Proximate composition and Functional Properties of Yeast Fermented Agathi Leaf (Sesbania grandiflora) Powders

R. Sahul Hameed\textsuperscript{a} and P. Manju priya\textsuperscript{b*}

\textsuperscript{a} Assistant Professor, Department of Home Science, School of Sciences, The Gandhigram Rural Institute Deemed To Be University, Dindigul, Tamilnadu, India,

\textsuperscript{b} M.Sc. Food Science and Nutrition student, Department of Home Science, School of Sciences, The Gandhigram Rural Institute Deemed To Be University, Dindigul, Tamilnadu, India.

Abstract

Green Leafy Vegetables (GLVs) are fresh-cut sections of edible plants that play an integral role in the human diet as a source of dietary fiber, vitamins and minerals. GLVs are generally cooked to improve their quality and acceptability. It found that the cooking conditions and processing methods affect the nutritive value of GLVs. Fermentation seems to enhance the nutritional and medicinal value of the foods; hence, this study aimed to determine the proximate composition and functional properties of yeast fermented Agathi leaves (Sesbania grandiflora). Collected Agathi leaves from a local farm were cleaned, washed and separated the leaves from the stalks. The leaves were subjected to various thermal processing such as boiling (20min), simmering (10min), steaming (10min) and dried at 60°C for few hours. The dried leaf powders were dissolved in water at 1:10 ratio then fermented with 3% w/v Bakers’ yeast for 20 hours in a shaking water bath. The fermented slurry was dried in a cabinet drier at 60°C for 4-5 hours, made into powder and stored in air-tight containers under refrigeration condition until further analysis. Phytochemicals, nutritional and functional properties of the fermented Agathi leaves powders were analyzed by following standard procedures. Phytochemical screening of the fermented leaves powder showed the presence of Phenols, Steroids, Alkaloids, Glycosides, Saponins, Tannins, Quinines and Flavanoids in the aqueous extracts. Proximate analysis revealed that fermented Agathi leaf powder contains 6.83-8.10% moisture, 35.59-45.90g% crude protein, 9.06-10.31% minerals, and 7.74-9.49g% crude fiber. The functional properties of the fermented leaf powders were 0.56-0.63g/ml for bulk density, 2.70-3.95g/g for Water Absorption Capacity (WAC), 0.96-1.20g/g for Oil Absorption Capacity (OAC), 30.99-51.83% for Foaming Capacity (FC) and 51.26-67.73% for Emulsifying Capacity (EC). A marked difference in the nutrient content and functional properties of fermented and unfermented Agathi leaf powders was observed. The findings suggest that fermented Agathi leaf powders are concentrated with nutrients like protein, minerals, and crude fiber and exhibited good phytochemical profiles and functional properties that can be used to develop functional food products for the malnourished.

Keywords: Agathi Leaf – Yeast Fermentation – Cabinet Drying – Nutrient composition – Functional Properties - Phytochemicals

* Corresponding Author: Email ID: manjuprmani@gmail.com
Introduction

India is rightfully called the “Botanical garden of the world” because it is abundant in vegetables, fruits, spices, and herbs that are serving as food as well as medicine [1]. Green Leafy Vegetables (GLV) is one of its kind and has a unique place among vegetables as they are the cheapest source of high-quality nutrients and are recognized as ‘poor man’s vegetables’ [2] and [3]. Sesbania grandiflora (Agathi) is a species of tropical climate [4], short-lived, quick-growing, soft-wooded tree, and as an ornamental plant [5]. Agathi leaves play an essential role in the diets as a source of amino acids, minerals, vitamins and antioxidants [6]. It also serves as a local remedy for bruises, catarrh, dysentery, eyes, fevers, headaches, smallpox, sores, sore throat, and stomatitis [4]. The Agathi leaves showed anxiolytic, anticonvulsive, hepatoprotective and antihelmintic properties [7] which can bring various health and medicinal benefits upon regular consumption.

The consumption of green leafy vegetable is considerably low due to their poor acceptability [8]. The leaves are generally cooked to improve their palatability however it cause changes in the physical and nutritional composition. The colour of the cooked leaves are less attractive than the fresh ones [9]. It is known that nutrient losses occur in the preparation and cooking of the leaves. In contrast, the heating process makes available most of the phenolic compounds trapped in fiber of green leafy vegetables, although the radical scavenging activity is also increased in the cooked green leafy vegetable [10]. Cooking might have improved the sensory qualities of leafy vegetable, but it doesn't extend the shelf life longer. Dehydration seems to be the simplest technology for preserving GLV, especially when they are abundantly available [11]. Water in food is reduced to a very low level during dehydration, thus achieving better microbiological preservation and reducing the undesired reactions during storage, owing to the reduction in water activity [12] and concentrate the nutrient contents also. Whereas dehydration/drying alone may not be effective on antinutritional factors in the leafy vegetables and it has to combine with other techniques like thermal processing and fermentation. Fermentation significantly improves the nutrients quality by improving the digestibility and destroying the antinutritional factors non-thermally [13]. The reduction in antinutritional factors and better phytochemicals profile upon fermentation was also reported by Jannathulla et al. [14] and Carciochi et al. [15] Hence the present study was aimed to analyze the proximate composition and functional properties of Agathi leaves and determine the effect of cooking before fermentation on its quality.

Materials and Methods

Agathi bundles were collected from Dindigul Vegetable Market located in Dindigul district, Tamil Nadu, India. The leaves were examined by the expert in the Department of Biology, The Gandhigram Rural Institute (Deemed to be University), Gandhigram, Dindigul, Tamil, Nadu, India and reported as Sesbania grandiflora (Agathi). The Analytical Grade (AR) chemicals were used for the analyzing the quality of leaf samples. Bakers’ yeast (Saccharomyces cerevisiae) and Potassium Metabisulfate (KMS) used for fermentation were purchased from a local departmental store.

The leaf bundle was checked for its quality and removed the defective ones. The leaves were separated from the stalk and washed with running tap water to remove the dirt and sand. Cleaned leaves were transferred to the aluminium trays and loaded in the cabinet drier (Biotronic Instruments, Tamilnadu, India) then dried at 60°C for 4-5 hours. Grind the dried leaves using the blender, packed in air-tight containers and stored at refrigeration temperature until further analysis. The prepared leaf powder was labelled as control (T0).

Fermentation was carried out as follows: the leaf powder blended with distilled water at 1:10 ratio and kept in a shaking water bath for an hour (30°C temperature and 100 rpm shaking speed). After that 0.1% of Potassium Meta-bisulphite (KMS) and 3% bakers’ yeast were added to the suspensions and kept the suspension in a shaking water bath for 20 hours. Then it was dried in the cabinet drier at 60°C.
for 3-4 hours and powdered. The fermented leaf powders were packed in an air-tight container, labelled as T₁ and stored in the refrigerator. The leaf suspensions were boiled for 20 minutes, simmered for 10 minutes and steamed for 10 minutes before subjected to yeast fermentation to study the effect of thermal processing on fermentation. The cooked and fermented leaf powders were labelled as T₂, T₃ and T₄ for boiled, simmered and steamed then fermented Agathi leaf powders respectively.

The nutrient content of the powder samples was analyzed using AOAC [16] methods. The moisture content was measured using Digital Moisture balance (Shimadzu, Japan) and expressed the results in percentage. The crude protein content was determined by Microkjeldhal method using Kelps Nitrogen Analyser (Pelican Equipment Inc, Chennai) and the Nitrogen conversion factor (6.25) was adopted to calculate protein content. Mineral content was estimated by incinerating the sample at 600°C in a Muffle furnace for 6 hours and record the ash content at the end. Fibroplus instrument (Pelican Equipment Inc, Chennai) was used for estimating crude fiber content of the sample. Crude protein, mineral and crude fiber contents of the samples were expressed as g/100 g on wet basis.

The functional properties such as bulk density, water absorption capacity, oil absorption capacity, emulsifying activity and foaming capacity of the leaf powders were determined by adopting the methods described by Kaur and Singh [17], Sosulska [18], Lin and Humbert [19], Yasumatsu et al. [20] and Lin et al. [21] respectively. The results obtained from the analysis were expressed in g/ml for bulk density, g/g for water and oil absorption capacity, percentage for emulsifying activity and foaming capacity.

The aqueous extract was prepared by mixing the leaf powders with distilled water at 1:20 ratio and kept in a shaking water bath for overnight at 30°C temperature at 100 rpm speed for phytochemicals screening. Then they were centrifuged at 2000g for 15 minutes and collected supernatant then tested it for the presence of phytochemicals such as phenolic compounds, anthocyanin, steroids, coumarins, saponin, tannin, glycosides, flavonoids, quinone and alkaloids by following the standard method described by Karthikeyan and Vidhya [22] and Hasan et al. [23].

Statistical Analysis

All the analyses were carried out in triplicates and the results were analyzed statistically by Analysis of Variance (ANOVA) using SPSS software version 17. Duncan Multiple Range Test (DMRT) at 95% confidence level (p<0.05) was used to find out the mean with a significant difference.

Results and Discussion

Phytochemical properties of fermented Agathi (Sesbania grandiflora) leaf powders are presented in Table 1. The yield of Agathi leaf powders were ranged between 14.0 and 18.0 percent. It was high for T₀ (22.44%) and low for T₂ (14.54%). pH of control Agathi leaf powder (T₀) was 5.89 and it was ranged from 7.12 to 7.23 upon fermentation of Agathi leaf powders. This shows that the production of alkaline compounds during fermentation of the leaves by the yeast [24].

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Yield (%)</th>
<th>pH</th>
<th>Moisture (%)</th>
<th>Protein (g/100g)</th>
<th>Minerals (g/100g)</th>
<th>Crude fibre (g/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₀</td>
<td>22.44±0.21a</td>
<td>5.89±0.02c</td>
<td>7.53±0.33b</td>
<td>35.59±0.91d</td>
<td>9.06±0.04c</td>
<td>8.57±0.01b</td>
</tr>
<tr>
<td>T₁</td>
<td>17.95±0.09a</td>
<td>7.12±0.07b</td>
<td>8.10±0.25a</td>
<td>44.23±1.01b</td>
<td>10.31±0.19a</td>
<td>8.48±0.02b,c</td>
</tr>
<tr>
<td>T₂</td>
<td>14.54±0.11c</td>
<td>7.21±0.06a</td>
<td>7.18±0.09b</td>
<td>45.90±0.49b</td>
<td>9.30±0.20b</td>
<td>9.49±0.22a</td>
</tr>
<tr>
<td>T₃</td>
<td>16.44±0.21b</td>
<td>7.23±0.03a</td>
<td>6.86±0.33b</td>
<td>41.09±1.47c</td>
<td>6.47±0.15d</td>
<td>8.11±0.16d</td>
</tr>
<tr>
<td>T₄</td>
<td>19.13±0.37b</td>
<td>7.18±0.25b</td>
<td>7.97±0.30a</td>
<td>40.47±0.65c</td>
<td>9.13±0.30b,c</td>
<td>7.74±0.18d</td>
</tr>
</tbody>
</table>

Table 1 Physicochemical Properties of Fermented Agathi (Sesbania grandiflora) leaf powder

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To, T1, T2, T3 and T4 denote control, boiled and fermented, simmered and fermented and steamed and fermented Agathi leaf powders respectively.

Values reported as Mean ±Std Dev.; Means with different superscript indicate they were significantly different at p<0.05

The moisture content of the fermented leaves were ranged between 6.83 and 8.10. T3 recorded the lowest moisture content of 6.83 percent among the treatments. Ijarotimi et al. [25] found that the moisture contents of fermented Moringa oleifera seed flour was significantly lower (8.13 g/100 g) when compared with germinated Moringa oleifera seed flour (9.43 g/100 g), and raw Moringa oleifera seed flour (10.60 g/100 g).

The protein content of the fermented leaf powders was significantly (p<0.05) higher (40.47 to 45.90 g/100g) than the control (35.59g/100g). Among the various treatments, T2 had the highest protein content of 45.90 g/100g and the lowest in the T4 (40.47 g/100g). Ifesan et al. [2] stated that the protein content of the selected leafy vegetables (Bush green, Fluted pumpkin leaf, Bitter leafand White campwood leaf) were ranged from 14.27% to 30.26% for dried leaves and from 16.96 to 25.89% for fermented leaves. It shows that the dried and fermented leafy vegetables are a good source of protein and are comparable to the protein rich foods such as soybeans, cowpea, melon and pumpkin (23.10-33.00%). A slight increase in the protein content of the Mucuna bean isolate flours prepared from fermented and germinated samples was reported by Udensi and Okoronkwo [26]. Osman et al. [27] found a significant increase in the protein content of Sicklepod (Cassia obtusifolia) leaves from 21.87 to 30.20% on fermentation due to the decrease in carbon ratio of the total mass. The researchers advocated that the increase in the protein during fermentation may be due to bio-conversion of such carbohydrates into microbial protein by intermediary metabolism, nitrogen fixing ability or microbial growth [14], [28], and [29]. The control leaf powder showed mineral content of 9.06 g/100g which was slightly lower than the fermented leaf powders (9.13-10.31g/100g) except T3 (6.4 g/100g). Higher mineral content noted in the fermented leaf powders may be due to the break down of the complexes and destruction of antinutritional factors in the leaves. T2 was found to be high in crude fibre content (9.49g/100g) among the treatments as well as control (8.57g/100g). The reduction in fiber content of the African locust bean flour from 8.08 to 6.65 g/100g during fermentation was also reported by Ijarotimi and Keshinro [30].

Functional properties such as bulk density, Water Absorption Capacity (WAC), Oil Absorption Capacity (OAC), Emulsion Activity (EC) and Foaming Capacity (FC) of fermented Agathi (Sesbania grandiflora) leaf powders are given in Table 2. Bulk density gives an indication of the relative volume of packaging material required. Generally, higher bulk density is desirable for the greater ease of dispersibility and reduction of paste thickness. The bulk density of the fermented leaf powders were ranged between 0.56-0.63 g/ml. Udensi and Okoronkwo [26] reported that there was no significant differences (P<0.05) in the bulk density of Mucuna bean isolates prepared from fermented and raw samples.

Table 2 Functional properties of Fermented Agathi (Sesbania grandiflora) leaf powders

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Functional properties of Agathi leaf powder</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bulk Density (g/mL)</td>
<td>WAC (g/g)</td>
</tr>
<tr>
<td>T0</td>
<td>0.59±0.005b</td>
<td>2.69±0.010d</td>
</tr>
<tr>
<td>T1</td>
<td>0.59±0.004b</td>
<td>3.94±0.095a</td>
</tr>
<tr>
<td>T2</td>
<td>0.62±0.004a</td>
<td>2.70±0.120d</td>
</tr>
</tbody>
</table>

75

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JOAASR-Vol-3-2(Conference Proceedings) January -2021
<table>
<thead>
<tr>
<th>Phytochemicals</th>
<th>T₀</th>
<th>T₁</th>
<th>T₂</th>
<th>T₃</th>
<th>T₄</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phenols</td>
<td>+++</td>
<td>++</td>
<td>-</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Steroids</td>
<td>++</td>
<td>+++</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Alkaloids</td>
<td>+</td>
<td>++</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Glycosides</td>
<td>++</td>
<td>+++</td>
<td>+</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Saponins</td>
<td>+++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Tannins</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Quinones</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Anthocyanin</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Coumarins</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
</tbody>
</table>

"+++" indicates the high presence of constituents, "+" indicates the medium presence of constituents, "-" indicates the absence of constituents; T₀, T₁, T₂, T₃, and T₄ denote control, boiled and fermented, simmered and fermented and steamed and fermented Agathi leaf powders respectively.

The water absorption capacity of fermented leaf powders were ranged between 2.7 and 3.95 g/g. A significant difference (p<0.05) between control and fermented leaf powders was observed. Similar result was reported by Jiarotim and Keshinro [30] who found that the water absorbing capacity of African locust bean flour increased from 2.06 to 2.11 g/g on fermentation. Oke and Bolarinwa [31] also corroborated that the water absorption capacity of the fermented cocoyam flour increased from 231.29 to 287.59% and it further increased with increasing fermentation period. The oil absorption capacity of control leaf powder was 1.01 g/g and found a non-significant difference with fermented leaf powders (1.20 -1.23 g/g) except T₄ (0.96 g/g). This suggest that oil absorption capacity of the leaf powders were not affected by drying and fermentation. Omoba et al. [32] reported the fermentation does not increase the oil absorption capacity of millet flour which was 166 percent.

A significant difference (p<0.05) in emulsifying activity of control and fermented leaf powders was observed. T₁ recorded the highest emulsifying activity of 67.73 percent followed by T₄ (58.89%) compared to control (T₀ 48.27%). High emulsifying activity of fermented leaf powder was attributed to the high protein content in the leaf powder. The foaming capacity of fermented leaf powders was ranged from 30.99 to 51.83 percent. Among the treatments, T₄ showed the highest foaming capacity (51.83%) and the lowest in T₂ (30.99%). There was a significant increase in the foaming capacity of Mucuna isolate prepared from fermented samples was reported by Udensi and Okoronkwo [26].
Aqueous extract of the fermented Agathí leaf powder showed presence of phytochemicals like phenols, steroidal, alkaloids, glycosides, tannins, quinone, flavonoids and coumarin and absence of anthocyanin which suggest that phytochemicals in Agathí leaf powder were soluble in water (Table 3). Among the treatments, T3 showed better phytochemical profiles. Gupta and Apte [33] reported there was a significant (p<0.05) difference in the yield between aqueous and ethanolic extracts prepared from Sesbania grandiflora leaves which was 25.8 and 16.8 percent respectively. Phenolic compounds, flavonoids and saponins were significantly higher (p<0.05) in ethanolic extract of the leaves compared to aqueous extract whereas tannins were higher in aqueous extract of the leaves. Palermo et al. [34] reported that changes in the phytochemical profile upon cooking might result in thermal degradation led to concentration and the matrix softening effect, which increases the extractability of the phytochemicals.

Conclusion

From the result it is evident that the fermented agathí leaf powder shows higher protein, mineral and crude fiber content. The leaf powders also showed good functional properties especially water/oil absorption, emulsifying activity and foaming capacity. They also exhibit better phytochemical profiles and identified the presence of steroids, alkaloids, glycosides, saponins, quinone, flavonoids and coumarins. There is a slight difference in the proximate composition, functional properties and phytochemical profiles in the cooked/fermented leaf powders. The findings suggest that fermented Agathí leaf powder have the potential to be used for value addition. They are concentrated with nutrients like protein, minerals, and crude fiber and exhibited good phytochemicals profiles and functional properties that can be used to develop functional food products for the malnourished.

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Conflict of Interest

No conflict of interest.

Authors Contribution

Dr. R. Sahul Hameed has conceptualized the study, interpreted the results and prepared the manuscript. Ms. P. Manju priya has conducted the study and reported the results with statistical analysis.

Reference


