

Nutritional, Functional, and Microbial Evaluation of Dehydrated *Alternanthera sessilis* Powder: An Underutilized Green Leafy Vegetable

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Abstract

Green leafy vegetables hold a prominent place among food crops due to their high levels of nutrient composition. *Alternanthera sessilis* is a popular green leafy vegetable in India, which contains significant antioxidant activity and phytochemical content in it. In general, Green leafy vegetables tend to spoil easily as they are highly perishable in nature. To prevent losses and increase shelf-life, the demand for preservation and processing has been growing tremendously in the modern world. Therefore, the present study was intended to dehydrate the *Alternanthera sessilis* leaf employing the tray drying method and to analyze its various quality attributes such as Physical, Proximate, Functional, and microbial quality. The results indicate that the Dehydrated *Alternanthera s.* powder contains high levels of Calcium (379 mg±1.25), Fiber (3.56 g±1.5), protein (4 g±1.0), and possesses a high anti-oxidant activity of 77.35%. The obtained microbial results were found to be within the limit and indicate that dehydrated leaf powder was microbially safe and can be stored at ambient temperature for future use. Furthermore, it can be concluded from the research findings that the Dehydrated *Alternanthera s.* powder can be incorporated into different food items to combat micronutrient deficiencies in the developing countries.

Key words: *Alternanthera sessilis*, Dehydration leaf powder, Tray drying, Antioxidant activity, Preservation

Food is necessary for humans to meet their fundamental needs for growth and well-being. The idea of using food as medicine is prevalent in many conventional medical procedures and emphasizes the significance of nutrition. An unhealthy lifestyle has been related to several non-communicable diseases, including obesity, diabetes, cardiovascular disease, gastrointestinal disease, and comorbidities. However, there is proof that healthy eating can reduce the disease burden. More people are becoming aware of disorders linked to a sedentary lifestyle and how they affect dietary intake and overall health (1). Consuming a healthy diet is crucial for managing and preventing chronic diseases as well as improving one's overall sense of well-being.

Green leafy vegetables have a significant position among food crops as they are economically affordable and possess an array of micronutrients. They are a good source of minerals including calcium, iron, and phosphorus as well as vitamins such as beta-carotene, ascorbic acid, riboflavin, and folic acid. Numerous untapped greens in nature have a high nutritional value and may feed the world's expanding population. Several of them are climate-adaptive and tolerant. Despite the fact that they may be raised on marginal lands with lower maintenance costs, they are still underutilized due to a lack of awareness and

the lack of popularization of the technology needed for their preservation and innovative product development (2).

Green leaves tend to decay fast because most crops are seasonal, and they are also infrequently available in adequate numbers year-round (3). The high inherent moisture content of leaves must be quickly reduced to an acceptable residual percentage of moisture content to prevent any enzymatic reactions and oxidation. As a result, roughly 30% of the total production spoils rapidly, causing significant nutritional loss. To prevent losses and keep them accessible and available throughout the year at an affordable price demands preservation and processing techniques.

Alternanthera sessilis sometimes referred to as "sessile joy weed" locally, is a popular green leafy vegetable in India. *Alternanthera sessilis*, is a prostrate weed that is either annual or perennial and found abundantly in India's hottest regions. Indians frequently eat green *A. sessilis* stems and leaves as leafy vegetables, especially in South India where they are believed to have many health advantages. *Alternanthera sessilis* is a common ingredient in the cuisine of the people of Tamil Nadu and other South Indian states (4).

In order to feed the world's expanding population, there has been an increase in concern over the nutritional worth of

foods. Fortification and enrichment of food sources can help to make up for the lack of critical nutrients. The dehydration of green leaves can be a powerful tool in the effort to defeat malnutrition as it can enhance nutrient composition when incorporated into different food products. In this study, an attempt was made to dehydrate *Alternanthera sessilis* employing tray drying and to evaluate its various quality attributes such as physical, proximate, functional, and microbial analysis.

MATERIALS AND METHODS

Alternanthera sessilis (Ponnanganikeerai) was obtained from a local supermarket in Chennai. The project has been approved by the Independent Human Ethical Committee (IHEC) conducted by the Department of Home Science, SDNB Vaishnav College for Women, Chromepet, Chennai-44, on 12/10/2022. The Protocol No – SDNBVC/HSC/IHEC/2022/27. Dehydration of *Alternanthera sessilis* Leaf Powder Employing Tray Drying Method

Dehydrated leaf powder of *Alternanthera sessilis* (Ponnanganni) was formulated as per the methods suggested by (5). One of the earliest techniques of food preservation recorded in the literature was drying. By removing enough moisture from food during drying, foods are preserved from deterioration and spoilage. Tray dryer [Specification - Aluminium trays of dimensions approx. 80 x 40 x 3 cm. with a capacity of 5 kgs per tray, temperature – max. 1000c] was used to dehydrate A S leaves. Fresh leaves of *Alternanthera sessilis* were cleaned thoroughly and destemmed and only the leaves were weighed, washed, tray dried at 70 degrees Celsius for 5 hours, and blended into a fine powder in a domestic blender and stored in an airtight container.



Fig 1 *Alternanthera sessilis* and dehydrated leaf powder

Quality Analysis of Formulated Dehydrated Leaf Powder of *Alternanthera sessilis*

The dehydrated *Alternanthera sessilis* (AS) leaf powder was analyzed for its various quality attributes such as Physical, Proximate, Functional, and microbial quality.

Physical Properties of Dehydrated *Alternanthera sessilis* Powder

The physical properties such as Water Absorption Capacity (WAC), and Oil Absorption Capacity (OAC) were assessed for the dehydrated *Alternanthera sessilis* leaf powder (Ponnanganni) as per the method suggested by (6).

Proximate Analysis of Dehydrated *Alternanthera sessilis* Powder

The proximate composition of the dehydrated *Alternanthera sessilis* powder such as protein, fat, carbohydrate, energy, dietary fiber, moisture, ash content, Calcium, Vitamin A, and Iron was analyzed and the method followed for the same is exhibited in (Table 1).

Table 1 Proximate composition analysis technique and references

S. No	Parameters	Test Methods
1	Energy	AOAC, (2016)
2	Protein	AOAC, (2016)
3	Fat	AOAC, (2016)
4	Carbohydrates	(IS 1656 : 2007)
5	Fiber	AOAC, (2016)
6	Ash	AOAC, (2016)
7	Iron	(IS 1656 : 2007)
8	Moisture	AOAC, (2016)
9	Calcium	(IS 1656 : 2007)
10	Vitamin A	(IS 1656 : 2007)

Functional Properties of Dehydrated *Alternanthera sessilis* Powder

The functional properties of dehydrated *Alternanthera sessilis* leaf powder (Ponnanganni) such as Total phenol count, Total flavonoid count, and Antioxidant and Phytochemical properties were analyzed. The method followed for the same is exhibited in (Table 2).

Table 2 Functional Properties of Dehydrated *Alternanthera sessilis* (AS) Powder

Functional Properties	Method
Total phenol count	Folic-Ciocalteu Assay, (9)
Total flavonoid count	Colorimetric Assay, (10)
Antioxidant properties	DPPH radical scavenging activity, (11)
Phytochemical analysis	As per the method suggested by (12)

Microbial Analysis of Dehydrated *Alternanthera sessilis* Powder

Superior quality and safety are frequently top priorities when it comes to food and food items since they affect consumer acceptability and choice. Food with no or little microbial contamination can boost consumer confidence as well as food intake. Hence, to ensure the quality and safety of the food being processed, the microbiological examination is a crucial step (13). The dehydrated *Alternanthera sessilis* leaf powder (Ponnanganni) was analyzed for its Total Plate Count (TPC) by plate count method, and Yeast and Mold Count (YMC) by spread plate method. The method followed for the same is represented in (Table 3).

Table 3 Microbial analysis of dehydrated *Alternanthera sessilis* leaf powder

Microbial Analysis	Method
Total Plate Count (TPC)	(IS 5402 : 2012)
Yeast and Mold Count (YMC)	(IS 5402 : 2012)

RESULTS AND DISCUSSION

Physical Properties of Dehydrated *Alternanthera sessilis* Powder

The physical properties of dehydrated *Alternanthera sessilis* leaf powder (Water Absorption Capacity (WAC), and Oil Absorption Capacity (OAC)) were analyzed as per the standard for the dehydrated *Alternanthera sessilis* (AS) powder. The results are provided below (Table 4).

It has been proved that the amount of hydrophilic and lipophilic groups in proteins and carbohydrates determines how well food systems absorb water and oil. The Water Absorption and Oil Absorption Capacity of the dehydrated *Alternanthera sessilis* leaf powder (Ponnanganni) were found to be 3.52 ± 0.05

and 1.35 ± 0.01 respectively. According to (15), the Water Absorption Capacity and Oil Absorption Capacity of dried beetroot leaves powder were found to be 1.21 ± 0.041 and 1.23 ± 0.07 respectively, which was lower than the result obtained in the current investigation which could be due to the presence of less amount of the hydrophilic and lipophilic component present in the dried beetroot leaves powder. According to (16), Proteins play a crucial role in the creation of viscous meals including soups, gravies, dough, and baked goods by increasing water holding capacity, which improves the ability to swell. Moreover, as fat affects flavor retention and enhances food mouth feel, its ability to absorb oil plays a crucial function in food processing.

Table 4 Physical Properties of Dehydrated *Alternanthera sessilis* Leaf Powder

Parameter	Result
Water Absorption Capacity	3.52 ± 0.05
Oil Absorption Capacity	1.35 ± 0.01

Proximate analysis of dehydrated *Alternanthera sessilis* powder

The proximate composition of the dehydrated *Alternanthera sessilis* leaf powder such as protein, fat, carbohydrate, energy, dietary fiber, moisture, ash content, Calcium, Vitamin A, and Iron was analyzed employing standard procedures and the obtained results are tabulated in (Table 5) and compared with relevant literature.

Table 5 Proximate composition of dehydrated *Alternanthera sessilis* leaf powder

Nutrients	Dehydrated leaf powder
Energy (Cal)	65.4 ± 0.15
Protein (g)	4.0 ± 1
Fat (g)	0.012 ± 0.01
Carbohydrate (g)	0.290 ± 0.802
Dietary fiber (g)	0.356 ± 0.802
Ash (g)	0.51 ± 0.83
Moisture (%)	6.16 ± 0.01
Iron (mg)	5.0 ± 0.1
Calcium (mg)	379 ± 0.15
Vitamin A (mg)	50 ± 0.1

Energy

"Food energy is defined as the energy released by carbs, lipids, proteins, and other organic components" (17). Energy or food calories are measured in kilojoules (kJ) or kilocalories (kcal) and are produced when the three main calorogenic components (carbohydrates, fats, and proteins) in a diet are completely burned with enough oxygen (17). Generally, leafy vegetables have a low caloric value, making them ideal for weight management. The calorific value of dehydrated *Alternanthera sessilis* leaf powder was found to be 65.4 ± 0.15 kcal. This was higher than the study supported by (18), who stated the energy value of dehydrated beetroot leaves powder as $39.7 \text{ kcal} \pm 0.15$. Previous research work by (19), also recorded higher energy values in dehydrated betel leaves (285.14 ± 0.010). Hence, it can be concluded that the formulated dehydrated *Alternanthera sessilis* leaf powder was low in calories, making it appropriate for consumption by the general population who prefers low-calorie foods.

Protein

Proteins are necessary macronutrients that are important to the body's processes and operations. The result revealed that dehydrated *Alternanthera sessilis* leaf powder contained an

appreciable amount of protein ($4 \text{ g} \pm 1.0$) and this value was found to be higher than the protein content ($3.60 \pm 0.08 \text{ g}$) of dehydrated ash gourd peel by (20). However, the protein values of this current investigation were found to be lower than the protein value of dehydrated tender tamarind powder (4.8 ± 1.0) as reported by (21). The presence of a significant quantity of protein in Dehydrated AS. Leaf powder signifies that the dehydrated *Alternanthera sessilis* leaf powder can be considered as a concentrated source of protein and could be used as a novel ingredient to manage protein deficiency in developing countries.

Lipids

For a number of biological processes, lipids are essential nutrients. The amount of energy that can be converted from fats is significant, so 20–35% of the total energy consumed should come from fats (22). The fat content of the dehydrated *Alternanthera sessilis* leaf powder was found to be 0.012 ± 0.01 which was comparatively lower than the Fat content of dehydrated betel leaves (4.46 g), dehydrated Adusa (*Adhoda vasica*) leaves (2.5 ± 0.15), and dehydrated moringa leaves (5.54 ± 0.25) (23) (24)(25). Humans are considered to require a diet that contains no more than 1-2 percent of their caloric energy as fat, as excessive fat consumption has been linked to diseases like atherosclerosis, cancer, and aging (26). Hence, Dehydrated AS powder can be incorporated into different food products as it has a low calorific value.

Carbohydrates

Carbohydrates contribute to fat metabolism and spare proteins as an energy source for human beings (27) The body's main energy source is macronutrients called carbohydrates, which are composed of carbon, hydrogen, and oxygen (28) The Carbohydrate Content of the dehydrated *Alternanthera sessilis* leaf powder was found to be $2.90 \text{ g} \pm 0.001$, which was found to be almost similar when compared to the carbohydrate content of dehydrated Lettuce ($3.0 \text{ g} \pm 0.10$) as reported by (29) and higher than the carbohydrate content of dehydrated Ambadiyele and Kariyele leaves ($7.33 \text{ g} \pm 0.03$) as reported by (23). According to the results, dehydrated *Alternanthera sessilis* leaf powder is a good choice for consumers who are concerned about their health because of its low carbohydrate content.

Dietary fiber

The Fiber Content of the formulated dehydrated *Alternanthera sessilis* leaf powder was found to be $3.56 \text{ g} \pm 0.001$. The reported value in this study was found to be higher than dehydrated tamarind leaves powder (1.0 g), and dehydrated tomato powder (0.07 ± 0.01), (21)(30). According to (20) the dehydrated ridge gourd peel was reported to possess 3.26 ± 0.11 of dietary fiber which was found to be similar to the fiber content of Dehydrated AS leaf powder. Many studies have shown a connection between dietary fiber and body weight and general metabolic health (including effects on glucose and lipid regulation and insulin sensitivity). The results indicate that the Dehydrated AS leaf powder has high fiber content which tends to regulate the blood sugar level in diabetic individuals by reducing the absorption of fat and sugar from the food.

Ash content

"Ash refers to the inorganic residue present after complete oxidation of organic matter in a foodstuff". The amount of ash in the sample is a good indicator of the total number of minerals present in the food product. The ash content of the formulated dehydrated *Alternanthera sessilis* leaf powder was found to be $0.51 \text{ g} \pm 0.02$. According to (29), the ash content

of the Dehydrated Spinach was found to be $0.6\text{g} \pm 0.01$ which was comparatively lower than the formulated Dehydrated Leaf powder of *Alternanthera sessilis*. This study findings implies that the Dehydrated AS Leaf Powder was a good source of mineral elements based on the reported value of ash Content.

Moisture content

The amount of water in a food product is referred to as its moisture content. It impacts the weight, shelf life, texture, flavor, and appearance of the food goods. The physical and chemical properties of the food product can deteriorate as a result of even minor changes in moisture content (31). The result revealed that Dehydrated A S Leaf powder contained a moisture content of $6.16\% \pm 0.01$ and this value was found to be lower than the moisture content of dehydrated betel leaves (12.66%) reported by (23), and dehydrated Adusa (*Adhotoda vasica*) leaf powder (11.34%) reported by (24). Hence, it can be concluded the tray drying has effectively reduced the overall moisture content of A S leaf powder thereby prolonging the shelf life because of the low moisture content.

Iron

According to the World Nutrition Assessment 2016, India ranks 170th out of 180 nations for women's anemia, making it one of the nations with the highest rates of iron deficiency (32). India experiences a 1.8% GDP loss due to the high prevalence of anemia among adolescent girls (33). Iron has various functions in the body; it serves as a carrier of oxygen to the tissues, as a transport medium for electrons within cells, and as an integrated part of important enzyme systems in various tissues. The Iron content of the formulated Dehydrated AS. Leaf powder was found to be $5.0\text{ mg} \pm 0.1$ respectively. According to (21) the iron content of the dehydrated tamarind leaves powder was found to be 0.18mg which was lower than the formulated Dehydrated Leaf powder of *Alternanthera sessilis*. Generally, plant foods and iron-fortified foods contain non-heme iron. Dehydrated AS. Powder seems to be high in Iron content which on incorporation with different food products helps to combat iron deficiency Anemia.

Calcium

The most common mineral in the human body is calcium. The regulation of vital processes such as muscle contractions, nerve impulses, and enzyme activity as well as the strength and structure of bones are all dependent on it (34). The Calcium content in the formulated Dehydrated Leaf powder of *Alternanthera sessilis* was found to be $379\text{ mg} \pm 0.01$ respectively. The results were found to be almost similar when compared to the Dehydrated Cauliflower powder which was found to be $380.64\text{ mg}/100\text{ g}$ (35). The calcium content of dehydrated Kachnar leaves (*Bauhinia purpurea*) powder was found to be 240 mg (36) which was lower than the Dehydrated AS. Powder. Since Dehydrated AS. Powder was found to be an excellent source of calcium and therefore it can be effectively incorporated into various food products to fight calcium deficiency in adult women who are prone to osteoporosis.

Vitamin A

Vitamin A, also known as retinol, and retinoic acid (RA) are widely recognized as important factors in the maintenance of healthy cells and tissues. RA possesses a fundamental ability to regulate cell growth, generally by slowing the cell cycle rate and inducing immature and transformed cells to differentiate toward a more mature phenotype. (37) The Vitamin A content of the formulated Dehydrated Leaf powder of *Alternantherasessilis* was found to be $50\text{ mg} \pm 0.1$, According to

(38)) the Vitamin A content of the Shade Dried Nsukka was found to be $3.69\text{ mg}/100\text{ g}$ which was relatively lower than the formulated Dehydrated Leaf powder of *Alternanthera sessilis*.

Functional Properties of Dehydrated *Alternanthera sessilis* Powder

The functional properties of dehydrated *Alternanthera sessilis* leaf powder (Ponnanganni) such as Total phenol count, Total flavonoid count, and Antioxidant and Phytochemical properties were analyzed and the results are exhibited in (Table 6).

Table 6 Functional Properties of Dehydrated *Alternanthera sessilis* Leaf Powder

Parameters	Sample
Total phenol count ($\mu\text{g}/\text{mg}$).	30.78 ± 0.01
Total flavonoid count ($\mu\text{g}/\text{mg}$).	16.34 ± 0.01
Antioxidant (%)	77.35 ± 0.01

Phenolic chemicals are crucial plant components having an antioxidant effect because of their redox characteristics. The hydroxyl groups in the plant extracts help neutralize free radicals (39). Phenols, which are phytochemicals or bioactive molecules, have long been studied for their potential to improve human health and treat or prevent a wide range of ailments. Antioxidant effects are produced by phytochemicals. It has been demonstrated that phenol protects against serious illnesses like cancer and cardiovascular disease. Oxidative stress brought on by reactive oxygen species complicates the pathogenesis of neoplasia, atherosclerosis, and neurological diseases. The dehydrated *Alternantherasessilis* leaf powder (Ponnanganni) was analyzed for its Total Phenol count which was found to be $30.78 \pm 0.01\text{GAE} (\mu\text{g}/\text{mg})$.

Flavonoids, which are secondary antioxidant metabolites, differ in their efficacy depending on the presence and position of free OH groups (39). Many flavonoids have been found to have anti-oxidant, free radical scavenging, anti-cancer, anti-HIV, and properties that protect against coronary heart disease (17). The total Flavonoid content of the dehydrated *Alternantherasessilis* leaf powder (Ponnanganni) was found to be $16.34 \pm 0.01\text{ GAE} (\mu\text{g}/\text{mg})$.

Antioxidants are described as "substances that specifically prevent or delay the oxidation of physiologically important molecules either by quenching free radicals or by chelating redox metals" (40). Proteins, amino acids, flavonoids, peptides, and other phenolic compounds—all of which are contained in food—play a significant role in preserving health. The risk of diabetes, atherosclerosis, cancer, and heart disease is reduced by antioxidants found in nature. Natural antioxidants in food can reduce the amount of oxidative damage done to DNA, proteins, lipids, and nucleic acids in the body, which can cause degenerative illnesses. The DPPH free radical scavenging activity of the formulated Dehydrated Leaf powder of *Alternantherasessilis* was studied at different concentrations from 100 to 400 $\mu\text{g}/\text{ml}$. The Dehydrated leaf powder obtained 77.35% of inhibition at a concentration of 400 $\mu\text{g}/\text{ml}$, where its IC₅₀ value is 222.69 $\mu\text{g}/\text{ml}$ which denotes a good radical scavenging ability.

The dehydrated *Alternanthera sessilis* (AS) powder (Ponnanganni) was analyzed for its phytochemical composition and the results indicated the presence of many phytochemicals such as glycosides, phenols, proteins, carbohydrates, Quinones, starch, and alkaloids. Phytochemicals are of tremendous interest and have significant antioxidant potential due to their favorable effects on human health and major health benefits for consumers. Epidemiological studies and animal studies suggest

that eating fruits, vegetables, and whole grains regularly may reduce the prevalence of several diseases linked to oxidative damage (41).

Table 7 Phytochemical constituents of dehydrated *Alternanthera sessilis* (AS) powder

Phytochemicals	Present/ Absent
Acid	-
Alkaloids	+
Anthocyanin/Betacyanine	-
Carbohydrates	+
Cardiac Glycosides	-
Coumarins	-
Flavonoids	+
Glycosides	+
Phenols	+
Proteins	+
Quinones	+
Saponins	-
Starch	+
Tannins	-
Terpenoids	+

Microbial quality of dehydrated *Alternanthera sessilis* powder

The Microbial analysis of the dehydrated *Alternanthera sessilis* leaf powder (Ponnanganni) was done aseptically. The total bacterial count and yeast mold count were examined. The values are provided in (Table 8).

Table 8: Microbial quality of dehydrated *Alternanthera sessilis* leaf powder

Microbial analysis	Count In Cf/g
Total Plate Count	2×10^4
Yeast And Mould Count	3×10^3

The total plate count is the enumeration of aerobic, mesophilic organisms that grow in aerobic conditions under moderate temperatures of 20-45°C. This includes all aerobic bacteria, yeast, molds, and fungi that grow in the specific agar. This count includes all pathogens and nonpathogens and is used to determine the hygienic status of food produced. The total plate count of the dehydrated AS powder was found to be 3×10^5 cfu/gm and can be concluded that the dehydrated *Alternanthera sessilis* leaf powder was microbially safe to consume because of the low micro-organism population seen in the product. This could be due to the clean and sterile method followed by the researcher while preparing the product. According to FSSAI standards, the safe limit for dehydrated products is not more

than 4×10^4 cfu/g. Thus, it can be concluded that the formulated powder was within the recommended safe limit and it is microbially safe to consume.

Yeast is a type of fungus that requires a warm, moist environment to produce food sources. Eukaryotic creatures are yeasts. Molds are also classified as fungi (42). The yeast mold count of the sample was analyzed using the spread plate method. The Yeast Mold growth of the dehydrated AS powder was found to be Nil and can be concluded that the dehydrated *Alternanthera sessilis* leaf powder (Ponnanganni) was microbially safe to consume because of the absence of microorganism population seen in the product. This could be due to the clean and sterile method followed by the researcher while preparing the product. According to FSSAI standards, the safe limit for dehydrated products is not more than 4×10^4 cfu/g. Thus, it can be concluded that the formulated product was within the recommended safe limit and it is microbially safe to consume.

CONCLUSION

Green leafy vegetables are particularly perishable and seasonal, making dehydration one of the best methods for preserving them. *Alternanthera sessilis* leaves, which are cheaply and widely available, can act as a reservoir of nutrients and be used to treat micronutrient deficiencies in underdeveloped nations. According to the findings of the current investigation, the dehydrated *Alternanthera sessilis* (AS) powder (Ponnanganni) was Nutritious, cost-effective, microbially safe and can be incorporated into different food products to enhance its nutritional quality. The presence of phytochemicals and their antioxidant activity makes dehydrated leaf powder, a functionally therapeutic food ingredient. The leaf's phytochemical content renders it pharmacologically active, and because of its potential to enhance consumer health, it may be used as a food supplement. It can be summarized from the current investigation that low cost dehydrated A S Leaf powder can be recommended for the population suffering from osteoporosis, Iron deficiency anemia, and protein energy malnutrition as they are rich in calcium, iron, and protein.

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