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Effect of drying methods on nutrient quality of Basil (*Ocimum viride*) leaves cultivated in Ghana

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Abstract

Basil (*Ocimum viride*) leaves were dried using five different drying methods: microwave-drying at power 3, oven-drying at 110°C, hot-air-drying at 100°C, sun-drying at 33°C, and ambient-air-drying at 28°C. The object was to analyse the effect of the drying methods on the nutritional characteristics of the spicy basil leave. Moisture content of the fresh and dried leaves was determined using laboratory oven kept at 105±3°C for 24 h. Extracts from fresh and dried leaves samples were analysed for protein, iron (using UV spectrophotometer), and carbohydrates (using handheld refractometer). Microwave-drying and oven drying were the methods that produced the best results for preserving most nutrients compared to the fresh herb, whereas ambient-air-drying, hot-air-drying, and sun-drying brought about substantial losses in basil leave nutritional values. Microwave-drying was the optimum method for basil leave drying as it required shorter treatment time of 4 min and gave the best retention of protein and carbohydrates when compared to oven-drying which required 17 min, preserving 42% (wt) of iron.

Introduction

Basil (*Ocimum viride*) is a tender-growing aromatic annual herb indigenous to West Africa, but also cultivated in India. The use of basil and other spicy herbs in food preparations are not only for flavouring from their strong spicy aroma, but also for other purposes such as their medicinal, antioxidant, anti-inflammatory, antiviral or antimicrobial properties (Chipault *et al*., 1956; Baritaux *et al*., 1991; Risch, 1997). In developing countries, particularly in Ghana, basil is used in its fresh form in food preparations (such as flavouring chicken soups, sauces, etc) and other local purposes. However, the plant is scarce during off-seasons, which necessitates good preservation. Also, the plant is highly perishable, and has to be preserved against deterioration and spoilage.

Drying is the most common and effective method that increases the shelf life of spicy herbs by inhibiting the growth of microorganisms and preventing the onset of some biochemical reactions that may alter the organoleptic and nutritional characteristics of the dried leaf. However, drying must be performed carefully in order to preserve the aroma, appearance and nutritional characteristics of the raw herbs as much as possible (Crivelli *et al.*, 2002). The drying may cause losses in volatilities or formation of new volatilities as a result of oxidation reactions, esterification reactions (Diaz-Maroto *et al*., 2002).

Many studies about drying effects on the volatile composition of basil leaves have been performed and reported. The volatile composition of basil is found to be dependent on the variety and/or geographical cultivation of the basil plant. Linalool, methylcinnamate, eugenol, and methyleugenol are the main components in Fijian basil (Brophy *et al*., 1986), while linalool and methylchavicol are the major compounds in Egyptian basil (Karawya *et al*., 1974), and linalool, methylchavicol, and eugenolthe main components in Israel basil (Fleisher, 1981). Basil (*Ocimum basilicum* L.) cultivated in Taiwan is found to contain large amounts of methylchavicol (Tsai and Sheen, 1989), while the main compounds in basil (*Ocimum basilicum* L. cv. Di Genova grande verde) cultivated in Liguria (Italy) are eucalyptol, linalool, eugenol, and methyleugenol; with the common aroma compound, methylchavicol, found in many basil types not present (Di Cesare *et al.*, 1994, 2000, 2001, 2002).

Drying is reported to influence changes in the volatile compounds present in basil. Decreases in the total amounts of essential oils have been reported between 36–45% in sweet basil during drying at ambient temperature (Nykänen and Nykänen, 1987). A study by Yousif *et al.* (1999) showed significant difference in concentrations of linalool and methylchavicolin in air-dried samples compared to those present in fresh samples, while that of vacuum-

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microwave dried samples showed substantial increase of about 2.5 fold for linalool and 1.5 fold for methylchavicol, compared to that present in air-dried samples. Di Cesare *et al.* (2003) found microwave drying to retain high percentages of characteristic volatile compounds (eucalyptol, linalool, eugenol, and methyleugenol) in basil (*Ocimum basilicum* L.) compared to samples dried by air-drying and freeze-drying with blanching, except freeze-dried unblanched leaves. Other studies on drying methods on volatilities of bay leaf (Diaz-Maroto *et al*., 2002), and spearmint (Diaz-Maroto *et al*., 2003) have been reported.

Studies into drying effects on volatile components of basil leaf have been reported. However, data on drying effects on nutritional qualities of basil leaf is not available at the time of this study. The aim of this study was to examine the influence of five drying methods: room-drying at ambient temperature, sun-drying, hot-air-drying, oven-drying, and microwave-drying on protein, iron, and carbohydrate contents of basil (*Ocimum viride*) cultivated in Ghana. The results of this study will provide useful data for applying the most effective drying method for basil (*Ocimum viride*) leaves cultivated in Ghana to maintain the nutritional value of the spice.

Materials and Methods

Samples

Fresh leaves of cultivated basil (*Ocimum viride*) with its stalks were obtained from gardens in the Kumasi metropolis (Ghana). The leaves were carefully cleaned manually to remove dirt and damaged ones, and were removed from the stalks. The leaf samples were divided into 6 batches. One batch was analysed as fresh within 24 h of harvesting.

Drying methods

The remaining 5 batches of basil leaves were immediately dried using one of the following methods. The drying conditions employed in each of these methods were selected after trials had been conducted to achieve a percentage moisture content of $<20\%$ using the shortest possible time for the drying. The reported data are means of three replications.

Microwave-Drying: Ten grams (10 g) of raw basil leaves were placed onto a glass fibre sheet in a microwavable plate and then dried in a microwave oven (Sanyo 800 W Compact Microwave, EM-S1067, China) at atmospheric pressure for 4 minutes at power 3.

Hot-Air-Drying: Ten grams (10 grams) of raw basil leaves were placed in a perforated tin container, and the leaves air-dried with a commercial regulated hand dryer (Carmen, Hair Ionic Speed Styler 13308, 1500W, UK) at 100°C. The temperature of the hot air was verified using a laboratory thermometer.

Oven-Drying: Ten grams (10 g) of raw basil leaves were spread evenly on baking sheets and placed in a conventional laboratory oven (Gallenkamp OVE.100.130 M, UK) at 110°C for 17 min.

Sun-Drying: Ten grams (10 g) of basil leaves were folded into a thin sheet of paper and placed on a flat plate in direct sunlight (UV) rays for 8 h - 38 min at an average temperature of 33°C (relative humidity 62%). The folded sheet was turned occasionally to allow even contact of the sun rays. The paper wrap was employed to reduce the possible effect of the environs on the leaves.

Ambient Air-Drying: A ten grams of basil leaf sample was air-dried at ambient temperature in a 'dark' well-ventilated room for 168 h (7 days) at average temperature of 28°C (average relative humidity of 61%).

Moisture analysis

Moisture content of the fresh and dried leaves was determined using a laboratory oven (Gallenkamp OVE.100.130 M, UK) kept at 105±3°C for 24 h. Triplicate determinations were made, and the moisture content calculated on a wet basis from the difference between the wet and dry weight divided by the wet weight (AOAC, 1975). Reported data are the means of the three replications.

Nutritional analyses

Protein: Overall protein content was analysed using direct measurement according to the McClements' Method (McClements, 2011), using a UV spectrophotometer (Beckman DU-650 UV-Vis, Beckman Coulter, USA) at a wavelength of 280 nm. The UV lamp was warmed up to 15 min. The wavelength was adjusted to 280 nm, and was calibrated to zero absorbance with the blank sample (distilled water) only. About 4 g of the leaf samples were ground, mixed with 25 ml distilled water. The extracts obtained after squeezing the mixture were diluted with distilled water and placed in a transparent cuvette, and the tryptophan and tyrosine content of the proteins (representing the proteins) in the sample directly measured from the absorbance of the solution at 280 nm. The tryptophan and tyrosine content of the proteins absorbed strongly at 280 nm, and were directly measured without the need for special reagents. Reported data are the means of triplicate measurements.

Carbohydrate: Total carbohydrate contents of the fresh and dried samples were measured directly using a handheld refractometer (Brix RHB-32ATC, SYOPTEK, China), according to McClements' Method (McClements, 2011). About 4 g of the leaf samples were ground, mixed with 25 ml distilled water. The extract obtained after squeezing the mixture was kept at 20°C before the analyses. A small quantity of the extract (kept at 20°C) was dropped on the daylight plate of the refractometer using a micro pipette, and the concentration of total sugars (representing the total carbohydrates content) measured at a wavelength of 589.3 nm via the refractive index with quartz. Reported data are means of three replications.

Iron: Contents of iron in the samples were determined using a UV-Visible spectrophotometer (Beckman DU-650 UV-Vis, USA) at a wavelength of 510 nm. About 4 g of the leaf samples were ground, mixed with 25 ml distilled water. The extract obtained after squeezing the mixture was mixed with 35 ml sodium citrate to adjust the pH to 6. Exactly 2 ml of freshly prepared hydroquinone solution was added to the leave extract solution followed by addition of 5 ml ortho-phenanthroline solution in a 100 ml volumetric flask. The solution was topped up to the mark with distilled water and allowed to stand for 10 minutes for colour formation. The iron concentration of each sample was determined using the UV/Vis spectrophotometer at a wave length of 510 nm in triplicates. Reported data are the means of triplicate measurements.

Results and Discussions

Reports in literature show varied differences in essential oil concentration and composition of various cultivars of basil. The basil used in this study is classified as *Ocimum viride*, a cultivar indigenous to West Africa and India. Its fragrant leaves smell like lemon thyme. Literature on the drying effects on essential oil composition and concentration as well as on volatilities is readily available, but same is not the case for the nutritional characteristics of the herbal spice.

Effect on moisture content

Figure 1 depicts the moisture contents of raw and dried basil leaves. The results are expressed in percentage wet weight basis. The initial moisture content of the fresh basil leaves was 91.20% ± 0.96.

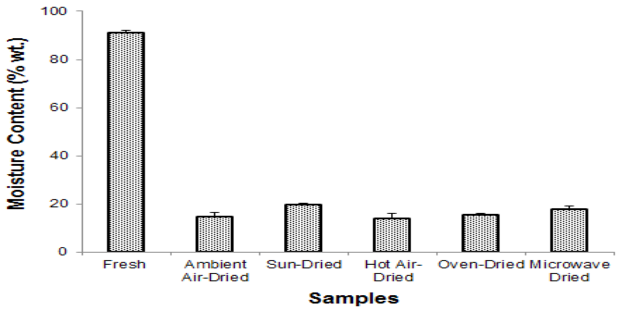

Figure 1. Moisture content of raw and dried basil leaves. Results are averaged of three replications with standard deviations represented as error bars.

Hot-air-dried leaves had the lowest moisture content (14.06% ± 1.97), whilst sun-dried leaves had the highest moisture of 19.71% ± 0.50. The relatively dried leaves obtained from hot-air-drying method might be due to the extremely high temperature (100°C) applied at a moderately short time. Leaves dried in the room at ambient air temperature (28°C) were the second most dried after hot-air dried leave (moisture content of 14.70% ± 1.84). This might be due to the long drying time employed (7 days, i.e. 168 h). This was because, according to Yousif *et al*. (1999), during the long hours of drying heat was conducted from the surface to the interior of the leaves and the rate of evaporation of water on the surface of the leaves was faster than the rate of diffusion to the surface. It must be emphasised that the drying conditions (i.e. temperature and time) were not optimised to obtain the same moisture content for all dried leaves. However, all dried leaves achieved a percentage moisture content less than 20% wt.

Effect on protein

The influence of drying methods on protein content in basil is shown in Figure 2. Microwave dried basil leaves preserved the most protein in the dried leaves compared to the other drying methods. An amount of 4.01 mg/g ± 0.10 of protein was found in the microwave dried leaves compared with 4.50 mg/g ± 0.13 in the fresh leaves. This represents about 89% (wt) of the protein preserved in the microwave dried leaves in relation to that of fresh leaves. This was followed by oven drying (3.05 ± mg/g 0.13) – approximately 68% (wt), whilst leaves dried in the room at ambient temperature had the smallest amount of protein (0.50 mg/g ± 0.10), about 11% left over. The heating causes denaturation of protein cells leading to loss of protein due to weakening of the three-dimensional conformation of the protein cells (Janine, 2011; Meyerzon, 2012). Therefore the long heating time for ambient dried-leaves caused more loss to protein in the basil leaves (about 89% loss) than any of the drying methods. A comparison of

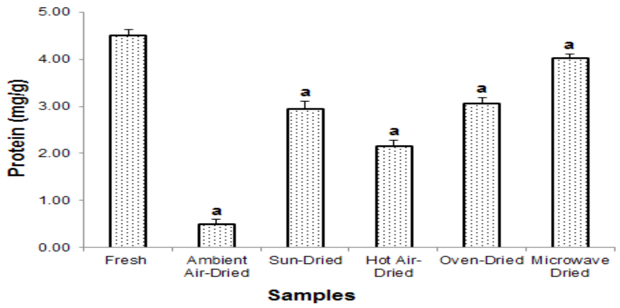

Figure 2. Protein content of raw and dried basil leaves. Results are averaged of three replications with standard deviations represented as error bars. The letter ‘a’ above bars indicates a significant difference ($p < 0.05$) compared with raw leaves.

protein levels of dried leaves with those present in fresh samples showed significant differences at 95% ($p < 0.05$), represented by the letter “a” on Figure 2.

Effect on carbohydrates

Figure 3 shows the effect of drying methods on carbohydrates in basil leaves. All heating methods, except hot-air drying did appear to affect the carbohydrate content in the basil leaves. Only the carbohydrate level in hot air-dried leaves was significantly different at the 95% confidence level ($p < 0.05$) from the raw leaves (see Figure 3). Microwave-dried leaves preserved most of the carbohydrates in the leaves (about 98%) compared with that in the fresh leaves. Hot air-dried leaves relatively lost more carbohydrates (about 87% wt. of the carbohydrates retained) than all the other drying methods. Generally, during the heating, the starch was turned to dextrin which drove off the water, whilst the sugar caramelised quickly and then burnt. The amount lost due to heating may be the low molecular weight carbohydrates, which are usually lost during heating (FAO, 1980). The results indicated that all drying methods applied retained appreciable amounts of carbohydrates in the basil leaves. Only the carbohydrate content in hot air-dried basil leaves differed significantly at 95% ($P < 0.05$) from the carbohydrates content in fresh leaves.

Effect on iron

The impact of drying methods on the iron value in basil leaves is shown in Figure 4. Oven dried leaves contained more iron than in other dried leaves. About 42% (wt) of iron was retained in the oven-dried leaves compared with 22% (wt.) for microwave-dried leaves. Microwave drying retained the highest amounts of carbohydrates and proteins than all drying methods, but this was not the case for iron content. Ambient air-dried leaves contained the least amount of iron, about 8% (wt). Iron bioavailability increases when certain vegetables are cooked (Yan *et al*., 2002).

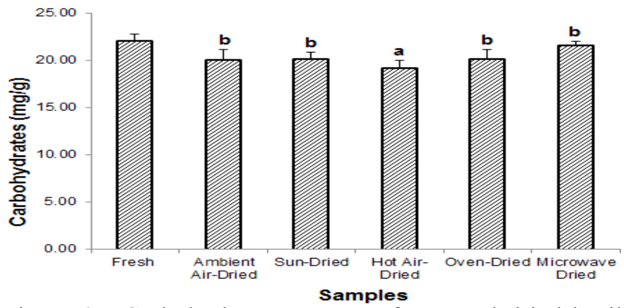

Figure 3. Carbohydrate contents of raw and dried basil leaves. Results are averaged of three replications with standard deviations represented as error bars. Letters ‘a’ and ‘b’ above bars indicate significant and insignificant difference ($p < 0.05$) respectively compared with raw leaves.

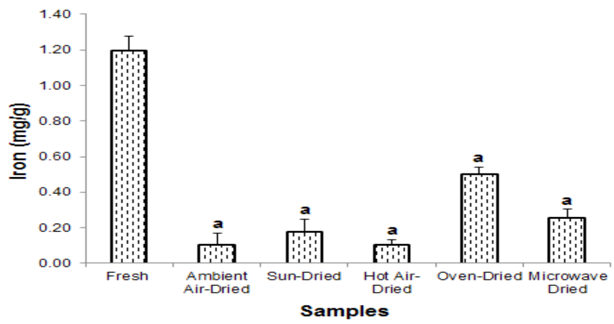

Figure 4. Iron contents of raw and dried basil leaves. Letter ‘a’ above bars indicate significant difference ($p < 0.05$) compared with raw leaves.

However, the rather substantial decrease of iron by the drying methods used in this study compared to that in the raw leaves indicated that all the drying methods employed do not favour iron content in basil leaves. This may be because the heating caused oxidative deterioration of iron, which in effect resulted in released and decreased of the iron in the dried leaves. Even the oven drying method, which retained a comparatively high iron levels caused a loss as high as 58% as compared to that found in the raw basil leaves. A comparison of iron levels in the dried leaves with that present in fresh leaves showed significant difference at 95% level ($p < 0.05$).

In general, microwave drying was the most favoured method for drying basil (*Ocimum viride*) leaves, though iron levels in microwave dried leaves were lower than that in oven-dried samples. All other nutrient values (protein, carbohydrates) were higher in microwaved-dried leaves with relatively low losses in relation to the raw leaves. This is because microwave energy transfer causes a quick evaporation of water from the leave tissue at a shorter treatment time, which reduces oxidation and other side reactions, preserving the nutritional values. Other studies on basil (*Ocimum basilicum* L.) on flavour volatilities and physical properties (Yousif *et al*., 1999), chemical composition (Di Cesare *et al*., 2003) confirmed microwave drying as the optimum drying method for allowing larger retentions of characteristic volatile (flavour) compounds, preserving sensory qualities, flavour, and colour of dried basil leaves.

Conclusion

The nutritional quality of dried basil leaves depends on the drying method utilised. Microwave-drying and oven drying methods produced the best results for preserving the most significant amounts of nutrients in the dried leaves relative to the fresh herb. Ambient-air-drying, hot-air-drying, and sun-drying brought about substantial losses in the basil leave nutritional qualities and required several minutes to hours. Microwave drying was the optimum method for drying basil leaves. It was very quick drying process requiring just 4 minutes treatment that resulted into a best quality dried basil leaves. It preserved high values of protein and carbohydrate than oven-drying that required 17 min, preserving only relatively appreciable amount of iron than microwave-dried leaves.

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