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Determination of Water-Soluble Vitamin Content in Selected Vegetables and Fruits

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Abstract

The aim of this study was to determine the amounts of water-soluble vitamins [thiamine hydrochloride (B_1), riboflavin (B_2), nicotinic acid (B_3), pantothenic acid (B_5), pyridoxine hydrochloride (B_6), folic acid (B_9) and vitamin C] in some vegetables and fruits using HPLC.

It was determined that vitamin B_1 in vegetables and fruits ranged from 0.09±0.01 to 19.00±1.7 µg/g, vitamin B_2 from 0.12±0.01 to 5.80±0.51 µg/g, and vitamins B_3, B_5, and B_6 in the same samples ranged from 0.52±0.04 to 101.00±9.30 µg/g, 0.43±0.03 to 49.60±4.40 µg/g, and 0.41±0.03 to 180±17 µg/g, respectively. Vitamins B_9 and C ranged from 0.09±0.01 to 150.00±14.00 µg/g and 35.00±3.00 to 1593.00±121.00 µg/g, respectively.

Our findings suggest that the majority of fruits and vegetables are sufficiently rich in water-soluble vitamins.

Keywords: Vitamin B_1, B_2, B_3, B_5, B_6, B_9, C, fruit and vegetable

1. Introduction

Vitamins can be divided into two main groups: water-soluble and fat-soluble. The majority of water-soluble vitamins make up the B complex. In fact, the term B complex refers to all known essential water-soluble vitamins, except vitamin C. B vitamins function as follows: thiamine (B_1), riboflavin (B_2), niacin (B_3), pantothenic acid (B_5), pyridoxine (B_6), biotin (B_7), folate (B_9), and cobalamin (B_{12}). B vitamins act as coenzymes in various enzymatic processes, including important functions in the brain and nervous system [1]. Specifically, the active forms of thiamine, riboflavin, niacin, and pantothenic acid function in the electron transport chain of the citric acid cycle. Consequently, they form essential coenzymes in mitochondrial aerobic respiration and cellular energy production through their direct role in the formation of adenosine triphosphate (ATP), the cell's energy unit. Acetyl-CoA containing pantothenic acid provides the main substrate for this cycle [2]. B vitamins have reciprocal contributions to the citric acid cycle and the electron transport chain, a central catabolic process in mitochondria [3].

Vitamin C is one of the essential, water-soluble vitamins required for the normal metabolic functions of the human body. It exists in two biologically active forms: L-ascorbic acid and L-dehydroascorbic acid. Both forms exhibit vitamin C activity. L-ascorbic acid is readily oxidized to DHA, which can then be reduced back to ascorbic acid. This occurs through the transfer of electrons, due to vitamin C's ability to act as an electron donor (reducing agent or antioxidant) for other molecules. This reducing role of vitamin C explains many of its biochemical and molecular functions in the body [4], [5].

Vitamin deficiency causes serious illnesses, metabolic disorders in humans, even though only small concentrations are needed to maintain good health, and this can lead to disease or even death [6], [7].

As is known, vitamins are natural components of foods, and a balanced diet provides all the necessary vitamins. Water-soluble vitamins, which play an important role in catabolic and anabolic metabolism, are excreted in the urine. Since these vitamins are not stored in the body, they need to be consumed daily. Therefore, it is necessary to know which foods are rich in vitamins. For this reason, the study aimed to determine the levels of seven water-soluble vitamins—thiamine hydrochloride (B_1), riboflavin (B_2), nicotinic acid (B_3), pantothenic acid (B_5), pyridoxine hydrochloride (B_6), folic acid (B_9), and vitamin C in commonly consumed fruits and vegetables.

2. Materıal and Methods

Fresh vegetables and fruits obtained from the market were wrapped in aluminium foil, kept in the refrigerator at 4°C, and analysed within a maximum of 1 days. For the analyses, 1.0–2.0 g of the thoroughly homogenized samples was taken into PVC tubes, and 0.5 mL of 1.0 M HClO4 was added to each tube. After vortexing, the total volume was made up to 5 mL with distilled water, and the mixture was incubated in an ultrasonic water bath at room temperature for 10 minutes. It was then centrifuged at 4500 rpm for 10 minutes, and the supernatant was carefully transferred to 1.0 mL HPLC vials. The studies were performed using HPLC (SHIMADZU Prominence-I LC-2030C 3D Model PDA detector) on a Supelcosil LC-18-DB column (150 mm - 4.6 mm ID; 5 µm) at a flow rate of 1.0 mL/min, with methanol-5 mM heptane sulfonic acid sodium salt 0.1% triethylamine (TEA) (25:75 v/v); pH 2.8 mobile phase.

Vitamins B_1, B_2, B_3, and B_5 were determined at 260 nm, vitamin B_6 and vitamin B_9 at 290 nm, and vitamin C at 245 nm wavelength [8], [9].

2.1. Statistical analysis

All measurements were made in three parallels, and the results were given as Mean ± Standard deviation and statistical significance was expressed as $p<0.05$.

3. Results and Discussion

Table 1 shows the amounts of vitamins B_1, B_2, B_3, B_5, B_6, B_9, and C in some vegetables and fruits. However, among the general public, all of these researched materials are referred to as vegetables.

As shown in Table 1, among the vegetables examined, cabbage and lettuce were relatively poor in vitamins, while sorrel and rhubarb were richer. Similarly, among fruits, cucumber and eggplant were relatively poor in vitamins, while peas and tomato were richer.

Vitamin B_1 is a coenzyme in the pentose phosphate pathway, an essential step in the synthesis of aromatic amino acid precursors of fatty acids, steroids, nucleic acids, various neurotransmitters, and other bioactive compounds necessary for brain function [10].

The lowest B_1 content in the examined vegetables and fruits was found in radish and eggplant, respectively while the highest amounts were found in rhubarb and tomato, respectively.

Vitamin B_2 undergoes phosphorylation to produce Flavin mononucleotide (FMN), which is then broken down into Flavin adenine dinucleotide (FAD). As cofactors in energy metabolism, FMN and FAD are essential for coenzyme function in various oxidation and reduction reactions in all aerobic life forms [11].

Table 1. Vitamin B and C contents of various fruits and vegetables.

Fruit / Veritable	Vitamins (µg/g)						
	B_1	B_2	B_3	B_5	B_6	B_9	C
Carrot*	0.68±0.04	0.58±0.03	7.50±0.54	3.90±0.32	4.64±0.38	0.18±0.01	98±90
Black carrot*	0.52±0.04	0.34±0.02	12.11±1.04	3.2±0.28	3.72±0.30	0.16±0.01	105±90
Cabbage*	0.47±0.04	0.33±0.25	3.90±0.32	2.2±0.18	0.6±0.05	0.45±0.03	353±28
Red cabbage*	0.53±0.04	2.9±0.23	16.94±1.42	2.4±0.18	1.9±0.13	0.92±0.07	982±83
Fresh mint*	1.08±0.08	3.43±0.28	16.29±1.48	4.26±0.36	3.92±0.32	1.19±0.1	262±21
Parsley*	1.89±0.15	1.97±0.16	21.85±1.82	2.40±0.19	1.62±0.12	1.76±0.13	1593±12
Green onion leaf*	0.51±0.04	0.64±0.05	2.38±0.18	0.43±0.03	0.57±0.04	0.62±0.05	242±18
Dry onion*	0.71±0.06	0.48±0.03	6.76±0.55	0.72±0.06	1.42±0.11	0.4±0.03	79±70
Spinach*	0.56±0.04	1.06±0.09	2.11±0.15	2.54±0.2	1.20±0.1	2.28±0.19	354±26
Radish*	0.35±0.03	0.35±0.03	2.35±0.19	0.82±0.07	0.90±0.08	1.1±0.09	201±17
Dill*	0.61±0.05	1.28±0.11	8.52±0.76	1.76±0.15	0.95±0.09	1.41±0.11	302±26
Lettuce*	0.39±0.03	0.34±0.03	1.84±0.15	1.12±0.1	0.64±0.05	1.36±0.11	65.00±60
Purslane*	0.66±0.06	4.16±0.38	17.52±1.51	0.82±0.07	2.71±0.23	0.7±0.06	248±20
Cress*	2.10±0.18	4.90±0.42	18.94±1.81	0.64±0.05	3.31±0.28	1.20±0.11	835±75
Sorrel*	2.34±0.20	5.38±0.48	13.23±1.24	0.71±0.06	3.44±0.29	3.61±0.30	870±78
Arugula *	0.95±0.08	1.92±0.18	13.56±1.29	3.60±0.31	1.88±0.17	8.23±0.77	1085±91
Leek*	0.66±0.05	0.69±0.06	4.13±0.37	1.50±0.14	1.54±0.14	0.56±0.05	218±19
Potato*	0.54±0.04	0.41±0.03	0.52±0.04	2.68±0.22	16.4±1.54	0.12±0.01	235±21
Garlic*	1.25±0.10	0.69±0.06	10.28±0.95	1.06±0.09	13.04±1.20	0.46±0.40	116±10
Broccoli*	0.55±0.04	0.58±0.05	2.86±0.22	2.26±0.19	0.75±0.07	1.49±0.13	996±89
vine leaf*	3.66±0.30	0.66±0.06	1.67±0.16	0.51±0.04	4.51±0.41	2.1±0.19	570±51
Cauliflower*	0.38±0.03	0.57±0.05	3.36±0.29	3.59±0.31	6.40±0.59	1.0±0.10	450±41
Rhubarb*	19.00±1.7	2.38±0.19	73.47±6.96	2.90±0.23	180.00±17	6.32±0.56	290±24
Cucumber**	0.43±0.04	0.49±0.04	1.78±0.16	2.6±0.22	0.51±0.04	0.12±0.09	119±9
Squash**	0.56±0.04	0.46±0.03	5.20±0.35	1.10±0.09	0.90±0.08	0.09±0.01	154±13
Fresh bean**	0.58±0.04	0.83±0.07	2.95±0.23	0.46±0.03	0.47±0.04	0.39±0.03	156±14
Peas**	3.04±0.28	1.19±0.10	9.58±0.88	0.52±0.04	5.56±0.50	0.63±0.05	476±42
Green pepper**	0.61±0.05	0.49±0.05	4.53±0.40	3.1±0.28	3.95±0.35	0.36±0.30	1451±11
Red pepper**	0.66±0.06	0.42±0.03	3.60±0.32	0.73±0.06	1.28±0.11	0.13±0.01	797±53
Tomato**	7.54±0.70	5.80±0.51	101±9.30	49.6±4.40	17.92±1.60	150.00±14	389±36
Eggplant**	0.09±0.01	0.12±0.01	2.89±0.22	1.17±0.10	0.41±0.03	0.23±0.02	35±3.0
Strawberry**	0.38±0.03	0.57±0.05	1.04±0.01	1.21±0.10	3.75±0.32	0.30±0.02	306±27

Plants that are botanically classified as vegetables (*) and fruits (**) are denoted accordingly

The lowest amounts of vitamin B_2 in vegetables and fruits were found in cabbage and eggplant, respectively while the highest amounts were found in sorrel and tomato.

Vitamin B_3, is a precursor to NAD and NADP, which are cofactors for many enzymes in the body. There are numerous redox reactions in which NAD and NADH are converted into each other. This vitamin plays a vital role in human health by facilitating energy synthesis and supporting antioxidant defense mechanisms [12].

The lowest amounts of vitamin B_3 in vegetables and fruits were found in potato and strawberry, respectively, while the highest amounts were found in rhubarb and tomato.

Vitamin B_5 is a substrate for the synthesis of the commonly found CoA. Besides its role in oxidative metabolism. Vitamin B5 contributes to the structure and function of brain cells through its role in the synthesis of CoA. Cholesterol, amino acids, phospholipids, and fatty acids. Its contribution to the endocrine system, particularly in hormone synthesis and regulation, is equally important [13].

In terms of vitamin B5 content, the poorest vegetables and fruits are green onion leaves and fresh bean, respectively, while the richest are fresh mint and tomato.

Vitamin B_6 acts as a catalyst in a number of important biochemical reactions, including protein metabolism, nervous system functions, red blood cell production. immune system strengthening, and hormonal balance. Additionally, vitamin B_6 plays a role in the synthesis of neurotransmitters such as serotonin, norepinephrine, and dopamine [14].

The vegetables and fruits poorest in vitamin B_6 are green onion leaves and eggplant, respectively while the richest are rhubarb and tomato.

Vitamin B_9 is known in its active form as tetrahydrofolate (THF). B9 plays a vital role in a number of cellular reactions known as folate-mediated single-carbon metabolism, including DNA synthesis. DNA and RNA modifications, red blood cell production and metabolism of amino acids necessary for cell division, and the synthesis of amino acids and nucleic acids [15].

The vegetables and fruits poorest in vitamin B9 are potato and squash, respectively, while the richest are arugula and tomato.

Vitamin C acts as an electron donor for numerous enzymes involved in collagen biosynthesis, peptide amidation, tyrosine metabolism, carnitine biosynthesis, and catecholamine biosynthesis. It is also a potent antioxidant and has been shown to protect lipids in human plasma from oxidative damage. It contributes to the conservation of reduced glutathione (GSH) and the regeneration of α-tocopherol. Vitamin C is known to scavenge nitrosing agents and inhibit the formation of potentially mutagenic N-nitroso compounds [16].

The lowest amounts of vitamin C in fruits and vegetables are found in lettuce and eggplant, respectively while the highest amounts are found in parsley and green pepper.

Uğur et al. (5) found in their research that the amounts of vitamin C in red pepper, broccoli, green pepper, red cabbage, tomato and strawberry are consistent with our findings.

Mina et al. (17) determined the amounts of vitamins B_1, B_2, B_6 and C in beans, eggplant, carrots, green peppers, onions, potatoes and tomatoes. For example, they found the amounts of vitamins B_1, B_2, B_6 and C in green peppers to be 0.034, 0.050, 0,23, 102.267 mg/100g, respectively. They also reported that the amounts of vitamins B_1, B_2, B_6, and C in potatoes were 0.081, 0.093, 0.277, and 19.067 mg/100g, respectively. Their findings are consistent with our results.

Karatas et al. (18) reported that the vitamin B9 in dry onions, carrots, lettuce, cauliflower, parsley, cucumbers and spinach were 133, 140, 395, 560, 640, 280 and 658 ng/g, respectively.

It can be said that our findings are consistent with the findings of Karatas et al. (18).

Ismail and her friends (19) found the amounts of vitamins B_1, B_2, B_3, B_6 and B_9 in carrots to be 0.02, 0.02, 0.016, 0.06 and 0.19 mg / 100 g respectively, and the amounts in spinach to be 0.08, 0.1, 0.01, 0.26 and 0.12 mg / 100 g respectively. It can be said that their findings are consistent with our findings.

Kasim and Kasim (20) determined the amounts of vitamins C, B_1, B_2, B_3, B_6 and B_9 in samples of tomatoes, red peppers, eggplants, carrots, radishes, cabbage and strawberries. For example, they reported that the amounts of vitamins C, B_1, B_2, B_3, B_6 and B_9 in tomatoes were 19.8, 0.03, 0.025, 0.613, 0.076 and 13 mg/100 g respectively, and in radishes they were 19.2, 0.031, 0.018, 0.249, 0.055 and 117 mg/100 g respectively. It can be said that the results in the literature are consistent with our findings.

In some cases, the presence of vitamin values that do not conform to the literature can be explained by differences in the harvesting times and geographical conditions of the samples.

4. Conclusion and Suggestions

The water-soluble vitamin content of fruits and vegetables consumed raw or cooked was compared. Considering that water-soluble vitamins are degraded by heat and pass into the cooking water. changes in vitamin content depending on cooking and storage conditions can be investigated.

Conflict of Interest

Author declares that there is no known conflict of interest.

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