J. Agric. Food. Tech., 8(1)1-9, 2018

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ISSN 2090 – 424X
Journal of Agriculture and Food Technology
www.textroad.com

Effect of Selected Processing Methods on the Nutritional and Anti-Nutritional Properties of Spider Plant *(Gynandropsis Gynandra)*

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ABSTRACT

In Kenya spider plant (Gynandropsis gynandra) is consumed by various communities hence could be utilized to enhance food and nutrition security especially in rural areas. However, there is limited information on the effect of different processing methods on its nutritional and anti-nutritional properties. The main aim of this study was to investigate the effect of different processing methods (fermentation, boiling and drying) on the nutritional and anti-nutritional properties of spider plant. Prior to fermentation and drying, blanching was done as a pre-process treatment. For nutritional analysis, proximate composition, mineral and antioxidant activity were determined. Anti-nutritional analysis involved determination of phytochemicals i.e. alkaloids, tannins, saponnins, terpenes, flavonoids, steroids and anthraquinones. The results of this study showed that fresh spider plant leaves were significantly higher in crude protein, crude fat, crude fibre and calcium than all the treated leaves, as was expected. Fermented leaves had significantly higher iron content compared to boiled and dried leaves while dried leaves had significantly higher amounts of sodium, magnesium and phytochemicals, and consequently highest antioxidant activity. Among the methods tested, drying was the best method since it retained significantly higher amounts of crude fat, sodium, magnesium and calcium compared to fermented and boiled leaves.

KEYWORDS: boiling, drying, fermentation, spider plant

1. INTRODUCTION

Spider plant (*Gynandropsis gynandra*) is a hardy native vegetable capable of withstanding high daytime temperatures, intense sunlight, and drought. It is a fast growing plant, thrives in degraded soils and in the right conditions can be harvested in less than three weeks after planting [1]. Although spider plant requires little input and the yields are usually high, the plant is still considered a weed by commercial farmers in Kenya and other countries [2]. In Kenya there has been an increase in the consumption of indigenous vegetables though the number still being low compared to exotic vegetables [3], with spider plant particularly being widely consumed by various communities especially in the rural areas due to its perceived antioxidant and superior nutritional properties [4]. Methods of preparation mostly vary due to community and preferences with the most common processing methods being boiling, steaming, frying as well as fermentation [5].Indigenous vegetables such as spider plant are not usually marketed fast enough during peak season due to their high perishability, resulting to high post-harvest losses [6] and further leading to limited supply coupled with high prices off season [7]. In order to provide nutritional security, there is a need to know which processing method would retain most of the inherent nutrients as well as reduce anti-nutrients found in indigenous vegetablessuch as spider plant. Although there is limited information on the nutritional and anti-nutritional properties of indigenous vegetables such as spider plant, it is usually on the fresh leaves that there is limited information on the changes that occur after various processing methods and how they compare to each other. Indigenous leafy vegetables such as spider plant are sustainable alternatives of exotic crops since they require low inputs, are pest resistant and are well adapted to the ecosystem. The current government policies take little notice of the role played by indigenous leafy vegetables hence have done little to promote this sector[5]. Since both novel and traditional processing methods are used to prepare spider plant, it is important to understand how they affect its overall quality. Research and dissemination of information about indigenous vegetables in our environments would help in expanding the base for global food security.

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2. MATERIALS AND METHODS

2.1 Sampling and treatments

The purple stem cultivar, which is the most common cultivar available in the market was used for the research. The spider plant material used were obtained from Bobaracho farm, Kisii County, which is a supplier to Darajambili market, Kisii town, one of the biggest open air markets in Western Kenya. The region was preferred because it is the main growing of spider plant. The samples were transported to Dedan Kimathi University of Technology for sample treatments and analysis.However, some analysis such as amino acid profile and antioxidant activity were done at Kenya Industrial Research and Development Institute (KIRDI). The samples collected were subjected to different process treatments i.e. blanching, drying, fermentation and boiling. Blanching was a pre-processing step, prior to drying and fermentation, for inactivation of endogenous enzymes.Blanching involved dipping spider plant leaves into hot water of about 90 °C for 5 seconds and then immediately cooling in cool water to prevent cooking. Analysis were done on the three treatments (drying, fermentation and boiling) and the control (fresh spider plant leaves) in triplicates. Drying was done by evenly spreading 1kg of whole spider plant leaves on a metallic tray covered with aluminium foil in an oven at 40 °C for 8 hours. Fermentation involved dipping 1kg of whole spider plant leaves in 3 litres of brine containing 5% glucose. The vegetables were allowed to ferment naturally for 48 hours at a temperature of 40 °C with the endpoint being a pH of ≤4.5. Boiling was done by immersing 1kg of spider plant leaves in 4 litres of boiling water at the temperature of 95 °C for about 5 minutes and then draining the process water.

2.2 Methods

2.2.1 Proximate composition

The parameters that were analysed include moisture content(AOAC 2012, Method 948.12), crude ash (AOAC 2012, Method 935.42), crude protein (AOAC 2012, Method 990.03), crude fat (AOAC 2012, Method920.39) and crude fibre (AOAC 2012, Method 978.01) using methods described in AOAC[8].

2.2.2 Evaluation of amino acid profile

Extraction of the metabolites was done by the method described by Kim *et al.*[9]. Two milligrams of the ground sample were extracted using 4ml of 2.5:1:1 v/v/v methanol: water: chloroform. Thereafter, Ribitol (10µL, 0.2mg/ml) was added as an internal standard denoted as (IS). Extraction was done at 37 °C through the mixing frequency of 1200 rpm for 30 minutes by use of a thermo mixer comfort (Model 5355, Eppendorf AG, Hamburg, Germany). The supernatant (0.8mL) that was obtained was transferred into a new tube, then addition of 0.4ml of water was done, and the solution centrifuged for 3 minutes at 16,000×*g*.

The centrifugal concentrator (CVE-2000, Eyela, Japan) was used to dry the methanol/water phase for 2 hours; this was then further dried in a freeze dryer for 16 hours. Methoxime (MO)- derivatization was done by addition of 80µL methoxyamine hydrochloride (20mg/mL) in pyridine and then shaking it for 90 minutes at 30 °C. Trimethylsilyl etherification was done by adding 80µL of MSTFA at 37 °C for 30 minutes. An aliquot of 20µL was injected in GC/MS.

The extracts were directly injected into the GC-MS for analysis. Library–MS searches were done using NIST/EPA/NIH, mass spectral library (NIST 05) and NIST mass spectral search program Version 2.0d, Chemco and Adams data base were used for characterization purposes in the GC-MS data system. The samples were analysed on a 7890A stand-alone gas chromatograph (Agilent Technologies, Inc., Beijing, China) and a 5975C mass selective detector (Agilent Technologies, Inc., Santa Clara, CA, USA) using the following conditions: Inlet temp of 270 °C, transfer line temp of 280 °C, and the column oven temperature was programmed from 35 to 280 °C with the initial temperature maintained for 5 minutes then 10 °C/minute to 280 °C for 10.5 minute and the final one for 29.9 minute 50 °C/minute to 285 °C.

The GC was fitted with a HP-5 MS low bleed capillary column (30 m × 0.25 mm internal diameter 0.25-µm) (Restek, Bellefonte, PA, USA). Helium was used as the carrier gas at a flow rate of 1.25ml/minute. The ion source temperature of 250 °C was maintained by the Agilent 5973 mass selective detector and the quadruple temperature maintained at 180 °C. The MS ion source temperature was set as 230 °C. Electron impact (EI) mass spectra were obtained at acceleration energy of 70 eV and an auto sampler 7683 (Agilent Technologies, Inc., Beijing, China) was used to automatically inject of the 1.0µL aliquot extract into the split/splitless mode. Fragment ions were analysed over 40-550m/z mass range in the full scan. The filament delay of 5 minutes.

2.2.3 Evaluation of mineral profile

This test was carried out as described in AOAC 2012, Method 985.01 [8]. About 0.2g of the spider plant leaves was weighed using an analytical balance into polytetrafluoroethylene vessels and 3ml of HNO_3 (67%, analpure) and 1ml of H_2O_2 (30%, analytical grade) was added. The time program used was as follows: 2 minutes at 250W, 2 minutes at 0W, 5 minutes using 400W, 2 minutes at 0W, 2 minutes at 400W and finally 7 minutes using 600W. After the digestion, solution was diluted with 25ml deionised water in a volumetric flask and then the analyte was analysed for calcium (420nm), iron (272nm), sodium and magnesium (285nm) by atomic absorption spectroscopy (AAS) (Shimadzu AA-7000) and relayed to a spectrophotometer (ICPE 9000). The calibration curve was determined by using standards with various parts per million concentrations (0, 1, 1.5, 2, 2.5 and 3mg/kg).

2.2.4 Evaluation of antioxidant activity

The radical scavenging activity was done using DPPH (1,1-diphenyl-2-picrylhydrazyl) according to the method described by Yen and Chen [10] with modifications from Pasko *et al.*[11]. The spider plant was extracted by using methanol because of its capability of donating hydroxyl radical to DPPH and thus make it stable.

The method measures the reactivity of test compounds against a stable free radical and gives strong absorption band at 517 nm in the visible region. The concentrations of the extracts that were prepared are: 0.05, 0.1, 0.5, 1.0, 2.0 and 5mg/ml of methanol in a cuvette placed in the spectrophotometer (analytical grade). Ascorbic acid was used as the antioxidant standard at the same concentration as the extract. One ml of the extract was placed in a test tube, and then 3ml of methanol was added followed by 0.5ml of 1mM DPPH in methanol. The mixture was shaken vigorously and left to stand for 5minutes. A blank solution was prepared containing the same amount of methanol and DPPH (Ab). The absorbance of the resulting solution (Aa) was measured at 517nm with a UV-vis spectrophotometer (Analytik Jena Specord 210, Germany). All the tests were run in triplicates and the radical scavenging activity was then calculated using the formula:

$$\%\ inhibition = \frac{Ab - Aa}{Ab} * 100$$

Where: Ab was absorption of the blank and Aa absorption of the extract

2.2.5 Assay of phytochemicals

Qualitative analysis to determine the presence of phytochemicals was carried out as described by Harborne[12]. Ground leaf powder (200g) of spider plant was soaked in a mixture of chloroform and methanol (1:1) for 24 hours and subsequently in absolute methanol for 24 hours. The crude extracts were separately concentrated *in vacuo* and then further concentrated by separately being soaked in activated charcoal (15 minutes), for removal of the chlorophyll, and stirred thoroughly followed by sieving using filter paper (595 Rundfilter, 270mm). The filtrates were further concentrated *in vacuo* and stored in labelled sample bottles. Each extract (2g) was used in the screening tests.

2.2.5.1Alkaloids

Two grams of the extract mixed with 20ml of 1% sulphuric acid were warmed in a 50ml conical flask on a water bath for 2 minutes, with intermittent shaking. Centrifugation was then done and the supernatant was pipetted off into a small conical flask. One drop of Meyer's reagent was added to 0.1ml of the supernatant in a semi-micro tube. A cream precipitate indicates presence of alkaloids.

2.2.5.2Flavonoids

A portion of the aqueous filtrate of the extract was mixed with five millilitres of dilute ammonia solution followed by addition of conc. sulphuric acid. The presence of flavonoids is indicated by formation of a yellow precipitate; however, the precipitate disappears after some time hence the need to be keen.

2.2.5.3Tannins

Tannin were determined using the Folin-Dennis colorimetric method as described by Kirk and Sawyer [13]. The dried powdered sample (0.5g) was boiled in 20ml of water in a test tube and then filtered using a Whatman no.42 filter paper. Then 0.1% ferric chloride was added dropwise. A brownish green or blue-black precipitate indicates presence of tannins.

2.2.5.4Phenols

Ferric chloride test was performed by diluting the extract using 5ml distilled water, followed by dropwise addition of neutral Ferric chloride solution. A dark green or blue-black precipitate indicates presence of phenols.

2.2.5.5Steroids

Two millilitres of anhydrous acetic were added to 0.5g ethanolic extract of each sample, 2ml of sulphuric acid was subsequently added. A colour change from violet to blue or green indicates presence of steroids.

2.2.5.6Saponin

About 2g of each sample were separately boiled in 20ml of distilled water in a water bath and filtered. Ten millilitres of the obtained filtrate were mixed with 5ml of distilled water and shaken vigorously to form a stable persistent froth. The froth was mixed with 3 drops of olive oil and shaken vigorously, then observed for the formation of emulsion.

2.2.5.7 Terpenoids

Five millilitres of each extract were mixed with 2ml of chloroform, and conc. sulphuric acid was then added carefully to form a layer. A formation of reddish- brown precipitate at the interphase indicates presence of terpenoids.

2.2.5.8 Anthraquinones

The plant extract was boiled with 10% hydrochloric acid for 5 minutes, then filtered and allowed to cool. Subsequently, it was mixed with an equal volume of chloroform. Formation of rose-pink colour indicates the presence of anthraquinones.

3. RESULTS AND DISCUSSION

3.1 Proximate composition

The moisture content of fresh spider plant leaves was significantly lower than that of fermented and boiled spider plant leaves while significantly higher than that of the dried spider plant leaves (Table 1). However, fermented and boiled leaves were not significantly different from each other. This observation could be attributed to the addition of water during the fermentation and boiling process, as well as the ability of crude fibre to absorb water hence leading to increased water in the vegetables [14].

Crude ash content in dried spider plant leaves was significantly higher than that of fresh leaves while that of fermented and boiled spider plant leaves were significantly lower than that of fresh leaves. The reduction could be attributed to leaching of some of the soluble minerals in to the processing water that was later discarded. Furthermore, the fermented vegetables might have some of its ash content used up by the fermenting bacteria for their metabolic activities [15].

The crude protein of fresh spider plant leaves was significantly higher than that of fermented and dried spider plant leaves (Table 1). These results were in contrast to the increased trend observed by Alector and Adeogun[16] though they used sun drying as opposed to the oven drying at 40 °C that was used in this study. Prolonged fermentation periods could lead to usage of the proteins as alternative sources of carbon if the source of sugars for fermenting wasn't enough [15] and hence the lower amounts in fermented vegetables.

Table 1: Proximate composition of processed spider plant (*Gynandropsis gynandra*)

Parameters	Treatments			
	Fresh	Fermented	Boiled	Dried
Moisture (%)	82.29 ± 0.41^{a}	86.64 ± 0.32^{b}	87.17 ± 0.13^{b}	9.14 ± 0.27^{c}
Crude ash (%)	2.82 ± 0.03^{a}	2.53 ± 0.02^{b}	2.15 ± 0.03^{c}	2.95 ± 0.01^{d}
Crude protein (%)	5.24 ± 0.07^{a}	3.80 ± 0.08^{b}	4.95 ± 0.09^{a}	4.15 ± 0.53^{b}
Crude fat (%)	2.43 ± 0.09^{a}	2.16 ± 0.05^{ab}	2.11 ± 0.21^{b}	2.19 ± 0.12^{ab}
Crude fibre (%)	1.66 ± 0.08^{a}	1.47 ± 0.05^{b}	1.18 ± 0.02^{c}	1.19 ± 0.07^{c}

The data are mean values ± standard deviation (SD) of triplicates, values within a row marked with different superscripts are significantly different ($p<0.05$)

Crude fat contents for all of treated spider plant leaves (fermented, boiled and dried) were significantly lower than that of fresh spider plant leaves (Table 1). The losses in boiled spider plant leaves could be attributed to complex fat molecules being broken down in the boiling water which is then discarded off after the processing [17]. The crude fibre content of the fresh vegetables was significantly higher than that of fermented, boiled and dried spider plant leaves (Table 1). However, the boiled and dried spider plant leaves were not significantly different from each other. The high loss of fibre in both boiled and dried treatments maybe due to both involving heat processes, that would

have led to breakage of weak polysaccharide and glycosidic bonds hence leading to increased solubilisation of the crude fibre [18].

3.2 Amino acid profile

From the amino acid profile obtained, both essential and non-essential amino acids were present in the spider plant leaves (Table 2). The essential amino acids present included: valine, threonine, leucine, isoleucine, lysine, methionine, phenylalanine and tryptophan, while the non-essential amino acids were aspartic acid, glutamic acid and arginine.

Of all the essential amino acids, leucine had the highest concentration although it was not significantly different amongst the various treatments. The valine concentration of fresh spider plant leaves was significantly higher than that of the boiled spider plant leaves, while the concentrations of fermented and boiled spider plant leaves were not significantly different from each other but significantly lower than that of dried spider plant leaves. Isoleucine concentration of fresh spider plant leaves was significantly lower than that of the boiled treatment, however it was not significantly different from that of fermented and dried treatments.

Table 2: Amino acid profile of processed spider plant (*Gynandropsis gynandra*) (mg/100g)

Amino acid	Treatments			
	Fresh	**Fermented**	**Boiled**	**Dried**
Valine	0.624 ± 0.002^{ac}	0.621 ± 0.002^{ab}	0.621 ± 0.001^{b}	0.624 ± 0.001^{c}
Threonine	0.398 ± 0.002^{a}	0.399 ± 0.001^{a}	0.400 ± 0.001^{a}	0.398 ± 0.002^{a}
Leucine	1.018 ± 0.002^{a}	1.016 ± 0.002^{a}	1.018 ± 0.002^{a}	1.015 ± 0.002^{a}
Isoleucine	0.540 ± 0.003^{ab}	0.537 ± 0.001^{b}	0.544 ± 0.002^{c}	0.542 ± 0.002^{bc}
Aspartic acid	0.578 ± 0.001^{a}	0.576 ± 0.002^{a}	0.576 ± 0.002^{a}	0.577 ± 0.002^{a}
Lysine	0.281 ± 0.002^{a}	0.278 ± 0.001^{b}	0.281 ± 0.001^{a}	0.277 ± 0.001^{b}
Glutamic acid	4.552 ± 0.002^{a}	4.554 ± 0.002^{a}	4.552 ± 0.002^{a}	4.367 ± 0.002^{b}
Methionine	0.248 ± 0.001^{a}	0.248 ± 0.002^{a}	0.254 ± 0.002^{b}	0.252 ± 0.002^{b}
Phenylalanine	0.747 ± 0.002^{ab}	0.750 ± 0.003^{b}	0.743 ± 0.002^{a}	0.746 ± 0.002^{ab}
Arginine	0.476 ± 0.001^{a}	0.467 ± 0.002^{b}	0.466 ± 0.002^{b}	0.472 ± 0.002^{c}
Tryptophan	0.079 ± 0.002^{a}	0.073 ± 0.002^{b}	0.068 ± 0.001^{c}	0.064 ± 0.002^{c}

The data are mean values ± standard deviation (SD) of triplicates, values within a row marked with different superscripts are significantly different ($p<0.05$)

Valine, isoleucine and leucine are considered as branched chain amino acids, they are the most important when it comes to manufacture, maintenance and repair of muscle tissue. They operate synergistically when dosed in the right amounts. From various studies its believed that a ratio of 2-1-1 (Leucine-Isoleucine-Valine) is desired for efficient synergistic effect of muscle protein synthesis [19]. In this study, similar ratios were observed in the data on various amino acid profiles of the treatments.

Methionine concentration of fresh and fermented spider plant were not significantly different from each other. Similarly, concentrations in the boiled and dried spider plant leaves were not significantly different from each other. Both sets (fresh and fermented, boiled and dried) were significantly different from each other. Methionine assists in the breakdown and usage of fats and its considered an antioxidant since it readily supplies sulphur to inactivate free radicals. For threonine and phenylalanine, there was no significant differences amongst all the treatments. Threonine allows better absorption of other nutrients, hence proteins containing threonine would be more bio-available than others while Phenylalanine allows nerve upgrading that would enable maximum contraction and relaxation of muscles[20].

Lysine concentration of fresh spider plant leaves was significantly higher than that of fermented and dried treatments, however it was not significantly different from that of boiled spider plant leaves. Lysine aids the body in calcium absorption, consequently leading to bone and muscle growth. Tryptophan concentration of fresh spider plant leaves was significantly higher than that of fermented, boiled and dried treatments, however, the concentrations of dried and boiled treatments were not significantly different from each other.

Tryptophan, isoleucine, leucine and lysine are important to the body since they undergo ketogenesis to result in the formation of Acetyl CoA, which is used for energy production in kreb's cycle and synthesis of fatty acids [20]. Of all the amino acids, glutamic acid had the highest concentration although its concentration in fresh spider leaves was not significantly different to that of fermented and boiled treatments, but was significantly higher to that of the dried spider plant leaves. Together with aspartic acid, glutamic acid is usually the most abundant amino acid in agricultural products [21].

3.3 Mineral profile

A profile of the predominant minerals found in spider plant (calcium, iron, sodium and magnesium) was done (Table 3). The magnesium, sodium and iron contents in dried vegetables were significantly higher than for the other treatments (fermentation, boiled & fresh). This observation could be attributed to the increased ratio of total solids available. This was also in line with previously observed increase in ash content.

The magnesium content of fresh spider leaves was significantly higher than that of the boiled treatment, significantly lower than that of the dried vegetables but not significantly different to that of fermented vegetables (Table 3). Magnesium would gradually leach into water but would be retained quite fairly at relatively high temperatures though not usually too high temperatures. Only a small fraction of magnesium would be leached in cold water as compared to hot water[22] and this explains why magnesium content was significantly different in boiled vegetables. The RDA (Required Dietary Allowance) for magnesium is 320mg/day for women and 420mg/day for men.

Table 3: Mineral profile of processed spider plant (*Gynandropsis gynandra*) (mg/100g)

Mineral	Treatments			
	Fresh	Fermented	Boiled	Dried
Magnesium	67.63 ± 0.58^{a}	67.07 ± 0.4^{a}	65.33 ± 0.58^{b}	75.87 ± 0.29^{c}
Sodium	22.73 ± 0.12^{a}	21.10 ± 0.10^{b}	20.97 ± 0.12^{b}	24.20 ± 0.20^{c}
Iron	1.90 ± 0.10^{a}	2.13 ± 0.06^{b}	1.80 ± 0.10^{a}	2.50 ± 0.10^{c}
Calcium	247.23 ± 0.29^{a}	238.27 ± 0.12^{b}	235.83 ± 0.12^{c}	242.4 ± 0.35^{d}

The data are mean values ± standard deviation (SD) of triplicates, values within a row marked with different superscripts are significantly different ($p<0.05$)

The sodium content of fresh spider plant leaves was significantly higher than that of fermented and boiled leaves but significantly lower than that of dried leaves (Table 3). Fermented and boiled vegetables had sodium contents that are not significantly different from each other. The RDA for sodium is expressed as a maximum of 2400mg/day.

The iron content of fresh vegetables was significantly lower from that of fermented and dried vegetables (Table 3). It was however not significantly different from that of boiled vegetables. The iron content increased during fermentation, which could be attributed to non-heme iron which is predominantly found in grains, seeds, nuts and the dark leafy parts of leafy vegetables [23], in various chemical forms such as ferritin which is a predominant component of Leucine [24]. The RDA is 3-18mg/100g but toxic at levels above 45mg/100g.

The calcium content was significantly different for all the treatments done on the vegetables. Specifically, fresh spider plant leaves had the highest concentration while boiled had the lowest concentration. Calcium would be lost through leaching in both fermentation and boiled vegetables but the loss would be more significant in boiled vegetables [22]. The RDA for calcium is 1300mg/day for adolescents, 1000mg/day for people aged 19 – 50 years and 1200mg/day for people over 50 years.

3.4 Antioxidant activity

The antioxidant activity of the various spider plant treatments was determined (Table 4) and comparisons done against the internal control of ascorbic acid as well as the experimental control of fresh spider plant leaves. From the study, all the spider plant extracts showed significantly higher free radical scavenging capabilities as compared to the antioxidant standard. The results on the antioxidant activity of fresh spider plant leaves were similar to the findings of Deepa Shree and Gopal [25]and Stangeland *et al.*[26].

Table 4: Antioxidant activity of processed spider plant (*Gynadropsis gynadra*) by DPPH

Parameters	Standard (vit. C)	Treatments			
		Fresh	Fermented	Boiled	Dried
IC_{50} (mg/ml)	0.01	0.04	0.06	0.12	0.05
Maximum Inhibition (%)	65.2 ± 0.46^{a}	72.9 ± 0.36^{b}	73.2 ± 0.30^{b}	71.9 ± 0.20^{c}	81.3 ± 0.27^{d}

IC_{50} value - the concentration, which scavenged 50% of the DPPH radicals

The data are mean values ± standard deviation (SD) of triplicates, values within a row marked with different superscripts are significantly different ($p<0.05$)

The antioxidant activity is usually associated with the levels of phytochemicals present. In this study, dried vegetables showed presence of most phytochemicals (such as alkaloids, tannins, phenols, saponins and terpenes) in contrast to other treated vegetables (Table 5) and consequently had the highest antioxidant activity (Table 4).

3.5 Phytochemical profile

Depending on the formation of various precipitates in the spider plant leaves tested, various phytochemicals were either present or absent (Table 5) depending on the intensity of the precipitate formed. Fresh spider plant leaves have various phytochemicals that contribute to the bitter taste and these are affected in various ways during the processing of foods. Most of the phytochemicals are water soluble meaning that they would be lost to the process water during various processing methods [27]. For instance, some of the phytochemicals such as tannins and phenols present in fresh vegetables were not detected in fermented and boiled samples. The findings on the phytochemical profile of fresh spider plant leaves were similar to those of Deepa Shree and Gopal[25] and Mishra *et al.*[28].

Table 5: Qualitative phytochemical profile of processed spider plant (*Gynandropsis gynandra*)

Phytochemical	Treatments			
	Fresh	Fermented	Boiled	Dried
Alkaloids	+	-	±	+
Flavonoids	+	+	±	±
Tannins	+	-	-	±
Phenols	+	-	-	+
Steroids	-	-	-	±
Saponins	+	-	-	+
Terpenes	+	-	±	+
Anthraquinones	-	-	-	±
Cyanogenic glycosides (2 hours)	-	-	-	-
Cyanogenic glycosides (48 hours)	-	-	-	-

Key: + (Positive), (-) Negative and (±) Doubtful

Spider plants was found to have the essential amino acids phenylalanine and tryptophan (Table 2), which are some of the constituents required for biosynthesis of alkaloids, and therefore a strong indicator of the potential occurrence of alkaloids.

CONCLUSION

In conclusion, drying resulted into higher retention of crude ash, crude protein, crude fat and crude fibre, as well as magnesium, sodium and β-carotene compared to fermentation and boiling. Furthermore, dried spider plant leaves exhibited the highest antioxidant activity and retained most of the phytochemicals. Therefore, drying could be a better preservation method for spider plant (Gynandropsis gynandra)

The dried spider plant leaves retained a fair amount of the proximate qualities, as well as having the highest content of sodium, magnesium and phytochemicals, hence it could be milled into powder form and incorporated to foods that are ready to eat to ensure its superior qualities are utilised and not lost during cooking through heat and leaching.

ACKNOWLEDGEMENT

We wish to express our sincere appreciation to the staff of Kenya Industrial Research and Development Institute (KIRDI) for the technical staff and expertise during the laboratory analysis. The authors declare that they have no competing interests.

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