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Nutritional composition of some fruits harvested in the ripening period cultivated in Vietnam

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Fruit is an important source of nutrition for humans as well as medicinal value. This article presents the nutritional composition of popular fruits cultivated in Vietnam (mango, cucumber, guava, custard apple). When ripe, these fruits had specific flavors and colors with high nutritional content. While custard apple, mango and guava contained a high content of vitamins, proteins, lipids and sugar, the highest amino acid content was found in cucumber, followed by guava, custard apple and mango. The main amino acids are glutamic acid, aspartic acid, and leucine. In addition, these fruits exhibited a high mineral content, mainly phosphorus, nitrogen and magnesium. The results are served as scientific basis for harvesting, preserving and consuming fruits in Vietnam as well as around the world.

Keywords: Ripe fruits, nutritional composition, amino acid, minerals mango, cucumber, guava, custard apple.

INTRODUCTION

Fruit is an important and indispensable food for humans and animals (Lewis, 2002; Prasanna et al., 2007). Fruit is important source of vitamins, minerals, dietary fiber, and antioxidants (Kader, 2008). Each fruits will have different nutritional ingredients. Fruits play an important role in human health. Fruits not only provides nutrition to the human body but also prevents diseases (Van Duyn and Pivonka, 2000; Liu, 2013).

The world's existing researches have been investigating nutritional value of fruits in different ecological regions (Dike, 2010; Jahan et al., 2011; Ekpete et al., 2013; Assirey, 2015). Abbey et al. (2017) studied nutritional value of cucumber in different locations and showed that cucumber cultivated in Rivers state had the highest value in Ca and Mg content while the one cultivated in Plateau state had the highest value in K^+, Cu, Mn, Na^+ and Zn content. Pratistha Srivastava et al. (2017) studied mineral elements in custard apple and strawberry fruit pulp showed that the predominant mineral elements in the custard apple and strawberry were Ca, Fe and P. Custard apple also exhibited a huge amount of sugar and proteins. However, research on the nutritional composition of fruits in Vietnam is limited. Studies have shown that the nutritional composition of fruits is affected by many pre- and post-harvest factors such as cultivation, the ripening stage at harvest and agricultural techniques (Benkeblia et al., 2011; Tyagi et al., 2017). The nutritional composition of fruits is most affected by maturity and ripening stages (Streif et al., 2009).

In Vietnam, many cultivars imported from abroad with high quality and yield are widely grown in various provinces and cities. Harvesting and preserving many fruits, however, is now based on only gardeners' experience but without scientific knowledge. This affects the quality of most of the fruits in the market and consumers' health (Kader, 2008).

Vietnam is one of the world biggest exporters of fruits, mainly including mango, guava, custard apple, orange, cucumber (Loan and Hoa, 2016). Although not only do these fruits provide human body with essential nutrients, they are also a main source of income for farmers. Therefore, determination of fruit nutritional composition at ripening time will provide consumers with its nutritional, medicinal and economic values to make the most effective use.

We collected samples, analyzed physiological and biochemical indicators to determine the nutritional composition of some Vietnam's popular fruits when they were ripe, which helps consumers use and preserve the fruits better as well as serves as scientific basis for the further research.

MATERIALS AND METHODS

Research materials

Cucumber was harvested in Tan Dan commune, Soc Son district, Hanoi, Vietnam (21° 15′ 25″ N and 105° 43′ 53″ E). Guava was harvested in Thanh Thuy commune, Thanh Ha district, Hai Duong, Vietnam (20° 53′ 1″ N and 106° 26′ 45″ E). Mango was harvested in Dong Tan commune, Huu Lung district, Lang Son, Vietnam (21° 31′ 36″ N and 106° 21′ 41″ E). Custard apple was harvested in Quang Thinh commune, Lang Giang district, Bac Giang, Vietnam (21° 26′ 31″ N and 106° 16′ 4″ E). All the samples were healthy fruits with low incidence of pests, stable and high yield.

Amino acid content, mineral element content, vitamin content were analyzed at the Institute of Biotechnology and Institute of Chemistry of the Vietnam Academy of Science and Technology.

Determination of water content and dry matter content (Minh and Khanh, 1982)

Water content was calculated by the formula:

$$\text{Dry matter (\%)} = \frac{\text{Weight of dried fruit}}{\text{Weight of fresh fruit}} \times 100$$

$$H_2O\,(\%) = 100\% - \text{dry matter (\%)}$$

Determination of fruit fresh weight, fruit flesh ratio (Adinde et al., 2016)

Fruit fresh weight was determined by an electronic scale with an accuracy of 10^{-4}g.

Fruit flesh ratio was calculated by the formula:

$$\text{Flesh of fruit (\%)} = \frac{\text{Weight of fresh fruit flesh}}{\text{Weight of fresh fruit}} \times 100$$

Determination of reducing sugar content, starch by Bertrand method (Chau et al., 1998)

10 mL experimental solution was put in a 1000 mL conical flask, 10mL fehling was then added. The mixture was boiled for 3 minutes. Precipitate appeared and was filtered into a Buchner vacuum filter. The flask and the filter funnel were cleaned with hot distilled water for 3-4 times. The resulting sediment of Cu_2O in the Buchner filter was completely dissolved by using $Fe_2(SO_4)_3$ (5 mL) in H_2SO_4 and carefully stirred with a glass rod. The flask and the filter funnel were rinsed and placed in the conical flask. The resulting solution was titrated with $KMnO_4$ 1/30N until a light pink color appeared within 20-30 seconds. Calculated the amount of $KMnO_4$ using for titration, looked up the table for an equivalent amount of reducing sugar in the sample. A control experiment was conducted at the same time in which sugar solution was replaced with distilled water.

+ Reducing sugar content in the materials was calculated by the formula:

$$X = \frac{a \times V_1 \times 100}{V \times b \times 1000}$$

Where: *X* is the reducing sugar content (%); *a* is the amount of glucose found in the table which is equivalent to the amount of $KMnO_4$ 1/30N used for titration of the sample minuses the amount of $KMnO_4$ 1/30N for titration in the control sample (mg); *V* is the volume of diluted sample solution (mL); V_1 is the volume of analyzed sample solution (mL); *b* is the weight of the sample (g); *100* is the conversion factor to %; the coefficient converts g to mg.

+ Starch content in the materials is calculated by the formula:

$$Y = \frac{a \times V_1 \times 100 \times 0.9}{V_2 \times b}$$

Where: *Y* is the content of starch (%); *a* is the amount of reducing sugar; V_1 is the volume of analyzed sample solution (mL); V_2 is the volume of diluted sample solution (mL); *b* is the weight of analyzed sample (g); *100* is the conversion factor to %; *0.9* is the coefficient of converting glucose into starch.

Determination of vitamin C content by titration method (Ermakov et al., 1972)

5 g of sample was triturated with 5 mL of 5% HCl in a ceramic bowl. It was grinded and put in a volumetric flask where distilled water was then added to 50 mL mark and well stirred. 20 mL of the solution was put in a 100 mL conical flask and titrated by I_2 solution with starch as a color indicator until blue color appeared. Vitamin C content was calculated by the formula:

$$X = \frac{V \times V_1 \times 0.00088 \times 100}{V_2 \times b}$$

Where: X is the content of vitamin C in the materials (%); V is the volume of diluted sample solution (mL); V_1 is the volume of 0.01N I_2 solution (mL); V_2 is the volume of analyzed solution (mL); b is the weight of sample (g); *0.00088* is the weight (g) of vitamin C which was equivalent to 1 mL of 0.01N I_2.

Determination of protein content by Lowry method (Holme and Peck, 1998)

5 mL of C (including a 0.5 mL of 1% $CuSO_4$ solution) was added to 1 mL of the sample in the test tube, mixed thoroughly and incubated at room temperature for 10 minutes. The solution was mixed with 0.5 ml of D (1N Folin), incubated for 30 minutes and measured by colorimeter at a wavelength of 750 nm. Protein concentration was calculated by standard graph.

Determination of lipid content by Soxhlet method (Mui, 2001)

A flask was put on a bain-marie, the amount of ether added equals to a half of volume of the flask. Material bag was put in the extraction thimble which is connected with the flask. Solvent was added to submerge the material bag and above the upper part of siphon arm of the thimble. Cooling tube © was installed, the material was soaked in the solvent for a few hours. Soxhlet extractor was put inside the bain-marie so that the condensation rate for the solvent should be set at about 10-15 drops per hour. After the extraction, the flask was removed, a welding tube was installed to distill the ether. The flask containing lipids was dried to rest mass which was called b.
Lipid content in 100 g of sample was calculated by the formula:

$$X = \frac{(a - b) \times 100}{c}$$

Where: X is the lipid content (%); a is the weight of the flask and lipid; b is the weight of the flask; c is the weight of lipid-separated samples.

Determination of cellulose content in fruits (Mui, 2001)

0.5 - 1 g of crushed sample (dried to rest mass) was put into a 250 mL conical flask. Add to the flask, 16.5 ml of a mixture of 15 ml of concentrated nitric acid and 1.5 ml of concentrated acetic acid. A reflux cooling tube was installed, the sample was boiled for 30 minutes. It was cooled and diluted with hot water. The mixture was filtered by filter paper whose weight had been already known. Cellulose precipitate was washed for many times with hot distilled water. It was washed with ethyl alcohol once or twice and then with ethyl ether. The filter paper containing cellulose was dried to the rest mass so that weight of cellulose could be determined. The content of cellulose was calculated by the formula:

$$X = \frac{a \times 100}{b}$$

Where: X is the cellulose content (%); a is the weight of cellulose (g); b is the weight of samples (g).

RESULTS AND DISCUSSION

Morphological and physiological characteristics of fruits in the ripening period

Prior to studying nutritional composition of some fruits cultivated in Vietnam, we collected samples, determined the ripening time and studied morphological and physiological characteristics. The results are shown in Table 1 and Figure 1.

Table 1 and Figure 1 about morphological and physiological characteristics of some fruits in Vietnam show that ripe mango was light yellow, sweet and slightly sour, fragrant, average 541.28 g in weight per individual fruit with 8.72 cm diameter, 14.12 cm length and 453.75 cm^3 volume. Ripe cucumber had green and light white peel, greenish-white pulp, faint aroma. The fruit is average 165.33 g in weight, 3.75 cm in diameter, 16.45 cm in length and 170.00 cm^3 volume. Ripe guava had green and light yellow peel, off-white pulp, sweet and musky aroma, an average weight of 274.30 g, diameter of 8.43 cm, length of 8.28 cm and volume of 342.18 cm^3.

Table 1. Physiological characteristics of some ripe fruits

Physiological criteria	Mango (*Mangifera indica* L.)	Cucumber (*Cucumis sativus* L.)	Guava (*Psidium guajava* L.)	Custard apple (*Annona squamosa* L.)	Unit
Length of fruit	14.12	16.45	8.28	7.28	cm
Diameter of fruit	8.72	3.75	8.43	8.35	cm
Volume of fruit	453.75	170.00	342.18	247.00	cm^3
Weight of fruit	541.28	165.33	274.30	248.46	gam
Flesh of fruit	80.18	85.82	82.82	55.54	% fresh fruit weight
Weight of peel	9.82	10.83	13.65	38.21	% fresh fruit weight
Weight of seed	10.00	3.35	3.53	6.25	% fresh fruit weight
Color, shape of fruit	Light yellow, sweet and slightly sour, fragrant	Green and light white peel, greenish-white pulp, faint aroma	Green and light yellow peel, off-white pulp, sweet and musky aroma	Light yellow peel, milky white pulp, distinctive aroma, sweet flavor	

Mango (*Mangifera indica* L.)
16 weeks old

Cucumber (*Cucumis sativus* L.)
1 weeks old

Guava (*Psidium guajava* L.)
14 weeks old

Custard apple (*Annona squamosa* L.)
15 weeks old

Figure 1. Color, shape of fruit

Table 2. Main nutrient ingredients

No.	Nutritional ingredients	Mango (*Mangifera indica* L.)	Cucumber (*Cucumis sativus* L.)	Guava (*Psidium guajava* L.)	Custard apple (*Annona squamosa* L.)	Unit
1	Water	82.60	96.84	86.69	70.96	% fresh fruit weight
2	Dry matter	17.40	3.16	13.31	29.04	% fresh fruit weight
3	Reducing sugar	11.00	1.77	6.20	10.97	% fresh fruit weight
4	Starch	3.14	0.90	2.20	4.82	% fresh fruit weight
5	Protein	4.36	0.80	6.36	7.18	% of dried flesh
6	Lipid	7.98	0.10	3.80	6.32	% of dried flesh
7	Cellulose	1.55	0.69	0.85	2.35	% of dried flesh
8	Vitamin B_1	0.06	0.03	0.05	0.14	mg/100g fresh fruit flesh
9	Vitamin B_2	0.10	0.07	0.04	0.15	mg/100g fresh fruit flesh
10	Vitamin B_3	0.08	0.09	0.68	0.76	mg/100g fresh fruit flesh
11	Vitamin B_5	0.05	0.26	0.45	0.19	mg/100g fresh fruit flesh
12	Vitamin B_6	0.26	0.04	0.15	0.23	mg/100g fresh fruit flesh
13	Vitamin A	1.12	4.64	202.04	6.42	IU
14	Vitamin C	30.73	4.80	280.13	36.20	mg/100g fresh fruit flesh
15	Vitamin E	1.67	0.04	0.58	-	mg/100g fresh fruit flesh
16	Vitamin K	8.24	12.51	2.23	-	µg/100g fresh fruit flesh

Notes: **–** : Not found during the research period

The custard apple had light yellow peel, milky white pulp, distinctive aroma, sweet flavor. The fruit was average 248.46 g in weight with 8.35 cm in diameter, 7.28 cm in length and 247.00 cm^3 in volume.

In terms of ratio of fruit flesh - peel - seed, cucumber had the highest fruit flesh ration at 85.82%, followed by guava at 82.82% and mango at 80.18%. Meanwhile, custard apple had the lowest fruit flesh ration at 55.54%. Custard apple had the highest peel ration at 38.21% while mango was at the highest place of seed ratio with 10%.

These results show that all the fruits reached the maximum size and entered the physiologically ripening time; therefore, studying nutritional composition at this time is scientifically logical.

Nutrient composition analysis

Table 2 describes major nutritional composition of mango, custard apple, guava and cucumber cultivated in Vietnam.

Table 2 reveals that nutritional composition of some fruits cultivated in Vietnam was relatively high, especially moisture content. Cucumber had the highest moisture content at 96.84%, followed by guava and custard apple at 86.69% and 70.96% respectively. Reducing sugar content of mango was relatively high at 11.00%, that of custard apple was 10.97%, while that of cucumber was only 1.77%. In terms of starch content, custard apple was at the first place with 4.82% whereas that of cucumber was the lowest at 0.90%.

Custard apple with the highest protein content had 7.18% of dry matter; meanwhile mango with the highest lipid content had 7.98% of dry matter. Cucumber had the lowest lipid content at 0.10% and 0.80% protein content. These results showed similarities to the ones in Pratistha Srivastava et al. (2017) on nutritional information of custard apple pulp.

The highest proportion of cellulose was recorded in custard apple at 2.35%, followed by that of mango, guava and cucumber at 1.55%, 0.85% and 0.69% respectively. The results had analogies with changes in acrid taste of the fruits when they are ripe.

In addition, all the fruits had high vitamin content. Mango was rich in vitamin C at 30.73 mg/100g fresh fruit flesh, which was the highest content, followed by vitamin E, vitamin A, B-group vitamin and the smallest amount of vitamin K at 8.24 μg/100g fresh fruit flesh. These results were similar to the ones in Zafar and Sidhu (2017) study, in which mango was a rich source of vitamin A and vitamin C. The highest content in cucumber was vitamin C at 4.80 mg/100g fresh fruit flesh, followed by vitamin A and B-group vitamin. The content of vitamin E in cucumber was only 0.04 mg/100g fresh fruit flesh while that of vitamin K was the lowest at 12.51 μg/100g fresh fruit flesh. Guava had considerable amount of vitamin C and vitamin A, in which vitamin C at 280.13 mg/100g fresh fruit flesh and vitamin A at 202.04 mg/100g fresh fruit flesh, and vitamin E at 0.58 mg/100g fresh fruit flesh and B-group vitamin, highest in vitamin B_3 at 0.68 mg/100g fresh fruit flesh. Vitamin K accounted for the lowest content at 2.23 μg/100g fresh fruit flesh. This is true when compared to the results of Chiveu et al. (2017) studied on guava which was rich in sugar, minerals and Vitamin C. Custard apple's vitamin C content was the highest at 36.20 mg/100g fresh fruit flesh, followed by vitamin A content at 6.42 IU and B-group vitamin content including the highest one of vitamin B_3 at 0.76 mg/100g fresh fruit flesh, vitamin E and K contents were not recorded during the research period. The results showed that fruits cultivated in Vietnam had remarkable amount of nutrients such as sugar, proteins, lipids, vitamins, etc. This is true when compared to the world's existing researches on nutritional composition of mango, guava, custard apple and cucumber. According to Torres-León et al. (2016), mango was widely distributed and had high nutritional potential for human. Joseph and Priya (2011) pointed out that guava had high nutritional values for human in the world.

Amino acids analysis

Table 3 shows that amino acids content in mango, cucumber, guava and custard apple at the ripening time was relatively high, ranging from cucumber to guava, custard apple and mango. The amount of glutamic acid in cucumber was the highest at 2.99%, followed by that of leucine at 1.05%, phenylalanine at 0.87%, lysine at 0.81% and tyrosine, the lowest, at 0.17%. The figures in guava varied significantly including 2.23% aspartic acid to 0.28% glutamic acid, 0.23% alanine and 0.03% methionine. In custard apple, the biggest amount of amino acids was that of glutamic acid (0.32%), followed by that of leucine (0.22%), aspartic acid (0.21%), the smallest was histidine and methionine (0.02%).

Table 3. Composition of amino acids (Unit: %)

No.	Amino acid	Mango (*Mangifera indica* L.)	Cucumber (*Cucumis sativus* L.)	Guava (*Psidium guajava* L.)	Custard apple (*Annona squamosa* L.)
1	Aspartic acid	0.14	0.59	2.23	0.21
2	Glutamic acid	0.21	2.99	0.28	0.32
3	Serine	0.03	0.21	0.13	0.07
4	Histidine*	0.01	0.18	0.09	0.02
5	Arginine	0.23	0.48	0.12	0.05
6	Glycine	0.08	0.47	0.13	0.14
7	Threonine*	0.06	0.24	0.10	0.13
8	Tyrosine	0.02	0.17	0.06	0.04
9	Alanine	0.11	0.44	0.23	0.15
10	Valine*	0.10	0.48	0.15	0.16
11	Methionine*	0.01	0.30	0.03	0.02
12	Phenylalanine*	0.08	0.87	0.14	0.12
13	Isoleucine*	0.07	0.30	0.12	0.10
14	Leucine*	0.13	1.05	0.22	0.22
15	Lysine*	0.11	0.81	0.21	0.12
16	Proline	0.11	0.33	0.07	0.17
17	Cysteine	0.02	0.39	0.07	0.03
	Total	**1.52**	**10.30**	**4.38**	**2.07**

Where: ***** *: Amino acids that are not substituted*

The amino acids content in mango was lower than that in other fruits including the highest of arginine at 0.23%, followed by that of glutamic acid at 0.21% and the lowest of histidine and methionine at 0.01%.

The results revealed that the fruits had fairly high content of amino acids, mainly glutamic acid, aspartic acid, leucine, etc. Meanwhile, that of other amino acids such as tyrosine, histidine, methionine was quite low.

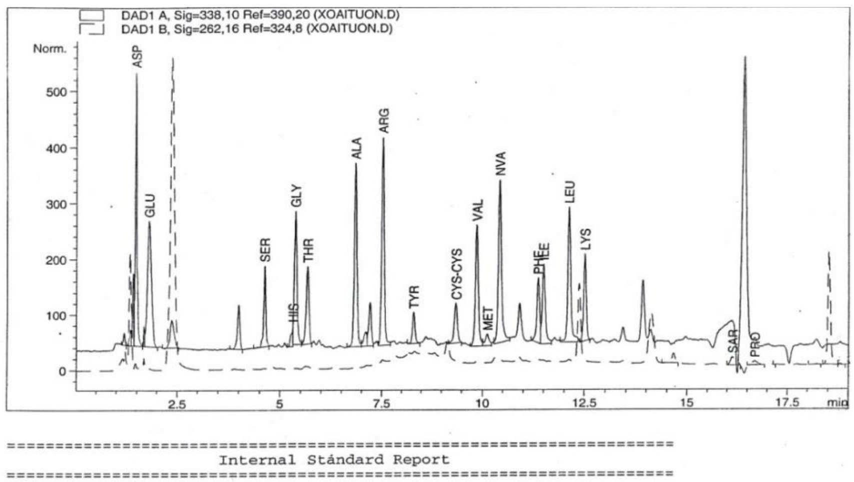

Figure 2. Chromatogram of amino acids in mango (*Mangifera indica* L.)

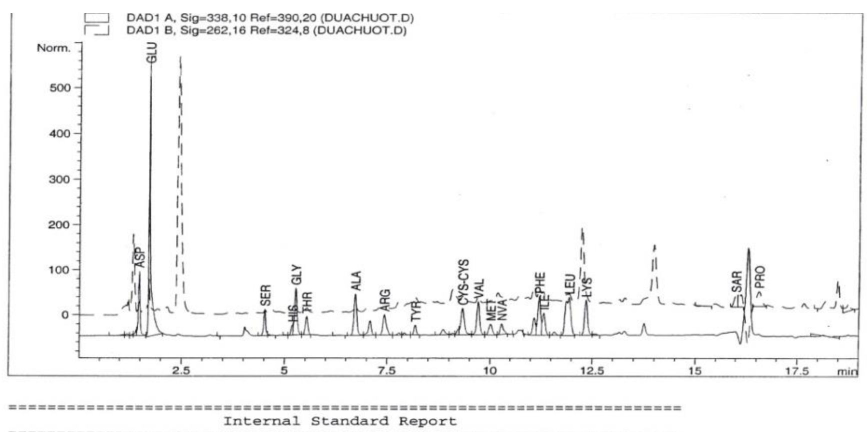

Figure 3. Chromatogram of amino acids in cucumber (*Cucumis sativus* L.)

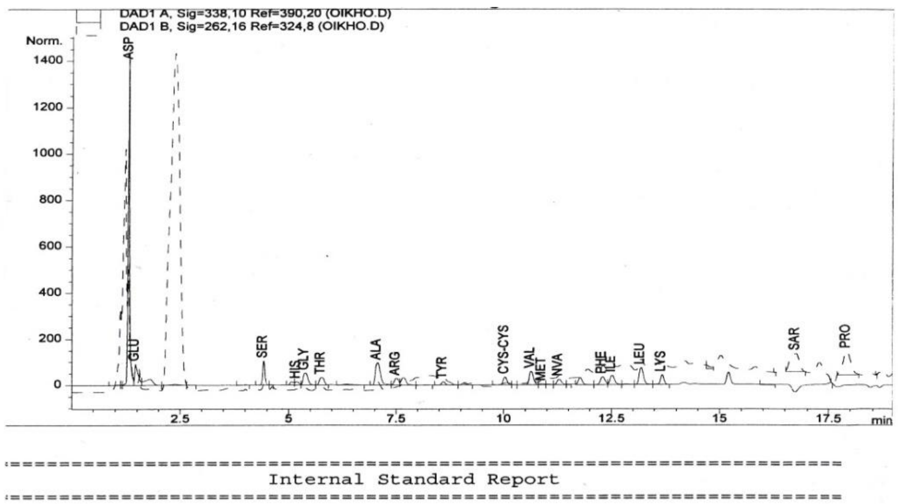

Figure 4. Chromatogram of amino acids in guava (*Psidium guajava* L.)

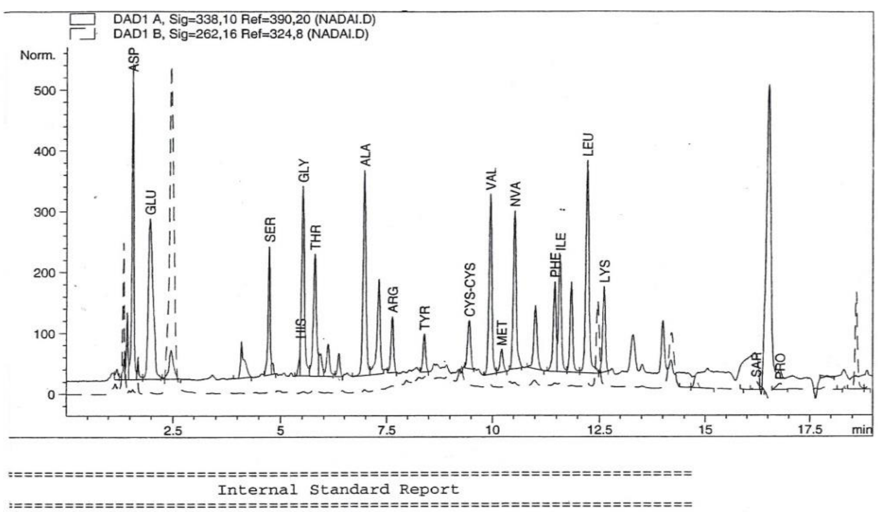

Figure 5. Chromatogram of amino acids in custard apple (*Annona squamosa* L.)

Mineral analysis

Table 4 shows the content of mineral elements in custard apple, mango, guava and cucumber. The relatively high content of some mineral elements has been found. The content of natrium in mango was the highest at 0.082%, followed by that of magnesium and phosphorus at 0.075% and 0.065% respectively, the lowest was nitrogen content at 0.007%. Meanwhile, potassium content was not recorded during research period. This was similar to the results found in Zafar and Sidhu (2017) study which showed that mango was rich in minerals. In cucumber, the highest mineral content was phosphorus at 0.561%, followed by that of sulfur and magnesium at 0.219% and 0.183% respectively, the lowest was zinc content at 0.020%. Meanwhile, manganese content was not recorded during research period. In guava, nitrogen content was the highest at 1.195%, followed by 0.204% potassium, 0.121% sulfur and 0.005% iron. The figures in custard apple were lower than in other fruits including phosphorus, magnesium and natrium (0.099%, 0.098% and 0.005% respectively). These results were similar to those found in Pratistha (Srivastava et al., 2017) showed that P was the predominant mineral found in custard apple.

Table 4. Composition of mineral elements (Unit: %)

No.	Mineral composition	Mango (*Mangifera indica* L.)	Cucumber (*Cucumis sativus* L.)	Guava (*Psidium guajava* L.)	Custard apple (*Annona squamosa* L.)
1	Na	0.082	0.079	0.037	0.005
2	Fe	0.034	0.064	0.005	0.006
3	K	-	0.030	0.204	0.078
4	Mg	0.075	0.183	0.113	0.098
5	Ca	0.063	0.122	0.102	0.050
6	P	0.065	0.561	0.028	0.099
7	S	0.050	0.219	0.121	0.045
8	N	0.007	0.028	1.195	0.010
9	Mn	0.011	-	0.015	0.042
10	Zn	0.037	0.020	0.023	-

Notes: – : Not found during the research period

It can be seen that guava had the highest mineral content, followed by cucumber, mango and the lowest was that of custard apple.

In short, mineral contents found in the fruits were at the high level, including huge amount of minerals such as phosphorus, nitrogen, magnesium and the minimum amount of natrium, potassium, manganese, zinc.

CONCLUSION

In Vietnam, all mango, custard apple, guava and cucumber have distinctive color, flavor with high nutritional properties when they are ripe. They contain a large amount of reducing sugar, lipids, proteins and vitamins, including mainly vitamin C, vitamin A and B-group vitamin. In addition, a high content of amino acids and mineral elements such as P and Mg are found in these fruits. These results show that the fruits grown in Vietnam like mango, guava, custard apple and cucumber are a good source of nutrients to meet the demands in the market as well as scientific basis for better harvesting and preservation.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

LVT and BBT conceived the idea and designed the experiments. LVT and NTK implemented the experiments. LVT, BBT and BDC analyzed the research data. LVT and BBT wrote the manuscript. All authors agreed with the final version of the manuscript.

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