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Research Article

Development of a Sauce Using *Gymnema sylvestre* Leaves

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Plant derived products have attracted enormous attention due to their diverse range of biological and therapeutic properties. *Gymnema sylvestre* is an underutilized medicinal herb that is widely distributed in different parts of the world. It is rich in phytochemicals with antidiabetic and antiobesity properties; however, it is less popular due to its bitter taste. This study was focused on developing a sauce using leaves of *Gymnema sylvestre*. The most acceptable composition (17.2% water, 4.8% vinegar, 3.2% sweet potato, 2.6% chili, 2.0% sugar, 2.0% cinnamon, 2.0% cardamom, 1.8% ginger, 1.8% garlic, 1.2% onion, 1.2% salt, 0.1% citric acid, and 0.1% sodium benzoate) of the sauce was with 60% leaf extract. Final product contains 73.54% ± 1.68 moisture, 19.92% ± 2.59 carbohydrate, 2.98% ± 0.44 ash, 2.61% ± 0.58 protein, 0.88% ± 0.05 fiber, and 0.05% ± 0.01 fat. The total flavonoid content was 243.67 ± 8.57 μ moles of rutin equivalent, total phenolic content was 65.44 ± 0.51 μ moles of gallic acid equivalent, and % of inhibition of DPPH of total antioxidant capacity was 43.70 ± 0.72. Sauce formulated with 1000 ppm sodium benzoate had six weeks of shelf life. The results showed that development of a sauce from *G. sylvestre* leaves is an effective way of delivering the health benefits to the potential consumers.

1. Introduction

Currently, people are looking for a quick, easy, and convenient food. Therefore, fast foods are in high demand. Sauce is a more popular food product among people due to the increased consumption of fast food. It is one of the instant side dishes which is used for dipping or used as a condiment. Mostly, sauces are with low nutritional value and high sodium and calorie content. High consumption of fast food leads to health problems [1, 2]. Vast evidence indicates that a plant based diet can reduce the risk of chronic diseases and promotes sound human health, with functional foods containing physiologically active components [3].

G. sylvestre is a dicotyledonous medicinal herb belonging to the family Asclepiadaceae which is known as "Masbadda" in Sinhala and "Chirukurinja" in Tamil [4, 5]. It is well known for its sweet taste suppressing activity and is found to be useful for the treatment of diabetes mellitus and obesity [6, 7]. It is used as a stomachic, diuretic, inhibited absorption of glucose in the small intestine and has inhibitory action against glucan synthesis and has antieruodonic and antiviral effect [8–10].

G. sylvestre leaves have several functional properties but direct consumption is challenging due to the bitter and astringent taste and these plant based products are lacking in the market [11]. Therefore, this study was focused on developing novel functional food product from *G. sylvestre* leaves, mainly to supply the health benefit to fast food consumers.

2. Materials and Methodology

This study was conducted in four phases. At the first phase, four sauce formulations were prepared by changing the concentration of leaf extract as 50, 60, 70, and 80% (w/w). At the second phase, two sauce formulations were developed by changing the thickening agents to sweet potato flour and pumpkin flour. Finally, sauce formulation was prepared and physicochemical characteristics were evaluated.

2.1. Preparation of Sauce. Initially, prepared leaf extract was boiled with continuous stirring at 55 to 60°C for 2 to 3 minutes. Then sweet potato flour was added to the leaf extract

and heated up to 65°C with continuous stirring. Subsequently salt, sugar, vinegar, citric acid, and spices were added and mixed while boiling. Lastly, sodium benzoate (1000 ppm) was added. The final mix was boiled at 65 to 70°C with stirring until reaching 25° Brix. Then, it was immediately transferred into sterilized clean glass bottles and stored at room temperature.

2.2. Sensory Evaluation. Sensory evaluation was done by simple ranking test with five-point hedonic scale. The sensory attributes (color, odor, taste, appearance, texture, and overall acceptability) were evaluated by untrained panel comprising 15 panelists.

2.3. Proximate Analysis. To determine the nutritional content of sauce and leaves, the proximate composition, moisture, ash, fat, protein, total fiber, and carbohydrate content [12], was evaluated.

2.4. Functional Properties. Phenolic content, flavonoids, and antioxidant capacity were determined in leaves and sauce by Folin-Ciocalteu reagent method, aluminium chloride method, and DPPH free radical scavenging activity, respectively [13, 14].

2.5. Shelf Life Evaluation. To determine the storage stability of sauce titratable acidity, pH, water activity, and Brix were analysed as physicochemical characteristics at weekly intervals for six weeks [12]. Total plate count and yeast and mold count were also evaluated.

2.6. Statistical Analysis. Nonparametric tests were used to analyse the sensory evaluation. Significant differences between the results were calculated by analysis of variance with the help of Minitab software and SPSS software.

3. Results and Discussion

3.1. Sensory Evaluation. Sensory evaluation results revealed the selection of the best leaf extract and thickening agent. First, sensory evaluation was done for the selection of appropriate leaf extract; Figure 1 shows that 60% extract formulated sauce has scored the highest median score for overall acceptability. Color of the sauce has increased with increasing leaf extract due to the increase of chlorophyll content but consumer's preference for the odor and taste of the sauce has decreased with increasing leaf extract due to the bitterness and astringent taste of *G. sylvestre* leaves. Therefore, 60% leaf extract was effective for preparation of sauce.

Most sauces are thickened with starchy products like flour, corn starch, arrow root, bread crumbs, potato starch, and rice flour [15]. Some commercial products used other kinds of starches for thickening [15]. Figure 2 shows second sensory result which reveals that sauce containing sweet potato flour as a thickening agent had highest median score for all the sensory attributes except taste. Therefore, sweet potato flour was selected as the best thickening agent for the sauce formulation. In this study, natural food ingredients

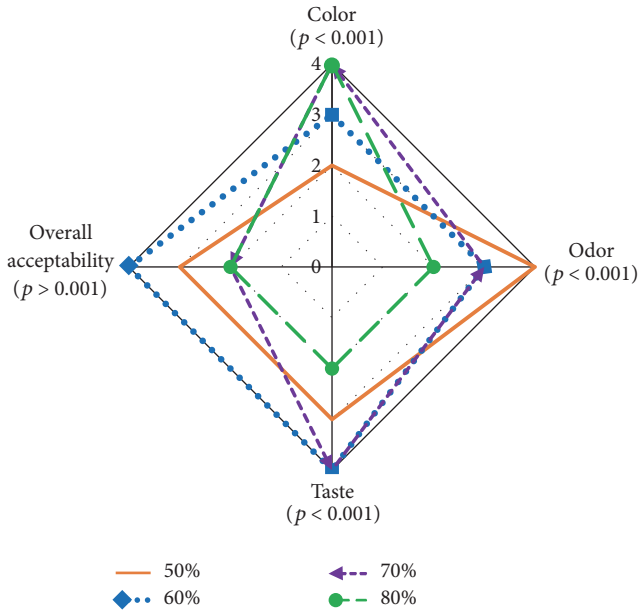


Figure 1: Spider web analysis of sensory attributes for sauce containing leaf extracts.

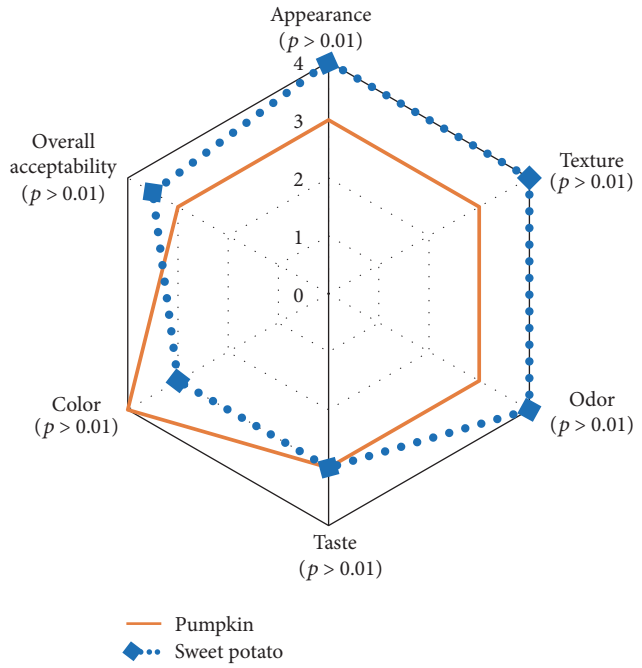


Figure 2: Spider web analysis of sensory attributes for sauce containing thickening agents.

have been used as thickening agents, which is an effective way of incorporating beneficial constituents. Consumption of sweet potato provides pharmacological investigations on the antidiabetic, antihypertensive, anti- inflammatory, antimicrobial, and antioxidant activity [16, 17].

After sensory evaluation, by using sensory results, the final formulation of *G. sylvestre* sauce was prepared, which contains 60% extract, 17.2% water, 4.8% vinegar, 3.2% sweet

Table 1: The proximate composition of the *G. sylvestre* leaves and sauce product.

Proximate value	Amount (g/100 g wet basis)	
	G. sylvestre leaves	Sauce
Moisture	79.69 ± 1.78	73.54 ± 1.68
Total solids	20.31 ± 1.78	26.45 ± 1.68
Carbohydrate	7.17 ± 2.44	19.92 ± 2.59
Crude protein	10.29 ± 0.76	2.61 ± 0.58
Ash	2.04 ± 0.80	2.98 ± 0.44
Crude fiber	0.29 ± 0.01	0.88 ± 0.04
Crude fat	0.50 ± 0.14	0.05 ± 0.01

The values are Mean ± SD of three independent determinations.

potato, 2.6% chili, 2.0% sugar, 2.0% cinnamon, 2.0% cardamom, 1.8% ginger, 1.8% garlic, 1.2% onion, 1.2% salt, 0.1% citric acid, and 0.1% sodium benzoate.

3.2. Proximate Analysis. Proximate composition was done to determine the nutritional value of sauce which is shown in Table 1. There was significantly ($p < 0.05$) high amount of moisture content in *G. sylvestre* leaves compared to sauce. In comparison, moisture content of tomato sauce is 66.65 ± 0.14 [18] lower than *G. sylvestre* sauce because tomato pulp contains higher amount of total solids than leaf extract. Sauce is generally considered as low fat product; however, *G. sylvestre* sauce has very small amount of fat compared to other sauces (tomato sauce contains 0.62 ± 0.01 fat) [18].

3.3. Functional Properties. Phytochemicals are rich in plant species; therefore plant derived products are considered as functional foods [3]. From Table 2, it has been demonstrated that sauce has high phenolic content and antioxidants compared to its leaf counterpart. In processing of sauce, several ingredients are added, cinnamon, cardamom, ginger, garlic, onion, and sweet potato, which are rich sources of antioxidants due to the presence of various phenolic compounds [19]. The processing methods such as blending and heating may cause enhancing the phenolic content via increasing softening of the tissues and liberating the bound phenolic compounds present in the cell matrix [20].

3.4. Physicochemical Properties. Table 3 shows physicochemical properties of the *G. sylvestre* sauce. Tomato sauce shall not have less than 25° Brix value, 4.6 pH, and 0.8% titratable acidity (SLSI Standards). The same standards were applied to *G. sylvestre* sauce when prepared. Brix value of the sauce is influenced by the presence of sugar and sweet potato flour. The FDA (approximate pH of food and food products 2007) has reported that the pH value of sauce should be within 4.4 to 5.4. According to the regulations, it is necessary to maintain the pH at 4.6 or less than 4.6 to preserve the product because production of botulism toxin by *Clostridium botulinum* is inhibited in this pH range [21]. Scientific report stated that acidity value is influenced by sodium benzoate, vinegar, and citric acid [21, 22].

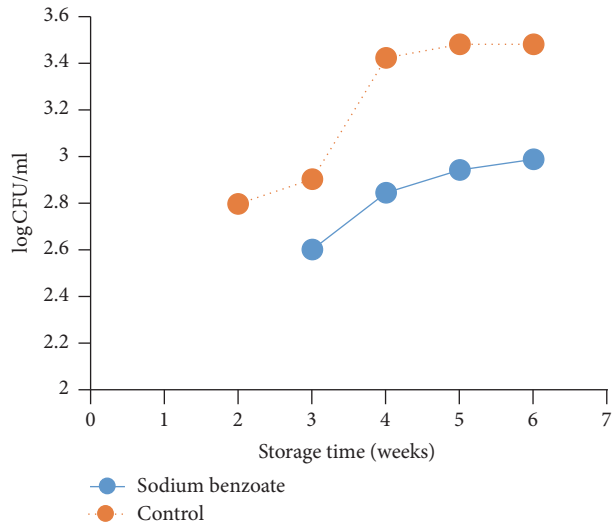


Figure 3: Changes of total plate count in sauce during storage.

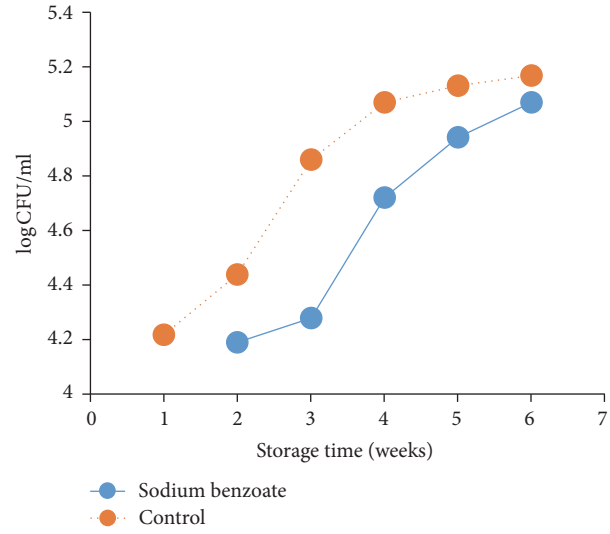


Figure 4: Changes of yeast and mold count in sauce during storage.

3.5. Shelf Life Evaluation. *G. sylvestre* sauce development study shows that there was an increasing number of bacteria, yeast, and mold growth during six weeks of storage when product was stored in sterile bottles at room temperature (30 ± 2°C), which is indicated in Figures 3 and 4. FDA (2013) has reported that the acceptable level of yeast and mold count of sauce is 100 CFU/g. Initially, sauce was free from any microbial growth. *Aspergillus* spp. and *Penicillium* spp. are those types of fungi that frequently grow on sauce compared to bacterial growth due to low pH because yeast and mold need acidic medium to promote the sporulation [23]. The range of acidic medium for the yeast and mold sporulation is pH 3 and above [23]. Increasing microbial growth is due to the low heating temperature (less than 75°C) applied during the preparation of sauce. Therefore, spores of microbes may be remaining after processing. If provided the favorable condition, they can accelerate their growth [24].

Table 2: The functional properties of the *G. sylvestre* leaf extract and sauce.

Functional properties	Amount	
	G. sylvestre leaf extract	Sauce
Total antioxidant activity (% of inhibition of DPPH)	24.15 ± 1.48	43.70 ± 0.72
Total flavonoid (μ moles of rutin equivalent per ml of sample)	247.79 ± 6.26	243.67 ± 8.57
Total phenolic content (μ moles of gallic acid equivalent per ml of sample)	52.48 ± 0.51	65.44 ± 0.51

The values are Mean ± SD of three independent determinations.

Table 3: Physicochemical properties of the sauce formulated with *G. sylvestre* leaves.

Properties	Value
Total soluble solids (Brix)	25°
pH	4.52 ± 0.01
Titratable acidity (% of acetic acid equivalents)	0.82 ± 0.11
Water activity	0.77 ± 0.01

The values are Mean ± SD of three independent determinations.

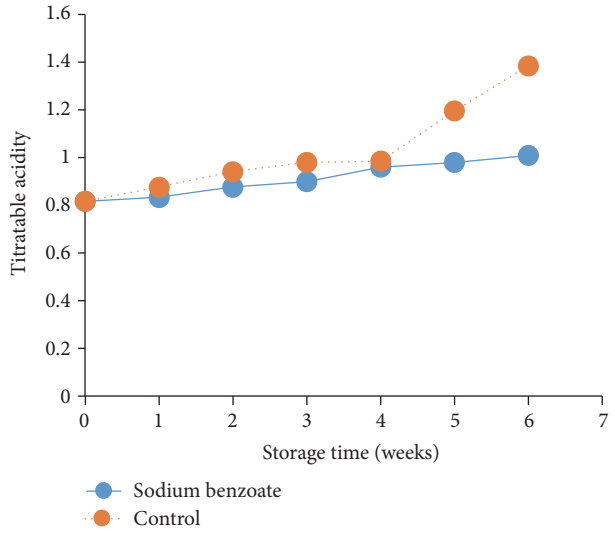


Figure 5: Changes of titratable acidity in sauce during storage.

At the same time, the temperature during storage will affect the growth of microorganisms because, theoretically, microorganisms grow faster at temperature of 20 to 40°C [24]. Another possibility for causing an increasing amount of microbial growth in sauce product is cross contamination from utensils to product or from handlers to product during handling and preparation [21, 24].

Increase in acidity value is due to the production of acid at low ion at low concentration during the storage, which is specified in Figure 5. Scientific report stated that this acidity value is influenced by sodium benzoate, vinegar, and citric acid added to product; increasing of acidity may result from production of acid from polysaccharide degradation and sugar oxidation or through breakdown of pectin molecule of sauce [21].

Preservatives are commonly used in almost all the processed food items in order to enhance the shelf life and maintain the product's quality. Sodium benzoate and sodium sorbate are most commonly used preservatives which are recommended by Sri Lanka Standards. In this study, usage of sodium benzoate as preservative on *G. sylvestre* sauce shows effectiveness in terms of bacteria, yeast, and mold retardation. Theoretically, sodium benzoate is able to retard the growth of bacteria from Bacillaceae, Enterobacteriaceae, mold, and yeast because benzoic acid is able to prevent microorganism from using substances rich in energy for their growth [25].

4. Conclusion

G. sylvestre leaf extract is an alternative ingredient for the production of sauce. *G. sylvestre* sauce has numerous health beneficial ingredients. The final sauce formulation recorded more than 70% preference for all the sensory attributes tested and it was complementary to the required Sri Lanka Standards. The sauce with 1000 ppm sodium benzoate had six weeks of shelf life at room temperature. Further studies are needed to verify the therapeutic effect of *G. sylvestre* leaves after being processed into a sauce.

Conflicts of Interest

All authors declare that there are no conflicts of interest regarding the publication of this paper.

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