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## Research Article

### IMPACT OF DRYING CORIANDER HERB ON ANTIOXIDANT ACTIVITY AND MINERAL CONTENT

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<p>B. B. Borse Plantation Products, Spices and Flavour Technology, Central Food Technological Research Institute, Council of Scientific and Industrial Research, Mysore – 570 020, India</p> <p><b>DOI: 10.7897/2321-6328.01203</b></p> <p>Article Received on: 02/05/12 Accepted on: 10/07/13</p>	<p>The present study investigated the impact of drying on quality, mineral content and antioxidant activity of coriander herb after four drying treatments. The coriander herb was subjected to different drying methods viz., Low Temperature Low Humidity (LTLH) drying, Infrared (IR) drying, Sun drying and hot air oven drying (60°C, 80°C and 100°C) and analysed. LTLH dried coriander showed higher retention of total chlorophyll (5.3 g %), carotenoids (27.3 mg / 100 g), ascorbic acid (110.5 mg / 100 g) and greenness (-6.73) compared to other drying methods and close to fresh herb. LTLH dried coriander was extracted with different solvents viz., ethanol and aqueous ethanol (50, 60 and 70 %) and evaluated for antioxidant activity. Extract of 60 % ethanol showed higher Radical Scavenging Activity (70 % at 50 ppm), Reducing Power Assay (0.85 Abs at 40 ppm) and Total Polyphenols (5.5 g gallic acid equivalents [GAE] per 100 g) compared to other solvent extracts. The effect of drying on mineral content was estimated. Minerals viz., K, Ca, Fe, Mg, Mn, Zn and Cu were determined. LTLH dried coriander showed higher mineral contents viz., K (9464.9 µg / g), Mg (461.3 µg / g), Mn (68.8 µg / g), Zn (15.8 µg / g), Ca (734 µg / g) and Fe (1316.7 µg / g) followed by IR, hot air (60°C) and sun drying.</p> <p><b>Keywords:</b> coriander; LTLH drying; chlorophyll; colour, carotenoids, antioxidant activity, mineral content.</p>

## INTRODUCTION

Coriander, also popular as Cilantro or Chinese Parsley, is an aromatic annual herb (of Apiaceae or Umbelliferae) cultivated for its seeds and foliage which are used all over the world as culinary spice, flavouring agent and for its various medicinal / aromatic applications. The foliage is a very good source of phytochemicals such as vitamin C (160- mg / 100 g FW), vitamin A (β-carotene 12 mg / 100 g FW)<sup>1</sup> and Vitamin B12 (60 mg / 100 g)<sup>2</sup>, polyphenols and essential oils. Coriander, like many spices, contains antioxidants which can delay or prevent the spoilage of food seasoned with this spice and also provide such protections upon its ingestion. Most of the studies in coriander have been focused on its seeds<sup>3</sup> and very little attention is paid to the constituents in leaves<sup>4</sup> although foliage is popular for their versatile use in various types of foods. The fresh coriander leaves contain 2-decenal and 2-dodecenal, important odorants<sup>5</sup>. A study found both the leaves and seed to contain antioxidants, but the leaves were found to have a stronger effect<sup>6</sup>. Chemicals derived from coriander leaves were found to have antibacterial activity against *Salmonella choleraesuis* and this activity was found to be caused in part by these chemicals acting as non-ionic surfactants<sup>7</sup>. Coriander has been used as a folk medicine for the relief of anxiety and insomnia in Iran. Experiments in mice support its use as an anxiolytic<sup>8</sup>. Coriander has been documented as a traditional treatment for diabetes. A study on mice found that coriander extract had both insulin-releasing and insulin-like activity. Coriander has long had a reputation for helping digestion and getting rid of gas, also

shows that coriander may help to control cholesterol and diabetes. For this treatment, simply prepare a kind of “coriander tea”- boil some crushed coriander leaves or seeds in water for a few minutes and then drink this water. Fresh coriander leaves are perishable in nature and require immediate processing or preservation. Drying is the major processing technology practised for coriander leaves so far. However and has a limitation on aromatic herbs as it results in considerable losses of flavonoid components and attractive colour pigments<sup>9-11</sup>. Therefore, there is a need for alternate processes for shelf-life extension and for developing other coriander leaf-based products.

## MATERIAL AND METHODS

### Material

Fresh coriander herb (*Coriandrum sativum*) in bulk was procured from the local market, Mysore, India. The plant was identified and authenticated by Agri. Horti. Dept., CSIR-CFTRI, Mysore, India. The roots as well as extraneous foreign material were removed and the greens were washed in water to remove dirt and soil.

### Methods

#### LTLH Drying (Low Temperature Low Humidity)

1 kg of fresh coriander was loaded in a LTLH drier with dehumidifier (Bry-Air, Haryana, India, model/CFM-FFB-170, voltage-230) at 50°C and with a relative humidity of 25–30 %. The drying for coriander was carried out for a period of 270 minutes.

**Conventional Hot Air Drying**

1 kg of fresh coriander was loaded in a Conventional hot air oven drier (Technico, Chennai, India, model no: 747, size: 121x361x361, Rating: 6 kW, mains – 440 AC),

**IR Drying**

1 kg of fresh coriander was loaded in a conventional hot air oven drier; where the IR facility was provided and the drying temperature was set at 60°C. The drying was carried out for a period of 180- 240 minutes.

**Sun Drying**

1 kg of fresh coriander was spread on a tray and then it was kept in direct sunlight exposure area. The drying for leaf coriander was carried out until the leaf coriander was dried well for a period of 9 h.

**Analysis of Dehydrated Leaves**

The fresh and dried leaves (Sundried, IR dried, Cross flow dried and LTLH dried) of coriander herb were analyzed for quality parameters viz., moisture, surface color value, chlorophyll, ascorbic acid (vitamin C) and  $\beta$ -carotene content.

**Estimation of Moisture**

Fresh and dried coriander herbs (5 g) were analyzed for moisture by using toluene distillation method using Dean and Stark apparatus. The experiment was carried out for a period of 2-3 h<sup>12</sup>.

**Color Measurement**

Color measurement was carried out by the method of Hunt<sup>13</sup>. Coriander greens were dried by various drying methods and collected to examine change of colour and compared using a hunter colormeter model “Lab scan XE” (Hunter associates laboratory, USA) using universal software, based on three colors co-ordinates namely L, a and b. L’ represents the lightness index, ‘a’ represents red-green, while ‘b’ represents yellow-blue color components. The instrument was calibrated using a standard white (L = 90.70, a = -1.08, b = 0.65) and blank reference tile under illuminated conditions such as illuminate C and view angle 10°.

**Chlorophyll Estimation**

Estimation of chlorophyll content was carried out by method as per Ranganna<sup>12</sup>. About 2 g of representative sample was macerated with acetone in a pestle and mortar. The supernatant layer was decanted and the extraction was

repeated until the residue was colorless. Then the extracts were pooled, filtered and made up to 250 ml in a volumetric flask. A 25-50 ml aliquot of the acetone extract was taken into a separating funnel and mixed with 50 ml diethyl ether and water was added until the water layer was apparently free of all the fat-soluble pigments. Water layer was drained off and ether layer washed four times with 25 ml portions of distilled water until the layer was free of acetone. The ether layer was taken into a 50 ml volumetric flask and made up to the mark. 3-4 g of anhydrous sodium sulfate was added to remove the moisture. After the solution became clear, a suitable aliquot was diluted with ether such that absorbance falls between 0.2 and 0.8 at 660 nm and 642.5 nm. The absorbance was taken at both the wavelengths.

$$\begin{aligned} \text{Total chlorophyll} &= 7.12 \times \text{O.D. at } 660 \text{ nm} + 16.8 \times \text{O.D. at } 642.5 \text{ nm} \\ \text{Chlorophyll 'a'} &= 9.93 \times \text{O.D. at } 660 \text{ nm} - 0.777 \times \text{O.D. at } 642.5 \text{ nm} \\ \text{Chlorophyll 'b'} &= 17.60 \times \text{O.D. at } 642.5 \text{ nm} - 2.81 \times \text{O.D. at } 660 \text{ nm} \end{aligned}$$

The above equations provide chlorophyll content in mg/l in the solution used for recording absorbance. The chlorophyll content in the coriander greens sample was calculated taking the dilution factor into consideration, and the results were expressed as mg % on dry basis.

**Estimation of Ascorbic acid (vitamin C)**

The ascorbic acid was determined by 2, 6-dichlorophenol-indophenol visual titration method (2001) as per Ranganna<sup>12</sup> given as follows:

**Standardization of Dye**

Standard ascorbic acid (100 mg of l-ascorbic acid made up to 100 mL with 3 % HPO<sub>3</sub>, 10-ml diluted to 100 mL with 3 % HPO<sub>3</sub>), 5 mL was transferred to Erlenmeyer flasks containing 5 mL of metaphosphoric acid (3 %). A micro burette was filled with the dye. Then, it (ascorbic acid solution) was titrated against the standard indophenol dye solution to a rose pink colour, which persisted for around 15 sec. The dye factor was determined as milligram of ascorbic acid per millilitre of the dye, using the formula:

$$\text{Dye factor} = 0.5 / \text{titre value}$$

**Preparation of Sample**

Fresh and dried coriander herb (2 g) was ground with aqueous metaphosphoric acid (3 %) in a pestle and mortar. The solution was filtered and made up to 50 ml with 3 % HPO<sub>3</sub>. Around 10 ml of aliquot was taken and titrated against the standard dye to a pink end point, which persisted for at least for 15 sec. Vitamin C content was calculated as

$$\text{Ascorbic acid (mg per 100 g or mL)} = \frac{A \times B \times V \times 100}{W \times \text{Aliquot of the extract taken}}$$

where A is volume in mL of standard dye used for titration, B, weight in mg of ascorbic acid equivalent to 1 mL of indophenol solution, i.e. dye factor, V, volume made up and W, weight in g of sample.

**Extraction of Carotenoids**

Coriander greens powder prepared from dried greens was used for the extraction of carotenoids. The method of Raju<sup>14</sup> was employed for the extraction of carotenoids. In brief 2-3 g of edible portion were well ground along with 2-3 g of anhydrous sodium sulphate and 2mM  $\alpha$ -tocopherol and pigments were extracted using ice-cold acetone. The extraction was repeated three times, or until the residue was

rendered colourless, indicating complete extraction of pigments. The solvent was removed at 40°C under reduced pressure (40 milli bar) in a rotavapor, dissolved in methanol (50 ml) and diluted suitably to 0.6 and absorbance was recorded at 450 nm.  $\beta$ -carotene concentration was estimated as,

$$\text{Carotenoids (mg /100 g)} = (A/e) \times \text{Dilution factor.}$$

Where, A is OD of sample at 450 nm and e is extinction co-efficient of beta carotene

### Extraction of Coriander Herb

The dried coriander herb (25 g) was grinded and packed into the column and solvents viz., ethanol and aqueous ethanol (50, 60 and 70 %) was allowed to stand for 2 h and eluted with material solvent ratio 1:20. The solvent was desolventized in a rotary evaporator (Heidolph, Germany) at 50°C and the extract obtained was stored in the refrigerator until used.

### Determination of Polyphenols in Coriander Herb Extracts

Samples were analyzed for total polyphenol content according to Singleton and Rossi<sup>15</sup>. A known volume of the extract (10 mg) was dissolved in 10 ml water. A 0.1 ml aliquot of the resulting solution was added to Folin-Ciocalteu reagent (0.5 ml) and 20 % saturated solution of Na<sub>2</sub>CO<sub>3</sub> (1.5 ml) was added. This was made up to 10 ml with distilled water and incubated at 27°C for 2 h. Optical density was measured at 765 nm using a spectrophotometer. The concentration was calculated using gallic acid as a standard and the results were expressed as gallic acid equivalents per 100 g of extract.

### Free Radical Scavenging Activity of Coriander Herb Extracts

Free radical scavenging activity was measured by the 1, 1-diphenyl-2-picrylhydrazil (DPPH\*) method<sup>16</sup>. Different concentrations (10, 20 and 30 ppm) of extracts were taken,

four ml of 0.1 mM methanol solution of DPPH\* was added to these test tubes and shaken vigorously. The tubes were then incubated in the dark at room temperature for 20 minutes. A control sample was prepared as above without extract and methanol was used for the baseline correction. Changes in the absorbance of the samples were measured at 517 nm. All analyses were run in triplicate and the values were averaged. Radical scavenging activity was expressed as the inhibition percentage and was calculated using the following formula

$$\text{Radical scavenging activity (\%)} = \frac{(\text{Control OD} - \text{Sample OD})}{\text{Control OD}} \times 100$$

### Reducing Power Assay (RPA) of Coriander Herb Extracts

The reducing power was determined according to the method of Oyaizu<sup>17</sup>. Various concentrations (10, 20 and 30 ppm) of extracts (2.5 ml) were mixed with 2.5 ml of 200 mol / l sodium phosphate buffer (pH 6.6) and 2.5 ml of 1 % potassium ferricyanide. The mixture was incubated at 50°C for 20 minutes. 2.5 ml of 10 % trichloroacetic acid (w/v) was added; the mixture was centrifuged at 6500 rpm for 10 minutes. The upper layer (5 ml) was mixed with 5 ml deionised water and 1 ml of 0.1 % of ferric chloride and the absorbance was measured at 700 nm. Higher absorbance indicates higher reducing power. The assays were carried out in triplicate and the results are expressed as mean values ± standard deviations.

**Table 1: Drying Time, Carotenoid and Ascorbic acid Content of Coriander Herb**

Coriander leaf	Time (h)	Moisture (%)	Carotenoids (dwb, mg / 100 g)	Ascorbic acid (dwb, mg / 100 g)
Fresh	-	70	34.3 ± 0.05 <sup>f</sup>	120.5 ± 0.05 <sup>e</sup>
Hot air (60°C)	6.5	5.5	25.8 ± 0.06 <sup>d</sup>	25.0 ± 0.01 <sup>d</sup>
Hot air (80°C)	5	5.6	20.0 ± 0.04 <sup>c</sup>	18.7 ± 0.02 <sup>c</sup>
Hot air (100°C)	4	5.3	14.7 ± 0.04 <sup>a</sup>	12.5 ± 0.01 <sup>a</sup>
Sun dried	9	6.0	14.0 ± 0.04 <sup>a</sup>	15.0 ± 0.01 <sup>b</sup>
IR dried (60°C)	4	4.3	17.5 ± 0.01 <sup>b</sup>	56.2 ± 0.04 <sup>c</sup>
LTLH dried (50°C)	4	4.7	27.3 ± 0.01 <sup>e</sup>	110.5 ± 0.04 <sup>f</sup>

Values are mean ± SD of triplicates; Values having different superscripts are significantly (p < 0.05) different

**Table 2: Colour Estimation for Coriander Leaf by Master Colour Data (Hunter Lab 2\*/C)**

Sample (Coriander leaf)	L	a	b
Standard	90.7 ± 0.02	-1.09 ± 0.007	0.64 ± 0.03
Fresh leaves	35.9 ± 0.02	-10.6 ± 0.02	22.4 ± 0.007
Hot air (60°C)	33.3 ± 0.02	-6.7 ± 0.03	13.7 ± 0.007
Hot air (80°C)	33.2 ± 0.007	-6.5 ± 0.01	13.3 ± 0.01
Hot air (100°C)	32.5 ± 0.02	-6.2 ± 0.007	12.6 ± 0.01
Sun dried	37.2 ± 0.01	-5.2 ± 0.01	11.1 ± 0.01
IR dried (60°C)	37.2 ± 0.01	-7.6 ± 0.007	15.5 ± 0.01

Values are mean ± SD of triplicates; Where; L\* (lightness) axis: black to white (0 to 100) a\* (red - green) axis: positive values are red; negative values are green; 0 is neutral b\* (yellow - blue) axis: positive values are yellow; negative values are blue; 0 is neutral

**Table 3: Mineral Content of Coriander Herb Dried by Different Drying Methods**

Minerals (µg / g)	Oven dried	Sun dried	LTLH dried	IR dried
Calcium	705.2 ± 0.1	703.4 ± 0.4	734.2 ± 0.1	730.6 ± 0.2
Copper	5.5 ± 0.01	1.73 ± 0.1	6.31 ± 0.2	9.33 ± 0.2
Iron	751.9 ± 0.2	252.1 ± 0.5	1316.7 ± 0.2	860.6 ± 0.3
Potassium	6753.7 ± 0.3	2082.5 ± 0.3	9464 ± 0.3	9350 ± 0.1
Magnesium	390.1 ± 0.02	148.7 ± 0.2	461.3 ± 0.2	439.5 ± 0.1
Manganese	58.1 ± 0.3	20.8 ± 0.2	68.8 ± 0.1	27.4 ± 0.1
Zinc	10.2 ± 0.2	10.3 ± 0.1	15.8 ± 0.02	7.4 ± 0.3

Values are expressed as mean ± SD of triplicates

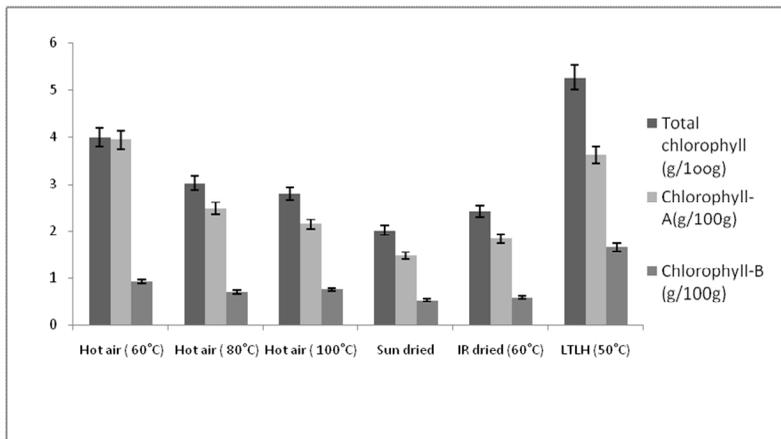


Figure 1: Chlorophyll Content (g / 100 g) of Dried Coriander Herb by Various Drying Methods

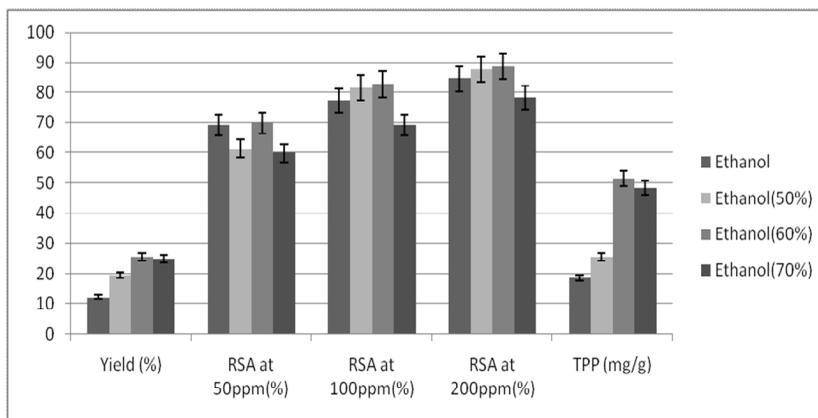


Figure 2: Yield, RPA, RSA and TPP of Coriander Extract

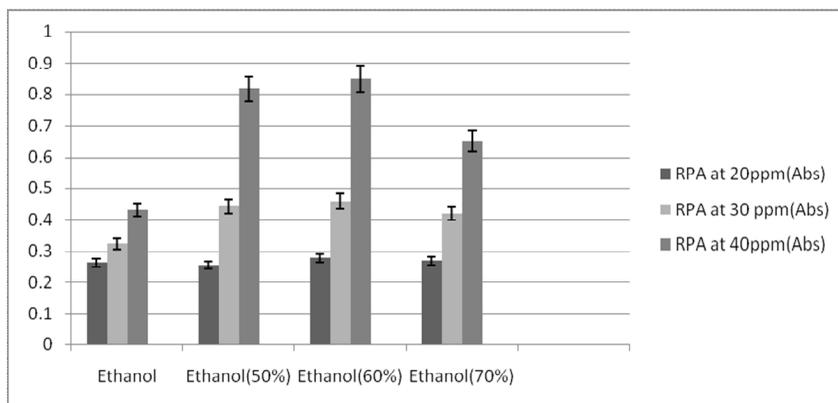


Figure 3: Reducing Power Assay (RPA) of Coriander Extracts

**Mineral Estimation**

The minerals in coriander herb dried using different driers were determined using inductively coupled plasma - atomic emission spectrometry (ICP-AES, Ultima 2). Five grams of the dry leaf coriander powder was converted to ash using muffle furnace (600°C, 8 h) and dissolved with 2 mL of concentrated nitric acid solution and the volume made up to 25 mL using triple distilled water<sup>18</sup>. The calibration curves were prepared from standards. The samples were subjected to estimation of calcium, iron, zinc, manganese, magnesium, potassium and copper using respective standard solutions.

**Statistics**

All the analyses were carried out in triplicate and the results were provided as mean value with standard deviation. The obtained data were subjected to statistical analysis and the means compared by Duncan’s New Multiple Range test (p < 0.05) are presented.

## RESULTS AND DISCUSSION

### Quality Characteristics of Coriander Herb Dried by Different Driers

Fresh coriander was dried using LTLH drier at 50°C, conventional hot air oven (60, 80 and 100°C) drier; IR drier at 60°C and sun dried. In hot air drying, drying time reduced with increasing temperature (6.5 h to 4 h). Drying by LTLH, hot air (100°C) and IR was faster and took 4 h while sun drying and hot air (60 and 80°C) took more time as shown in Table 1.

### Colour

On drying the fresh coriander herb, the green, yellow colour decreased as indicated by decrease in *a* and *b* value compared to fresh leaves. The loss of green and yellow colour was higher in sun dried herb. These results are in accordance with findings of Mandhyan<sup>19</sup> who studied the effect of drying on colour of green leafy vegetables. The *L*, *a* and *b* values were higher in case of LTLH dried sample followed by IR dried and hot air dried coriander (Table 2).

### Ascorbic acid, Chlorophyll and β-carotene Content

Loss of Ascorbic acid, chlorophyll and β-carotene in dried herbs was observed irrespective of drying methods (Table 1 and Figure 1). Sun drying showed higher loss of pigments due to instability of pigments to sunlight. The loss of pigments was less during drying in hot air at 60°C and 80°C as compared to 100°C. Chlorophyll, carotenoids and ascorbic acid content was retained higher in LTLH than other drying methods. The results indicate that LTLH method was more suitable for the drying of coriander herb.

### Radical Scavenging Activity

It is well known that free radicals cause autoxidation of unsaturated lipids in food<sup>20</sup>. In addition, antioxidants are known to interrupt the free-radical chain of oxidation and to donate hydrogen from phenolic hydroxyl groups, thereby, forming stable free radicals, which do not initiate or propagate further oxidation of lipids<sup>21</sup>. Recent reports have described antioxidants and compounds with radical scavenging activity present in onion, garlic, sage, and thyme extracts<sup>22,23</sup>. The determination of scavenging stable DPPH\* was a very fast method to evaluate the antioxidant activity of the extracts. With this method it was possible to determine the antiradical power of an antioxidant activity by measurement of the decrease in the absorbance of DPPH\* at 517 nm, resulting from a color change from purple to yellow. The absorbance decreased when the DPPH\* was scavenged by an antioxidant, through donation of hydrogen to form a stable DPPH\* molecule. In the radical form this molecule had an absorbance at 517 nm which disappeared after acceptance of an electron or hydrogen radical from an antioxidant compound to become a stable diamagnetic molecule<sup>24</sup>. The data obtained, reveal extract of 60 % ethanol had higher radical scavenging activity compared to other solvent extracts as shown in Figure 2. It was also observed that the activity increased with the increase in concentration of extracts and reached maximum at 200 ppm. Thus coriander extracts are free-radical inhibitors, antioxidants that react with free radicals. Antioxidant activity of natural antioxidants has been shown to be involved in termination of free radical reactions and reducing power<sup>25-26</sup>.

### Total Phenolic Content

The phenolic compounds in coriander 60 % ethanol extract contained highest amount of polyphenols, 5.5 g gallic acid equivalents (GAE) per 100 g extract compared to other solvent extracts. The Folin-Ciocalteu method is actually not an antioxidant test but instead an assay for the quantity of oxidizable substances, i.e., phenolic compounds.

### Reducing Power Assay

During the reducing power assay, the presence of reductants (antioxidants) in the tested samples would result in reducing Fe<sup>3+</sup> / ferricyanide complex to the ferrous form (Fe<sup>2+</sup>). The Fe<sup>2+</sup> can therefore be monitored by measuring the formation of Perls Prussian blue at 700 nm<sup>27</sup>. The reducing power (as indicated by the absorbance at 700 nm) of extracts rose with an increase in concentration and was higher for 60 % ethanol extract 0.85 Abs at 40 ppm. The antioxidant activity has been reported by some investigators to be concomitant with the development of reducing power<sup>28,29</sup>. Gordon<sup>30</sup> reported that the antioxidant action of reductones is based on breaking of the radical chain by donation of a hydrogen atom.

### Mineral Estimation

The impact of drying on mineral content of coriander herb was estimated. The mineral compositions are shown in Table 3. The results of the analyses were established to give nutrient value per g of dried coriander. Mineral elements were found to vary widely depending on the different dryings. According to results, Fe content was highest followed by Ca, Mg, Mn, Zn and Cu were in least amount. Calcium is the major component of bone and assists in teeth development<sup>31</sup>. The Mg, Fe and P levels are adequate. The importance of these elements cannot be overemphasized because many enzymes require them as cofactors<sup>31</sup> (Akpanabiatu, Basse, Udosen and Eyong, 1998). LTLH dried coriander showed higher mineral contents viz., K (9464.9 µg / g), Mg (461.3 µg / g), Mn (68.8 µg / g) and Zn (15.8 µg / g). In dried coriander leaf Cu (15.8 µg / g), Ca (795.2 µg / g) and Fe (1860.6 µg / g) was high in IR dried followed by hot air (60°C) and sun dried. This work attempts to contribute to knowledge of the nutritional properties of coriander herb. In addition, knowledge of the mineral contents, as condiments is of great interest.

## CONCLUSIONS

Drying of herbs has been found to be a very useful technique for increasing the amount of phenolic compounds and antioxidant capacity of the extracts. Among the drying methods tested, LTLH was found to be the best method. The results showed that LTLH drying method is very effective for retention of chlorophyll, ascorbic acid, colour, carotenoid and major minerals for drying of coriander herb compared to IR, Sun and oven drying methods. Extract of 60 % ethanol showed higher RSA, RPA and TPP compared to other solvent extracts. Our results indicate that inclusion of coriander herb in the cuisine will increase the content of antioxidants and minerals vital for health and thus probably would prevent oxidative deterioration of food.

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