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Investigation of appropriate packaging material and shelf-life stability of *Moringa oleifera* leaf powder

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ABSTRACT:

Moringa oleifera, a tropical plant produces leaves that contain high levels of vitamin A and protein in addition to other vitamins and minerals. Hence its leaves are dried, milled and used as a food supplement in several countries. However, the stability of the nutrients during storage has not been much investigated. The objective of this study is to determine the appropriate packaging material and shelf-life stability of *M. oleifera* leaf powder. *M. oleifera* leaves were solar dried and milled into powder. After the initial analysis, the powder was weighed in aluminium foil, high density polythene and low density polythene sachets. Each was put into a paper envelope and sealed off. The envelopes were put on shelves in a kitchen cabinet and sampled at two month intervals for nutrient analysis. Protein and moisture were determined by proximate method; vitamin C by indophenol method; beta-carotene and alpha-tocopherol by HPLC. pH was measured with a pH meter; water activity by dielectric and conductivity method; mould and yeast by ISO 7954 (1987) and aflatoxin by HPLC. The results showed that protein levels did not vary with time and mode of storage; vitamin C was lost after two months of storage with all packaging materials. Beta-carotene and alpha-tocopherol levels reduced to about half the initial value after six months.

Keywords:
Moringa oleifera leaf powder, beta-carotene, alpha-tocopherol, vitamin C, packaging materials, shelf-life.

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INTRODUCTION

Moringa oleifera also referred to as "The Miracle Tree", horseradish-tree and drumstick- tree, is one of about thirteen plants in the Moringaceae family. It is a leafy vegetable with high contents of protein, vitamins A, B, C and minerals. *M. oleifera* leaves are reported to contain three times the Potassium in bananas; four times the Calcium in Cow's milk; two times the protein of yoghurt; four times the vitamin A of carrots and seven times the vitamin C of oranges (Fuglie, 1999, Babu, 2000). It is therefore not surprising that ancient medicine claims that *M. oleifera* leaves prevent 300 diseases and cure 67 (Fahey, 2005), because good nutrition promotes good health. Nutrients are also concentrated in the pods of the plant. *M. oleifera* leaves are also high in iron content but low in phosphorus (Jongrungruangchok *et al.*, 2010).

In Senegal and Haiti, health workers treat malnutrition in young children with *M. oleifera* powder; they also give the powder to pregnant women and nursing mothers. One rounded tablespoonful (8 g) of *M. oleifera* leaf powder will satisfy about 14% of the protein, 40% of the calcium, 23% of the iron, and almost all the daily vitamin A needs of a child 1-3 years old (Saint Saveur*et et al*., 2010). In Phillipines, *M. oleifera* is prescribed for anaemia (Fuglie, 1999). *M. oleifera* is therefore becoming a plant of high economic value.

The germplasm is tolerant to bacteria, drought, fungus and mycobacteria (Duke, 1978), but the young plants could be attacked by fungal diseases; however, these could be controlled by effective and inexpensive products made from mancozeb or maneb, and in organic farming, by regular clearing of weeds around the plants and spraying with neem leaf or seed extracts (Saint Saveur*et et al*., 2010). *M. oleifera* produces leaves all round the year and hence could be easily cultivated in the tropics. Nutrients are also found in the tender pods (Babu, 2000, Saint Saveur*et et al*., 2010). The leaves have negligible amount of tannins, whereas cyanogenicglucosides, glucosinolates, trypsin and amylase inhibitors and lectins, were not detected (Makkar and Becker, 1997). This plant therefore has the potential for improving nutrition security and rural development.

Fuglie (1999) reported the following proximate values of *M. oleifera* fresh (raw) leaves and leaf powder (dried and milled leaves) per 100g. of edible portion: From the fresh leaves - Moisture 75.0%, Calories 92.0, Protein 6.7 g, Fat 1.7 g, Carbohydrate 13.4 g, Vitamin A-beta 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 2.7 g, Carbohydrate 38.2g, Vitamin A-beta carotene 18.9 mg, Vitamin B_1-thiamin 2.64 mg, Vitamin B_2 - riboflavin 20.5 mg, Vitamin B_3 - nicotinic acid 8.2 mg, Vitamin C - ascorbic acid 17.3 mg, Vitamin E - tocopherol acetate 113.0 mg.

Previously, emphasis had been made on the room temperature drying of *M. oleifera* leaves for maximum nutrient conservation (Fuglie, 1999). However, recent work showed that both solar and mechanical dryers have an advantage over room temperature drying in that they offer convenient storage conditions in terms of moisture, water activity and acceptable nutrient levels (Glover-Amengor and Mensah, 2012). The shelf- life and packaging material for *M. oleifera* leaf powder have not been investigated much. Although Mensah (2011) observed a general decline in nutrient content of *M. oleifera* leaf powder using different packaging materials, he only investigated crude protein, fat and some minerals. There is the need to investigate the vitamins as they are very important in *M. oleifera* nutrition. The objective of this study is to investigate appropriate packaging material for conserving nutrients during storage. When established, this has the potential for further boosting *M. oleifera* leaf powder trade as it will give an added advantage to product storage.

Table 1 Packaging type and nutrient levels with time of storage

Parameter	Packaging									
	Initial	Aluminium foil			LD PET			HD PET		
Time/months	0	2	4	6	2	4	6	2	4	6
Moisture(%)	7.4[a]	13.6[d]	13.7[d]	14.05[d]	9.5[b]	10.0[b]	13.3[c,d]	12.5[c]	12.5[c]	13.95[d]
Protein (%)	25	25	25	25	25	25	25	25	25	25
Vitamin C (mg/100g DW)	14.0[d]	7.8[b]	-	-	7.3[a]	-	-	10.5[c]	-	-
Beta-carotene (mg/100g DW)	51.5[e]	49.2[e]	45.1[de]	21.5[a]	35.04[f]	30.1[c]	29.9[c]	32.4[c]	29.9[ab]	22.1[ab]
Alpha-tocopherol (mg/100g DW)	215[i]	200[b]	175[g]	175[g]	147[f]	106[d]	102[c]	118[e]	100[b]	91[a]
pH	5.27c	5.23[b]	5.33[d]	5.40[e]	5.13[a]	5.34[d]	5.39[e]	5.16[a]	5.41[e]	5.48[f]
Mould and Yeast	2.3 x 10^{3}[d]	250[a]	320[a]	315[a]	1.2 x 10^{3}[c]	743[b]	740[b]	743[b]	300[a]	351[a]
Aflatoxin	-	-	-	-	-	-	-	-	-	-

MATERIALS AND METHODS

M. oleifera leaves were harvested from a field in the Accra metropolis, Ghana, early in the morning before 7 AM. Leaves were then put in an ice-chest and quickly transported to CSIR-FRI to prevent moisture loss. The leaves were treated with 1% saline for three minutes, after initial washing to remove dust and then rinsed with water to remove residual salt. The leaves were dried in a solar dryer (35-55^{o}C). Solar drying using a constructed dryer was selected for the shelf-life study because the solar dryer is cheaper to run and it also offered convenient storage conditions as the mechanical dryer (Glover-Amengor and Mensah, 2012, FDGS 998, 2009; FDGS 999, 2009). The solar dryer used in this study is a GIZ constructed one that was constructed with opaque polythene material that excludes UV penetration.

The study was started in the last week of March 2009 and ran into May. The humidity range during that period was 75-85% in the coastal belt. Three packaging materials were selected. These were high density (HD PET (3.9 ml)) and low density (LD PET (7.0 ml)) polythene material, and aluminium foil (10.3 ml). Low density and high density polythene materials are among those used in leaf powder packaging and these are either enclosed or not enclosed in a paper box (Saint Saveur *et al.*, 2010). Fifteen grams (15 g) of leaf powder was weighed into these materials and sealed off. These were then put into a paper envelope (11.0 ml) that was glued at its mouth. The bags were left on shelves in a cabinet at room temperature (28-31^{o}C). After the initial analysis, samples were withdrawn at 2-month intervals for nutrient analysis.

The following tests were performed: moisture, protein, vitamin C, beta-carotene, alpha-tocopherol, pH, water activity, mould and yeast, and aflatoxin. 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 beta-carotene and alpha-tocopherol were determined by HPLC (Rodriguez-Amaya and Kimura, 2004). Reversed phase chromatography was used. For beta-carotene analysis, measurement was taken at 450 nm in the visible range. For alpha tocopherol, values were read at 292 nm in the UV range. Water activity was measured by dielectric and conductivity method, using the Rotronic Hygro Lab water activity measuring instrument, while pH was measured with Lab Ph Meter (Radiometer, Copenhagen). Mould and yeast were determined by ISO 7954 (1987). Aflatoxin was determined by HPLC Methods (Pons, (1979) JAOAC 62, 586-594 (extraction procedure).

Statistical analysis was done using SPSS 16.0 and Minitab (version 14). ANOVA was used to test for significant differences between means. A multiple range test (Tukeys Honestly Significant Differences) was conducted at a level of significance of $p<0.05$.

A two-way ANOVA was conducted to test for significant interactions between variables.

RESULTS AND DISCUSSION

The results of the study are shown in table 1

All the parameters determined to assess the shelf-life stability of *M. oleifera* leaf powder differed significantly ($p<0.05$) with storage time except protein which remained constant, and aflatoxin which was not detected in the samples. Storage with Aluminium foil recorded the highest moisture content. The moisture content increased regardless of the packaging material used, and that of Aluminium foil was almost double that of the initial value after six months. Mensah (2011) also observed increases in moisture content when he tested

M. oleifera leaf powder in glass, LD PET, HD PET and different types of paper bags for 180 days, with the paper bags recording significant increases by day 16. All the paper boxes were reported to be contaminated with *Aspergillus flavus* by day 16.

Protein did not differ with the mode of storage. Mensah (2011) also did not observe any significant changes in protein and minerals he studied during the storage *M. oleifera* leaf powder in various packaging materials for 180 days. Vitamin C was not detected after the second month of storage with all packaging types. HD PET however, retained more vitamin C at two months than LD PET and Aluminium foil.

Storage in Aluminium foil resulted in a higher retention of beta-carotene up to four months that is 95.42% at two months, 87.54% at four months, but it dropped to less than 50%, that is 41.80% at six months. LD PET retained 67.99% at two months and, 58.35% and 57.96% respectively at four and six months. HD PET retained 62.79% beta-carotene at two months, 58.00% at four months and 42.82% at six months. This was also the case with alpha-tocopherol with Aluminium foil recording higher values than LD PET and HD PET .

The pH of the samples did not vary much during storage. Mould and yeast were reduced significantly with Aluminium foil storage whilst LD PET had higher values of mould and yeast count with storage. Although Mensah (2011) observed significant increases in colony forming bacteria units in the paper packaging materials by day 16, changes in glass and polythene materials were not significant.

In this study, aflatoxin was not detected in the samples over the storage time. There were significant interactions ($p<0.05$) between time and storage mode for all parameters except protein and aflatoxin.

CONCLUSION AND RECOMMENDATIONS

M. oleifera leaf powder could be produced and stored for up to six months without any change in the protein content of the leaf powder, using Aluminium foil, High density and Low density polythene as packaging materials. All the three packaging materials could be used for storage of *M. oleifera* leaf powder at least for six months for maximum conservation of protein; they could also be suitable for appreciable retention of the fat–soluble vitamins retaining more than 50% up to four months of storage. Vitamin C could not be retained with the packaging materials. It is recommended that polythene of varying thickness as well as paper of varying thickness is investigated.

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