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Effects of Drying Temperature on the Nutrients of Moringa (*Moringa oleifera*) Leaves and Sensory Attributes of Dried Leaves Infusion

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Research Paper

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Moringa possesses both medicinal and functional food properties. Hot air drying has been reported to affect the chemical constituents of moringa leaves. The effect of drying temperatures on the nutrients of moringa leaves and sensory attributes of dried moringa leaves infusion were investigated. Moringa leaves obtained from Bowen University Teaching and Research Farm in Nigeria were sorted, cleaned and dried in an oven at 60, 70 and 80ºC, milled, and sieved (250 µ pore size). The nutrients of the leaves and sensory attributes of dried leaves infusion were determined using standard analytical methods. Data were subjected to one-way ANOVA and the means with significant differences separated by Duncan's Multiple Range Test at $p < 0.05$. The moisture, protein, fat and crude fiber contents of moringa leaves decreased while the ash and tannin contents increased as temperature increased. Temperature had significant effect ($p < 0.05$) on the mineral composition of moringa leaves, except magnesium. No significant difference ($p > 0.05$) occurred in the magnesium, sodium, and phosphorus contents, along with the colour, aroma and flavor of water extract of moringa leaves at drying temperatures of 60 and 80 ^{o}C. Moringa leaves contain essential nutrients that are essential to the well-being of man. Furthermore, temperature of drying had varying effects on the components of the leaves.

Key words: Moringa, sensory attributes, minerals, antinutrient.

INTRODUCTION

Vegetable utilization and consumption have been reported to be a veritable vehicle to alleviate the global problem of nutritional deficiencies (Yang et al., 2006). Africa is blessed with a wide range of vegetables which could be utilized in combating the perennial problem of malnutrition facing the continent (Chadha et al., 2011; Ojiewo et al., 2013). Vegetables, due to the fact that they are rich in micronutrients and antioxidants, have been implicated in reducing the incidence of diseases such as high blood pressure, cardiac heart diseases, etc (Yang et al., 2006).

Moringa (*Moringa oleifera*), which is known by such names as 'horse radish tree', 'drumstick tree', 'never die tree', 'West Indian Ben tree', and 'radish tree' is widely

Figure 1. Moringa (*Moringa oleifera)* leaves.

grown in Africa and Asia and it is one of the promising plants which could contribute to increased intake of micronutrients and antioxidants (Yang et al., 2006). It belongs to the onogeneric family of tree called moringaceae (Foidl et al., 2011) and it is the most common of the fourteen species of genus moringa (Pakade et al., 2013a). Moringa has gained wide acceptance as medicine and food in Nigeria (Bamishaiye et al., 2011; Ijeomah et al., 2012). It has been reported that the leaves, flowers and fruits of moringa are more important nutritionally, whereas the roots, stem, wood and bark are known for their medicinal value such as stimulant, aphrodisiac, diuretic, blood pressure reduction, tumor healing, anti-fertility, antibacterial, anti-inflammatory, anti-ulcer and cholagogic properties (Pal et al., 1995, 1996; Prakash et al., 1988; Ruckmani et al., 1998; Sethi et al., 1998; Rao et al., 1999; Bennett et al., 2003; Fahey et al., 2001; Dipti, 2012; Mbikay, 2012). The leaves of moringa are known to be rich in different forms of phytochemicals

Moringa leaves can be consumed either raw or cooked, or dried over a screen for several days and ground into a fine powder that can be added to almost any food as a nutrient supplement (Makkar and Becker, 1996). Moringa leaf is rich in iron, potassium and vitamins especially vitamin A. A 100 g serving of the fresh cooked leaves is adequate to provide the daily requirements of calcium, about 75 % of iron and half of the protein requirement of a 3 year old child (Tree for life, 2005). Moreover, recently, they are highly recommended for pregnant and nursing mothers as well as young children (FAO, 2014). According to Makkar and Becker (1997), moringa leaf (Figure1) contains 260 g kg^{-1} protein, with its essential amino acids being higher than the amino acid pattern of the FAO reference protein, but comparable to those in soybeans. Furthermore, the essential amino acids are higher than adequate concentration when compared with recommended amino acid pattern of FAO/WHO/UNO reference protein for a 2 to 5 year-old child (Makkar and Becker, 1996). Moringa leaves contain negligible amount of tannins (12 g kg^{-1}), 0.8-5.0% saponin, 3.1% phytate, and no trace of trypsin, amylase indicators, lectins, cyanogenicglucosides and glucosinolates (Makkar and Becker, 1997). However, genetic variation, agroclimatic conditions, postharvest handling, locational variations and different means of food preparation have been reported to influence the quality attributes of moringa leaves (Chadha et al.,2011; Pakade et al., 2013a; Siddhuraju and Becker, 2003; Iqbal and Bhanger, 2006; Anjorin et al., 2010; and Pakade et al., 2013b).

Moringa leaf with a moisture content of about 74% (Gerna and Sengev, 2011), is a highly perishable food commodity. Drying, a processing unit which removes moisture from food material by heat and mass transfer (Premi et al., 2010), is a common method used in extending the shelf life of vegetables. Drying involves the use of different temperature regimes which could affect the nutritional value of vegetables (Gerna and Sengev, 2011). Gernah and Sengev (2011) also reported that drying at 30-34 $^{\circ}$C increased the proximate, carotenoid, vitamin C, elemental and antinutrient composition of

Table 1. *Effect of temperature on the proximate and antinutrient composition of* Moringa oleifera.

Nutrient	**Temperature (ºC)**		
	60	**70**	**80**
Moisture (%)	8.91^{b}	8.71^{ab}	8.62^{a}
Ash (%)	3.56^{a}	3.80^{b}	3.79^{b}
Protein (%)	31.33^{c}	30.89^{b}	30.25^{a}
Fat (%)	2.66^{b}	2.45^{a}	2.40^{a}
Crude **fiber** (%)	17.56^{b}	17.21^{a}	17.26^{a}
Carbohydrate (%)	35.99^{a}	45.55^{a}	37.69^{a}
Caffeine (%)	ND	ND	ND
Tannin (mg/100g)	8.59^{a}	8.75^{ab}	8.89^{b}

Means within a row with same superscripts are not significantly different at $p<0.05$.

moringa leaves. Gyamfi et al., (2011) compared the effect of drying at room temperature with oven drying and freeze-drying on the mineral composition of moringa leaves and recommended drying at either room temperature or freeze drying. Gyamfi et al., (2011), however, did not specify the exact temperature used for oven drying. Furthermore, drying at room temperature may not be appropriate for commercial processing due to the lengthening of drying period while freeze drying is not feasible in a developing economy as Nigeria. Premi et al., (2010) dried moringa leaves at 50-80 ºC and reported that drying time reduced considerably with increased temperature. However, Premi et al., (2010) only related the effect of the drying temperatures to the color attribute of the moringa leaves. Singh and Prasad (2013) also dehydrated moringa leaves at 50-80 ºC and based their comparison on the dehydration parameters (dehydration and rehydration ratios) and color characteristics (L, a, b values). Arun et al., (2011) reported that oven drying (60 ºC) of pretreated moringa leaves did not result in any significant change in the nutrients in comparison with wind and sun drying. Wangcharoen and Gomolmanee (2013) only reported on the effect of oven drying (50 and 100 ºC) on the antioxidant activity of moringa leaves. Thus, no single study has been able to focus on the effect of hot air drying (which is the most feasible method of drying for developing countries) on a wide range of properties of moringa. This paper therefore focused on the effect of drying temperature on the proximate, mineral and vitamin composition of moringa leaves, and sensory qualities of dried moringa leaves infusion.

MATERIALS AND METHODS

Fresh and fully grown *Moringa oleifera* leaves were obtained from the Teaching and Research Farm of Bowen University, Iwo, Nigeria. The leaves were sorted to remove foreign materials and rinsed with distilled water. After draining, the leaves were dried in an oven (Gallenkaup Model) at 60, 70 and 80 ºC for 24 h. The dried leaves were ground and passed through 250 μm sieve. The ground samples were packed in a ziplock polyethylene bag and stored at 4ºC for further analysis.

Analyses

The proximate composition of the leaves was determined according to AOAC, (2000). Ascorbic acid, riboflavin, thiamine and niacin were determined according to AACC, (1983), and the minerals according to IITA, (1991). Tannin was determined according to the method of Griffiths and Jones (1977) as described by Adeola and Aworh (2012) while caffeine was determined according to Venkatesh et al., (1994).

The hot water extract of the dried moringa leaves was evaluated for color, taste, aroma, flavor, appearance and overall acceptability by a panel of fifty assessors, on a 9-point hedonic scale where 1= dislike extremely, 5=neither like nor dislike and 9= like extremely.

All the data were subjected to descriptive analysis using SPSS version 16.0.

RESULTS AND DISCUSSION

Proximate and antinutrient composition

The moisture content of the dried moringa leaves ranged from 8.62 to 8.91 % (Table 1). As expected, increase in the temperature of drying resulted in a decrease in the moisture content of samples, and this is expected to improve the shelf life of the leaves since the activity of spoilage agents such as microorganisms and autolysis will be greatly hampered at such low moisture content. However, there may be an increase in the incidence of non-enzymic browning since according to Derossi et al., (2011), the use of high temperature may result in the production of brown melanoidin pigments in vegetables. The same trend was observed for protein, fat and crude fiber. Derossi et al., (2011) also stated that drying of vegetables leads to break down of nutrients. However, the ash and tannin contents increased with temperature.

Table 2. Effect of drying temperature on mineral composition of moringa leaves.

Minerals	Temperature(ºC)		
	60	70	80
Iron (mg/100g)	15.79^{c}	15.15^{b}	14.90^{a}
Calcium (mg/100g)	664.77^{b}	662.73^{b}	653.11^{a}
Potassium (mg/100g)	817.68^{a}	869.72^{c}	859.56^{b}
Magnesium (mg/100g)	216.45^{a}	215.22^{a}	211.91^{a}
Sodium (mg/100g)	264.77^{ab}	259.73^{a}	265.06^{b}
Phosphorus (mg/100g)	197.11^{b}	194.77^{b}	190.04^{a}
Iron (mg/100g)	15.79^{c}	15.15^{b}	14.90^{a}
Calcium (mg/100g)	664.77^{b}	662.73^{b}	653.11^{a}

Means within a row with same superscripts are not significantly different at $p<0.05$.

Table 3. Effect of drying temperature on vitamin composition of moringa leaves.

Vitamins	Temperature (ºC)		
	60	70	80
Ascorbic acid (mg/100g)	35.75^{c}	22.40^{b}	17.41^{a}
Thiamin (mg/100g)	2.36^{b}	2.23^{ab}	2.04^{a}
Riboflavin (mg/100g)	18.47^{c}	17.53^{b}	16.29^{a}
Niacin (mg/100g)	7.90^{c}	6.30^{b}	5.56^{a}
β-carotene (µg/100g)	449.77^{b}	442.12^{ab}	436.24^{a}

Means within a row with same superscripts are not significantly different at $p < 0.05$.

Table 4. Effect of temperature of drying on sensory attributes of dried moringa leavesr infusion.

Attributes	Temperature (ºC)		
	60	70	80
Color	7.6^{a}	7.7^{a}	6.9^{a}
Taste	7.3^{a}	6.6^{a}	6.5^{a}
Aroma	7.0^{a}	6.2^{a}	6.8^{a}
Overall acceptability	7.5^{b}	7.0^{a}	6.8^{a}

Means within a row with same superscripts are not significantly different at $p < 0.05$.

Increasing the temperature of drying from 70 to 80 ºC did not significantly ($p > 0.05$) affect the moisture, ash, fat and crude fiber contents of the leaves. Caffeine was not detected in the moringa leaves.

Mineral composition

Iron, calcium, magnesium and phosphorus contents reduced with temperature (Table 2). Except for magnesium, temperature had significant effect ($p < 0.05$) on the mineral composition of moringa leaves. The iron, calcium, potassium and magnesium contents of the leaves ranged from 14.90 -15.79, 653.11 - 664.77, 817.68 - 869.72 and 211.91- 216.45 mg/100 g, respectively. The sodium and phosphorus contents were found to be between 259.73 and 265.06, and 190.04 and 197.11 mg/100 g, respectively. Ilelaboye et al., (2013) reported that heat processing resulted in the reduction of mineral composition of vegetables.

Vitamin composition

As the temperature increased, there was significant reduction ($p < 0.05$) in the vitamin composition of moringa leaves (Table 3). According to Derossi et al., (2011), drying causes degradation of vitamins in vegetables. The ascorbic acid, thiamin and riboflavin ranged between 17.41 and 35.75, 2.04 and 2.36, 16.29 and 18.47 mg/100 g, respectively. Niacin and β-carotene, on the other hand, varied from 16.29-18.47 mg/100 g and 436.24-449.77 µg/100 g.

Sensory attributes

The sensory attributes of the hot water infusion of moringa leaves decreased with temperature (Table 4). However, there was no significant difference ($p > 0.05$) in the sensory attributes. This result contradicted Premi et al., (2010) who reported that there were differences in the color attribute of moringa leaves dried at 50-80 ºC, and that the one dried at 60 ºC was the most preferred. This difference in the two results may be explained by the objective nature of the sensory tests, which varies from one individual to another.

CONCLUSION

Drying moringa leaves at temperatures between 60 and 80 ºC resulted in a decrease in protein, fat, crude fiber, mineral and vitamin contents, with increase in ash and tannin contents. There was no significant difference ($p > 0.05$) in the moisture, ash, fat and crude fiber contents of the leaves dried at 70 and 80 ºC. The sensory attributes of the hot water infusion of moringa leaves were not affected by the temperatures used for the drying.

REFERENCES

AACC (1983). American Association of Cereal Chemists' Approved Methods. St Paul MN.

AOAC (2000). Official Method of Analysis.17th ed., U.S.A, Association of Analytical Chemists.

Adeola AA, Aworh OC (2012). A comparative evaluation of the chemical properties of wild tamarind (*Tamarindus indica* L.) fruits in Nigeria. Food 6: 49-57.

Anjorin TS, Ikokoh P, Okolo S (2010). Mineral composition of *Moringa oleifera* leaves, pods and seeds from two regions in Abuja, Nigeria. International Journal of Agriculture and Biology 12: 431–434.

Arun PR, Rajan AP, Santhalia S (2011). Comparative analysis of preservation techniques on *Moringa oleifera* . Inter.J. Agric. and Food Sci. 1: 12-22.

Bamishaiye EI, Olayemi FF, Awagu EF, Bamshaiye OM (2011). Proximate and phytochemical composition of *Moringa oleifera* leaves at three stages of maturation. Advance Journal of Food Science and Technology 3: 233-237.

Bennett RN, Mellon FA, Foidl N, Pratt JH, Dupont MS, Perkins L (2003). Profiling glucosinolates and phenolics in vegetative and reproductive tissues of the multi-purpose trees Moringa oleifera L. (horseradish tree) and Moringa stenopetala L. Journal of Agricultural and Food Chemistry 51:3546-3553.

Chadha ML, Engle LM, Hughes Jd'A, Ledesma, DR, Weinberger KM (2011). AVRDC- The World Vegetable Centre's approach to alleviate malnutrition. Pp. 183-197. In, Thompson, B., Amoros, L. (eds). Combating micronutrient deficiencies: Food-based approaches. Italy, FAO.

Derossi A, Severini C, Cassi D (2011). Mass Transfer Mechanisms during dehydration of vegetable Food: Traditional and Innovative Approaches. Pp. 305-54. In, El-Amin, M. (ed). Advanced Topics in Mass Transfer. Croatia, InTech.

Dipti S (2012). Analgesic effect of the ethanolic extract of *Moringa oleifera* Linn. plant on induced albino mice. Int Res J Pharm 3:372-373.

Fahey JW, Zalcmann AT, Talalay P (2001). The chemical diversity and distribution of glucosinolates and isothiocyanates among plants. Phytochemistry 56:5–51.

FAO (2014). Moringa. Traditional Crop of the Month. FAO. http://www.fao.org/traditional-crops/moringa/en/

Foidl N, Makkar HPS, Becker K (2011). The potential of *Moringa oleifera* for agricultural and industrial uses. Available online: *http://www.empaeg.com/UserFiles/File19947.pdf*

Gernah DI, Sengev AI (2011). Effects of processing on some chemical properties of the leaves of the drumstick tree (*Moringa oleifera*).
Nig. Food J. 29: 70-77.

Griffiths DW, Jones DIH (1977). Cellulase inhibition by tannins in the testa of field beans (*Vicia faba*). J. the Sci. of Food and Agric. 28:938-989.

Gyamfi ET, Kwarteng IK, Ansah MO, Anim AK, Ackah M, Kpattah L, Bentil NO (2011). Effects of processing on *Moringa oleifera*. Proceedings of the International Academy of Ecology and Environmental Sciences 1:179-185.

IITA (1991). Selected methods for soil and plant analysis. Manual serie No. 1. Ibadan: International Institute of Tropical Agriculture.

Ijeomah AU, Ugwuona FU, Abdullahi H (2012). Phytochemical composition and antioxidant properties of *Hibiscus sabdariffa* and *Moringa oleifera*. Nig. J.Agric., Food and Environ. 8: 10-16.

Ilelaboye NOA, Amoo IA, Pikuda OO (2013). Effect of cooking methods on mineral and antinutrient composition of some green leafy vegetables. Archives of Applied Science Research 5:254-260.

Iqbal S, Bhanger MI (2006). Effect of season and production location on antioxidant activity of *Moringa oleifera* leaves grown in Pakistan. Journal of Food Composition and Analysis 19:544-551.

Makkar HPS, Becker K (1996). Nutritional value and antinutritional components of whole and ethanol extracted *Moringa oleifera* leaves. Animal Feed Science and Technology 63: 211-228.

Makkar HPS, Becker K (1997). Nutrients and antiquality factors in different morphological parts of the *Moringa oleifera* tree. The Journal of Agricultural Science 128:311-322.

Mbikay M (2012).Therapeutic potential of *Moringa oleifera* leaves in chronic hyperglycemia and dyslipidemia: a review. Frontier in Pharmacology 3:24.

Ojiewo C, Tenkouano A, Hughes Jd'A, Keatinge JDH (2013). Diversifying diets: using indigenous vegetables to improve profitability, nutrition and health in Africa. Pp. 291-302. In, Franzo J, Hunter D, Borelli T, Mattei F (eds). Diversifying food and diets: Using agricultural biodiversity to improve nutrition and health. Rome, Bioversity International.

Pakade V, Cukrowska E, Chimuka L (2013a). Metal and flavonol contents of *Moringa oleifera* grown in South Africa. South African Journal of Science 109(3/4). Available online: http://reference.sabinet.co.za/webx/access/electronic_journals/sajsci/sajsci_v109_n3_4_a7.pdf

Pakade V, Cukrowska E, Chimuka L. (2013b). Comparison of antioxidant activity of *Moringa oleifera* and selected vegetables in South Africa. South African Journal of Science 109(3/4).

Pal SJ, Mukherjee PK, Saha K, Pal M, Saha BP (1995). Antimicrobial action of the leaf extract of *Moringa oleifera* Lam. Ancient Science of Life 14:197-199.

Pal SJ, Mukherjee PK, Saha K, Pal M, Saha BP (1996). Some pharmacognostical characteristics of *moringa oleifera* lam. leaves. Ancient Science of Life 15: 288-292.

Prakash AO, Pathak S, Shukla S, Mathur R (1988). Pre and post-implantation changes in the uterus of rats: Response to *Moringa Oleifera* Lam. extract. Ancient Science of Life 8:49-54.

Premi M, Sharma HK, Sarkar BC, Singh C (2010). Kinetics of drumstick leaves (*Moringa oleifera*) during convective drying. African Journal of Plant Science 4: 391-400.

Rao KNV, Gopalakrishnan V, Loganathan V, Nathan SS (1999). Anti inflammatory activity of *Moringa oliefera* Lam. Ancient Science of Life 18:195-198.

Ruckmani K, Kavimani S, Jayakar B, Anandan R (1998). Anti-ulcer activity of the alkali preparation of the root and fresh leaf juice of *Moringa oleifera* Lam. Ancient Science of Life 17: 220 – 223.

Sethi N, Nath D, Shukla SC, Dyal R (1998). Abortifacient activity of a medicinal plant "*Moringa oleifera*" in rats. Ancient Science of Life 8: 172 – 174.

Siddhuraju P, Becker K (2003). Antioxidant properties of various solvent extracts of total phenolic constituents from three different agroclimatic origins of drumstick tree (*Moringa oleifera* Lam.) leaves. Journal of Agricultural and Food Chemistry 51: 2144-2155.

Singh Y, Prasad K (2013). *Moringa Oleifera* leaf as functional food powder: characterization and uses. Inter. J. Agric. and Food Sci Technol. 4: 317-324.

Tree for Life (2005). Moringa Book. http://www.treeforlife.org

Venkatesh S, Swamy MM, Reddy YSR, Suresh B, Sethuraman M(1994). A simple method for determination of caffeine content in tea samples. Ancient Science of Life 14: 35- 38.

Wangcharoen W, Gomolmanee S (2013). Antioxidant activity changes during hot-air drying of *Moringa oleifera* leaves. Maejo International Journal of Science and Technology 7: 353-363.

Yang RY, Chang LC, Hsu JC, Weng BBC, Palada MC, Chadha ML, Levasseur V (2006). Nutritional and functional properties of moringa leaves− from germplasm, to plant, to food, to health. Available online: http://formad-environnement.org/Yang_ghana_2006.pdf