in the chemical and nutritional compositions of taro tuber (Temesgen & Ratta, 2015). Up to this point in the world, there have been several studies on the nutritional composition of taro tuber; in particular, Rashmi et al. (2018) have determined that taro tuber has 26.46% glucid, 1.5% protein, 4.5 mg% vitamin C, and 2.38 mg% vitamin E. Wills et al.'s (1983) results showed that the content of nutrients was 1.6% protein, 0.4% lipid, 44 mg% Ca, 31 mg% Mg, 1.7 mg% Fe, and 1.1% Zn. Temesgen and Ratta (2015) have determined the content of nutrients in taro root, such as 26.8% glucid, 0.34% protein, 0.11% lipid, 2.5% crude fiber, 1.91% ash, 14.3 mg/100 g vitamin C, 0.028 mg/100 g vitamin B_1, 0.029 mg/100 g vitamin B_2, and 0.78 mg/100 g vitamin B_3 (Temesgen & Ratta, 2015). In addition, globally, some authors have studied the nutritional composition of taro tuber (e.g., Alcantara et al., 2013; Koffi et al., 2020). In Vietnam, up to this point, there are very few studies on physicomechanical, biochemical, and sensory indicators of taro tubers which have been published in scientific publications. Along with agronomic criteria, the analysis identifies that the chemical composition of taro tubers to determine the optimal harvest time that has practical significance is very important. The purpose of this study was to determine the changes in physicomechanical, nutritional, and sensory indicators of taro tubers at different harvest times in order to choose the right time to harvest taro tubers for processing and preservation.

2. Materials and methods

2.1. Materials

Ba Be taro tuber *Colocasia esculenta* at the harvest time of 280, 300, and 320 days (from the bean roots) at three taro tuber farms in Ba Be district, Bac Kan Province, was subjected to study. Chemicals used in the research such as diethyl ether, water, calcium pectate, and kali manganate were supplied by Vietnam producers.

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2.2. Methods of determining physicomechanical indicators

The diameters were determined by the numerical ruler (the error of 0.1 mm). The weights were determined by using a CP224S Sartorius analytical balance (accuracy of 0.0001 g). The percentages of peel and flesh were determined by calculating their weights compared to the total weight of taro tubers. After draining, taro tubers were peeled, the skins and the flesh of taro tubers were weighed, and then the weights of the peel and the flesh were calculated (Loi & Hien, 2021).

2.3. Methods of determining nutritional indicators

The water content of taro tubers was determined according to Vietnamese standard TCVN 2309 (Vietnamese National Standards, 2009), the protein content was determined according to Vietnamese standard TCVN 9936 (Vietnamese National Standards, 2013), the glucid content was determined according to Vietnamese standard TCVN 4594 (Vietnamese National Standards, 1988a), and the lipid content was determined according to Vietnamese standard TCVN 4592 (Vietnamese National Standards, 1988b). The content of minerals was determined according to the method specific to each element, and the P content was determined according to Vietnamese standard TCVN 9516 (Vietnamese National Standards, 2012a). The contents of K, Na, Ca, Mg, Fe, Zn, and Mn were determined according to Vietnamese standard TCVN 1537-1 (Vietnamese National Standards, 2007). The content of vitamin B_1 was determined according to Vietnamese standard TCVN 5164 (Vietnamese National Standards, 2008), vitamin B_2 was determined according to Vietnamese standard TCVN 8975 (Vietnamese National Standards, 2011), vitamin B_6 was determined according to Vietnamese standard TCVN 12349 (Vietnamese National Standards, 2018), vitamin B_{12} was determined according to Vietnamese standard TCVN 9514 (Vietnamese National Standards, 2012b), and vitamin C was determined according to Vietnamese standard TCVN 6427-2 (Vietnamese National Standards, 1998).

The content of amino acid was determined by the high-performance liquid chromatography (HPLC) method with PAD detector 2996, fluorescence 2475. The chromatography columns were the amino acid Symmetry RP18 (150 mm x 4.6 mm x 3.5 pm) and Symmetry Shield RP18 column (150 mm x 4.6 mm x 5 pm) Water firm. The flow rate was l mL/min, and the column temperature was 35 °C. The amino acids were quantified by fluorescence detection wavelength excitation at 340 nm and emission wavelengths of 450 nm (Jajić et al., 2013). An amount of 10 g of crushed taro tuber was weighed using an analytical balance and transferred into a 25-mL volumetric flask, 10 mL mixture of ethanol and water at the ratio of 40:60 was added, and the solution was shaken and ultrasonicated for 60 min. A volume of 2 mL of the obtained extract was transferred into a 10-mL flask, shaken, and filtered through a filter paper and then again through a Whatman filter of 0.45 µm, and then 2 mL of the extract was taken to pump column chromatography.

2.4. Methods of determining sensory indicators

The sensory indicators of taro tuber are determined according to Vietnam standard TCVN 3215. The color, smell, taste, and structure of taro tuber are determined according to a 5-point scale consisting of six levels, and the sensory panel includes nine members. The total score of the highest sensory indicators is 20 points, and the lowest score is 0 points. The average score of the panel members for each sensory indicator was calculated and then multiplied by the corresponding important coefficient of that criterion called the weighted score of each criterion, and then the total number of points with the weights of all sensory indicators that have a common score was calculated: very good grades (18.6–20 points), good grades (15.2–18.5), average grades (11.2–15.1), poor grades (7.2–11.1), very poor grades (4.0–7.2), and bad grades (0–3.9). The important coefficients agreed upon by the panel were the color (1.1), smell (1.3), taste (0.7), and structure of taro tubers (0.9) (Vietnamese National Standards, 1979).

2.5. Analytical data processing methods

Using data processing methods, information and data were systematized by EXCEL software for analysis and evaluation. The analyzed data were processed for SAS 9.0 statistical analysis. Statistical hypothesis analysis by ANOVA and mean values were compared by LSD at $p<0.05$ (Loi & Hien, 2021).

3. Results and discussion

3.1. The changes in diameter and weight of taro tubers at different harvest times

The results of the changes in the diameters and weights of taro tubers are presented in Table 1.

Table 1 shows that the diameters and the weights of taro tubers at different harvest times have a significant change. At the harvest time of 280 days, taro tubers are round and flat, with a taro tuber diameter of 5.1 cm and a taro tuber weight of 65 g. At the time of harvest of 300 days, taro tubers are round with a diameter of 5.6 cm and a weight of 71 g. Similarly, at the time of harvest of 320 days, taro tubers are round with a diameter of 5.9 cm and a weight of 73 g. Based on physicomechanical indicators, the time to harvest taro tubers is 300 days. The results of this study are also consistent with the results of Rashmi et al. (2018), Temesgen

Table 1. Changes in physicomechanical indicators of taro tubers at different harvest times

No.	**Physicomechanical indicators**	**Harvest times (days)**		
		280	**300**	**320**
1	Shape of taro tuber	Flattened circles	Flattened circles	Flattened circles
2	Diameter of taro tuber (cm)	5.1±0.1	5.6±0.1	5.9±0.2
3	Weight of taro tuber (g)	65±1.2	71±1.3	73±1.3

and Ratta (2015) and Wills et al. (1983), because taro tubers have developed stably and entered the aging stage by this time.

3.2. The nutritional compositions of taro tuber at different harvest times

The changes determined in the nutritional compositions of taro tuber are important indicators that are presented in Table 2.

The results of the analysis have determined the nutritional composition of taro tuber at the harvest time of 280 days: 70.67% water, 24.51% glucid, 2.34% protein, and 0.25% lipid; at 300 days: 69.83% water, 26.17% glucid, 2.82% protein, and 0.32% lipid; and at 320 days: 69.52% water, 26.43% glucid, 2.87% protein, and 0.34% lipid. In addition to the components such as water, glucid, protein, and lipid, at the harvest time of 320 days, the amounts of vitamins B_1, $B_{2,}$ B_6, B_{12}, and C and minerals are higher compared to the harvest time of 280 and 300 days. At the harvest time of 320 days, reduced water content for taro tuber has reached aging. The results of this study are also consistent with the results of Rashmi et al. (2018), Temesgen and Ratta (2015) and Wills et al. (1983), because, at the harvest time of 320 days, taro tubers have transition aging. Based on the nutritional composition, the time to harvest taro tubers is 300 days from the date of rooting because the nutritional components of taro tubers have fully developed and stabilized by this time.

3.3. The changes in the amino acid content of taro tubers at different harvest times

The results determine the change in the amino acid content of taro tubers at different harvest times, which are presented in Table 3.

The results in Table 3 show that at the harvest time of 280 days, 13 amino acids, including amino acids with high percentage such as 10.53% phenylalanine, 9.47% leucine, 9.31% valine, 9.06% glycine, 8.45% isoleucine, 8.41% alanine, and 8.34% tyrosine, have been identified. Among the 13 amino acids obtained at the harvest time of 280 days, seven essential amino acids, namely, leucine, isoleucine, lysine, methionine, valine, phenylalanine, and histidine, have been identified (Figure 1).

Table 2. The nutritional compositions of taro tuber at different harvest times*.

No.	Nutritional compositions	Harvest times (days)		
		280	300	320
1	Water (%)	70.67^{a}	69.93^{bc}	69.52^{bc}
2	Glucid (%)	24.51^{a}	26.17^{b}	26.43^{c}
3	Protein (%)	2.34^{a}	2.82^{bc}	2.87^{bc}
4	Lipid (%)	0.25^{a}	0.32^{b}	0.34^{c}
5	Ca (mg%)	64.78^{a}	67.35^{b}	68.03^{c}
6	Fe (mg%)	1.59^{a}	1.72^{bc}	1.73^{bc}
7	Mg (mg%)	28.63^{a}	34.21^{b}	34.52^{c}
8	Mn (mg%)	0.38^{a}	0.43^{bc}	0.43^{bc}
9	P (mg%)	71.29^{a}	75.54^{b}	75.68^{c}
10	K (mg%)	409.83^{a}	447.62^{b}	451.37^{c}
11	Na (mg%)	8.57^{a}	9.03^{b}	9.16^{c}
12	Zn (mg%)	0.56^{a}	0.63^{bc}	0.64^{bc}
13	Vitamin B_1 (mg%)	0.08^{a}	0.13^{b}	0.15^{c}
14	Vitamin B_2 (mg%)	0.04^{a}	0.09^{b}	0.12^{c}
15	Vitamin B_6 (mg%)	0.29^{a}	0.31^{b}	0.34^{c}
16	Vitamin B_{12} (mg%)	0.32^{a}	0.37^{b}	0.39^{c}
17	Vitamin C (mg%)	4.28^{a}	5.23^{b}	5.47^{c}

*In the horizontal row, numbers with different exponents have a statistically significant difference (with P<0.05).

Table 3. The change in the amino acid content of taro tubers at different harvest times*.

No.	Amino acids (%)	Retention time (min)	Harvest times (days)		
			280	300	320
1	Aspartate	13.717	4.43^{a}	3.87^{b}	3.89^{c}
2	Serine	15.104	Not detectable	4.73^{b}	4.94^{c}
3	Glutamate	16.012	4.37^{a}	4.76^{b}	4.86^{c}
4	Glycine	17.280	9.06^{a}	8.67^{b}	8.73^{c}
5	Histidine	17.904	4.29^{a}	3.62^{b}	3.97^{c}
6	Alanine	21.955	8.41^{a}	8.95^{b}	9.12^{c}
7	Proline	23.277	7.86^{a}	5.74^{bc}	5.76^{bc}
8	Tyrosine	26.671	8.34^{a}	7.98^{b}	8.03c
9	Valine	27.849	9.31^{a}	9.07^{bc}	9.09^{bc}
10	Methionine	28.390	8.58^{a}	8.15^{bc}	8.17^{bc}
11	Lysine	31.060	4.06^{ac}	3.89b	4.02^{ac}
12	Isoleucine	31.873	8.45^{a}	8.17^{b}	8.25^{c}
13	Leucine	32.475	9.47^{a}	9.42^{bc}	9.43^{bc}
14	Phenylalanine	33.920	10.53^{a}	10.21^{b}	10.26^{c}
	Total		97.16	97.23	98.52

*The ratios (%) were calculated according to the chromatographic peak areas. In the horizontal row, numbers with different exponents have a statistically significant difference (with P<0.05).

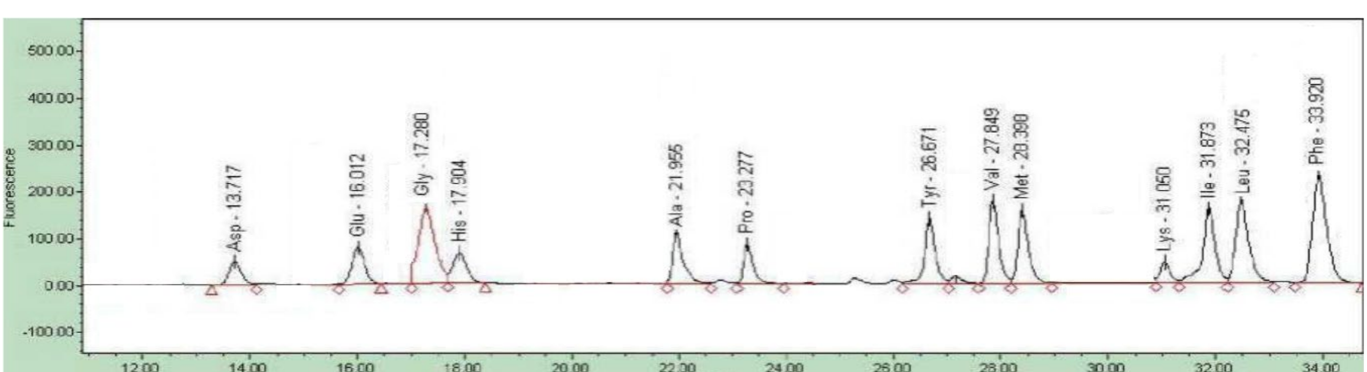

Figure 1. Gas chromatogram of amino acids in taro tubers at the harvest time of 280 days.

In taro tubers at the harvest time of 300 days, 14 amino acids have been identified. In addition to the 13 amino acids identified in the harvest time of 280 days, one amino acid, i.e., serine, with 4.73% content was also identified. At the time of harvest of 300 days, there were some amino acids accounting for a high percentage, namely, 10.21% phenylalanine, 9.42% leucine, 9.07% valine, 8.95% alanine, 8.67% glycine, 8.17% isoleucine, and 8.15% methionine. In the 14 amino acids obtained at the harvest time of 300 days, seven essential amino acids, namely, leucine, isoleucine, lysine, methionine, valine, phenylalanine, and histidine were identified (Figure 2).

In taro tubers at the harvest time of 320 days, 14 amino acids were identified, of which there were seven essential amino acids. Compared with the harvest time of 280 days, at the moment, there is only one amino acid, namely, serine, with 4.94% content. Compared with the harvest time of 300 days, at the time of harvest of 320 days, the number of amino acids in taro tubers did not change, but the content of these amino acids changed with the time of harvest. Some amino acids with typical changes are as follows: 0.08% isoleucine, 0.13% lysine, 0.1% glutamate, 0.35% histidine, 0.21% serine, and 0.17% alanine. Thus, at the time of harvest of 300 and 320 days, there was no change in the number of amino acids, but the content of amino acids changed slightly. The reason for this phenomenon is that taro tubers have developed stably and switched to the aging stage (Figure 3).

Based on the composition of amino acids, the time to harvest taro tubers is 300 days from the date of rooting because the amino acids of taro tubers are fully developed and stable by this time.

3.4. The changes in the sensory indicators of taro tubers at different harvest times

The sensory indicators of taro tubers are indicated by the color, smell, taste, and structure of this type of this product. The results of determining the sensory indicators of taro tubers were carried out by the descriptive method and are presented in Table 4.

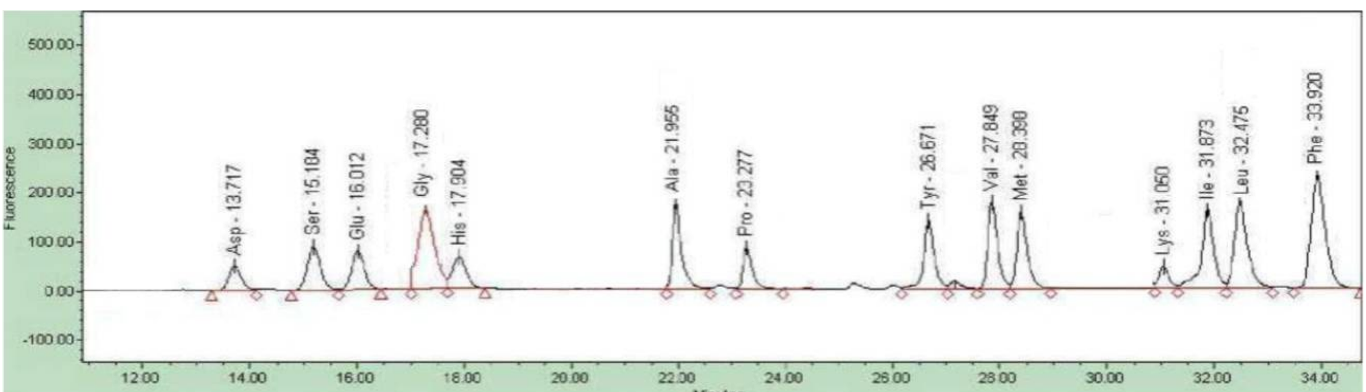

Figure 2. Gas chromatogram of amino acids in taro tubers in the harvest time of 300 days.

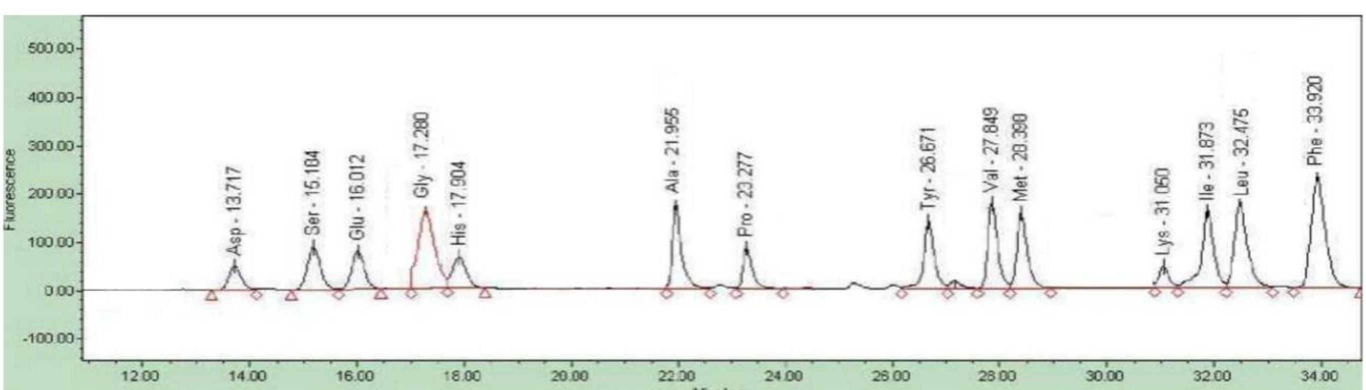

Figure 3. Gas chromatogram of amino acids in taro tubers at the harvest time of 320 days.

Table 4. The change in the sensory indicators of taro tubers at different harvest times.

No.	Sensory indicators of meat taro tubers	Harvest times (days)		
		280	300	320
1	Color	Ivory white	Lily white	Lily white
2	Smell	Light aroma	Characteristic aroma	Characteristic aroma
3	Taste	Fatty taste	Fatty and fleshy taste	Fatty and fleshy taste
4	Structure	Loose	Loose and friable	Loose and friable

Table 4 shows that, at the time of harvest of 280 days, the meat taro tubers are ivory white and have a light aroma, a fatty taste, and a loose structure. At the time of harvest of 300 and 320 days, the meat taro tubers are pure white and have a characteristic aroma, a fatty and fleshy taste, and a loose and friable structure. The results of this study are also consistent with the results of Rashmi et al. (2018) and Wills et al. (1983). Through the analysis of sensory indicators such as color, smell, taste, and structure of meat taro tubers, choosing the time to harvest taro tubers at 300 days for processing and storage is appropriate.

4. Conclusion

The purpose of this study was to determine the changes in physicomechanical, nutritional, and sensory indicators of taro tubers at different harvest times. The physicomechanical, nutritional, and sensory indicators of taro tubers were determined at three harvesting stages of 280, 300, and 320 days. As a result, the right time to harvest taro tubers is 300 days or more because taro tubers have fully developed in terms of size, weight, nutritional composition, and sensory indicators by this time. Specifically, at 300 days, taro tubers had a diameter of 5.6 cm and a weight of 71 g, with 69.83% water, 26.17% glucid, 2.82% protein, and 0.32% lipid. In taro tubers at the time of harvest of 300 days, 14 amino acids have been identified, of which there were seven essential amino acids, namely, leucine, isoleucine, lysine, methionine, valine, phenylalanine, and histidine. Through the analysis of sensory indicators such as color, smell, taste, and texture of taro tubers, choosing the time to harvest taro tubers at 300 days for processing and storage is appropriate.

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