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# Nutritional evaluation of *Moringa oleifera* leaves using three drying methods

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**ABSTRACT:**

*Moringa oleifera,* is a tropical plant with many useful parts. Nutritionally, it is noted for high protein and vitamin A content. In recent times a lot of interest has been generated in the nutritional benefits of this plant, so there is a need to process it in a cost effective manner that will conserve the nutrients and ensure its availability as a food supplement. The objective of this study is to determine the optimal conditions (method, temperature and humidity) for drying *Moringa oleifera* leaves for maximum nutrient conservation. Leaves of *M. oleifera* were either solar, mechanical or room temperature dried and milled into powder. The powders were analysed for moisture and protein by proximate method; vitamin C by indophenol method; vitamins A, vitamin E, and luthein/zeaxanthin using HPLC. pH was measured with a pH meter; water activity by dielectric & conductivity method; mould and yeast by ISO 7954 (1987) and mycotoxins by HPLC. The fresh leaves were also analysed. The results showed that drying decreased protein levels in the leaves up to 19%. Vitamin levels decreased (63% to 85%) depending on vitamin type, with all the drying methods used. Although beta-carotene and vitamin C levels were less affected by drying at room temperature, this method did not offer convenient moisture content and water activity for good storage of powder. Both solar and mechanical drying offered products with good moisture and water activity levels that are convenient for storage as well as appreciable nutrient levels.

**Keywords:**
*Moringa oleifera*, drying methods, beta carotene, vitamin C, water activity.

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## INTRODUCTION

*Moringa oleifera* (*M. oleifera*) is one of about thirteen species in the *Moringaceae* family. The plant, originating from the southern foothills of the Himalayas in northwestern India, is now cultivated in Africa, Central and South America and other tropical, sub-tropical and semi-arid regions of the world. *M. oleifera* is a plant with many useful parts. Every part of the plant is useful as food, medicine, or for industrial purposes (Ramachandran *et al.,* 1980; Babu, 2000; Fahey, 2005; Khalafalla *et al.,* 2010; Saint Saveur *et al.,* 2010). Humans use its leaves, flowers and young pods as vegetables whilst others use it as fodder (Moyo *et al.,* 2011). *M. oleifera* is used to treat malnutrition, anaemia and to correct vitamin A deficiency in several countries (Fuglie, 1999).

The plant, which produces leaves throughout the year, is reported to be tolerant to bacteria, drought, fungus and mycobacteria and could therefore be easily cultivated in the tropics. It is a readily available backyard tree in homes where it will provide the much-needed nutrient–rich leaves for household nutrition (Luu *et al.*, 2005; Saint Saveur *et al*., 2010). Nutrients in *M. oleifera* are found mainly in the leaves and tender pods. *M. oleifera* leaves contain high levels of vitamins A, B and C (Fuglie, 1999) as well as high calcium and iron, but are low in phosphorus. The leaves also contain appreciable amounts of magnesium, selenium and zinc. Additionally the leaves are high in protein content but are low in fat and carbohydrates. *M. oleifera* leaves are also rich in the sulphur-containing amino acids methionine and cystine that are often not found in abundance. The leaves have negligible amounts of tannins. Trypsin and amylase inhibitors, lectins, cyanogenicglucosides and glucosinolates were not detected in the leaves (Makkar and Becker, 1997). If the benefits of this plant resource are well tapped, it has the potential to improve food and nutrition security and promote rural development.

Proximate Analysis of *M. oleifera* fresh (raw) leaves and leaf powder (dried and milled leaves) showed the following per 100g. of edible portion (Fuglie, 1999): For the fresh leaves - Moisture 75.0%, Calories 92.0, Protein 6.7g, Fat 1.7g, Carbohydrate 13.4g, Vitamin A - B carotene 6.8 mg, Vitamin $B_1$ - thiamin 0.21 mg, Vitamin $B_2$ - riboflavin 0.05mg, Vitamin $B_3$ - nicotinic acid 0.8 mg, Vitamin C - ascorbic acid 220.0 mg,and for the leaf powder - Moisture 7.5%, Calories 205.0, Protein 27.1g, Fat 2.7g, Carbohydrate 38.2g, Vitamin A - B carotene 18.9mg, Vitamin $B_1$– thiamin 2.64mg, Vitamin $B_2$ - riboflavin 20.5mg, Vitamin $B_3$ - nicotinic acid 8.2mg, Vitamin C - ascorbic acid 17.3mg, Vitamin E - tocopherol acetate 113.0mg.

Emphasis, however, had been on room temperature drying of leaves for maximum nutrient conservation (Fuglie, 1999), without due consideration for storage conditions of the final product. Alternative drying methods have not been thoroughly investigated. *M. oleifera* should be processed in a cost effective manner that will remove drudgery and increase the volume of production to meet the increasing demand for the product (room drying takes about 96 hours as against 4-5 hours by solar and mechanical drying). The processing method should also ensure a very good product in terms of nutrient conservation. The current study aims at determining the optimal conditions (method, temperature and humidity) for drying *M. oleifera* leaves in order to ensure a good product and conserve appreciable nutrient levels.

## MATERIALS AND METHODS

*M. oleifera* leaves were sampled from the coastal belt of Ghana. Three different samples from the same field were tested. Samples were collected at two week intervals, very early in the morning, and transported in an ice chest to the laboratory at CSIR-Food Research Institute. Samples were then washed first with potable water to remove loose dust, followed by 1% saline for

three minutes (FDGS 998), and finally rinsed with potable water.

Samples were either mechanically dried at 50°C and 55°C using an electric dryer, or solar dried (35°C -55°C) with a GIZ constructed solar dryer or dried at room temperature (28°C -31°C). Three replicates were run for each drying method to ensure that variation was due to the drying method and not the sample itself. The samples were milled with a stainless steel hammer mill into powder of particle size 0.3mm (FDGS 998) which was put into clean polythene bags.

For each drying method, the following tests were performed: moisture, protein, vitamin C, vitamin A, vitamin E, pH, water activity, mould and yeast and mycotoxins. Tests were also performed on the fresh leaves. Crude protein was determined by the Kjeldahl method of AOAC 984.13 (1990); Moisture by AOAC 925.10 (1990). Vitamin C was determined by the Indophenol method and vitamins A, and E, were determined by HPLC (AOAC 992), Water activity was measured by dielectric & conductivity method, using the Rotronic HygroLab water activity measuring instrument, while pH was measured with Lab Ph Meter (Radiometer, Copenhagen). Mould and yeast were determined by ISO 7954 (1987). Mycotoxins were determined by HPLC Methods (Pons, W.A (1979) JAOAC 62, 586-594 (extraction procedure).

## RESULTS AND DISCUSSION

The results of the analysis is presented in Table 1

Leaf drying caused a mean reduction of 19% of protein with solar drying and a mean of 16% with mechanical drying; while vitamin C reduction ranged from 63% with room temperature drying to 75% with solar drying. Mechanical drying recorded a mean reduction of 73.7%. Beta carotene levels reduced by 82.9% with solar drying, 83.4% with mechanical and 76.2% with room temperature drying. Reduction in vitamin E levels ranged from 77% with solar to 85%

**Table 1: Various drying methods and nutrient levels in *M. oleifera* leaves**

| | Batch | Drying conditions | | Moisture (g/100g) | Proteins (g/100g DW) | Vitamin C (mg/100g DW) | Beta-caroten (mg/100g DW) | a-tocopherol (mg/100g DW) | Lutein+zeaxanthin (µg/100g DW) | Water activity | pH | Yeast and mould count (cfu/g) | Aflatoxin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Temperature | Time | | | | | | | | | | |
| Solar drying | 1 | 35-55°C | 3,5h | 8.0 | 26% | 16 | 27 | 128 | 1978.3 | 0.607/27.8°C | 5.27 | $3.8 \times 10^7$ | 0 |
| | 2 | 35-55°C | 4h | 3.6 | 23% | 12 | 31 | 160 | 1483.4 | 0.425/28.0°C | 5.46 | $2.3 \times 10^3$ | 0 |
| | 3 | 35-55°C | 5h | 5.0 | 27% | 14 | 34 | 172 | 1400.0 | 0.385/29.0°C | 6.10 | $1.6 \times 10^4$ | 0 |
| | **Mean** | | | **5.5** | **25%** | **14** | **31** | **153** | **1620.6** | | | | |
| Mecanical drying | 1 | 55°C | 4h | 8.1 | 26% | 10 | 27 | 74 | 2796.5 | 0.599/28.1°C | 5.35 | $8.0 \times 10^1$ | 0 |
| | 2 | 50°C | 6h | 4.8 | 23% | 18 | 40 | 101 | 2289.9 | 0.435/28.2°C | 5.56 | $6.3 \times 10^3$ | 0 |
| | 3 | 50°C | 6h | 6.2 | 28% | 17 | 22 | 131 | 2494.7 | 0.468/28.0°C | 5.84 | $2.6 \times 10^4$ | 0 |
| | **Mean** | | | **6.4** | **26%** | **15** | **30** | **102** | **2527.0** | | | | |
| Room temperature | 1 | 31°C | 48h | 13.6 | 27% | 23 | 57 | 98 | 1828.7 | 0.723/27.3°C | 5.69 | $7.0 \times 10^1$ | 0 |
| | 2 | 31°C | 96h | 10.2 | 23% | 19 | 38 | 108 | 1637.0 | 0.637/27.6°C | 6.01 | $2.5 \times 10^4$ | 0 |
| | 3 | 31°C | 96h | 9.9 | 29% | 19 | 36 | 125 | 1598.2 | 0.612/28.0°C | 5.89 | $5.5 \times 10^2$ | 0 |
| | **Mean** | | | **11.2** | **26%** | **21** | **43** | **111** | **1688.0** | | | | |
| Fresh leaves | 1 | - | - | 72.6 | 32% | 47 | 168 | 974 | 4635.0 | NA | 5.70 | $3.2 \times 10^3$ | 0 |
| | 2 | - | - | 72.5 | 31% | 52 | 240 | 545 | 3272.7 | NA | 5.70 | $1.9 \times 10^5$ | 0 |
| | 3 | - | - | 72.6 | 30% | 71 | 135 | 555 | 2043.8 | NA | 5.40 | $1.4 \times 10^5$ | 0 |
| | **Mean** | | | **72.6** | **31%** | **57** | **181** | **692** | **3317.2** | | | | |

with mechanical. Beta carotene and vitamin C levels were least affected by room temperature drying, however, room temperature drying did not offer convenient moisture and water activity levels for good storage (moisture >8%; water activity >0.7 (FDGS 999). Leaf drying did not affect pH. Mould and yeast levels were also not affected by the type of drying method; they were highly variable with each sample, but were below acceptable levels (FDGS 999). Aflatoxin was not detected in any of the dried samples, indicating that all methods offered satisfactory conditions with regard to aflatoxin content. Mechanical drying offered an advantage over solar with regards to lutein/zeaxanthin (23.8% reduction as against 51.1% with solar drying), but this nutrient is likely to be lost during storage because it is highly unstable.

The protein level in the leaves ranged from 25% for solar drying to 26% for mechanical and room temperature drying with the protein content of fresh leaves being 31% (DW). The protein content of the dried leaves compares favourably with the value of 27.1% reported by Fuglie (Fuglie,1999) and 27.51 reported by Oduro *et al*., (2008). Ogbe and Affiku, however, reported a value of 17.01% in leaves from Nigeria, whilst Jongrungruangchok *et al.,* (2010) reported 23.29% in leaves cultivated in Thailand and (Moyo *et al.,* 2011) reported 30.29mg/100g for leaves from South Africa. Therefore, although leaf drying in the current study decreased the protein level by up to 19%, values obtained were still high for the production of a protein concentrate that could be stored and used in treating protein - energy malnutrition.

The vitamin C levels obtained for fresh *M. oleifera* leaves in this study were lower than values reported in literature (120- 200mg/100g fresh weight or 360- 600mg/100g DW -Saint Saveur *et al*., 2010). The comparatively low vitamin C values could not make the powder a good source of this vitamin, but vitamin C itself is very unstable and is likely to be lost during storage. The beta carotene content of the dry leaves are high enough to meet the RDAs of children. Ten (10)g leaf powder will meet the RDA of children 1-13 years and 50-100% of all other age groups.

## CONCLUSION AND RECOMMENDATIONS

Both solar and mechanical dryers could be satisfactorily used for Moringa leaf powder production as they both offer convenient storage conditions in terms of moisture, water activity and acceptable nutrient levels. However, since solar energy is readily available in the tropics, solar dryers would have an advantage in that the cost of production will be minimised. Hence there is a potential of preparing good quality, nutrient dense *Moringa* leaf powder at minimal cost in the tropics and sub-tropics, using solar dryers, that could be a readily available supplement for preventing and fighting malnutrition. It could also serve as a source of income generation for rural folks who could process these leaves for the big markets.Simple solar dryers could be constructed from local materials and used for this purpose (Saint Saveur *et al*., 2010). Studies on the shelf-life of the leaf powder is recommended as well as supplementation trial with Moringa leaf powder.

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