NUTRITIONAL COMPOSITION OF PACKAGED *MORINGA OLEIFERA* LEAVES POWDER IN STORAGE

*Adejumo, Bolanle Adenike and Dan, Emmanuel James
Department of Agricultural and Bioresources Engineering,
Federal University of Technology, PMB 65, Minna, Niger State, Nigeria
*corresponding author:bolanleadejumo@gmail.com

Abstract
The effect of packaging materials and storage duration on the nutritional composition of moringa olierfera leaves powder was investigated with a view to ensure its quality retention. Fresh moringa oleifera leaves were defoliated, washed in saline water, rinse in sterile water, drained and dried at ambient room conditions. Drying was concluded when weight of the sample remained constant at three consecutive reading. The dried sample was then milled and sieve into 0.5 mm – 1.0 mm particle size powder using a sieve. With the initial nutritional properties of the moringa oleifera powder determined, the samples were packaged in a sterile glass jar, plastic jar and polyethylene bag and stored at ambient room conditions. The packaged samples were analysed monthly for nutritional properties for three months at three replicates. The experiment was carried out using a randomized block design of 3 packaging types x 3 months storage duration at 3 replicates (3 packaging types x 3 storage duration x 3 replicates = 27 samples). The nutritional properties were determined using standard methods. The results showed that there are no significant differences (P≤0.05) in moisture content, crude protein and sodium of all the package samples. Sample packaged in glass jar had the highest carbohydrate (43.53%), vitamin E (11.08 mg/g) and zinc (9.41) while the sample packaged in polyethylene bags had the lowest carbohydrate content (42.05%), ash content (10.30%) and zinc content (8.16mg/g). The moisture, crude fibre and carbohydrate content of the samples in each of the packaging materials were observed to decrease with increase in storage duration. Moringa leaves powder stored in glass and plastic jar had significantly higher crude fat (3.35 - 4.81%), crude protein (25.34-28.81 %) and ash (10.93-11.28 %) as storage duration increased.

Keywords: moringa oleifera, proximate, minerals, packaging, storage

Received: 05.03.2018 Reviewed: 14.06.2018 Accepted: 22.06.2018

1. INTRODUCTION

Moringa has been reported to be highly utilized by people in the tropics and sub-tropics for its numerous purposes (Fuglie, 2001). Moringa tolerates a wide range of soil types and pH (4.5–9), but prefers well drained soils in the neutral pH range (Ted, 2011). A study by Ozumba (2008) outlined several medicinal uses of moringa oleifera indicating that up to 81 remedies are produced from several parts of the tree. Fresh moringa olierfera leaves are readily eaten by cattle, sheep, goats, pigs, chick¬ens and rabbits and can also be used as food for fish (Singh et al, 2012). Several studies demonstrate that significant proportions of tradi¬tional fodder can be replaced with moringa leaves and significant weight gain over traditional fodder when 50% of fodder contained moringa (Manzoor et al., 2007).As a source of nutrient, moringa oleifera leaves probably rank as the best of all tropical vegetables. The leaves possess remarkable nutrients such as vitamin C, vitamin A, calcium, potassium, proteins, and medicinal qualities (Singh et al, 2012, Foidl and Paull 2008).Spoilage of fresh vegetables usually occurs during storage and transport. The need for preservation of fresh moringa oleifera leaves is very essential due to its medicinal and therapeutic properties.

Some reports have documented losses of nutrients from vegetables during drying (Yadav and Sehgal, 1997) The most popular drying method for moringa is air drying (drying at a room condition). According to Subaddra et al., (1997), careful drying of moringa leaves can result in 58% of the beta carotene being retained, but after three month storage in a sealed container away from sunlight, the leaves

powder can still contain 46% of the beta-carotene of the fresh leaves. To prevent such changes, a packaging material with the appropriate properties should be used for packaging moringa olierfera leaves powder (Meshas and Rodgers, 1994). The study of nutritional properties of moringa oliefera leaves in storage will provide adequate information and will help to reduce the dearth of information on its numerous nutritional qualities. The aim of this work is to evaluate the effect of packaging materials and storage duration on the nutritional properties of moringa olierfera leaves powder with a view to ensure its quality retention.

2. MATERIALS AND METHODS

Fresh moringa oleifera leaves were collected from Maizube farm Holdings, Minna Niger State. The fresh moringa oleifera leaves were defoliated, washed in saline water, rinse in sterile water, drained and dried at ambient room condition. Drying was concluded when weight of the sample remained constant at three consecutive reading. The dried sample was then milled and sieve into 0.5 mm – 1.0 mm particle size powder using a sieve. With the initial nutritional properties of the powder determined, the samples were packaged in a sterile glass jar, plastic jar and transparent polyethylene bag and stored at ambient room condition. The packaged samples were analysed monthly for nutritional properties for three months at three replicates. The experiment was carried out using a randomized block design of 3 packaging types x 3 months storage duration at 3 replicates (3 packaging types x 3 storage duration x 3 replicates = 27 samples). The drying experiment and proximate analysis was carried out in the Crop Processing and Storage Laboratory of the Department of Agricultural and Bioresources Engineering, and the Department of Biochemistry Federal University of Technology Minna, Niger State respectively. The proximate properties determined using the procedure prescribed by the AOAC 2006 include crude fibre, fat, protein, ash content, carbohydrate, moisture content, vitamin A (Rutkowski *et al*, 2006) and vitamin C. The mineral contents which include calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), iron (Fe), zinc (Zn), manganese (Mn) and copper (Cu) were determined using the atomic absorption spectrophotometer (AAS-Buck 205) and phosphorus was determined colorimetrically (AOAC, 2006**)**. All the determinations were done in triplicates. Data collected were analysed using SPSS (15.0) statistical package to determine the analysis of variance and separated means.

3. RESULTS AND DISCUSSION

The result of the effect of packaging materials on the nutritional properties, which include the proximate and mineral properties of moringa leaves powder are as presented in Table 1 and Table 2 respectively. The results showed that the type of packaging material did not significantly ($P \leq 0.05$) affect the crude fibre, crude fat, vitamin A, vitamin C, potassium, magnesium, manganese and calcium contents of the moringa leaves powder. However, the moisture, crude protein, ash, carbohydrate, vitamin E, sodium, zinc, iron and phosphorus contents of the moringa leaves powder was observed to vary significantly ($P \leq 0.05$) with type of packaging material. The moisture content of the unpackaged sample was significantly ($P \leq 0.05$) higher than the packaged samples while the crude protein was significantly ($P \leq 0.05$) lower. The unpackaged sample had the significantly ($P \leq 0.05$) higher moisture content (3.66%), carbohydrate (45.65%) and sodium (20.20mg/g) than all the packaged samples. This shows that the packaging materials used are effective in providing moisture migration and absorption by the packaged samples. There are no significant differences ($P \leq 0.05$) in moisture content, crude protein and sodium of all the package samples. Sample packaged in glass jar had the highest carbohydrate (43.53%), vitamin E (11.08 mg/g) and zinc (9.41) while the sample packaged in polyethylene bags had the

lowest carbohydrate content (42.05%), ash content (10.30%) and zinc content (8.16mg/g).
The results of the effect of packaging materials and storage duration on the nutritional properties of moringa oleifera leaves powder are as presented in Table 3 and Table 4 for the proximate and mineral properties respectively. The moisture, crude fibre and carbohydrate contents of moringa leaves powder packaged in each of the packaging materials were observed to decrease with increase in storage duration. The unpackaged sample maintained significantly higher moisture (3.50-2.92 %), crude fibre and carbohydrate content (46.40 - 44.73 %) compared to those packaged in the packaging material throughout the storage duration. The crude fat, crude protein and ash contents of the moringa leaves powder packaged in all packaging material types increased with increase in storage duration. Moringa leaves powder stored in glass and plastic jar had significantly higher crude fat (3.35 - 4.81%), crude protein (25.34-28.81 %) and ash (10.93-11.28 %) as storage duration increased.
The vitamins C and E content of the powdered moringa leaves evaluated for each type of packaging material was observed to decrease with increase in storage duration, while vitamin A was observed to increase with increase in storage duration. A general decrease was observed in the mineral content of powdered moringa leaves as storage duration increases.

Table 1: $^{+}$Effect of packaging materials on proximate composition of moringa oleifera leaves powder

Packaging material	Moisture Content (%)	Crude Fat (%)	Crude Protein (%)	Ash (%)	Crude Fibre (%)	NFE (%)	Vit.A (mg/g)	Vit.C (mg/g)	Vit.E (mg/g)
Control	3.66^{b}	4.12	23.40^{a}	10.89^{b}	12.82	45.66^{c}	12.67	18.38	11.06^{b}
Glass Jar	3.09^{a}	4.47	24.74^{b}	10.80^{b}	12.69	43.53^{b}	12.21	19.90	11.08^{b}
Sealed Polyethylene	2.87^{a}	4.29	26.84^{b}	10.30^{a}	11.58	42.05^{a}	12.81	19.27	10.67^{a}
Plastic Jar	3.04^{a}	4.26	26.17^{b}	11.05^{b}	12.71	42.41^{a}	12.54	20.15	10.48^{a}
MSE	0.11	0.18	0.51	0.11	0.27	0.45	0.13	0.46	0.09
LS	*	NS	*	*	NS	*	NS	NS	*

Means with different superscripts in the same column are significantly ($p \leq 0.05$) different
Key:
+: Mean values
NS: Not Significantly Different
MSE: Means Standard Error
LS: Level of Significance
*: Significantly different

Table 2: $^{+}$Effect of packaging materials and storage duration on mineral composition of moringa oleifera leaves powder

Packaging material	Na^{+} (mg/g)	K^{+} (mg/g)	Mg^{2+} (mg/g)	Mn (mg/g)	Ca^{2+} (mg/g)	Zn (mg/g)	Fe (mg/g)	P (mg/g)
Control	20.20^{b}	0.17	0.17	8.40	0.26	8.86^{b}	11.98^{c}	4.71^{b}
Glass Jar	18.47^{a}	0.33	0.04	8.29	0.32	9.41^{c}	8.89^{a}	3.75^{a}
Sealed Polyethylene	18.00^{a}	0.12	0.05	8.91	0.25	8.16^{a}	10.62^{b}	3.31^{a}
Plastic Jar	20.20^{b}	0.15	0.16	8.79	0.24	8.90^{b}	11.98^{c}	4.99^{b}
MSE	0.34	0.06	0.04	0.4	0.02	0.14	0.39	0.23
LS	*	NS	NS	NS	NS	*	*	*

Means with different superscripts in the same column are significantly ($p \leq 0.05$) different
Key:
+: Mean values
NS: Not Significantly Different
MSE: Means Standard Error
LS: Level of Significance
*: Significantly different

Table 3: Proximate composition of moringa oleifera leaves powder as affected by packaging material and storage duration

Parameter (%)	Month	control	GJ	SP	PJ	MSE	LS
Moisture	1	3.50^{a}	3.30^{b}	3.12^{c}	3.20^{c}	0.03	*
	2	3.20^{a}	$3.16a^{b}$	3.07^{c}	$3.12b^{c}$	0.02	*
	3	2.92^{a}	2.81^{b}	2.43^{c}	2.80^{b}	0.06	*
Crude Fat	1	3.35^{c}	3.80^{a}	3.62^{b}	3.78^{a}	0.06	*
	2	4.20^{b}	4.82^{b}	4.80^{a}	4.19^{b}	0.09	*
	3	4.81^{c}	5.49^{a}	5.45^{b}	4.81^{c}	0.10	*
Crude protein	1	22.65^{d}	23.62^{c}	25.34^{a}	25.28^{b}	0.35	*
	2	23.32^{d}	24.20^{c}	26.37^{a}	26.21^{a}	0.39	*
	3	24.24^{d}	26.39^{c}	28.81^{a}	27.01^{b}	0.49	*
Ash	1	10.82^{b}	10.78^{c}	10.23^{d}	10.93^{a}	0.08	*
	2	10.90^{a}	10.80^{b}	10.68^{c}	10.95^{a}	0.03	*
	3	10.94^{b}	10.82^{c}	9.98^{d}	11.28^{a}	0.14	*
Crude fibre	1	13.28^{a}	13.10^{b}	12.86^{c}	13.13^{b}	0.05	*
	2	12.80^{b}	12.97^{a}	11.97^{c}	12.98^{a}	0.13	*
	3	12.39^{a}	12.01^{b}	11.92^{c}	12.02^{b}	0.06	*
Carbohydrate	1	46.40^{a}	43.60^{b}	42.47^{d}	42.96^{c}	0.46	*
	2	45.84^{a}	43.52^{b}	42.18^{c}	42.18^{c}	0.01	*
	3	44.73^{a}	43.48^{b}	41.50^{c}	42.09^{d}	0.39	*

Means with different superscripts in the same row are significantly ($p \leq 0.05$) different
Key:
GJ: Glass jar
PJ: Plastic Jar
SP: Sealed Polythene
MSE: Means Standard Error
LS: Least Significance
*: Significantly different

Table 4: Vitamins and mineral composition of moringa oleifera leaves powder as affected by packaging material and storage duration

Parameter (%)	Month	control	GJ	SP	PJ	MSE	LS
Vitamin A	1	12.13^{a}	11.83^{c}	12.46^{b}	12.13^{b}	0.07	*
	2	12.99^{a}	12.84^{c}	12.54^{b}	12.54^{b}	0.09	*
	3	12.68^{c}	12.68^{c}	13.43^{a}	12.94^{b}	0.09	*
Vitamin C	1	19.80^{d}	21.38^{b}	20.92^{c}	22.56^{a}`	0.31	*
	2	18.32^{c}	20.05^{a}	18.89^{b}	18.89^{b}	0.19	*
	3	17.01^{d}	18.26^{b}	17.92^{c}	19.01^{a}	0.22	*
Vitamin E	1	11.14^{b}	11.38^{a}	10.76^{c}	10.65^{d}	0.09	`*
	2	11.08^{a}	10.96^{b}	10.68^{c}	10.43^{d}	0.08	*
	3	10.96^{a}	10.89^{b}	10.56^{c}	10.37^{d}	0.07	*
Na^{+}	1	21.20^{a}	18.90^{c}	18.60^{d}	20.30^{b}	0.32	`*
	2	20.10^{a}	18.70^{b}	18.20^{c}	20.00^{b}	0.25	*
	3	19.30^{b}	17.80^{c}	17.20^{d}	20.30^{b}	0.37	*
K^{+}	1	0.32^{a}	0.09^{d}	0.13^{c}	0.17^{b}	0.03	`*
	2	0.10^{b}	0.09^{c}	0.14^{a}	0.11^{b}	0.02	*
	3	0.10^{b}	0.81^{a}	0.33^{b}	0.17^{b}	0.10	*
Mg^{2+}	1	0.04^{b}	0.04^{b}	0.05^{b}	0.39^{a}`	0.05	*
	2	0.40^{a}	0.04^{b}	0.05^{b}	0.40^{a}`	0.05	*
	3	0.04^{b}	0.04^{b}	0.04^{b}	0.39^{a}`	0.05	*
Mn^{2+}	1	8.96^{c}	8.50^{d}	9.32^{a}	9.11^{b}	0.09	*
	2	8.08^{d}	8.24^{b}	8.21^{a}	8.19^{c}	0.40	*
	3	8.17^{c}	8.12^{d}	8.22^{b}	9.12^{b}	0.12	*

Ca^{2+}	1	0.29^{a}	0.40^{a}	0.28^{a}	$0.27^{a`}$	0.01	NS
	2	0.28^{a}	0.33^{a}	0.24^{a}	$0.21^{a`}$	0.01	NS
	3	0.20^{a}	0.22^{a}	0.23^{a}	$0.26^{a`}$	0.10	NS
Zn^{2+}	1	9.01^{b}	9.77^{a}	8.21^{d}	8.94^{c}	0.17	*
	2	8.96^{b}	9.33^{a}	8.11^{d}	8.82^{c}	1.09	*
	3	8.61^{c}	9.14^{a}	8.16^{d}	8.94^{c}	0.11	*
Fe^{3+}	1	12.28^{a}	9.00^{d}	10.18^{c}	11.98^{b}	0.04	*
	2	12.11^{a}	8.94^{d}	10.93^{c}	11.99^{c}	0.38	*
	3	11.56^{b}	8.72^{d}	10.72^{c}	11.98^{c}	0.38	*
P^{+}	1	5.12^{a}	4.12^{c}	3.57^{d}	4.95^{b}	0.20	*
	2	5.00^{a}	4.00^{c}	3.47^{d}	4.93^{b}	0.19	*
	3	4.02^{b}	3.12^{d}	3.31^{c}	4.94^{b}	0.22	*

Means with different superscripts in the same row are significantly ($p \leq 0.05$) different
Key:
GJ: Glass jar
PJ: Plastic Jar
SP: Sealed Polyethylene
MSE: Means Standard Error
LS: Least Significance
*: Significantly different

Proper preservation of food including plant and vegetable reduces destruction by packaging materials hence making it safe for consumption. The factors that affect the nutritional properties during storage are sensitivity of the nutrient to light, heat and oxygen (Morris *et al.*,2004). The basis of the packaging is to maintain the moisture content at minimal level in order to prolong the shelf life during storage and reduce colonization by microorganisms (Eklou *et al.*, 2006). The moisture content of moringa leaves powder packaged in all the packaging material types for the storage duration was within the range (less than 4.2 %) recommended for safe storage of dried products to prevent microbial growth during storage (Idah and Aderibigbe 2008). The higher moisture content observed in the control might be attributed to the increase in relative humidity of the storage environmental, hence encouraging the absorption of moisture from the surrounding atmosphere. Wilhelm *et al.* (2004) reported that moisture content of hygroscopic materials such as dried food is in direct relation to the humidity of the surrounding air.

Generally the crude fibre, carbohydrate, vitamin (A, C and E), sodium and calcium contents of the moringa leaves powder irrespective of the packaging materials was observed to decreased as storage duration increased., while the highest reduction in vitamin A and C, sodium and calcium contents were observed in the control sample. However, the general loss in the nutritional constituent of the moringa leaves powder as storage progress could be attributed to the storage duration, temperature, light and oxygen (Fuglie 2001).Glover-Amengor *et al.* (2012) reported that light and residual oxygen retained in packaging material prior to packaging can catalyze the oxidation of lipid in stored dehydrated vegetable resulting loses of fat soluble vitamins and the ascorbic acid (vitamin C) as storage duration increases. The nutritional composition of packaged moringa leaves powder was still within the range reported by Moyo, *et al*. 2011 and Diatta, 2001.

4. CONCLUSION

It can be concluded that the type of packaging material significantly influenced the moisture, crude protein, ash, carbohydrate vitamin E, sodium, zinc, iron and phosphorus contents of the moringa leaves powder. The crude protein, crude fat and ash increased with storage duration while carbohydrate, moisture, crude fiber, vitamins (A, C and E), sodium and calcium decrease with storage duration. Any of

the packaging materials used in the study can be used for the packaging of moringa oliefera leaves powder without an appreciable loss in its nutritional attribute for the period of three months.

5. REFERENCES

[1]. AOAC (2006), Official methods of food Analysis of the Association of Official Analytical Chemists (AOAC), 18th Edition. Washington D.C., 2006.

[2]. Diatta, S. (2001) Supplementation for pregnant and breast-feeding women with *Moringa oleifera* powder. In developmental potential for Moringa products, *Workshop proceedings*, October 29 – November 2, 2001, Dar Es Salaam, Tanzania.

[3]. Eklou A. S., Ines, M. S. and Francis N., (2006), Comparative study of drying methods on the seed quality ofinterspecific NERICA rice varieties and their parents. African Journal of Biotechnology, 5: 1618-1624.

[4]. Foidl, N., and R. Paull (2008), *Moringa Oliefera*, Pp 509-512 in: The Encyclopedia of furits and Nuts. CABI, Oxfordshire, U.K.

[5]. Fugile, L. J. (2001), The Miracle Tree, *Moringa Oliefera*: Natural nutrition for the tropics. CWS, Dakar, Senegal.

[6]. Glover-Amengor, M., Diako, C. and Kyei-Baffour, V., (2012), Investigation of appropriate packaging material and shelf life stability of *Moringa oleifera* leaf powder, *Journal of research in biology*, 2 (8): 691-695.

[7]. Manzoor, M., Anwar,F., Iqba, T. I., and Bhnager, M.I., (2007), Physico-chemical characterization of *Moringa concanensis* seeds and seed oil, *J. Am. Oil Chem. Soc.*, 84: 413-419.

[8]. Meshas, K.Y. and Rodgers, S.L., (1994), Food Science and you, 2nd edition, Glencoe, McGrawHill, Pp 399.

[9]. Morris, A., Barnett, A. and Burrows, O. J. (2004). Effect of processing on nutrient content of foods. Cajarticles, 37(3): 160-164.

[10]. Moyo, B, Masika P.J, Hugo A., and Muchenje V., (2011): Nutritional Characterization of *Moringa Oleifera*, *African Journal of Biotechnology*, Vol. 10(60), pp. 12925-12933.

[11]. Ozumba, N.A, (2008), *Moringa Oliefera. Areview of its medicinal and other uses*, Institute of Development studies, University of Nigeria, Enugu Campus. Pp35.

[12]. Idah, P. A. and Aderibigbe, B. A. (2008). Quality changes in dried tomatoes stored in sealed polythene and open storage systems. Department of Agricultural Engineering, Federal University of Technology, Minna, Niger State, pabaidah@yahoo.co.uk.

[13]. Rutkowski D.T., Arnold S.M., Miller C. N., Wu J., and Li J. (2006), Adaptation to ER stress as Mediated by Differential Stabilities of pro-survival and Pro-apoptic mRNAs and Proteins. PLoS Biol 4(11): e374. Doi:10.1371/journal.pboi.00403.

[14]. Singh, S., Mishra, S.P., Singh, P., Prasad, R.S and Das, R., (2012), Potential and Prospects of Moringa oleifera Lam (Sahjan) Institute of Forest Productivity. IFP/2012/01.

[15]. Subaddra, S., Monica, J. and Dhabhai, D. (1997). Retention and storage stabilty of beta-carotene in a dehydrated drumstick leavess (*Moringa Oliefera*): International Journal of Food and Nutrition. 48: 373-379.

[16]. Ted, L., (2011) (revised). Farm and forestry production and marketing profile for Moringa (*Moringa Oliefera*) In: Elevitch, C.R. (ed.). Specility crop for pacific Island Agroforestry. Permanent Agriculture Resources (PAR), Holualaoa, Huwai. http://agroforestry.net/scps.

[17]. Wilhelm, L.R., Suter, D.A. and Bruzwitz, G.H. (2004), Physical Properties of Food Materials. In: Food and Process Engineering Technology, 23-62, St Joseph, Michigan: ASAE. American Society of Agriculture Engineers. Pp 29 – 34.

[18]. Yadav S. and Sehgal S., (1997), Effect of home processing and storage on ascorbicacid and, ß carotene content of bathua (Chenopodium album) and fenugreek (Trigonella foenum graecum) leaves, Plant Foods for Human Nutrition 50: 239-247.