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Evaluation of Nutrient Composition of Ripe and Unripe Fruits of *Solanum sisymbriifolium*

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ABSTRACT—

Introduction: Solanum sisymbriifolium or lychee tomato is a small, viscid, and prickly wild shrub native to South America, widely distributed throughout Bangladesh. Although roots and other aerial parts of this plant are traditionally used for treating various ailments, much work has not yet been done to elucidate its nutritional and economic importance of the edible fruit of this medicinal plant. Therefore, to explore the nutritional value as a food source, the proximate value and mineral content of ripe and unripe fruit of S. sisymbriifolium were assessed in this study.

Materials and methods: AOAC methods have been followed to determine the proximate content, while the analysis of the mineral content has been done by using standard analytical methods.

Result and Discussion: This study investigated proximate values (moisture, ash, crude fiber, crude protein, and lipid) and selected mineral contents- magnesium (Mg), phosphorus (P), calcium (Ca), sodium (Na), iron (Fe), and potassium (K) of ripe and unripe fruits of Solanum sisymbriifolium using standard analytical methods. Compared to other minerals, Mg was present in higher concentrations in both ripe and unripe fruits. The concentration of Fe in unripe (0.013 mg/100g) and ripe fruit (0.024mg/100g) was the lowest. Although proximate compositions were variable between ripe and unripe fruits, only Ca was found in higher amount in the unripe fruit (08.91 mg/100g) than the ripe fruit (06.73 mg/100g) among all the other tested minerals which makes it a more preferable option for consumption.

Conclusion: The unripe and ripe fruits (preferably) of Solanum sisymbriifolium could be introduced as a functional food in the community for health promotion.

Keywords— *Solanum sisymbriifolium , Ripe fruit, Unripe fruit, Proximate composition, Mineral elements.*

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1. INTRODUCTION

Malnutrition continues to be a major component of illness and heightened mortality rates in developing countries. Most people in developing countries lack the means to afford effective and modern healthcare, including medicines used to treat various diseases [1]. Soaring concern about increased health care costs has prompted the researchers to develop cost-effective interventions centralizing on plant-derived products to tackle this critical public health problem. This led to the development of a new trend called Phyto-therapy where plant food and medicine are associated with specific therapies. With plant extracts, however, efficacy, less toxic side effects, and rational precautionary measures are often established [2]. Unfortunately, the majority of people in Bangladesh are suffering from malnutrition due to the ignorance of the nutritive value of fruits and vegetables abundant in this region [3].

Mineral elements are very vital for the maintenance of essential physiochemical processes of the body systems and can be categorized into two; macro (major) and micro (trace) minerals. Although the need for micro-minerals is lower than that of macro-minerals, they are essential and critical for health and immunity [4]. As they are important for growth, production, and reproduction [5] and serve as cofactors of several enzymes, the deficiency of these elements puts human health at great risk [6]. Lack of adequate information about the mineral elements of various wild plant sources in developing countries is the major drawback to their utilization to address this issue. Malnutrition can be overcome by incorporating micronutrients and phytochemical comprising fruits and vegetables into the diet [7].

Proximate analysis is important for determining various aspects of the food such as moisture and ash content are the determiner for microbial stability and total amounts of minerals respectively [8].The fat portion of food shapes the overall sensory characteristics while proteins are the building blocks of amino acids [9,10]. Lastly, the crude fiber content indicates the amount of indigestible fiber present in the food [11].

Solanum sisymbriifolium, also known as Viscid Nightshade, belongs to the largest family of flowering plants, Solanaceae, widely dispersed throughout Bangladesh due to their vast adaptive capacity. Although this plant has shown promising medicinal aspects, its nutritional value is yet to be elucidated. It is a vastly branched, viscid, prickly wild plant of 0.8-1.5 m in height. They are found abundantly on waste places, roadsides, landfills, and plowed fields as they are resistant to almost all types of soil. The plant has lobed or un-lobed leaves, pale blue and white flowers, fruits are globular berries and the fruit was encased in large, spiny calyces. Immature green fruits turn vibrant shiny red-colored and the flavor resembles tart cherries, with a tiny hint of tomato. The small edible succulent ripe fruits of the plant contain flattened, pale yellow seeds. In many regions, they are eaten raw and also cooked as ingredients in stews, sauces, jams, or pies. Insect and pest resistance and animal resistance feature of this plant due to the presence of Phyto-compounds containing foliage and spines respectively makes them worthwhile for sustainable and eco-friendly growers looking for naturally pest-resistant crops. Furthermore, litchi tomatoes are fast harvesting and take about only 3 months to produce their first fruit. Thus it could be a useful crop for serving various purpose if its fruits are established as a greater value as a crop [12].

Traditionally the root and the other parts of the plant have been stated to be used in treating pain, rheumatic disease, inflammation, hypertension, respiratory and urinary tract infections, and numerous central nervous systems disorders [13,14]. The existence of varied groups of phytochemicals in *Solanum sisymbriifolium* may be accountable for the reported activities. The root of this plant has been used to be effective as a diuretic and antihypertensive [15], emmenagogue [16], and fertility regulator [17], and several bioactive chemical constituents, such as cuscohygrine [18], solacaproine [19], solamine, solasodiene, and solasodine [20]. Studies also revealed that certain pirosolane-type and solanidane-type alkaloids are present in this plant [21]. Solasodine (molecular formula: C27H43NO2), an essential element of corticosteroids, sex hormones, and oral contraceptives has been successfully extracted from this plant [22]. Moreover, compounds possessing cardiovascular effects [23], anticonvulsant [13], and molluscicidal activity have also been found in this plant [24]. Results also showed the presence of a generous amount of several important phytonutrients in litchi tomatoes [25]. Research at the USDA-ARS Prosser worksite and the University of Idaho revealed that the berries shows a significant amount of antioxidant activity and also found to contain ascorbic acid, polyphenols, and b-carotene.

All these data suggest that the fruits of *S. sisymbriifolium* have the potential of a valuable food crop for possessing a good source of phytonutrients which expands the functionality of the plants as a medicinal herb. Although proximate value and mineral content of fruit indicate its value as an important source of nutrition, very little assessment have been done of the berries to determine their most effective consumption stage. The present study thus focuses on bridging the gap by determining how the quality of the fruits is changed through the ripening process in order to incorporate into the diet as a potential source of nutrition.

2. MATERIALS AND METHODS

2.1 Sample Collection and Extraction:

The samples for the present study were collected from the hilly areas of Khulshi, Chittagong, a district of Bangladesh. The experiment was carried out in the Department of Biochemistry and Molecular Biology, and Dr. Sheikh Bokhtear Uddin, Professor, Department of Botany, University of Chittagong, identified the plant. After collection the fruits were washed thoroughly and dried up for 4-5 days. The dried fruits were ground to a fine powder separately by using an electric grinder and finally, stored in air tight dark containers at 25^0C for the experiment.

2.2 Proximate Composition Analysis:

The moisture content of unripe and ripe fruits of *Solanum sisymbriifolium* was measured by following the method of the Association of Official Analytical Chemist (AOAC, 1980) [26], and the ash was determined by the standard method of AOAC (1995) [27]. The other nutrients such as crude protein was determined by the Micro-Kjeldahl method of AOAC (1960) [28], whereas crude fiber and lipid content were determined by AOAC (1980) [26].

2.3 Estimation of Mineral content:

The estimation of selected minerals, magnesium (Mg), phosphorus (P), calcium (Ca), sodium (Na), iron (Fe), and potassium (K) of ripe and raw fruit of *Solanum sisymbriifolium* was determined by the process as described in analytical methods (Petersen, 2002) [29]. Means of three replicates were considered for the result.

3. RESULT

3.1 Proximate Composition:

The proximate value and mineral composition of raw and ripe fruits of *Solanum sisymbriifolium* have been analyzed in this present study. It showed the percentage of moisture, ash, lipid, protein, and crude fiber present in both developing stages of fruits. In Table 1, the content of moisture, ash, lipid, protein, and crude fiber were respectively 81.07, 6.05, 13.72, 17.04, and 12.29 percent in unripe fruits and 76.24, 5.83, 12.84, 19.37, and 11.76 in ripe fruits are shown.

Table 1: Selected nutrients in ripe and unripe fruits of *Solanum sisymbriifolium.*

Parameters	Amount (%)	
	Unripe fruit	Ripe fruit
Moisture	81.07±1.51	76.24±2.08
Ash	6.05±0.13	5.83±0.35
Lipid	13.72±0.06	12.84±0.09
Protein	17.04±1.30	19.37±0.54
Crude Fibre	12.29±0.09	11.76±0.14

3.2 Mineral Content:

Table 2 represents the presence of six mineral contents of unripe and ripe fruits in terms of mg per 100 gm. Among the selected minerals both the ripe and unripe fruit is rich in magnesium which is 31.40 and 23.55 mg/100gm, respectively. The concentration of others such as potassium (k), calcium (Ca), phosphorus (P), iron (Fe) and sodium (Na) were 10.38, 08.91, 11.80, 0.13, and 0.61mg/100 gm in unripe fruits and 15.61, 06.73, 17.54, 0.24, and 1.57 in ripe fruits, respectively.

Table 2: Selected minerals in ripe and unripe fruits of *Solanum sisymbriifolium.*

Parameters	Amount (Mg/100g)	
	Unripe fruit	Ripe fruit
Potassium (k)	10.38±0.64	15.61±1.52
Calcium (Ca)	08.91±0.78	06.73±2.03
Phosphorus (P)	11.80±1.07	17.54±0.60
Magnesium (Mg)	23.55±3.03	31.40±2.28
Iron (Fe)	0.13±0.002	0.24±0.005
Sodium (Na)	0.61±0.34	1.57±0.07

4. DISCUSSION

4.1 Proximate Composition:

Recently, the significance of consuming a broad spectrum of edible plant sources has been pin down to address the escalating food and feed shortage. A plant-based diet is sufficient in providing carbohydrates, proteins, fats, vitamins, and minerals [30]. Numerous plans of action, the FAO's "Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources" and "Rome Declaration on World Food Security" [31, 32] have encouraged us to better understand the potential of wild and underdeveloped species in food and wider use.

Moisture is vital for various physiological reactions and the existence of plants [33]. Raw or unripe fruit (81.07%) of *Solanum sisymbriifolium* contain higher moisture content than that of the ripe berries (76.24%) (Table1), which is supported by the study that suggests that reduction in moisture percentage, might be universal and continued throughout the ripening process in some fruit [34].

The ash content did not show much difference between the two developmental stages. It is slightly low in the ripe fruits (5.83%) than that of immature ones (6.05%) (Table1). Overall the low ash content in both ripe and unripe fruits indicates that the food material possesses less mineral content. Based on the previous findings it can be stated that the berries contain moderate mineral elements [35]. Moreover, several other studies have shown supported evidence of decreasing ash content with ripening [36, 37].

Ripe fruits (12.84%) contain less fat content compared to immature green fruits (13.72%) (Table 1), a phenomenon reported by Barbera, G., et al [37]. This phenomenon could be explicated by the alteration of the lipid metabolism process to support the ripening of the fruit [38] where extra energy is provided by degrading the lipid membranes, during the process of ripening. Dietary fats act as energy sources and contribute to the diet increasing flavor and palatability of food [35].

The protein content has been found higher in ripe fruit (19.37%) than in raw fruit (17.04%)(Table 1) of *Solanum sisymbriifolium*. The proteins present in the plant might act as healing agents that provide the plant its medicinal potency to fight against numerous diseases [39]. Due to the lower risk of cardiovascular disease plant protein sources are superior to animal sources. Plant-based proteins lower LDL cholesterol and contain no cholesterol—an established key factor for heart disease.

Indigestible cellulose, lignin, pentosans, and other components of this type are classified as dietary fiber [40]. Crude fiber content between the two developmental staged fruits showed a slight difference (ripe fruit has 11.76 %, whereas raw fruit has 12.29%) (Table 1), and intake of dietary fiber have positive health benefits for preventing constipation, diabetes, hemorrhoids, obesity, coronary heart diseases, gallstones, and some type of cancer [41]. The descending order of protein, fat, and crude fiber percentage of the fruit reported by a study is similar to our findings [42].

4.2 Mineral Content:

Both plants and human beings require macro-minerals for maintaining biological functions and to activate hundreds of enzyme reactions. Fresh fruits and vegetables possess minerals [43] among which (Ca, K, Mg, and P) are essential for the entire plant [44]. The study has proved that withdrawal on the omission of these macro-minerals (among others) in plant nutrition subsequently developed several deficiency symptoms, for instance, chlorosis—a yellowing of healthy green leaf tissue [45, 46].

Both the mature and immature berries was rich in Magnesium that enhances their nutritional significance as it is the fourth most abundant dietary mineral [47]. However, the ripe fruits (31.40mg/100g) have a higher amount of Mg than unripe fruits (23.55 mg/100g) (Table 2). Because ripening creates a significant change in the concentration of Mg in green fruits which used as a central metal ion in Chlorophyll biosynthesis. It also acts as essential co-factor in several metabolic reactions [48] and an important constituent of bones, muscles, teeth, enzyme activity, and [49] prevents high blood pressure and depression [50].

Phosphorus exhibited a noteworthy presence in the ripe and raw fruits of *S. sisymbriifolium* and ripe fruit (17.54 mg/100g) possess higher content of P compare to raw fruit (11.80 mg/100g) (Table 2). The main function of phosphorus is in the formation of bones, teeth [51], and several other essential biomolecules such as phosphorylated metabolic intermediates and nucleic acids. It is also required to run several metabolic processes smoothly and to support the repair and maintenance of cells.

Between both types of fruits, the ripe fruits contain a higher concentration of K (15.61 mg/100g) compare to raw fruits (10.38 mg/100g) (Table 2). High K content indicates the enriched fruit color of ripe fruits. A potassium-rich diet may help to prevent stroke, maintain blood pressure and water balance of the body, and deficiency of it causes mental disorientation, fatigue, low blood sugar, numbness, muscle weakness, and coma [52]. K deficiency causes acid-base homeostasis and uncontrolled H^+ secretion [53].

Ca containing fruits reduces the incidence of osteoporosis and improves skeletal health [54], regulates nerve, muscle functions, and neuromuscular excitability [55]. Ripe fruits (6.73 mg/100g) were found to have less concentration of Ca in comparison with raw fruits (8.91 mg/100g) (Table 2). Although a low amount of Ca was found in the fruit as 0.224 g/kg reported by other researchers [42]. Several factors such as geographical location, soil and nutrient condition, or maybe the environmental aspects are responsible for this difference.

With the conversion of raw fruit to ripe one, the present study showed an escalation in sodium content and sodium found to be lower than potassium in both ripe (1.57 mg/100g) and unripe fruit (0.61 mg/100g) of *S. sisymbriifolium* (Table 2). Reducing sodium intake is nutritionally ideal for people suffering from high blood pressure [56]. A low sodium diet has been reported to inverse the problem of hypertension and high blood pressure while intake of potassium is beneficial to control the blood pressure [57]. The fruit of *S. sisymbriifolium* could be a suitable food to incorporate into the diet as it contains less sodium and high potassium.

The iron content of *S. sisymbriifolium* was 0.24 mg/100g and 0.13 mg/100g in unripe and ripe variety, respectively (Table 2), and was the least amount mineral among others. Its main role is to transport oxygen in the body by the formation of hemoglobin. The requirement of iron becomes prominent, especially during pregnancy. Iron deficiency syndromes such as extreme fatigue, anemia, weakness, depression, Headache, dizziness, poor resistance to infection [58] are relatively frequent in developing countries due to poor dietary iron intake [59].

Therefore, the results suggest that *S. sisymbriifolium* fruits are more beneficial more health if consumed ripened. Moreover, due to ripening variations in the proximate and mineral compositions with enhanced nutritional and medicinal properties of food crops have been reported [60, 61]. Diseases associated with mineral deficiency can be dealt with by consuming essential mineral and nutrient-rich diet [62].

5. CONCLUSION

The outcomes of this study demonstrated the extent of proximate value and selective mineral elements of both the ripe and unripe *S. sisymbriifolium* fruits. The variation in the results of this study showed that ripening significantly influenced the mineral composition of *S. sisymbriifolium* fruit as per except calcium concentrations all the mineral elements were higher in the ripe fruit. Therefore, consumption of the ripe *S. sisymbriifolium* fruit would be more beneficial for human health to supply the body with more minerals and nutrients. Taken together, the presence of phytonutrients and other crucial molecules make it a favorable fruit for treating malnutrition. Given their nutritional value, further study is required to explore the full potential of the sticky nightshade berries during ripening to promote its use in the diet to utilize their astounding benefits.

6. CONFLICT OF INTEREST

The authors declared no conflict of interest.

7. FINANCIAL SUPPORT

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