Nutritional value of persimmon, banana, lemon and longan cultivated in Northern Vietnam

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Abstract. An analysis of nutritional composition of some common fruits (persimmon, banana, lemon, longan) grown in Northern Vietnam was conducted. These fruits, at their ripening stage, showed distinctive flavors and colors and contain a high content of nutrients. They owned relatively high content of vitamins, protein, lipid and reducing sugar, and also contained essential amino acids mostly including glutamic acid, aspartic acid, leucine. Additionally, the mineral content in the fruits also achieved a high level, mainly phosphorus, nitrogen, potassium and magnesium. These obtained findings show that the fruits (persimmon, banana, lemon, longan) are a major source of nutrients as well as essential minerals for humans. The research results are also served as a scientific basis for collecting, processing, preserving and consuming these fruits in Vietnam.

1. Introduction
Fruits are widely known as not only an important source of nutrients but also one of the most valuable medicinal origins for human beings [1-3]. Fruit and fruit product export accounts for a large proportion in many countries around the world. That fruits in many different countries are very diverse and plentiful meets the wide consumption needs of consumers.

There have been many studies on the nutrition of fruits in many different ecological regions [4-9]. The research mainly focused on determination of the nutritional composition of fruits to benefit consumers. Shahrajabian et al. [10] studied the nutritional composition of longan fruit and pointed out that the longan fruit contained the highest value in mineral content such as phosphorus, calcium and exhibited large amount of vitamin C and protein. Srivastava et al. [11] concluded that the mineral constituents of custard apple and strawberries were mostly calcium, iron, phosphorus and a large amount of sugar, protein was also found in custard apple. Trong et al. [12] studied the nutritional composition of oranges showed that oranges at ripening stage were of good quality, containing a large amount of reducing sugar and vitamin C. The fruit is full of amino acids, including 9 types of irreplaceable ones. In addition, many mineral elements with high content were recognized in oranges. Trong et al. [13] studied the nutritional content of other fruits like mango, cucumber, guava, custard apple also drew a conclusion that these fruits had high content of vitamins, protein, lipid, reducing sugar, minerals and amino acids. Studies also show that the same fruit grown in different ecological regions will lead to differences in nutritional composition [14].
Vietnam is one of the biggest fruit exporters in the world [15]. Fruits that are widely grown in Vietnam and have brought significant economic values are longan, banana, lemon, persimmon, etc. Because of the economic benefits they bring, gardeners have invested in planting fruit trees as well as fruit production in many provinces and cities. Fruit products, therefore, have been increasing nationwide.

During the production and processing, fruit collecting and preservation steps are crucial to assure the quality of the fruits and may have direct effects on consumers. However, these steps applied for many fruits in Vietnam are not really scientifically based but experience of gardeners, which makes most of the fruits in the market are unqualified and affects consumers’ health. Consequently, determining the nutritional content of the fruits at their ripening stage is very important to help consumers know the nutritional and medicinal values of the fruit for the most effective use.

Although improving fruit quality after harvest have been increasingly concerned in the past few years, the number of researches in this field is still limited and unsystematic. Our research team conducted sampling, analysis, and made evaluation to determine the nutritional content of some fruits widely grown in Vietnam in order to assist consumers to use and preserve fruit better as well as provide a scientific basis for further research.

2. Materials and methods

2.1 Fruit sampling
The fruits were collected in Northern provinces of Vietnam: persimmons were collected in Luc Nam district, Bac Giang province; bananas were harvested in Yen Lac district, Vinh Phuc province; longan fruits were from in Hung Yen province and lemons were collected in Thanh Ha district, Hai Duong province. The sampled trees all grew well, suffered less pests, and showed high and stable yield. The fresh fruits after harvest were divided into two parts, one was used to analyze some physiological and biochemical parameters, another was dried at 105°C to analyze the contents of protein, lipid, tannin and cellulose.

2.2 Research method
Morphological, growth characteristics of ripe fruits were studied based on their length, volume, diameter, weight, color and flavor. The fresh weight of the fruits was determined by electronic scales with an accuracy of 0.001g. The size of the fruits is measured by a micrometer caliper. The volume of the fruits was determined in a volumetric measuring cup. The content of water and dry matter in the fruits was calculated by the description of Ma et al. [16]. The content of reducing sugar and starch was determined using Bertrand method while the content of vitamin C was based on the titration method [17]. The high-performance liquid chromatography method was used to measure the content of total organic acids [18]. The content of vitamin B₁, B₂, B₃ was determined by the fluorescent method, vitamin B₆ was determined by high-performance liquid chromatography (HPLC) [17, 19]. The content of protein and lipid was determined by Lowry method and soxhlet method respectively [20, 21]. Description of Mui [17] was used to measure the content of cellulose. The tannin content was determined by Lowenthal method [22]. The content of β-carotene and lycopene was determined by high-performance liquid chromatography (HPLC) [8]. The amino acid composition was determined by the description of Osman [23]. The sodium content (Na) was determined by flame photometer [24]. Calcium (Ca), magnesium (Mg), phosphorus (P), potassium (K), iron (Fe), zinc (Zn) and copper (Cu) were determined by atomic absorption spectrometer [7]. Total nitrogen content (N) of fruits was determined based on Kjeldahl method [25]. The experiments were conducted at Hong Duc University, Institute of Biotechnology and Institute of Chemistry under Vietnam Academy of Science and Technology. All experiments were conducted three times independently. The results are expressed as mean values and standard deviation (SD). Statistical processing of results was performed by Microsoft Excel software package, version 7.0.
3. Results and discussion

3.1 Morphological and growth characteristics

Before having studied nutritional composition of some fruits at their ripening stage, we had conducted sampling, determined the ripening time and analyzed morphological and growth characteristics. The results are shown in Table 1.

### Table 1. Morphological and growth characteristics of some fruits at their ripening stage

| Factors          | Persimmon (Diospyros kaki Lf.) | Banana (Musa paradisiaca L.) | Longan (Euphoria longan Lamk) | Lemon (Citrus limonia Osbeck) |
|------------------|--------------------------------|-------------------------------|-------------------------------|-------------------------------|
| Length (cm)      | 5.81 ± 0.34                    | 17.47 ± 0.64                  | 2.67 ± 0.15                   | 4.23 ± 0.24                   |
| Diameter (cm)    | 5.30 ± 0.26                    | 4.34 ± 0.25                   | 2.61 ± 0.18                   | 4.31 ± 0.41                   |
| Volume (cm³)     | 144.05 ± 1.49                  | 185.40 ± 2.57                 | 12.20 ± 0.62                  | 44.50 ± 1.15                  |
| Weight (gam)     | 129.04 ± 1.37                  | 185.21 ± 1.23                 | 12.65 ± 0.54                  | 43.73 ± 0.97                  |
| Color, flavor    | Yellow skin around its stem, bright yellow flesh, slight aroma. | Yellow fruit, white mixed with pale yellow flesh, aroma. | Yellowish brown, with visible spines fruits; thick, white flesh, slight aroma. | Light yellow and smooth skin, yellowish white flesh. |

**Notes:** Values are given as means of three replicates ± SD.

The obtained findings in Table 1 show that physiologically ripe persimmon (22 weeks) owned yellow color, bright yellow flesh, sweet taste and aroma, it had average weight of 129.04g, diameter of 5.30 cm, length of 5.81 cm and volume of 144.05 cm³. The physiologically ripe banana (19 weeks) had yellow color, white mixed with pale yellow flesh, and aroma, the fruit had average weight of 185.21g, diameter of 4.34 cm, length of 17.47 cm and volume of 185.40 cm³. The physiologically ripe longan fruit (19 weeks) showed yellowish brown color, thick white flesh, slight aroma, it has an average weight of 12.65g, diameter of 2.61 cm, length of 2.67 cm and volume of 12.20 cm³. The physiologically ripe lemon (22 weeks) had light yellow and smooth skin, yellowish white flesh, it had average weight of 43.73g, diameter of 4.13 cm, length of 4.23 cm and volume of 44.50 cm³.

The results on morphological and growth characteristics show that the fruits reached maximum size and entered the ripening stage; therefore, conducting a study on their nutritional composition at this time is reasonable and shows scientific basis.

3.2 Nutritional composition

The nutritional composition of persimmon, banana, longan and lemon at their ripening stage shown in Table 2 was relatively high. The fruits all had high water content, in which lemon had the highest at 92.98%, followed by that of persimmon at 82.54%, that of banana at 75.24%, the lowest belonged to the water content of longan fruit at 63.55%. Persimmon contained the highest reducing sugar content at 13.11%, followed by that of longan fruit, banana and lemon at 9.29%, 4.77% and 0.57% respectively. In terms of starch content, banana had the highest value at 12.72% while the lowest was recorded in lemon at 0.29%.

In terms of the content of protein and lipid, banana owned the highest content among the four fruits, of which the protein content reached 2.53% and that of lipid achieved 5.00%. Meanwhile lemons showed the lowest protein content at 0.87% and longan fruit had the lowest lipid content at 0.23%. These findings were consistent with that in Shahrajabian et al. [10].
Table 2. Key nutritional components

| Factors                | Persimmon (Diospyros kaki Lf.) | Banana (Musa paradisiaca L.) | Longan (Euphoria longan Lamk) | Lemon (Citrus limonia Osbeck) |
|------------------------|---------------------------------|------------------------------|------------------------------|---------------------------------|
| Water content (%)      | 82.54 ± 1.36                    | 75.24 ± 0.94                 | 63.55 ± 0.67                 | 92.98 ± 1.19                    |
| Dry matter (%)         | 17.46 ± 0.21                    | 24.77 ± 0.34                 | 36.45 ± 0.27                 | 7.02 ± 0.12                     |
| Reducing sugar (%)     | 13.11 ± 0.08                    | 4.87 ± 0.01                  | 0.48 ± 0.02                  | 0.29 ± 0.03                     |
| Starch (%)             | 0.95 ± 0.02                     | 12.72 ± 0.06                 | 2.53 ± 0.01                  | 12.72 ± 0.06                    |
| Lipid (%)              | 1.01 ± 0.02                     | 5.00 ± 0.03                  | 0.23 ± 0.01                  | 0.23 ± 0.01                     |
| Total organic acids (ldl/100g) | 37.01±0.15                  | 17.25±0.27                   | 36.88±0.49                   | 75.36±0.45                     |
| Vitamin B1 (mg/100g)  | 0.18 ± 0.01                     | 0.03 ± 0.01                  | 0.37 ± 0.02                  | 0.04 ± 0.01                     |
| Vitamin B2 (mg/100g)  | 2.01 ± 0.03                     | 0.06 ± 0.01                  | 0.10 ± 0.01                  | 0.02 ± 0.01                     |
| Vitamin B3 (mg/100g)  | 0.08 ± 0.01                     | 0.65 ± 0.05                  | 3.89 ± 0.05                  | 0.09 ± 0.01                     |
| Vitamin B6 (mg/100g)  | 0.12 ± 0.01                     | 0.39 ± 0.02                  | 24.42 ± 0.18                 | 0.07 ± 0.01                     |
| Vitamin C (mg/100g)   | 30.85 ± 0.72                    | 33.00 ± 0.35                 | 57.26 ± 0.32                 | 67.32 ± 0.85                    |
| β-carotene (µg /100g) | 71.10 ± 0.64                    | 25.20 ± 0.28                 | -                            | -                              |
| Lycopene (µg /100g)   | 48.90 ± 0.47                    | -                            | -                            | -                              |

Notes: Values are given as means of three replicates ± SD. (-) Not detected during the time conducting the research.

When it comes to cellulose, longan fruit had the highest content at 1.70%, followed by banana, persimmon and lemon at 0.86%, 0.84%, and 0.74% respectively. While the highest tannin content which was found in bananas was 0.93%, the lowest was in persimmon (0.08%). This was similar with changes in acrid taste of the fruits when they entered ripening stage.

Regarding the content of total organic acids, the lemon had the highest at 75.36 ldl/100g, followed by persimmon at 37.01 ldl/100g and longan fruit at 36.88 ldl/100g, the lowest was that of banana at 17.25 ldl/100g.

The results of vitamin content showed that all fruits contained relatively high vitamin content. Longan fruit had the highest vitamin C content at 57.26 mg/100g, followed by vitamins B6, vitamin B3, vitamin B1 and vitamin B2. The result was consistent with the study of Shahrajabian et al. [10] which concluded that the content of vitamin C in longan fruit was 60 mg/100g and also corresponded to the content of vitamin B1 and vitamin B2. This is also consistent with the results of Wall’s study on vitamin C content in longan [26]. Persimmon had the highest vitamin C content at 30.85 mg/100g, followed by that of vitamin B2 at 2.01 mg/100g, vitamins B1, B6 and B3. The content of vitamin C in persimmon grown in Vietnam is higher than persimmon grown in Turkey [14]. The vitamin C content was also the highest in banana at 33.00 mg/100g, followed by vitamin B3 at 0.65 mg/100g, vitamin B6 at 0.39 mg/100g, the lowest was vitamin B1 at 0.03 mg/100g. Lemons had the highest vitamin C content of all the fruits at 67.32 mg/100g, while the content of other vitamins is low.

In addition, persimmon also contained β-carotene content of 71.1 µg /100g and lycopene of 48.9 µg /100g, bananas had β-carotene content of 25.2 µg /100g, while lycopene content was not detected during the time conducting this research. These two contents were not detected in longan fruit and lemon at their ripening stage.
3.3 Amino acid composition

The total amino acid content in persimmon, banana, longan and lemon at their ripening stage was fairly high, of which the highest belonged to banana, followed by longan fruit, persimmon and lemon (Table 3). In banana, the highest lysine content was 1.16%, followed by glutamic acid at 1.10%, tryptophan at 0.92%, aspartic acid at 0.79%, leucine at 0.72%, the lowest was tyrosine at 0.10%, while the content of proline and cysteine was not detected during the time conducting the research. In longan, the highest alanine content reached 1.12%, followed by glutamic acid at 0.95% and aspartic acid at 0.70%, the lowest was arginine at only 0.05%, while cysteine content was not detected during the time conducting the research. This result was consistent with the ones from Shahrajabian et al. [10], in which the high value amino acids were at alanine 0.157g, aspartic acid at 0.126g and glutamic acid at 0.209g. The highest amino acid content of persimmon was aspartic acid at 0.62%, followed by arginine at 0.52% and glutamic acid at 0.37%, the lowest was cysteine and methionine at 0.04%, while tryptophan was not detected during the time conducting the research. In lemon, the highest amino acid content was glutamic acid at 0.81%, followed by serine at 0.51% and threonine at 0.42%, the lowest was methionine at 0.01%, while cysteine was not detected during the time conducting the research.

Table 3. Amino acid composition (Unit: %)

| Amino acid  | Persimmon (Diospyros kaki Lf.) | Banana (Musa paradisiaca L.) | Longan (Euphoria longan Lamk) | Lemon (Citrus limonia Osbeck) |
|-------------|---------------------------------|-------------------------------|--------------------------------|-------------------------------|
| Aspartic acid| 0.62 ± 0.03                     | 0.79 ± 0.01                   | 0.70 ± 0.02                    | 0.33 ± 0.02                   |
| Glutamic acid| 0.37 ± 0.02                     | 1.10 ± 0.01                   | 0.95 ± 0.04                    | 0.81 ± 0.03                   |
| Serine      | 0.25 ± 0.01                     | 0.24 ± 0.01                   | 0.23 ± 0.02                    | 0.51 ± 0.01                   |
| Histidine*  | 0.12 ± 0.01                     | 0.53 ± 0.03                   | 0.17 ± 0.01                    | 0.06 ± 0.01                   |
| Arginine    | 0.52 ± 0.02                     | 0.47 ± 0.01                   | 0.05 ± 0.01                    | 0.33 ± 0.02                   |
| Glycine     | 0.28 ± 0.01                     | 0.29 ± 0.02                   | 0.15 ± 0.01                    | 0.15 ± 0.01                   |
| Threonine*  | 0.22 ± 0.01                     | 0.27 ± 0.01                   | 0.25 ± 0.02                    | 0.42 ± 0.02                   |
| Tyrosine    | 0.17 ± 0.01                     | 0.10 ± 0.01                   | 0.55 ± 0.02                    | 0.09 ± 0.01                   |
| Alanine     | 0.29 ± 0.01                     | 0.26 ± 0.01                   | 1.12 ± 0.07                    | 0.19 ± 0.02                   |
| Valine*     | 0.24 ± 0.02                     | 0.47 ± 0.03                   | 0.23 ± 0.01                    | 0.11 ± 0.01                   |
| Methionine* | 0.04 ± 0.01                     | 0.11 ± 0.01                   | 0.08 ± 0.01                    | 0.01 ± 0.01                   |
| Phenylalanine* | 0.30 ± 0.02                  | 0.25 ± 0.01                   | 0.17 ± 0.02                    | 0.11 ± 0.02                   |
| Isoleucine* | 0.22 ± 0.01                     | 0.27 ± 0.02                   | 0.18 ± 0.02                    | 0.08 ± 0.01                   |
| Leucine*    | 0.31 ± 0.02                     | 0.72 ± 0.04                   | 0.29 ± 0.01                    | 0.13 ± 0.01                   |
| Lysine*     | 0.21 ± 0.01                     | 1.16 ± 0.10                   | 0.31 ± 0.02                    | 0.12 ± 0.01                   |
| Proline     | 0.24 ± 0.02                     | -                             | 0.12 ± 0.01                    | 0.24 ± 0.02                   |
| Cysteine    | 0.04 ± 0.01                     | -                             | -                              | -                             |
| Tryptophan* | 0.62 ± 0.01                     | 0.79 ± 0.03                   | 0.70 ± 0.04                    | 0.33 ± 0.02                   |

Notes: Values are given as means of three replicates ± SD. (*) indispensable amino acids. (-) Not detected during the time conducting the research.

The results show that fruits contain high content of amino acids including glutamic acid, aspartic acid, lysine, alanine, leucine, etc. Meanwhile, some amino acids such as arginine, tyrosine, cysteine showed relatively low content.

3.4 Mineral composition

The analyzing results of mineral composition in persimmon, banana, lemon and longan fruit at their ripening stage are listed in Table 4. The results showed that these fruits had some mineral components...
at pretty high level. In persimmon, the highest potassium content reached 1.010%, followed by nitrogen at 0.450%, phosphorus at 0.089%, zinc was the lowest at 0.007%, while sodium and copper content was not detected during the time conducting the research. This result was consistent with the one from Mir-Marqués et al.’s study on the mineral content of persimmon [27]. Some studies previously conducted on persimmons revealed that sodium and copper contents were obtained as 10 and 0.11 mg/100g, respectively [14]. The variation of mineral composition of fruits could be due to cultivar, soil characteristics, climate and sample preparation method [14]. In banana, the highest mineral content was phosphorus at 2.650%, followed by that of nitrogen at 0.606% and potassium at 0.302%, the lowest is sodium, iron and zinc content at 0.001%, while the copper content was not detected during the time conducting the research. This result was similar with the one from the study of Adepoju et al. [28] on the mineral composition of banana. In longan, the highest content of potassium was at 2.660%, followed by that of nitrogen at 0.731% and phosphorus at 0.316%, iron content is the lowest at 0.006%, while calcium and sodium were not detected during the time conducting the research. This is consistent with the results of Wall’s study on the content of minerals in longan [26]. Lemon had the highest nitrogen content of 0.245%, followed by that of potassium at 0.066%, zinc was at the lowest of 0.001%, while sodium and iron were not detected during the time conducting the research. The results showed that the longan fruit had the highest mineral content, followed by the banana, persimmon and lemon.

Table 4. Composition of some minerals (Unit: %)

| Mineral composition | Persimmon (Diospyros kaki Lf.) | Banana (Musa paradisiaca L.) | Longan (Euphoria longan Lamk) | Lemon (Citrus limonia Osbeck) |
|---------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|
| Ca                  | 0.058 ± 0.002                 | 0.013 ± 0.001                | -                             | 0.029 ± 0.001                |
| Cu                  | -                             | -                            | 0.052 ± 0.001                 | 0.002 ± 0.001                |
| Fe                  | 0.021 ± 0.001                 | 0.001 ± 0.001                | 0.006 ± 0.001                 | -                            |
| K                   | 1.010 ± 0.005                 | 0.302 ± 0.004                | 2.660 ± 0.003                 | 0.066 ± 0.002                |
| Mg                  | 0.031 ± 0.001                 | 0.013 ± 0.001                | 0.092 ± 0.002                 | 0.011 ± 0.001                |
| N                   | 0.450 ± 0.006                 | 0.606 ± 0.005                | 0.731 ± 0.004                 | 0.245 ± 0.004                |
| Na                  | -                             | 0.001 ± 0.001                | -                             | -                            |
| P                   | 0.089 ± 0.002                 | 2.650 ± 0.008                | 0.316 ± 0.002                 | 0.019 ± 0.002                |
| Zn                  | 0.007 ± 0.001                 | 0.001 ± 0.001                | 0.161 ± 0.002                 | 0.001 ± 0.001                |

Notes: Values are given as means of three replicates ± SD. (−) Not detected during the time conducting the research.

In short, the mineral content in the fruits was high, in which some mineral elements showing high content were phosphorus, nitrogen, potassium, etc. and some mineral elements are relatively low or not detected during the time conducting the research such as sodium, copper, calcium, iron, zinc, etc.

4. Conclusions
In Vietnam, fruits like persimmon, banana, longan, and lemon have typical colors and flavors at their ripening stage. The fruits all contained relatively high content of nutrients, in which persimmon, longan fruit and banana owned a large amount of reducing sugar, lipids, and protein, and many vitamins. Meanwhile, lemons contained little reducing sugar, starch but a large amount of vitamins, mainly vitamin C and B vitamins. In addition, many amino acids and high content of mineral elements such as phosphorus, nitrogen, potassium, magnesium were found in these fruits.

The results showed that persimmon, banana, longan fruit, and lemon grown in Vietnam had high nutritional composition, which meet the market demand and are served as a scientific basis for better harvesting and preserving fruits.
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