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Study of nutrient composition of litchi fruit (*Litchi chinensis* Sonn.) grown in Vietnam

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Abstract
Some of the nutrient composition of litchi fruit grown in Vietnam was studied. The main nutrients in litchi include sugar, vitamins, amino acids, organic acids, protein, lipids, mineral elements, etc. The results of the study also showed that the litchi fruit should be harvested at 10 weeks after anthesis (WAA) to ensure the nutritional value of the fruit during storage.

Keywords: Physiological Maturity, Nutrient, Litchi

1. Introduction
Litchi (*Litchi chinensis* Sonn.) is a species of the Sapindaceae family (Marboh *et al*., 2017) [8], which is a major fruit tree in tropical and subtropical regions. According to statistics, the countries with the largest production of litchi are China, Taiwan, Vietnam, Thailand, India, Bangladesh, Nepal and South Africa (Singh *et al.*, 2012) [13]. Commercial litchi production in the world has rapidly expanded over the years due to the increasing demand from the European market (Huang *et al.*, 2005) [5].
Vietnam is one of the largest litchi exporters in the world, with many varieties growing and bringing significant economic value. Because of the economic benefits of litchi, growers have invested in its cultivation as well as fruit production in many provinces and cities, so the product has increased nationwide.
Litchi fruit are small in size and when ripe, have different colors depending on the variety (Menzel, 2003). The litchi flesh is white and has a dark brown seed inside. Litchi fruit has long been recognized as a nutrient-dense fruit with high medicinal value since it is an excellent source of antioxidants, promotes heart health, improves digestion and helps to prevent cancer (Malaterre, 2016) [7]. Because of these nutritional and medicinal benefits, litchi fruit has recently become a popular research topic, with published studies on its nutritional composition, biological properties and yield enhancement measures.
The determination of nutrient content of fruits at physiologic ripeness time is very important to help the consumers about nutritional, medicinal as well as economic value of the fruit for the most effective use. So, we have collected samples and analyzed the physiological and biochemical targets to determine the nutritional ingredients of litchi when they ripen to help consumers use and preserve fruit better.

2. Materials and methods
2.1 Research materials
Litchi fruit was harvested in Thanhhoa Province, Vietnam. Physiological indicators were analyzed at the Biology Laboratory, Hongduc University and the National Institute for Food Control.

2.2 Research methods
Determining water content, dry matter content in fruit by electronic scales and desiccators (Minh and Khanh, 1982) [10]. Determination of length and diameter of fruit: The length and diameter of the fruit were measured by a Panme caliper and accurate to mm (Minh and Khanh, 1982) [10]. Determining the fruit volume by measuring the volume of water occupying the fruit in the measuring tubes (Minh and Khanh, 1982) [10]. The electronic balance was used to determine the fresh fruit weight with a precision of 10^{-4} (Minh and Khanh, 1982) [10]. Quantification of reducing sugar by the Bertrand method (Mui, 2001) [11]. Quantification of starch by the Bertrand method (Chau *et al.*, 1996). Quantification of total acid by Ermacov (Ecmacov, 1972) [4]. Quantification of vitamin C by titration method (Arya *et al.*, 2000) [1]. The content of total amino acids was analyzed at the National Institute for Food Control. Quantification of mineral elements (Ca, Mg, K, Fe, Na, P, Zn, Cu, Mn) by ICP - OES

atomic emission spectroscopy (Mui, 2001) [11]. The content of vitamins B1, B6, E, and amino acids was determined at the National Institute for Food Control.

3. Results and discussion

We discovered that at 9 WAA, the reducing sugar content reached 8.753% of fresh fruit, at 10 WAA, it reached 14.237% of fresh fruit, and at 11 WAA, it reached 13.907% of fresh fruit by analyzing physiological and biochemical changes in litchi since the fruit was fertilized until it was 10 WAA. At the same time, vitamin C content is at 9, 10, and 11 WAA, respectively 40.353%; 58.667%; 55.083%. This shows that the litchi stops growing and achieves its best qualities at 10 WAA. After 10 WAA, the volume of the fruit increased a little due to increased water content but sugar content and vitamin C content in the fruit reduce result in the quality of the fruit reduces. So, the litchi matures physiologically at 10 WAA (Fig. 1).

To evaluate the quality of litchi at the time of physiological maturity, we carried out analyzes of some morphological and anatomical characteristics of fruit (Table 1), some nutritional components of fruit (Table 2), amino acid composition (Table 3) and the content of some mineral elements (Table 4).

Table 1: Some morphological and anatomical characteristics of litchi

Physiological criteria	Value	Unit
Length of fruit	38.17 ± 0.052	mm
Diameter of fruit	36.81 ± 0.110	mm
Volume of fruit	19.270 ± 0.023	cm^3
Weight of fruit	20.411 ± 0.154	gam
Color, shape of fruit	The fruit is spherical or slightly elongated. The fruit skin is thin and rough, the shoulder is bright red pink, the end of the fruit is yellow or bright green, red color accounted for 2/3 of the color of the fruit (Fig. 1).	

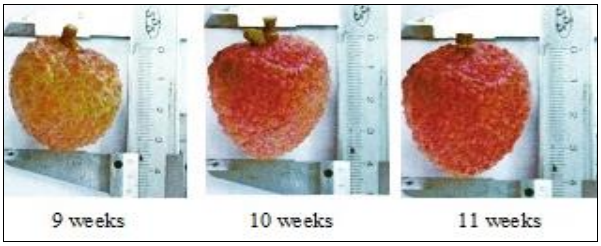

Fig 1: Litchi fruit at 9 WAA, 10 WAA and 11 WAA

At the time of physiological maturity, the litchi had a spherical shape with a length of 38.17 mm, a diameter of 36.81 mm. The fruit had a volume of 19.270 cm^3 and a weight of 20.411 g. The results of this study showed that at 10 WAA, litchi fruit size increased very slowly and remained almost unchanged (Fig 1). This is the time when the fruit has its characteristic colors. When the fruit is ripe, it has red mixed with yellow color and the fruit almost reaches maximum size. This result is consistent with the physiological characteristics of ripe fruit (Charoenchongsuk *et al.*, 2015) [3].

According to the data in Table 2, at the time of physiological maturity, litchi fruit contains large amounts of sugars such as sucrose, fructose and glucose (Jiang *et al.*, 2006) [6], which vary in proportion between varieties (Wang *et al.*, 2006) [14]. In the fruit period from 9 to 10 weeks, the content of reducing sugar increased rapidly and reached 14.237% when the fruit was at 10 weeks. These research results are consistent with the research on total sugar, which increases rapidly in the later stages of fruit development (Patel *et al.*, 2013). At 11 weeks, the content of reducing sugar decreased to 13.907% so the quality of the fruit decreased. Meanwhile, the amount of starch was low and decreased to 10 WAA to 0.736% of fresh fruit.

Because litchi fruit is succulent, the water content in the fruit was high at 75.856% when the litchi was 10 WAA. As the fruit grows, the total organic acidity in the fruit increases and reaches a relatively high rate, at 10 WAA, the index reaches 68.751 mg/100 g fresh fruit.

Litchi has a low vitamin content; when it reaches physiological maturity, the vitamin B_1 content is 0.012 mg/100 g, the vitamin B_6 content is 0.072 mg/100 g, and the vitamin E content is 0.065 mg/100g. Besides that, the fruits contain large amounts of vitamin C (up to 58.667 mg/100g of fresh fruit) at the time of physiological maturity.

Table 2: Some nutritional ingredients in litchi

S. No	Ingredient nutrition	Value			Unit
		9 WAA	10 WAA	11 WAA	
1	Water content	75.030 ± 0.026	75.856 ± 0.026	75.947 ± 0.026	%
2	Dry matter	24.970 ± 0.026	24.144 ± 0.052	24.053 ± 0.052	%
3	Reducing sugar	8.753 ± 0.036	14.237 ± 0.045	13.907 ± 0.126	%
4	Starch	1.275 ± 0.009	0.736 ± 0.007	0.428 ± 0.011	%
5	Organic acids	77.509 ± 0.268	68.751 ± 0.612	60.130 ± 0.836	mg/100g fresh fruit
6	Vitamin C	40.353 ± 0.118	58.667 ± 0.235	55.083 ± 0.478	mg/100g fresh fruit
7	Vitamin E	-	0.065 ± 0.014	-	mg/100g fresh fruit
8	Vitamin B_1	-	0.012 ± 0.007	-	mg/100g fresh fruit
9	Vitamin B_6	-	0.072 ± 0.021	-	mg/100g fresh fruit
10	Protein	4.058 ± 0.028	3.719 ± 0.028	3.574 ± 0.036	%
11	Lipid	3.130 ± 0.006	3.347 ± 0.008	3.107 ± 0.012	%

At 9 WAA and 11 WAA, the following are not analyzed: -:

The results of the data in Table 2 show that the content of protein in litchi fruit had relatively high. At 10 WAA, the index reached 3.719%. Changes in the protein content indicate a change in metabolic activities during the development of the fruit. The protein content of the fruit decreased during growth and development because the protein in fruit mainly acted as enzymes rather than reserves (Wills *et al.*, 1998) [15].

The lipid content of litchi fruit was relatively high; after 10 weeks, the lipid content reached 3.347%. The decrease in lipids is due to the strong metabolism in the fruit. Under the action of the lipase enzyme, lipids are hydrolyzed to provide material and energy for respiration. This is the physiological process that takes place mainly when the fruit enters the ripening stage (Wills *et al.*, 1998) [15].

According to the data in Table 3, the amino acid content in litchi at physiological maturity (10 WAA) was relatively high, with aspartic amino acid, glutamic acid, alanine accounting for 0.44%, followed by acids such as leucine (0.22%), glycine (0.19%), valine (0.17%). The lowest concentration of amino acids is histidine (0.02%) and methionine (0.02%), followed by tyrosine (0.05%) and lysine (0.06%). Thus, in the litchi at the time of physiological maturity, there is a full range of amino acids in a large proportion, which contains adequate amino acids that are not replaced.

Table 3: Composition of amino acids

No.	Amino acid	Value (%)
1	Aspartic acid	0.44 ± 0.004
2	Glutamic acid	0.44 ± 0.002
3	Serine	0.13 ± 0.003
4	Histidine*	0.02 ± 0.001
5	Arginine	0.08 ± 0.002
6	Glycine	0.19 ± 0.002
7	Threonine*	0.13 ± 0.005
8	Tyrosine	0.05 ± 0.001
9	Alanine	0.44 ± 0.005
10	Valine*	0.17 ± 0.002
11	Methionine*	0.02 ± 0.001
12	Phenylalanine*	0.14 ± 0.002
13	Isoleucine*	0.10 ± 0.001
14	Leucine*	0.22 ± 0.001
15	Lysin*	0.06 ± 0.001
16	Prolin	0.10 ± 0.001
17	Cystein + Cystine	0.11 ± 0.001

*Of which: *: are non-replaced amino acids*

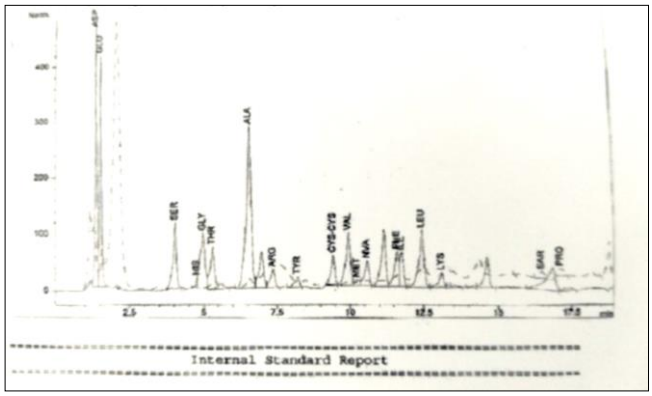

Fig 2: Amino acid composition chromatogram

Table 4: Composition of some mineral elements

S. No	Mineral composition	Value (%)
1	Na	0.002 ± 0.001
2	Fe	0.004 ± 0.001
3	K	0.087 ± 0.003
4	Mg	0.027 ± 0.002
5	Ca	0.025 ± 0.001
6	P	0.098 ± 0.004
7	N	0.435 ± 0.006
8	S	0.096 ± 0.005
9	Mn	0.026 ± 0.001

The highest percentage of minerals in litchis at the time of physiological maturity (10 WAA) is nitrogen at 0.435%, phosphorus at 0.098%, sulfur at 0.096%, and potassium at 0.087%. Sodium has the lowest content of these elements and reaches 0.002% of fresh fruit. There are also some elements with relatively high content, such as magnesium, manganese, and iron. As such, litchi contains many mineral elements and is high in content.

4. Conclusion

Throughout the process of the study, we found that litchis at physiological maturity (10 WAA) have good qualities, containing high levels of sugar, vitamin C, lipids and proteins. The fruit contains the full range of amino acids, including eight types of amino acids that are not replaced. Besides that, the litchi also contains many high-quality mineral elements. As a result, harvesting at 10 WAA is the most appropriate time; harvesting earlier or later reduces the quality of the fruit significantly.

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