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# PROXIMATE ANALYSIS OF SPINACH (*Spinacia oleracea)*: NUTRITIONAL AND BUSINESS IMPLICATIONS

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## ABSTRACT

*As the human population is rising, food demands are also surging up that can be met by cultivating wild vegetables, since they are considered low-cost food source among local populations. The current investigation during July 2023 to December 2023 is attempted, to quantitatively evaluate spinach (Spinacia oleracea), that is grown in Tagarapuvalasa, Visakhapatnam, Andhra Pradesh; India; for it's proximate composition levels and anti-microbial activity. Proteins, total carbohydrates and lipids were estimated by following Lowry et.al., [1951], Caroll et.al., [1956] and Bligh and Dyer [1959] respectively. The anti-microbial activity of the leaf extracts was determined by using the protocol reported by Shahriar et al. [2018b] and the zone of inhibition (ZOI) towards the microbes was calculated.*

*From the results of this study, it was found that spinach of the study area is a significant source of macronutrients and micronutrients. Moreover, it also showed the highest anti-bacterial potential as observed in the results of the analysis. Hence, awareness regarding the nutritional and functional properties of these under-utilized leaves may aid towards nutritional and food security in addition to generating novel therapeutic avenues. It may be concluded that, apart from cultivating spinach during the main season, its yield 15 to 30 days early and later main season also may be a more profitable business, not only for a bigger farmer but also to small and marginal farmers.*

**KEYWORDS:** *Spinach leaf extract, analysis, Nutrients, Anti-bacterial acitivity, Profit.*

## 1. INTRODUCTION

With the exponentially increasing human population, food needs are constantly rising. The human diet's significant portion consists of vegetables that are rich source of carbohydrates, fats and proteins [7]. This results in scarcity of land resources available for food crop's cultivation, especially vegetables [8]. As an alternative, the food demands can be met by growing wild vegetables, since they are considered low-cost food source among local populations.

Of all the other vegetables, green leafy vegetables (GLVs) have a significant contribution in maintaining normal body function and in averting diseases [6]. GLVs are cost-effective food available throughout the year that is rich in vitamins, minerals, proteins, antioxidants and dietary fibre. Therapeutic properties of leafy vegetables, such as anticarcinogenic, antibacterial and antidiabetic effects are proven in many research studies [18]. In the present study, *Spinacia oleracea* (spinach) leaves were analysed during July 2023 to December 2023, for their proximate composition and functional attributes in order to ascertain their usefulness towards nutritional security outcomes.

Evaluation of the proximate composition in spinach (*S. oleracea*) of Nasarawa state, Nigeria was done by Amos Idzi Ambo, et.al. (2023). Analysis of underutilized leafy vegetables is investigated by Sankar et.al. (2022), nutritional assessment and Proximate analysis of vegetables grown in Larkana, Pakistan was studied by Malghani et.al. (2022), nutritional characterization and food value addition properties of dehydrated spinach powder are done by Waseem et.al. (2021), Nutritional and Therapeutic implication of edible leaves is revealed by Pal and Zakir (2020) while El-Sayed (2020) successfully used spinach powder in the manufacture of soft cheese. Proximate and Antioxidant activity of *Brassica oleracea* (Kale) and *S. oleracea* (Spinach) Leaves was studies by Agarwal et.al. (2017), Miano (2016) analysed the nutritional value of Spinach (*S. oleracea*), Patricia et.al., (2014) done the Proximate composition and nutritive value of leafy vegetables consumed in Northern Côte d'Ivoire, Emebu and Anyika (2011) worked on the Proximate and

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mineral composition of Kale (*B. oleracea*) grown in Delta State, Nigeria. Proximate and essential nutrients evaluation of selected vegetables species from Kohat region, Pakistan was done by Hussain et.al. (2010); Nutritional evaluation of leafy vegetable Paratha was done by Pandey et.al. (2006); Composition, efficacy, and safety of spinach extracts is done by Lomnitski (2003); Pandey and Kalloo (1993) worked on genetic improvement of Spinach: *S. oleracea L.*

## 2. MATERIAL AND METHODS

### 2.1 Sample collection

Fresh samples of *S. oleracea* (spinach) used in this study were purchased fortnightly from local market during the entire study period. These plants were grown in Tagarapuvalasa region which is located along the banks of river Gosthani in Visakhapatnam, Andhra Pradesh; India, lying between 17°55¢52²N latitude and 83°25¢44²E longitude. The area has tropical climate having summer, rainy and winter seasons, recording annual average temperature of 31.5°C.

### 2.2 Preparation of extract

The samples were brought to the laboratory, roots and unwanted parts of the plants were removed by a sterile blade. Then, the leaves along with stem were washed thoroughly under running water to remove sand and other impurities. Each sample was separated into three parts. One part was used to find the moisture content. The remaining two parts were air-dried at room temperature to remove the surface water. The dried leaves were then ground into a fine powder, sieved and stored in zip-lock sterile polythene bag. Leaf extracts were prepared by soaking 15 gm of powdered sample in distilled water followed by filtration. The extract was stored in a sterilized airtight container at 4° C.

### 2.3 Methods

The moisture content of the sample was determined by oven drying 5 gm of the leaves at 150° C to a constant weight. Percentage of ash was obtained by igniting the powdered sample in a muffle furnace at 600° C. Proteins, total carbohydrates and lipids were estimated by following Lowry et.al., [10], Caroll et.al., [4] and Bligh and Dyer [3] respectively.

The anti-bacterial activity of the leaf extracts against pathogenic Gram-negative *Escherichia coli* (*E. coli*) and Gram-positive *Bacillus subtilis* (*B. subtilis*) was experimented, using a protocol reported by Shahriar et al. [18] and the zone of inhibition (ZOI) was calculated using ethanol and chloramphenicol as the negative and positive controls respectively.

### 2.4 Statistical analysis:

For statistical analysis of the data of the present study, SPSS 16.0 version was used. For tabular presentations mean values with standard errors (SE) were given. Proximate composition and zone of microbial inhibition (ZOI) of the samples were represented using bar graphs.

## 3. RESULTS

Leaf samples showed significantly high moisture content with the highest (94.29 %) in the month of August during the study period. The sample containing high moisture content was reported to have high ash content (34.19%) too, qualifying it as a good source of minerals. As the moisture content influences shelf life, the leaves analysed were not recommended for long-term storage. Furthermore, the samples showed the highest amounts of carbohydrates in the months of July and December (1.67%), proteins in the months of July (2.98%), October (2.92%) and December (2.87%) during the study period (Table 1, Fig 1).

**Table 1: Proximate composition of *Spinacia oleracea* (spinach) leaf samples of the study area during July 2023- December 2023. values are expressed as mean ± SE**

| Month | Moisture % wet weight | Total Carbohydrates % dry weight | Total Proteins % dry weight | Total Lipids % dry weight | Ash % dry weight |
|---|---|---|---|---|---|
| **July** | 92.67±0.03 | 1.67±0.01 | 2.98±0.12 | 0.77±0.01 | 22.87±0.02 |
| **August** | 94.29±0.02 | 1.43±0.12 | 2.01±0.10 | 0.23±0.12 | 34.19±0.03 |
| **September** | 89.81±0.12 | 1.34±0.04 | 1.99±0.17 | 0.37±0.04 | 29.64±0.02 |
| **October** | 91.38±0.04 | 1.56±0.06 | 2.92±0.15 | 0.75±0.06 | 31.08±0.03 |
| **November** | 92.21±0.01 | 0.89±0.01 | 2.01±0.08 | 0.99±0.01 | 22.27±0.01 |
| **December** | 91.87±0.03 | 1.67±0.09 | 2.87±0.14 | 0.97±0.09 | 32.69±0.02 |

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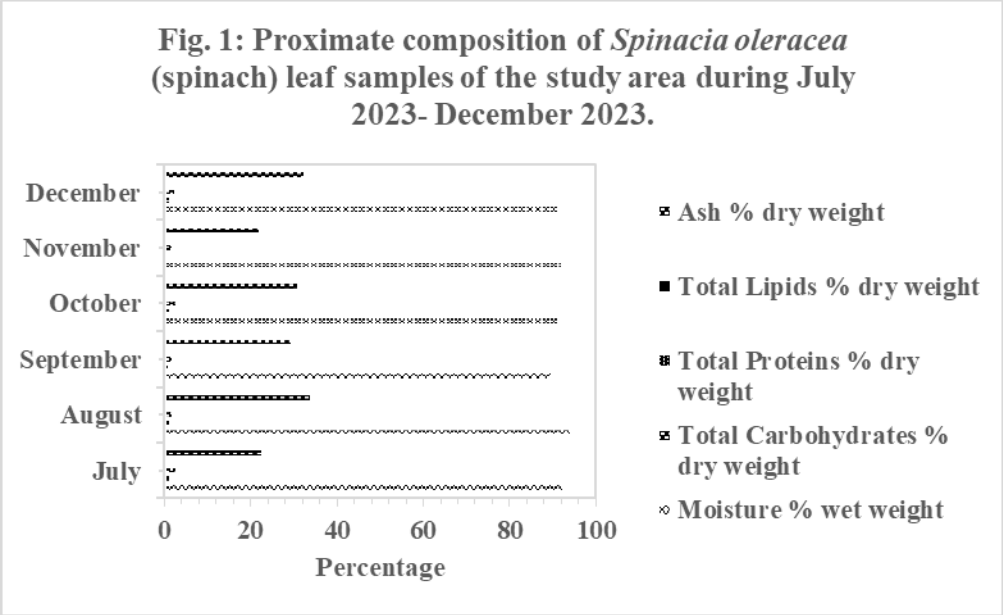
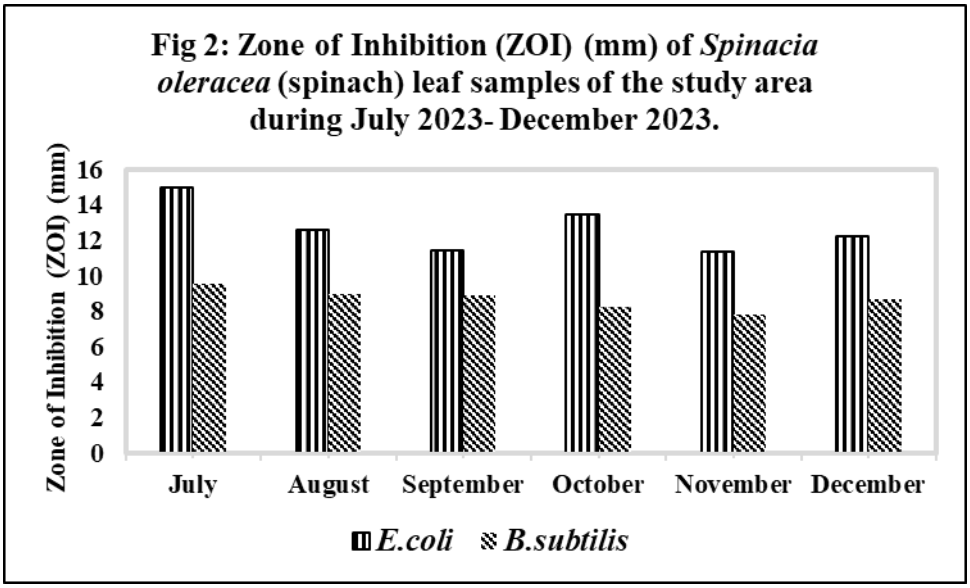



Interestingly, the leaf samples displayed low-fat content, with the lowest (0.23%) during August, thereby being suitable for fat restricted diets followed by several people, especially those suffering from obesity and other metabolic disorders.

**Table 2: Zone of Inhibition (ZOI) (mm) of *Spinacia oleracea* (spinach) leaf samples of the study area during July 2023- December 2023. values are expressed as mean ± SE**

| Name of the sample | Type of bacteria | July | August | September | October | November | December |
|---|---|---|---|---|---|---|---|
| Spinach leaf extract | ***E.coli*** | 14.97±0.03 | 12.56±0.02 | 11.45±0.03 | 13.45±0.02 | 11.34±0.07 | 12.21±0.05 |
| | ***B.subtilis*** | 9.56±0.05 | 8.98±0.02 | 8.90±0.06 | 8.23±0.03 | 7.78±0.05 | 8.67±0.07 |



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The leaf extract was highly effective in inhibiting the growth of *E. coli* and *B. subtilis* in the month of July during the study period as depicted per ZOI of 14.97 mm and 9.56 mm respectively (Table 2, Fig. 2) followed by ZOI for *E. coli* in the month of October and ZOI for *B. subtilis* in the month of August. More or less the samples of the present study displayed a higher anti-bacterial potential towards *E. coli* compared to *B. subtilis*, that may be due to the differences in the cell wall constituents of the strains.

## DISCUSSION

*S. oleracea* (spinach) is a high yield, good quality of uniform green leafy vegetable and resistant to major diseases [17]. It was recognized as a good source of vegetable fibre and protein content to manage against metabolic disorders such as diabetes and cardiovascular diseases [1]. In the present study, *S. oleracea* (spinach) leaves were found to be rich in proximate composition, but possessing a low-fat percentage thereby potentiating as an attractive nutritive food. Similar observation of rich proximate composition [2] omega 3 fatty acids and anti-inflammatory agent [12] lends support to the present investigation.

The leafy vegetables if consumed in sufficient amount would contribute greatly to the nutritional requirement for human health [16][14]. The efficacy of spinach leaf extract and the safety of its consumption were proved by isolating the natural antioxidant mixture (NAO), which specifically inhibits the lipoxygenase enzyme, promising anticarcinogenic effects [9]. The cheese containing a powder form of spinach, offers a healthy source of nutrients for normal body functions [5]. Replacing wheat flour with spinach powder in baked products could be a viable dietary approach to enhance the optimum supply of micronutrients and to combat micronutrient deficiencies among various population segments [19]. So, it can be known that spinach may be added in the regular diet in it's modified form for normal health benefits.

Wild vegetable species including spinach proved to have sufficient micro and macro nutrients while the proximate parameters are at moderate level [7]. This is in tune with the present research as all the samples showed high ash content. Further, the samples analysed in August were found to have the highest moisture, ash and low fat when compared with the findings of other samples during the study period. The reason may be the adequate availability of rain water to the plantation, as August month will fall under rainy season at the study area. These edible samples are attractive commodities owing to their low cost and ready availabilities. Thus, knowledge of the above properties may help the population in adapting an improved food choice.

Moreover, leaves being natural, contain components possessing low toxicity compared to synthetic drugs available in the market. The elemental toxicity in the vegetables, which is lethal, is well below WHO standards [11]. The present investigation witnessed therapeutic benefits of the leaf extract [13] as noticed by zone of inhibition towards bacterial growth. Hence, awareness regarding the nutritional and functional properties of these under-utilized leaves may aid towards nutritional and food security in addition to generating novel therapeutic avenues.

## CONCLUSION

Leaves are multi-purpose parts of the plant possessing high nutritional values and wide medicinal applications. Based on the nutritional and functional evaluation of these edible leaves, it can be summarized that these samples are significant sources of macronutrients and micronutrients. Moreover, they also showed the highest anti-bacterial potential as observed in the results of the present analysis. Therefore, consumption of these edible leaves may not only confer nutritional empowerment but also therapeutic benefits.

Edible leaves are one of the most economical forms of vegetable possessing multiple benefits. Whether it is intended for fresh consumption or processing, growing vegetable plants can be a profitable business. However, there are some factors that may influence the profitability, such as seed quality, optimal time of planting, method of planting, etc. As observed in the present study, cultivation of spinach utilizing the available area may be an affordable business besides fulfilling the nutritional needs of the local people. The present study area, being a semi-arid region, has bestowed with ample natural wealth of plant species. Based on the nutritional and functional evaluation of these edible leaves, it may also be suggested that, *S. oleracea* (spinach) may be cultivated early and later seasons as well, instead of growing only during the main season, so that the yield will be 15 to 30 days early and later main season too. Then, it may be a more profitable business not only to a bigger farmer but also to small and marginal farmers.

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