Study on nutrient compositions of son tra fruits (*Docynia indica* (Wall.)

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I. Background and objective of the study

Son tra or tao meo are the local names of the H'mong apple. Other local names are taorung, maccam, or macsamcha. The scientific name of son tra is *Docynia indica* (Wall.) Decne or *Pyrus indica* (Wall.) and the species belong to the Rosaceae family. Fruits of son tra are usually harvested around September and October [3].

Son tra can be found in India, Myanmar, and some southern provinces of China [3]. In Vietnam, son tra occurs mainly in the northern mountainous provinces, including Son La (Muong La), Lai Chau (Sin Ho, Phong Tho, Tuan Giao-Pha Din), Ha Giang (Dong Van, Meo Vac, Quan Ba), Lao Cai (Sapa, Bac Ha, Muong Khuong), Yen Bai (Mu Cang Chai). Son tra typically grows at elevation above 1000 masl. and is most common between 1500-1700 masl [3].

In Vietnam, son tra is increasingly used as a reforestation species for environmental services and is also planted for commercial purposes on a small scale for fruit production. Most types of son tra cannot be consumed directly in a raw state, requiring a certain kind of processing. Son tra is traditionally used in the form of syrup, alcohol, wine, and vinegar. The manufacturing of conveniently, ready-to-use products, like filter bag tea, agglomerated instant tea, and dry jam could potentially increase the demand of son tra and thus promote its production. The production area and market demand of son tra has grown over the last few years, due to consumers' belief in its positive effects on human health. Son tra has traditionally been used as a supplemental remedy to stimulate digestion and appetite, and treating bloating and heartburn [3]. Son tra can also be combined with other herbs to treat tonic spleen. According to the local knowledge, son tra is high in nutrient value and biological substances, which are necessary for the body. Despite this common knowledge, there is not yet scientific evidence that clearly proves the effects of son tra on human health.

Proving the positive effects of son tra on human health could increase its market potential, thus promoting the production of son tra in the hilly Vietnamese north. To scientifically show the health benefits of son tra and the value it adds, a study of its nutritional value is necessary.

This study is a part of the "Agroforestry for Livelihoods of Smallholder Farmers in Northwest Vietnam" project, funded by Australian Center for International Agricultural Research (ACIAR) with the overall aim to improve the performance of smallholder farming systems in Northwest Vietnam through agroforestry and co-funded by the CGIAR Research Program A4NH ("Agriculture for Nutrition and Health"). It focuses on the evaluation of nutritional and bioactive compositions present in son tra fruits, collected from three different provinces in Vietnam.

The chemical analysis of the son tra fruits has been conducted at the Department of Phytochemistry which belongs to National Institute of Medicinal Materials in Hanoi, Vietnam.

II. Materials and methods

1. Materials

The previous study was conducted by scientists at the Forestry Science Center of the Northwest (FSCN). At that time, thirty son tra mother trees were selected for the purpose of germplasm improvement. These trees were chosen from provinces where son tra trees are naturally concentrated, where ALFI operates, including Son La, Dien Bien, and Yen Bai. For the nutritional analysis, two samples from two mother trees in each province were taken in August 2013 for a comparative study. One additional sample per province was taken in 2014 to validate the results obtained from 2013. The sample codes and details of the collected samples are recorded in Table 1. To analyze variations in content composition of fruits grown in different places, all samples were picked at the same time in the same conditions. The selected samples were immediately packed in cool boxes and sent to laboratory for analysis. The species identity of samples was verified by the technical staff of FSCN. In the laboratory, the selected fruits were classified again to select fruits of the same ripeness grade. The selected fruits were divided in two portions. One portion was sliced into small pieces and dried at 40 C^o in an oven for phytochemical and nutrient evaluations. The second portion was used to evaluate the nutrient compositions in fresh fruits. The whole fruit was used.

Table 1: List of son tra samples taken from 3 AFLI provinces

No.	**Origin**	**Status of samples**	**Sample code**	**Collected time**
1	Tuan Giao, Dien Bien	Fresh	DBF-1	2013
		Dried	DBD-1	2013
2		Fresh	DBF-2	2013
		Dried	DBD-2	2013
3		Fresh	DBF-3	2014
		Dried	DBD-3	2014
4	Bac Yen, Son La	Fresh	SLF-1	2013
		Dried	SLD-1	2013
5		Fresh	SLF-2	2013
		Dried	SLD-2	2013
6		Fresh	SLF-3	2014
		Dried	SLD-3	2014
7	Tram Tau, Yen Bai	Fresh	YBF-1	2013
		Dried	YBD-1	2013
8		Fresh	YBF-2	2013
		Dried	YBD-2	2013
9		Fresh	YBF-3	2014
		Dried	YBD-3	2014

Chemicals and reagents

Chemicals and reagents used for analysis of nutrient compositions are listed in the following table.

Table 2: List of chemicals and reagents

- Gelatin;
- Iodine;
- 3.5-dinitrobenzoic acid;
- KOH;
- Picric acid;
- Magnesium powder;
- Kalium iodine;
- Bismuth subnitrate;
- Acetic anhydride;
- Sodium nitroprusside;
- Phosphomolybdic acid;
- Phosphotungstic acid;
- Acetic anhydride sodium nitroprusside;
- Sodium tungstate;
- Sodium molybdate;
- Phosphoric acid;
- Hydrochloric acid;
- Lithium sulfate;
- Bromine;
- Glacial acetic acid (98%);
- Basic bismuth nitrate;
- Potassium iodide;
- Sulphuric acid;
- Acetic anhydride;
- Ion-III-chloride;
- Potassium hydroxide;
- Vanillin;
- Sodium hydroxide;
- Ammoniac;
- Potassium iodine;
- Mercury;
- Mercury acetate;
- Copper acetate;
- Folin-Ciocalteu's phenol reagent (Merck Chemicals Argentina, Buenos Aires);
- Garlic acid (98% purity, Sigma);
- Anhydrous sodium carbonate (99% purity, Sigma); and
- Distilled water.

Solvents

The following solvents were used for analysis in pure form or redistilled:

- Methanol;
- N-hexane;
- Ethyl acetate;
- Ethanol;
- Diethylether; and
- Chloroform.

Instruments

The following instruments were used for analysis:

- Balancing techniques Precisa XT 620M;
- Analytical balance Prescia XT 220A;
- Oven Binder-FD 115;
- Spectrophotometer UV-VIS 1800, wave length: 190-900 nm, Shimadzu (Japan)
- Water bath WB14 (Memmert – Germany);
- Rotary evaporator, N1001SW (Eyela – Japan).

2. Methods

2.1 Phytochemical content

Detection of phytochemical groups

Phytochemical groups present in son tra fruits were extracted using suitable solvents. The phytochemical groups (alkaloids, saponins, cardiac glycosides, anthranoids, tannins, coumarin, flavonoids, carotenoids, organic acids, sterols, and free sugars) were screened using the characteristic chemical reactions based on the methods described in literature [4-7].

- Alkaloid group: Mayer, Bouchardat, and Dragendorff reagents, TLC method;
- Flavonoid group: Alkaline, FeCl3, and Diazo reagents, TLC method;
- Coumarin group: Diazo reagent, lactone-ring close and open reactions, TLC method;
- Tanin group: react to FeCl3 reagent, other specific reaction, gelatin reaction;
- Cadiac glycoside group: Baljet, Legal, Keller – Kiliani reagents, TLC method;
- Anthranoid group: Borntraeger reaction and TLC method;
- Phytosterol group: Borntraeger reaction and TLC method; and
- Free sugar/reducing sugar group and organic acid: Ninhyrin reaction and Fehling solution reaction.

Determination of total polyphenol content

The total polyphenol content (TPC) was determined by spectrophotometry, using gallic acid as the standard, in accordance with the method described by the International Organization for Standardization (ISO) 14502-1 [8].

Sample preparation: An accurate weight of 1 g of son tra sample was extracted by soaking in distilled water at 90 °C for three hours, twice. The combined extracts were then placed in a 50ml volumetric flask first, to which water was added until the solution reached the mark. The extract was filtered through 0.45 micron filter paper before analysis.

Standard curve of gallic acid: Gallic acid was used as the standard at concentrations of 200, 400, 600, 800, 1000 µg/ml. Each was dissolved in methanol. The total phenolic content was expressed as mg/g gallic acid equivalent using the standard curve equation $y = 0,0009x + 0,073$ ($R2 = 0,9953$), where y is absorbance at 760 nm and x is total phenolic content in the different extracts of fruits of *Docynia indica* expressed in mg/g. Fifty µl of the diluted sample extract or standard solution was transferred in pairs to separate tubes containing 250 µL of a Folin-Ciocalteu's reagent in water. Then, 0.5 ml of a sodium carbonate solution (20% w/v) was added. The mixture was vortexed and diluted with distilled water to a final volume of 5 ml. The tubes were then allowed to stand at room temperature for 60 min before absorbance at 760 nm was measured against water. Total polyphenol (TPC) were expressed on a dry weight basis as gallic acid equivalent (GAE) mg/g, using a calibration curve of a freshly prepared gallic acid solution. The analyses were done in triplicate.

2.2 Nutrient content

Analysis of nutrient compositions of son tra fruits

Materials and methods used for analyzing the macro- and micronutrient composition of son tra fruits are listed in above.

Methods of analyzing the nutrient compositions of the collected samples

No.	Contents	Methods	Main equipment	Assistant equipment	Tools	Chemicals, reagents
2.2.1 Macro-nutrient analysis						
1.	Protein	Kjeldahl method NMKL06	- Digestion system - Evaporator system	- Technical balance (0.01g precision) - Homogenor	- 25mL burette - 800ml digestion tubes - 500mL Conical flask - 5mL, 10mL pipets	- Sulfuric acid (H_2SO_4), high purity - NaOH - Blue methylene - Red methylene - 96% Ethanol - H_3BO_3 - K_2SO_4 - $CuSO_4$ - HCl 0,1N
2.	Lipid	Shoxhet Method FAO 14/7/1986	- Soxhlet extractor	- Homogenor - Desiccator - Analytical balance (0.0001g precision) - Oven - Water bath	- Filter paper - 500mL Conical flask - Glass filter funnel	- Petrolium ether - Hydrocloric acid (HCl)
3.	- Glucid, total sugars Reducing sugars	Lane and Eynon method ISO 5377:1991		- Homogenor - Analytical balance (0.0001g precision) - Water bath - Magnetic stirrer with hot plate	- 250ml Conical flask - Glass filter funnel - Volumetric flasks: 100mL, 200mL, 1L - Filter paper - Pipets: 5, 20ml - 25mL burette	- $CuSO_4$ - H_2SO_4 - Kali natri tartrat - NaOH - Blue methylene - $K_4Fe(CN)_6$ - $(CH_3COOH)_2Zn$ - D-glucose - HCl
4.	Humidity	FAO 14/7/1986	Desiccator or humidity detecting device			
2.2.2 Micro-nutrient analysis						
5.	Vitamin C	Lab-created method	HPLC	- Shaking machine - Homogenor - Centrifugal machine - Analytical balance - Technical	- 25mL volumetric flask - 50mL centrifugal tubes - 50 mL beaker	- Standard ascorbic acid - Acid metaphosphoric - KH_2PO_4 - Acid octo-phosphoric

				balance	- Glass funnel - Filter paper	
6.	Vitamins B group	Lab-created method	HPLC	- Shaking machine - Homogenor - Centrifugal machine - Analytical balance - Technical balance	- Volumetric flask: 25mL - Centrifugal tubes: 50mL - 50 mL beaker - Glass funnel - Filter paper	- Tricloacetic acid - Natriheptasulfonat - standard vitamine B-group: B1, B2, B3, B5, B6, B9, B12 - Acetonitrile - KH_2PO_4 - Acid octo-phosphoril - Acid acetic
7.	Fatty acids	Lab-created method	GCMS	- Homogenor - Ultrasonic vibrator machine - Analytical balance - Technical balance - Rotary vacuum evaporator - Oven	- 500 mL separatory funnel - 100 mL plastic jar with cap - 50 mL beaker - Glass funnel	- standard fatty acid: 37 compounds - Ethanol - n-hexane - KOH - NaCl
8.	Reducing sugars (glucose, fructose, sorbitol, maltose, sucrose)	Lab-created method	HPLC	- Homogenor - Ultrasonic vibrator machine - Analytical balance - Technical balance - Shaking machine	- Volumetric flasks - Filter funnels	- standard 4 sugar compounds - Acetonitrile
9.	Beta-caroten	Lab-created method	HPLC	- Homogenor - Ultrasonic vibrator machine - Analytical balance -	- Filter funnels - 100 mL plastic vials - 50 mL beaker - Glass	- Standard vitamin A, E, D - Ethanol - n-hexane - KOH - methanol - Acetonitrile

				- Vacuum machine - Oven	funnel	- NaCl

Notes: Available carbohydrate, total sugars, and individual sugars are reported as monosaccharide equivalents. Total carbohydrate was reported as ‘available carbohydrate’ calculated from the sum of free sugars (glucose, fructose, sucrose, maltose, and oligosaccharides) and complex carbohydrates (dextrins, starch). Protein is calculated from total nitrogen using the nitrogen conversion factors shown (6.25). The values given for fat refer to total fat and not just triglycerides. Metabolizable energy is given in kilocalories (kcal) and kilojoules (kJ). These values have been calculated from protein, fat, and carbohydrate using the following energy conversion factors:

	kcal/g
o Protein	4
o Fat	9
o Available carbohydrate	4

Beta-carotene is expressed as the sum of trans- and cis-beta carotene. Values given are the mean of three replicates ± standard derivation. Some values are reported as ‘<,’ indicating that the result was below the analytical limit of quantification (LOQ) or limit of detection (LOD). There is no distinction between ‘<’ and ‘not detected’.

Statistical analysis

The data were analyzed by using the unpaired Student’s t-test. Data were expressed as the means ± standard derivation (SD) of three independent replicates.

III. RESULTS

1. Average weight, pH, and water content of fresh son tra fruits

As shown in Table 2, among the three selected provinces, the average weight of fresh son tra fruits collected in Dien Bien was significant higher than those collected in Son La or Yen Bai provinces. The two latter fruits had a similar weight. The water content and pH values of the 09 samples were quite similar, ranged from 81.98% to 84.66% for water content and 3.05 to 3.19 for pH.

Table 2: Fresh fruit weight, water content, and pH of the nine son tra fruit samples from three provinces

	Sample	**Average mass of a fresh fruit (g), m.w ± SD**	**Water content (%)**	**pH**
[a] DB	DBF1	33.42 ± 3.51	82.9	3.19

	DBF2	39.52 ± 6.4	82.2	3.05
	DBF3	37.58 ± 4.55	82.6	3.11
[b] SL	SLF1	28.25 ± 4.21	84.7	3.09
	SLF2	23.36 ± 3.40	82.7	3.15
	SLF3	26.46 ± 4.34	83.1	3.12
[c] YB	YBF1	25.31 ± 2.86	82.4	3.11
	YBF2	27.56 ± 3.48	82.9	3.15
	YBF3	26.96 ± 4.71	82.0	3.10
T test	[a] DBF-SLF	*P=0.009	*P=0.221	*P=0.943
	[b] SLF-YBF	*P=0.73	*P=0.184	*P=1
	[c] DBF-YBF	**P=0.005	*P=0.709	*P=0.942

* P > 0.05 => the difference not statistically significant

** P < 0.05 => the difference statistically significant

2. Characterization of phytochemicals

Seven out of 11 tested phytochemical substance groups were detected in the son tra fruits, including flavonoid, saponin, polyphenol, tannin, organic acid, amino acid and reducing sugar (Table 3).

Table 3: Occurrence of phytochemical substances in son tra fruits

Compound group	**Specific reaction**	**Samples**								
		DBD 1	**DBD 2**	**DB D3**	**SLD 1**	**SLD 2**	**SLD 3**	**YBD 1**	**YBD2**	**YBD3**
Alkaloid	Mayer reagent	-	-	-	-	-	-	-	-	-
	Dragendorff reagent	-	-	-	-	-	-	-	-	-
	Bouchardat reagent	-	-	-	-	-	-	-	-	-
Anthranoid	Borntrager reaction	-	-	-	-	-	-	-	-	-
Cardiac glycoside	Liebermann reaction	-	-	-	-	-	-	-	-	-
	Baljet reaction	-	-	-	-	-	-	-	-	-

	Legal reaction	-	-	-	-	-	-	-	-	-
Flavonoid	**Cyanidin reaction**	+++	++	++	++	++	++	+	+++	+++
	NH_3 reaction	++	++	++	++	++	++	+	+++	+++
	10% NaOH reaction	++	++	++	+++	++	++	++	+++	+++
	5% $FeCl_3$ reaction	+++	+++	+++	+++	++	++	+++	++	+++
Coumarin	Ring-opening/closing reaction of lactones	-	-	-	-	-	-	-	-	-
	The fluorescence phenomenon	-	-	-	-	-	-	-	-	-
Saponin	**Detection of foam forming**	+++	+	+	+++	++	++	+ +	+ +	+
	Blood hemolytic test	-	-	-	-	-	-	-	-	-
Polyphenol	**$FeCl_3$ 5%**	+++	+++	+++	++	++	++	++	++	++
Tannin	**Gelatin 1%**	++	+++	+++	+++	++	++	+++	+++	++
	Lead acetate 10%	++	+++	+++	++	++	++	++	+	++
Organic acids	**Na_2CO_3 - reaction**	+++	+++	+++	++	+	+	++	++	+
Amino acids	**Ninhydrin reaction**	+	++	++	+	+	+	+	+	+
Reducing sugars	**Fehling solution reaction**	+++	+++	+++	+	++	++	+	+	+++

Note : (-) Negative
(+) Positive
(+): positive, (++): medium positive, (+++): strong positive

3. Determination of total polyphenol content (TPC)

The values of the TPC of nine son tra samples collected in three different places are shown in Table 4. The results from the TPC showed relatively little variation, with no significant difference between the fruits from Dien Bien, Son La, or Yen Bai provinces.

Table 4: Total phenolic content from water extract of nine son tra samples

Samples		***Total phenolic content*** **± SD [GAE, mg/g],dry weight**
[a]DB	DBD-1	23.60 ± 0.55
	DBD-2	22.33 ± 0.83
	DBD-3	22.56 ± 0.31
[b]SL	SLD-1	16.99 ± 0.65
	SLD-2	18.87 ± 0.85
	SLD-3	17.40 ± 0.42
[c]YB	YBD-1	24.96 ± 0.78
	YBD-2	22.53 ± 1.79
	YBD-3	24.15 ± 0.35
T test	[a]DBD-SLD	**P = 0.002
	[b]SLD-YBD	**P=0.003
	[c]DBD-YBD	*P=0.267

* P > 0.05 => the difference not statistically significant.

** P < 0.05 => the difference statistically significant.

4. Macronutrient compositions of son tra fruits

The macronutrients including protein, fat, and carbohydrates were shown in Table 5. The ash values also calculated in gram per 100 grams of fresh son tra collected in Dien Bien, Son La, and Yen Bai were 2.31 ± 0.06 g/100g, 2.32 ± 0.06 g/100g and 2.34 ± 0.05 g/100g, respectively.

Table 5: Macronutrient contents (means ± SDs) in g per 100 g edible fresh pulp portion of fresh son tra samples

Samples		**Nutrients (g/100 g)**			
		Protein	**Fat**	**Total carbohydrate**	**Ash**
[a] DBF	Sample 1	0.51	0.22	6.21	2.25
	Sample 2	0.58	0.28	6.24	2.30
	Sample 3	0.47	0.25	6.30	2.38

	Mean	**0.52 ± 0.06**	**0.25 ± 0.03**	**6.25 ± 0.05**	**2.31 ± 0.06**
[b] SLF	Sample 1	0.47	0.25	5.90	2.30
	Sample 2	0.52	0.28	5.95	2.22
	Sample 3	0.42	0.30	6.00	2.32
	Mean	**0.47 ± 0.05**	**0.28 ± 0.02**	**5.95 ± 0.05**	**2.28 ± 0.05**
[c] YBF	Sample 1	0.42	0.21	6.85	2.39
	Sample 2	0.37	0.24	6.92	2.28
	Sample 3	0.48	0.28	6.94	2.36
	Mean	**0.42 ± 0.06**	**0.24 ± 0.04**	**6.90 ± 0.06**	**2.34 ± 0.05**
T test	[a] DBF –SLF	* P = 0.311	*P= 0.30	*P = 0.099	*P = 0.57
	[b] SLF – YBF	*P = 0.338	*P = 0.25	**P= 2.10^{-5}	*P = 0.23
	[c] DBF – YBF	*P = 0.099	*P = 0.81	**P = 6.10^{-5}	*P= 0.54

* P > 0.05 => the difference not statistically significant
** P < 0.05 => the difference statistically significant

The analytical results of macronutrients showed that the content of protein and fat in son tra samples were similar with no statistically significant differences across provinces. However the carbohydrate content in the fruit samples from Yen Bai samples (6,90g/100g FW) was significant higher than those from Son La and Dien Bien (5.95 and 6.25 g/100 g, respectively).

Total sugar content and the content of fructose, glucose, saccarose and maltose are shown in the Table 6. The fructose content was determined as 1.88 to 2.06 g/100 g, glucose content as 1.39 to 1.52 g/100 g and two other disaccharide contents as 1.95 to 2.23 g/100 g for saccharose and 0.22g to 0.36g/100g for maltose. Total sugar content was significantly higher in son tra fruit samples from Yen Bai (6.25 g/100 g FW) than in those from Son La or Dien Bien provinces (5.64 and 5.71 g/100 g, respectively).

Table 6: Content of sugar in fresh son tra samples

Samples	**[1]Total sugar**	**Fructose**	**Glucose**	**Saccarose**	**Maltose**
[a] **DBF**	*5.71 ± 0.07*	1.91	1.42	2.11	0.22
[b] **SLF**	*5.64± 0.06*	1.88	1.39	1.95	0.27
[c] **YBF**	*6.25± 0.09*	2.06	1.52	2.23	0.36
T test	(*,1, a) $P_{DBF-SLF}$=0.27				
	(**,1, b) $P_{SLF-YBF}$=$1.9x10^{-4}$				
	(**1, c) $P_{DBF-YBF}$=$4x10^{-4}$				

* P > 0.05 => the difference not statistically significant.
** P < 0.05 => the difference statistically significant.

5. Micronutrient contents of fresh son tra fruits

Vitamins

Table 7 shows the contents of vitamin C, B_1, B_6, B_{12} and beta-carotene in son tra fresh fruits. It is notable that there was no trace of vitamin B_1, B_6, B_{12} and free fatty acids in these fruits. Vitamin C contents in son tra fruits from Dien Bien, Son La and Yen Bai were 19.02 ± 0.04; 22.91± 0.03 and 21.08± 0.02 mg/100g FW respectively.

The beta-carotene contents in fresh son tra ranged from 25.00 µg to 31.00 µg/100g.

Table 7: The content of vitamin C, B1, B6, B12, β-carotene and free fatty acids in fresh son tra fruits (FW)

Nutrients	**Results**		
	DBF	**SLF**	**YBF**
Vitamin C	***19.02*** *± 0.04*	***22.91*** *± 0.03*	***21.08*** *± 0.02*
aVitamin B_1	<	<	<
Vitamin B_6	<	<	<
Vitamin B_{12}	<	<	<
Beta-carotene	25.00	36.00	31.00

Some values are reported as ‘<’ meaning that the result was below the analytical limit of quantification (LOQ) or limit of detection (LOD).

Amino acid contents

Table 8 shows the content of standard amino acids in fresh son tra collected in Dien Bien, Son La, and Yen Bai. Eight essential amino acids and 9 nonessential amino acids were detected. The essential amino acids - valine, lysine, isoleucine, leucine and phenylalanine made up the large percentage (around 8.06- 22.82 mg/100g FW). Nonessential amino acids varied from 5.42 to 26.05 mg/100g FW. Among those non-essential amino acids, proline, aspartic acid, glutamic acid, and glycine appeared with relatively high content.

The following were not found: tryptophan (essential amino acid) and selenocysteine, asparagine, cysteine, and ornithine (nonessentials).

Table 8: Content of amino acids in son tra fruits

Nutrients	**Samples**		
	DBF1	**SLF1**	**YBF1**
Histidine	5.32	6.29	5.87

Valine	17.27	16.95	16.49
Methionine	2.29	1.81	1.79
Lysine	22.82	20.83	16.34
Leucine	22.62	19.95	21.44
Isoleucine	8.06	8.91	9.11
Phenylalanine	18.38	18.07	16.78
Threonine	10.25	9.60	8.14
Tryptophan	**NT	NT	NT
Arginine	10.01	11.28	11.36
Alanine	11.23	12.59	10.94
Proline	12.41	13.48	13.72
Cystine	ND*	ND*	ND*
Tyrosine	6.03	5.67	5.42
Aspatic acid	26.05	23.25	25.15
Serine	8.83	9.02	8.17
Glutamic acid	17.02	16.55	15.94
Glycine	10.22	11.17	12.89
Selenocysteine	**NT	NT	NT
Asparagine	**NT	NT	NT
Cysteine	**NT	NT	NT
Ornithine	**NT	NT	NT

* ND: No detection; **NT: No Test

Content of minerals in son tra

Table 9 shows the content of some essential minerals such as calcium, iron and phosphorus in son tra fruits.

Table 9: Content of minerals in fresh son tra fruits

Nutrients	**Unit**	**Results**		
		DBF	**SLF**	**YBF**
Ca	mg/100g	18.46 ± 0.06	18.88± 0.06	15.70± 0.08
Fe	mg/100g	0.21 ± 0.03	0.23± 0.02	0.19± 0.02
P	mg/100g	26.40 ± 0.06	18.88± 0.08	17.60± 0.08

The content of iron in fresh fruits was 0.21-0.23 mg/100g, as high as that of jujube, while the content of calcium and phosphorus in jujube is higher than that of son tra -25mg/100g and 44mg/100g respectively.

6. Comparison of selected nutrient contents of fresh and dried son tra fruits

For this comparison, protein, carbohydrate, vitamin C, and sugar contents of son tra fruit samples were analyzed and compared. It should be noted that samples were only collected in one location (Tram Tau) of the Yen Bai province.

Table 10: Selected nutrient contents in fresh and dried son tra fruit samples collected in Yen Bai

No	Unit (/100g)	Content of fresh fruit samples	Content of fresh fruit samples in dried basic	Content of dried fruit samples
Water	g	88.98		10.91
Protein	g	0.42	3.81	3.38
Lipid	g	0.24	2.17	1.99
Carbohydrat	g	6.90	62.61	54.82
Total sugar	g	6.25	56.71	52.02
Fructose	g	2.06	18.69	15.41
Glucose	g	1.52	13.79	10.89
Saccharose	g	2.23	20.24	18.51
Maltose	g	0.36	3.27	3.09
Vitamin C	mg	2.32	21.08	18.73

The fresh fruit has considerably greater levels of protein, carbohydrate, and total sugar than dried fruit. The content of vitamin C in fresh fruits is slightly higher than dried fruits.

IV. DISCUSSIONS

Nutritional facts of son tra fruit

Each 100 g sample of fresh fruit contained about 0.42-0.52 g protein, 0.24-0.28 g lipid, 5.95-6.90 g carbohydrates, and equivalent to 29.33-31.44 Kcal. The nutritional content of son tra fruit is less than that of orange, lemon, apple, etc. (Table 11).

Table 11: Nutrient composition of some common fresh fruits and the tested samples amount/100g [27]

Component	Unit	Orange	Lemon	Pear	Apple	*Hawthorn	SLF	YBF
Water	G	88.8	92.5	87.8	89.50	84.7	84.66	82.42
Energy	Kcal	38.0	24.0	45.0	38.0	29.33	28.20	31.44
Protein	G	0.90	0.90	0.70	0.80	0.52	0.47	0.42
Lipid	G	0.10	0.30	0.20	0.20	0.25	0.28	0.24

Carbohydrate	G	8.30	4.50	10.20	8.30	6.25	5.95	6.90
Ash	G	0.50	0.50	0.50	0.50	2.31	2.12	2.34
Total sugars	G	9.35	K	9.80	K	5.71	5.64	6.25
Fructose	G	K	K	6.23	K	1.91	1.88	2.06
Glucose	G	K	K	2.76	K	1.42	1.39	1.52
Saccharose	G					2.11	1.95	2.23
Maltose	G	K	K	0.01	K	0.22	0.27	0.36
Ca	Mg	34.00	40.00	19.00	44.00	18.46	18.88	15.70
Fe	Mg	0.40	0.60	0.30	0.20	0.21	0.23	0.19
P	Mg	23.00	22.00	16.00	25.00	26.40	18.88	17.60
Vitamine C	Mg	40.00	77.00	4.00	24.00	19.02	22.91	21.08
Vitamine B1	µg	0.08	0.04	0.02	0.06	ND	ND	ND
Vitamine B6	µg	0.06	0.11	0.03	0.08	ND	ND	ND
Beta-carotene	µg	71.00	K	27.00	5.00	25.00	36.00	31.00

Note: ND: No Detection
K: No Information

* *Hawthorn mean for fruits of Crataegus species*, which is found in China

The iron content in son tra ranged from 0.31-0.42 mg per 100g fresh fruits, similar to other fruits such as oranges (0.40 mg), lemons (0.60 mg) and kiwis (0.31 mg). The phosphorus content in son tra samples varied from 17.60 to 26.40 mg/100g fresh fruits, also similar to orange, lemon, apricot, jujube and pear (16-26 mg/100g fresh fruits). Moreover, son tra samples also contained calcium with a value of 15.70-18.88 mg/100g fresh fruits.

Although protein makes up only a small portion of son tra fruits, it is notable that son tra samples contained almost all essential amino acids. As shown in the Table 11, lipid content in son tra fruits is higher than those of oranges, pears, and apples, similar to hawthorn, but lower than that of lemon. In addition, beta-carotene content in son tra fruits is higher than that of pear, apple, and hawthorn but lower than that of oranges. The content of vitamin C in son tra fruits is about five times higher than those of pear but not much different to those of apple and hawthorn and lower than those of orange and lemon by two and three times, respectively. The amount of vitamin C that need each day depends on the age. Average daily recommended amounts for adults about 75-90 mg per day [http://ods.od.nih.gov/factsheets/VitaminC-Consumer/], therefore, eating 300-400 g son tra per day can provide the needed amount of vitamin C.

As reported previously in the literatures, *Docynia indica* fruits harvested from the wild in India has a vitamin C content of 14.8 mg/100g fresh pulp [14] and 85.1% moisture, 4.0g/100g ash, 6.7g/100g fat, 57.1g/100g carbohydrate, 200.5 mg/l00g calcium [15]. Our current study showed the vitamin C content in son tra to be around 1.5 times higher than those in India. Other parameters such as carbohydrates, lipid, calcium and ash were much lower than those in India.

In summary, this study delivered sound scientific evidences on the nutrient composition of son tra fruits in Vietnam. It shows that son tra contains vitamins and minerals in amounts similar to those of some popular fruits (orange, apple, pear, hawthorn). Thus, son tra could be considered as a good source of nutrients for human body.

Content of polyphenol in son tra fruits

In the list of top 100 richest on polyphenol food sources [23], son tra Vietnam can be placed in the position 87-95th (16.99mg to 24.96 mg GAE/100g in dried weight). Therefore, son tra could be classified as a fruit with relatively high content of polyphenol. Polyphenol has long been known to have antioxidant properties. These preliminary results provide foundational evidence about the health benefit son tra Vietnam - Docynia indica (Wall.) ***Decne*** fruits.

Nutrient content in dry and fresh son tra fruit

Dried fruits are easy for transportation, preservation, and usage. Additionally, as son tra is a seasonal fruit, the dried form can provide son tra for usage year-round.

The comparison of nutrition content in fresh and dry fruit can partially suggests the change in nutrient content after processing and preservation. For a more reliable conclusion about these differences, more samples should be analyzed for further study.

V. Conclusion

This was the first study conducted on nutrient composition of son tra in Vietnam, and has provided a scientific foundation the further studies. The results of the study show that son tra fruits contain nutrients essential to the human body comparable to other valuable fruits, and are especially high in polyphenol content. Polyphenol has long been known to have antioxidant properties, which are certainly connected to the potential health benefits of son tra.

Because son tra is a seasonal fruit and it grows only at high elevations in remote areas, the transportation of fresh fruits to lowland areas is difficult and costly. Dried fruits are easy for transportation, preservation, and usage. The comparison of nutrient content in fresh and dry fruits partially suggests the change in nutrient content after processing and preservation, as well as serving as a foundation to improve the son tra supply through product diversification.

The results also suggest that the nutritional content of son tra fruits may differ between regions, in this case – Son La, Dien Bien, and Yen Bai provinces.

This research analyzed the nutrient compositions including macronutrients (carbonhydrates, proteins, and fats, free sugars including monosaccharid (fructose and glucose) and disaccharide (maltose and sucrose), and micronutrients including: vitamin group (vitamin C, B1, B12, and beta-caroten), amino acids, and some essential minerals (calcium, iron and phosphorus) in the son tra fruits.

Phytochemical screening of son tra samples collected in Dienbien, Sonla, and Yenbai regions in Vietnam showed the present of phytochemical groups including polyphenols, saponin, tannin, organic acid, amino acid, and reducing sugar. These data provide very useful information for further biochemical characterization of son tra fruits and for testing the health benefits of fresh fruits and its processed products.

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