ISSN: 2224-0616
Int. J. Agril. Res. Innov. Tech. 14(1): 62-69, June 2024
DOI: https://doi.org/10.3329/ijarit.v14i1.74530

OPEN ACCESS
Available online at https://ijarit.online
https://www.banglajol.info/index.php/IJARIT

Assessment of nutritional contents of different parts of moringa plant from selected districts of Oromia, Ethiopia

Shure Soboka*, Nardos Matiwos and Tolera Oluma

Received 28 March 2024, Revised 29 May 2024, Accepted 20 June 2024, Published 30 June 2024

ABSTRACT

Moringa plants are among high-value trees and belong to the Moringaceae family, consisting of 13 species and highly distributed in Africa and southern Asia. It is multi-purpose tree with medicinal, nutritional, industrial and socio-economic values. Preliminary information indicates that the human dietary usage of the edible parts of these species is limited. Assessment of the nutritional quality of different moringa parts was not well documented in Oromia. Hence, the aim of this activity is to assess the nutritional qualities of different parts of moringa collected from different districts of Oromia. Sample collection was done from Bako from West Showa, Bishoftu from East Showa, Dalo Mena and Goro from Bale Zone, of Oromia representing mid and low land agro-ecologies of the region. Three to four sampling PAs were used from each district. Different parts of Moringa, namely, leaf, pod, bark, seed and flower were collected from the four districts at least in triplicate. The collected samples were made to dry at room temperature, milled with coffee miller, and passed through a 1 mm standard sieve. The prepared samples were analyzed for proximate and mineral compositions using standard methodologies. The result obtained indicated that leaf is rich in nutrients Ca, Na, Mn and Zn. Moringa flower is rich in nutrients like Zn and Mn, and second in K composition next to pod. The pod is also rich in K and Zn, while the fat and CP contents are high in the seed part of moringa. Generally, Higher % CP, K and P were found from the Bishoftu collection, while Mg, Ca and K were higher for the collection from DM. Bark is poor in protein content compared to other parts of the plant. However, Ca, Mg and Zn are double the optimum composition of plant material. Finally, it is possible to use different moringa parts for food fortification, where determination for antioxidant and nutritional composition analysis is mandatory, as well as future research directions.

Keywords: Moringa pod, Flower, Bark, Seed

Oromia Agricultural Research Institute, Food Science Research Directorate, Addis Ababa, Ethiopia

*Corresponding author's email: ibsasoboka2020@gmail.com (Shure Soboka)

Cite this article as: Soboka, S., Matiwos, N. and Oluma, T. 2024. Assessment of nutritional contents of different parts of moringa plant from selected districts of Oromia, Ethiopia. *Int. J. Agril. Res. Innov. Tech.* 14(1): 62-69. https://doi.org/10.3329/ijarit.v14i1.74530

Introduction

Moringa stenopetala, also called Shiferaw in Amharic, or cabbage tree, is a native tree in arid and semi-arid areas of the southern rift valley of Ethiopia and Kenya. The local farmers use the species as one of the major arable tree inter-crop in multi-storey systems especially by Konso people in Gamo Gofa (Dessalegn and Rupasinghe, 2021). Despite their nutritious edible parts, *Moringa* spp. is sometimes classified as "famine food", consumed by humans at times of food scarcity. For example, in southern Ethiopia, Moringa tends to be cultivated by communities living in marginal environments with small land holdings due to high population density (Kumssa *et al.,* 2017). In these areas, there is often a reliance on rain-fed agriculture as a source of livelihood and there are frequent food crop failures due to drought (Dechasa Jiru *et al.,* 2006). In many communities of Africa and Asia, the use of indigenous and locally available vegetables such as *Moringa* as a human food is often linked with low social class status (Ebert, 2014). *Moringa stenopetala* has a wide range of adaptations from arid to humid climates with a prospect to be grown in a wide range of land use classes (Dechasa Jiru *et al.,* 2006). The potential growing area falls in a rainfall range from 300-1400 mm per year with a soil reaction of 6-7.

All parts of the *Moringa* tree are edible and have long been consumed by humans. The leaves of the *Moringa stenopetala tree* are very nutritious. They can be consumed fresh, cooked or dried. A study done by (Kumssa *et al*., 2017) in northern Kenya and southern Ethiopia shows that most farmers around the area grow moringa for multiple purposes, where using it as a vegetable is the most important one. Other forms of consumption of *Moringa stenopetala* included boiled flowers and immature pods, dried and crushed leaves mixed with traditional beverages made from sorghum (chegga). While all the households from the Konso ethnic group consumed boiled fresh leaves of the plant. Result from the same study show Derashe ethnic group reported using *Moringa stenopetala* as medicine in the following forms: fresh roots of the tree were crushed and inhaled to treat common cold; branches were broken to initiate sap outflow, which was used to eye drops to treat eye infections; and fresh leaf juice had been used to treat head lice. This indicates that moringa is rich in different nutritional contents.

According to (Doerr *et al*., 2009), one gram of leaf powder has 25-fold more iron than spinach, 17-fold more calcium than milk, 15-fold more potassium than bananas and 9-fold more protein than yogurt (Koul and Chase, 2015). Leaves of *Moringa oleifera* are promoted in areas of chronic malnutrition as a nutritional supplement for weaning infants and nursing mothers. Nutritional analysis indicates that *Moringa* leaves contain a wealth of essential, disease preventing nutrients. They even contain all essential amino acids, which are unusual for a plant source. Since the dried leaves are concentrated, they contain higher amounts of many of these nutrients except Vitamin C (Leone *et al*., 2015).

Similarly, preliminary information indicates that the human dietary usage of the edible parts of these species is limited. Assessment of the nutritional quality of different moringa parts was not well documented in Oromia. Hence, this activity aims to assess the nutritional qualities of different parts of moringa collected from different districts of Oromia.

Materials and Methods

Description of the study area

Sample collection was done from Bako from West Shoa, Bishoftu from East Shoa, Dalo Mena and Goro from Bale Zone, of Oromia representing mid and low land agro ecologies of the region. Three to four sampling PAs were used for each district. Different parts of *Moringa*, namely, leaf, pod, bark, seed and flower were collected from the four districts at least in triplicate. The collected samples were cleaned, made to dry at room temperature, milled with coffee miller, and passed through a 1 mm standard sieve. The prepared sample was packed in high density PE bag and stored till quality analysis. Different physico-chemical quality analyses were undertaken using standard methodologies.

Chemical quality parameters on different parts of moringa

Moisture Content (MC): Approximately 3 g of Moringa flour sample was weighed on analytical balance. The moisture content was determined according to method 44-15A (AACC, 2000) by drying the sample in an oven at 130°C for 2 hours and the moisture percent was calculated according to the following equation.

$$\%\ \text{Moisture content} = \frac{\text{Initial weight} - \text{Final Weight}}{\text{Initial Weight}} \text{x}100$$

Ash content (Ash): The ash content was determined gravimetrically in accordance to (AACC, 2000) method 08-01. About 3g of Moringa flour sample was weighed on a pre-ignited and cooled procaine crucible. Ashing of the sample was done using muffle furnace model B 180, Germany, adjusted to 550°C for three hours. After cooling in desiccators, % ash was calculated from the mass difference on dry matter basis.

$$\%\ \text{Ash Content of the sample} = \frac{\text{M3} - \text{M1}}{\text{M2} - \text{M1}} \text{X } 1$$

Crude protein content (% CP): Crude protein content was determined by the micro-Kjeldahl procedure by taking about 0.5g flour samples using a K_2SO_4 - $CuSO_4$ catalyst according to (AACC, 2000) method 46-12 using Distiller model K-9840, Hanon instrument, China. The protein was calculated using the formula below and multiplied by 6.25 as a constant.

$$\%\ \text{Nitrogen} = \frac{\text{VHCl X NHCl X 14.00}}{\text{Sample Weight on dry basis}}\ \text{X}100$$

Fat Content (% FC): Fat was determined using the continuous solvent extraction gravimetric method using a soxhlet apparatus, as described by (Pike, 2003). Samples were weighed into extraction thimble and covered with cotton wool. The recovering aluminum cap was weighed. About 50 ml of organic solvent (diethyl ether) was poured into the cap connected to the thimble and sample. The extractor was connected to a heating mantle. The extract obtained was dried in a hot air oven and held in desiccators for cooling after which it was weighed.

The fat content will be calculated as:

$$\%\ \text{Fat} = \frac{\text{wt of fat}}{\text{Original wt of sample}} * 100$$

Mineral Content: The mineral content of different parts of *Moringa* sample was determined using the method described by (AOAC, 2006). One gram of sample was used in the determination of the mineral content. The ash in the porcelain crucible was dissolved with a few drops of distilled water, followed by 5 ml of 2N hydrochloric acid and filtered through Whiteman filter paper into a 100 ml volumetric flask. The minerals, such as calcium (Ca), Magnesium (Mg), Zinc (Zn), Manganese (Mn) and Iron (Fe) were determined using Atomic Absorption Spectrometer Novaa 350, analytic jena, Germany. In contrast, Sodium (Na) and Potassium (K) were then determined by using Flame photometer FP-902 PG instrument, while phosphorous (P) content was determined using UV-spectrophotometer model spectra-5200.

Statistical analysis

All data collected was subjected to the analysis of variance (ANOVA) using SAS GLM procedure (SAS Institute, 1998). The significance between mean values (mean separation) was expressed by the Least Significant Difference Tests (LSD) method.

Results and Discussion

Moringa leaf and bark

The proximate and mineral composition analysis of moringa leaf and bark has been shown in (Table 1). Higher results of most quality characters like % MC (9.99%), % ash (16.31), Ca (64428.76 ppm) Zn (195.97 ppm), Mn (82.03 ppm), Fe (1078.51 ppm) and Mg (10486.28 ppm) for leaf part and % MC (19.67), % Ash (17.61), Ca (11524.47 ppm), K (614.90 ppm), Zn (3452.67 ppm), Mn (87.49 ppm), Fe (52.23 ppm) and Mg (727.79 ppm) for moringa bark are obtained for samples from Dalo mena district. The result indicated that moisture content varied from the maximum (9.99%) to the lowest (7.72%) for collections from Dalo Mena and Bako, respectively, where the higher mean MC was recorded for the sample collected from Goro. The higher mineral contents of both the leaf and bark part collected from Dalo Mena district are mostly due to the high mineral content of the soil. Similarly, collections from east Showa (Bishoftu town) are higher in % CP (33.88), K (19867.55 ppm) and P (4928.76 ppm), where Na (3014.98 ppm) was recorded by collection from Bako.

Moringa bark and leaves are rich in protein and minerals (Gandji *et al.*, 2018), which agrees with the result obtained in the current study. Studies done by (Lyons *et al.*, 2017) on the nutrient content of moringa show the mean content of Zn (31 ppm), Ca (20000 ppm) and Mg (3700 ppm), which is similar to the result obtained from the current study. Similarly, (Fakankun *et al.*, 2013) obtained mean mineral concentrations of elements were Ca (26000), Mg (643), K (8210), Na (2980), Mn (69.9), Fe (169) and Zn (15.3) mg/kg for different moringa collections. This result also confirms that the results obtained in the current study are in close agreement with those findings. The variations in ash, crude lipid and protein contents of the reported values may be due to different ages of trees, and possibly due to different stages of maturity (Yang and Chang, 2006). According to (Hagos *et al.*, 2018), the total ash content of the *M. stenopetala* leaves powder was found to be 17.80% and 17.20% Shire endaslassie and Abi-Add, respectively. The same author reported that the crude protein varied from 27 to 30% for samples collected from the same location. The high moisture, ash, lipid, and protein contents of *M. stenopetala* leaf and bark suggest that the plant may be useful for body-building, prevention of aging while the high crude fiber content will help in bowel movement and high carbohydrate content may be useful in making a good source of energy for the body.

Table 1. Nutrient composition (ppm) of Moringa leaf and bark collection from selected district of Oromia.

Parameters	Range	Bako		Bishoftu		Dalo manna		Goro	
		Leaf	Bark	Leaf	Bark	Leaf	Bark	Leaf	Bark
% MC	Maximum	8.64	8.99	8.74	9.68	9.99	11.68	9.97	19.67
	Minimum	7.72	7.54	8.16	8.42	8.95	11.15	9.30	8.79
	Mean	8.09	8.26	8.50	8.88	9.35	11.48	9.55	13.00
% CP	Maximum	32.14	16.25	33.88	14.47	27.99	12.37	29.40	10.09
	Minimum	19.29	6.15	24.64	11.06	24.42	11.01	24.18	8.68
	Mean	26.48	11.06	29.11	12.52	25.99	11.63	27.53	9.26
% Ash	Maximum	12.70	11.99	16.14	12.67	16.31	17.61	13.50	10.76
	Minimum	8.49	7.27	11.67	9.15	14.18	12.16	12.83	9.50
	Mean	10.98	9.26	13.46	10.92	15.06	15.30	13.09	10.09
Ca ppm	Maximum	23118.14	4269.86	17839.97	3845.08	64428.76	11524.47	24912.28	2878.52
	Minimum	16301.14	894.06	16103.49	1880.71	45695.39	9282.53	17997.67	1964.75
	Mean	18612.78	2650.39	17046.18	2800.66	56487.50	10473.59	21405.38	2533.93
Na ppm	Maximum	1104.56	16828.86	1745.62	22268.01	1590.82	116755.16	3014.98	22554.89
	Minimum	1000.82	9180.17	1197.79	14891.48	974.81	94095.07	2623.85	10662.59
	Mean	1046.60	13100.35	1393.27	17658.40	1358.96	107000.79	2825.22	16687.82
K ppm	Maximum	19219.97	489.93	19867.55	457.46	19698.42	614.90	17915.99	531.81
	Minimum	15214.73	379.99	15753.66	370.57	17447.07	518.54	15232.47	412.90
	Mean	17590.82	428.13	18472.26	404.06	18376.43	577.78	16915.07	465.64
P ppm	Maximum	4436.27	33740.95	4928.76	20537.66	3604.65	21146.08	3892.55	18932.98

	Minimum	3631.20	16188.18	4823.34	18600.74	3301.95	21007.46	3640.00	16289.63
	Mean	4128.34	22364.57	4880.29	19787.02	3433.99	21086.34	3791.03	17929.23
Zn ppm	Maximum	35.23	2712.21	36.36	3311.96	195.97	3452.67	51.22	2822.85
	Minimum	33.01	1916.78	22.09	2525.63	36.25	2337.59	42.61	2674.13
	Mean	34.16	2310.05	28.64	2826.45	92.41	3046.56	47.79	2743.11
Mn ppm	Maximum	65.61	33.14	30.24	36.52	82.03	87.49	51.66	17.35
	Minimum	45.94	27.94	26.53	33.39	72.54	40.52	41.01	12.85
	Mean	54.53	30.30	28.20	34.60	77.95	64.90	46.29	15.81
Fe ppm	Maximum	265.20	27.55	392.12	21.70	1078.51	52.23	193.03	25.85
	Minimum	145.79	22.19	288.75	17.52	383.27	23.99	122.84	18.35
	Mean	195.97	24.13	324.70	19.18	837.92	42.05	159.65	21.78
Mg ppm	Maximum	5349.37	192.46	9791.94	101.33	10486.28	727.79	6415.87	145.64
	Minimum	5045.32	107.16	5895.57	61.36	10144.42	538.61	5195.74	121.86
	Mean	5151.68	137.47	7195.64	76.11	10265.77	614.98	5854.01	130.21

Moringa flower

Moringa flowers were collected only from Bako (west Showa) and Bishoftu (East Showa) (Table 2). Higher % MC (10.79), % CP (26.88), and Fe (278.59 ppm) was obtained from the sample collected from Bishoftu. Moringa flower collected from Bako is also higher in Mg (8442.75 ppm), Ca (34027.68 ppm), Na (1633.73 ppm), K (41215.68 ppm), P (6432.53 ppm), Zn (44.22 mg/l), Mn (66.21 ppm) and % Ash (11.4). The variation between the maximum and minimum nutrient content value of moringa flower collection is huge. For instance, % CP varied from 0.81 to 26.19%, Ca varied from 34027.68 to 4429.81 ppm and Mg varied from 2724.59 to 8442.75 ppm. This strong variation in nutrient composition is most probably due to the variation between soil nutrient composition, moringa landrace and age of the plant. Moringa flowers can be eaten as a vegetable or used to make a tea. As stated in (Palada, 2021), the flowers are rich in calcium and potassium. In addition, moringa flowers also provide a year-round source of nectar for bees because bees are very attracted to its flowers. According to (Betawadkar *et al.*, 2022), dried *Moringa olifera* flowers, the protein content of 25.16% and ash 6.01% are present. The result shows that the crude protein content is comparatively similar with legumes such as cowpea, pigeon pea, and Bambara groundnut. The level of crude protein content has specific nutritive significance as it is used in infant protein and enhances the immune system against diseases. Many studies show that the flowers contain 31%, the leaves contain 44%, and the pods contain 30% of amino acids (Javed *et al.*, 2021), also stated that the fat content of moringa flower varied from 7.0 to 8.3, protein from 19-21%, Ash from 2-4.3% for moringa flower dried under different conditions. The result obtained from the current study is so closely similar to those findings.

Table 2. Nutrient composition (ppm) of Moringa flower collection from selected district of Oromia.

Parameters		Bako	Bishoftu	Mean	Parameters		Bako	Bishoftu	Mean
% MC	Maximum	9.50	10.79	10.79	P ppm	Maximum	6432.53	5810.93	6432.53
	Minimum	9.22	9.69	9.22		Minimum	5139.69	3607.86	3607.86
	Mean	9.40	10.21	9.80		Mean	5606.30	4797.17	5201.73
% CP	Maximum	26.19	26.88	26.88	Zn mg/l	Maximum	44.22	39.97	44.22
	Minimum	0.81	20.11	0.81		Minimum	28.12	27.09	27.09
	Mean	9.39	24.45	16.92		Mean	34.98	32.73	33.85
Mg ppm	Maximum	8442.75	6630.50	8442.75	Mn ppm	Maximum	66.21	38.98	66.21
	Minimum	2724.59	4275.77	2724.59		Minimum	22.26	34.51	22.26
	Mean	5018.03	5321.45	5169.74		Mean	40.19	36.06	38.12
Ca ppm	Maximum	34027.68	25863.45	34027.68	Fe ppm	Maximum	275.02	278.59	278.59
	Minimum	4429.81	4882.09	4429.81		Minimum	197.57	103.02	103.02
	Mean	16321.42	12474.43	14397.93		Mean	243.15	181.25	212.20
Na ppm	Maximum	1633.73	1112.63	1633.73	Ash %	Maximum	11.43	10.64	11.43
	Minimum	680.46	730.54	680.46		Minimum	6.37	8.80	6.37
	Mean	1023.19	911.69	967.44		Mean	9.71	9.70	9.71
K ppm	Maximum	41215.68	21730.80	41215.68					
	Minimum	17200.56	13160.77	13160.77					
	Mean	31520.78	18110.97	24815.88					

Moringa seed and pod

Moringa pod and seeds nutrient composition is presented in (Table 3). Moringa seeds and pods are edible but the seeds must be boiled or fried first for a few minutes to remove the fine transparent hull before consumption. Seeds are consumed green before the color changes to yellow. Dry seeds can be ground to a powder and used for seasoning sauces. Mature seeds contain about 40% oil which is excellent in quality (73% oleic acid, similar to olive oil) for cooking (Palada *et al.*, 2017). The fat content of moringa seeds collections from the current study varied from 38.50 to 32.00%, which is in close agreement with the findings from the above study. Moringa seed protein content varied from 39.91 (Goro) to 14.25 from the same district where the maximum mean 36.23% was for collection from (Dalo mena). Collection from Delo mena is also higher in Ca (8189.85 ppm), Zn (87.49 ppm), Mn (23.99 ppm) and Fe (56.71 ppm). Collection from Bako also got maximum % Ash (5.02), Mg (8887.36 ppm), Na (326.19 ppm) and P (7842.35 ppm). The minimum nutrient scores are also obtained for collection from Bishoftu and Dalo mena. The mean moisture, oil, protein, ash and crude fiber contents of the *M. stenopetala* seeds analyzed were 6.1, 41.4, 42.6, 4.6 and 5.1 (g/100 g), respectively.

The fresh pods of the tree could be used as cheap protein supplement sources for feeding ruminant and monogastric animals during dry periods of the year. The pod of moringa collection in the current study is rich in nutrients like Na, K, Zn, and Fe. Especially collection from Delo mana is high in % CP (28.06), % Ash (12.74), Mg (11270.20 ppm), Ca (25334.74 ppm) and P (4747.51 ppm) and Zn (87.14 ppm). Where the maximum F ppm (95.92) and Mn (16.79 ppm) were recorded by collection from Bishoftu. According to (Abrar and Azmach, 2017), moringa pod is rich in nutrients like Protein (26%), Ca (30 mg/100g), Mg (24 mg/100g), P (1100 mg/100g), K (259 mg/100g) and Fe (5.3 mg/100g), which are in close agreement with the finding in the current study except for some plant nutrients.

Table 3. Nutrient composition of Moringa seed and pod collection from selected district of Oromia.

Parameter	Range	Bako		Bishoftu		Dallo Manna		Goro
		Seed	Pod	Seed	Pod	Seed	Pod	Seed
%MC	Maximum	5.90	8.67	8.43	19.42	7.67	12.48	6.21
	Minimum	5.62	8.25	5.91	10.53	7.59	11.71	5.52
	Mean	5.81	8.48	7.07	13.96	7.63	12.11	5.90
%CP	Maximum	36.02	12.26	34.52	19.40	38.46	36.69	39.91
	Minimum	34.44	4.58	29.98	6.94	34.01	18.07	14.25
	Mean	35.41	5.49	31.50	9.43	36.23	28.06	28.28
Ash %	Maximum	5.02	5.87	4.66	14.90	3.72	13.81	4.92
	Minimum	4.81	5.75	3.98	9.96	3.71	12.20	4.74
	Mean	4.94	5.82	4.34	12.39	3.71	12.74	4.85
Mg ppm	Maximum	8887.36	2955.15	8827.32	2931.34	7156.15	11366.81	7488.24
	Minimum	7729.01	1866.41	6843.49	1518.52	7137.04	11111.37	7233.25
	Mean	8158.60	2450.35	7881.97	2429.58	7146.60	11270.20	7339.67
`Ca ppm	Maximum	5973.46	2751.74	4925.15	4437.01	8189.85	26571.43	6158.85
	Minimum	4677.66	1288.53	3367.27	2302.19	7399.51	24651.16	4370.30
	Mean	5238.08	1890.02	4208.08	3718.01	7794.68	25334.74	5060.72
Na ppm	Maximum	326.19	352.40	280.19	1002.35	203.20	767.20	254.22
	Minimum	200.14	283.92	198.27	651.09	186.86	726.43	242.88
	Mean	248.42	313.56	241.86	782.26	195.03	748.69	248.12
K ppm	Maximum	13295.10	17317.52	12392.93	51536.58	11904.38	43196.62	12781.81
	Minimum	10900.31	17116.36	9516.83	38966.69	11796.50	40461.08	11683.60
	Mean	12313.69	17224.06	11026.41	44629.15	11850.44	41431.79	12253.75
P ppm	Maximum	7842.35	3531.41	7744.84	4946.02	6553.46	4939.00	7422.15
	Minimum	6925.85	3473.84	6539.52	3932.94	6521.30	4369.69	7277.29
	Mean	7510.45	3506.43	7038.35	4427.11	6537.38	4747.51	7333.81
Zn mg/l	Maximum	67.71	15.54	47.90	33.68	87.49	98.47	32.16
	Minimum	37.43	12.95	28.12	16.75	54.37	80.01	30.96
	Mean	50.87	14.33	40.05	23.82	65.89	87.14	31.60
Mn ppm	Maximum	9.00	11.46	15.39	19.11	23.99	8.98	9.81
	Minimum	7.84	9.52	10.98	14.27	5.98	5.81	7.89
	Mean	8.61	10.21	13.00	16.79	12.26	7.08	8.76
Fe ppm	Maximum	27.52	20.15	24.41	189.96	56.71	108.96	23.18
	Minimum	26.69	19.10	14.49	42.00	51.60	54.95	20.77
	Mean	27.16	19.45	19.64	95.92	53.79	73.42	22.04

Table 4 and figure 1 show the comparison of the mean nutrient composition of different parts (bark, flower, leaf, pod and seed) of moringa collections. The result shows that higher mean moisture content (11.52%) was obtained from pod of moringa where the maximum record was 19.67% from moringa bark. Ash content also varied from 3.71 (seed) to 17.61% in moringa bark. However, higher mean ash content was recorded by moringa leaf (13.15). Protein content also varies from 0.49% in pod to 39.91% for moringa seed whereas the higher mean % CP was obtained from moringa seed (32.88%). Generally seen that moringa leaf is higher in Na, Fe and Mn. Where moringa pod got higher records of potassium. The seed of moringa is higher in % CP, % Fat and Zn composition whereas the bark is the one with maximum Ca composition. Generally seen, all parts of moringa included in the current study are good sources of Zn, Mn and K. The seed of moringa is low in moisture composition, which is most probably due to its high oil content. The result also shown that there is a linear increase of Zn content when we move from bark, flower, leaf, pod and seed. The study done by (Fakankun *et al.*, 2013) has also shown a similar stratum in different parts of moringa.

The observed mean concentrations of the mineral elements in moringa plant (Fakankun *et al.*, 2013) were 26000, 643, 8210, 2980, 69.9, 169 and 15.3 mg/kg for Ca, Mg, K, Na, Mn, Fe and Zn, respectively. Considering separate parts of moringa, Ca (94900 mg/kg), Mg (762 mg/kg) and Na (9050 mg/kg) levels were highest in bark, K (11300 mg/kg) in the seed, Mn (86 mg/kg) and Fe (214 mg/kg) in the leaves. In most quality parameters, the result in the current study is in close agreement with the findings of this author except for some variations in some components. The most consumed part of moringa is the leaf. The level of Ca observed in the current study was 28388 mg/kg. The mean levels in literature (Fakankun *et al.*, 2013) is 30300 mg/kg, which are comparable to those recorded in this study. This level of Ca in the leaf of Moringa is about four times that in milk (Wikipedia) and six times that observed in *Amaranthus* sp. (a common vegetable in Nigeria) (Aggarwal *et al.*, 2022), hence as a supplement in human diet, moringa leaves and other parts has the potential to meet the daily requirement. Ca is an important element in the formation of bones and teeth; it is said to prevent osteoporosis. Beneficial effects of Ca exist in the human body up to an intake threshold of about 800 mg per day.

Table 4. Nutrient Composition of different parts of Moringa collection from selected district of Oromia.

Parameters		Bark	Flower	Leaf	Pod	Seed	Mean
%MC	Maximum	19.67	10.79	9.99	19.42	8.43	19.67
	Minimum	7.54	9.22	7.72	8.25	5.52	5.52
	Mean	10.40	9.80	8.87	11.52	6.61	9.28
Ash %	Maximum	17.61	11.43	16.31	14.90	5.02	17.61
	Minimum	7.27	6.37	8.49	5.75	3.71	3.71
	Mean	11.39	9.71	13.15	10.32	4.46	9.79
%CP	Maximum	16.25	26.88	33.88	36.69	39.91	39.91
	Minimum	6.15	0.81	19.29	0.49	14.25	0.49
	Mean	11.12	16.92	27.28	14.02	32.88	21.24
	Maximum	1.93	6.68	8.02	2.44	38.46	38.46
%Fat	Minimum	0.31	4.32	2.85	0.10	29.67	0.10
	Mean	1.13	5.51	6.17	1.48	33.86	10.59
Mg ppm	Maximum	11524.47	8442.75	10486.28	11366.81	8887.36	11524.47
	Minimum	894.06	2724.59	5045.32	1518.52	6843.49	894.06
	Mean	4614.64	5169.74	7116.78	5383.38	7655.14	6119.75
Ca ppm	Maximum	116755.16	34027.68	64428.76	26571.43	8189.85	116755.16
	Minimum	9180.17	4429.81	16103.49	1288.53	3367.27	1288.53
	Mean	38611.84	14397.93	28387.96	10314.25	5596.23	20595.46
Na ppm	Maximum	614.90	1633.73	3014.98	1002.35	326.19	3014.98
	Minimum	370.57	680.46	974.81	283.92	186.86	186.86
	Mean	468.90	967.44	1656.01	614.84	233.91	777.33
K ppm	Maximum	33740.95	41215.68	19867.55	51536.58	13295.10	51536.58
	Minimum	16188.18	13160.77	15214.73	17116.36	9516.83	9516.83
	Mean	20291.79	24815.88	17838.65	34428.33	11849.10	20754.99
P ppm	Maximum	3452.67	6432.53	4928.76	4946.02	7842.35	7842.35
	Minimum	1916.78	3607.86	3301.95	3473.84	6521.30	1916.78
	Mean	2731.54	5201.73	4058.41	4227.02	7115.46	4629.78
Zn mg/l	Maximum	66.69	44.22	51.22	98.47	87.49	98.47
	Minimum	12.85	27.09	22.09	12.95	28.12	12.85
	Mean	34.48	33.85	37.32	41.76	47.10	39.33
Mn ppm	Maximum	52.23	66.21	82.03	19.11	23.99	82.03
	Minimum	17.52	22.26	26.53	5.81	5.98	5.81
	Mean	28.30	38.12	51.74	11.36	10.66	27.83
Fe ppm	Maximum	727.79	278.59	1078.51	189.96	56.71	1078.51
	Minimum	61.36	103.02	122.84	19.10	14.49	14.49
	Mean	239.69	212.20	379.56	62.93	30.66	188.99

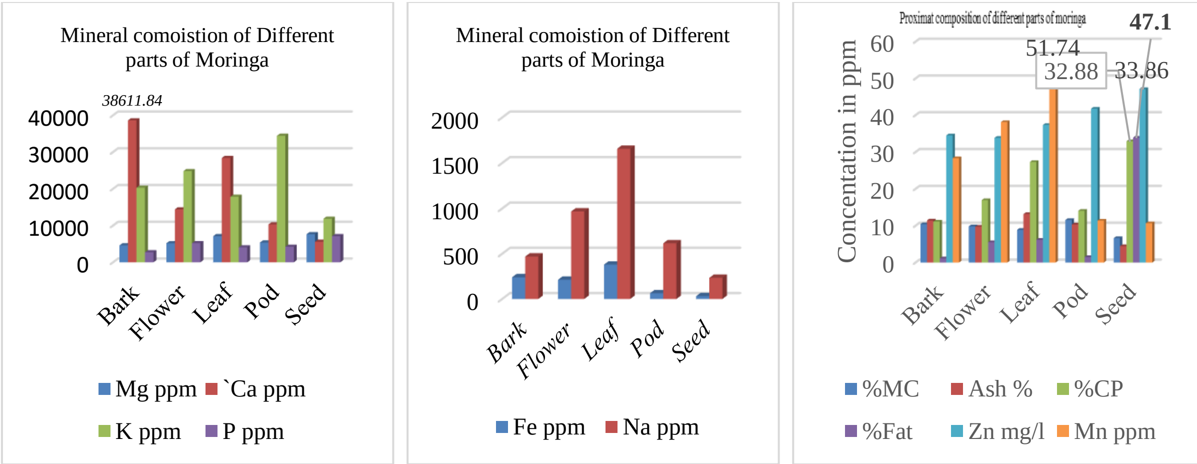

Fig. 1. Nutrient composition of different parts of *Moringa stenopetala*.

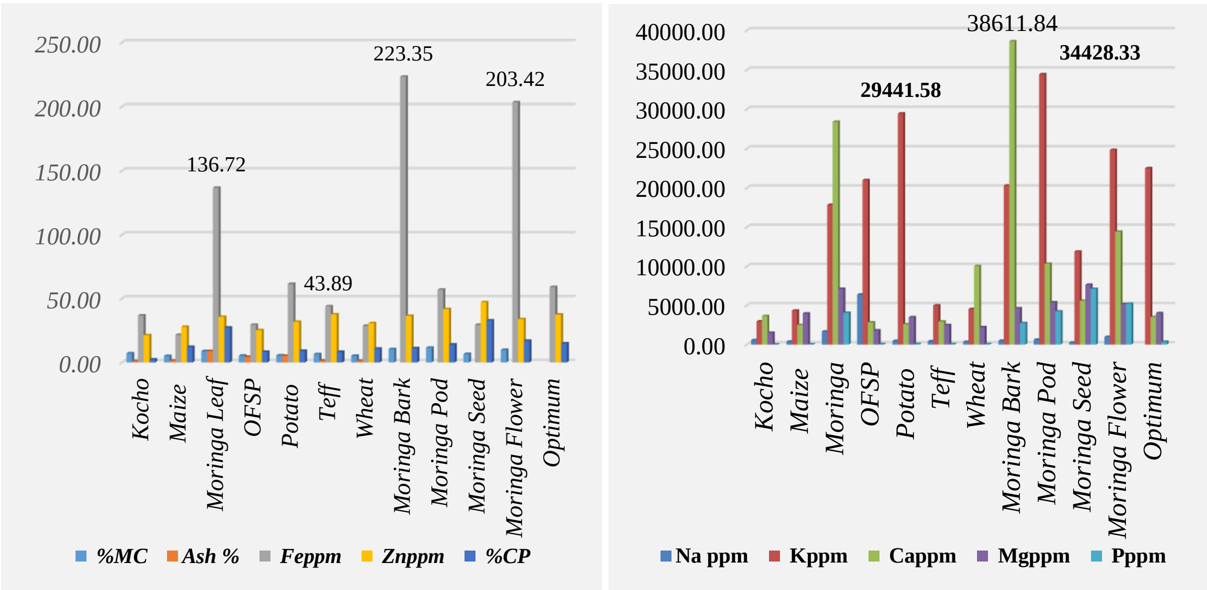

Fig. 2. Comparison of standard plant material nutrient content and nutrient composition of different moringa parts and different crops.

Conclusion

From the result of this experiment, it is clear that Moringa is rich in nutrient content as compared to other cereal and root crops. Accordingly, all the chemical/nutritional characteristics measured varied from sufficient to high compared to the standard nutrient composition of plant material. The result obtained indicated that the leaf is rich in nutrients such as Ca, Na, Mn and Zn, Moringa flower is rich in nutrients like Zn and Mn, and second in K composition next to the pod. The pod is also rich in K and Zn while the Fat and CP contents are high in the seed part of moringa. Generally, higher % CP, K and P were found in the collection from Bishoftu, while Mg, Ca and K were higher for the collection from Dalo mena. Bark is poor in protein content as compared to other parts of the plant. However, Ca, Mg and Zn are double the optimum requirement from plat material in moringa bark. Therefore, it is possible to use Moringa flour prepared from its different parts for food fortification for Ca, Fe, phosphorous and other nutrients or design or document methods for new product development. Finally, it is possible to use different moringa parts for food fortification where determination for antioxidant and nutritional composition analysis is mandatory and future research direction.

Acknowledgement

The authors are grateful to Oromia Agricultural Research Institute and Food Science Research Directorate for financial support and IQQO Food Technology and Process Engineering team staff for active participation in sample analysis and laboratory activities.

References

AACC. 2000. Approved Methods of the American Association of Cereal Chemists (10th edn). Method 08-01-16. Am. Assoc. Cereal Chem.

Abrar, T. and Azmach, N.N. 2017. The Miraculous Moringa Trees: From Nutritional and Medicinal Point of Views in Tropical Regions. *J. Med. Plants Stud.* 5(4): 151–162.

Aggarwal, D., Bhardwaj, A., Sobti, A.K., Fatma, S., Sharma, N. and Vasudha Bansal, V. 2022. Processing induced changes on coarse cereals (majorly millets) derived antioxidant compounds - a review. *Funct. Food Sci.* 2(8): 163. http://dx.doi.org/10.31989/ffs.v2i8.938

AOAC. 2006. AOAC International final report and executive summaries from the AOAC international presidential task force on best practices in microbiological methodology contract deliverable due to the U. S . Food and Drug Administration Presidential Task Force on. AOAC International Final Report And Executive Summaries From The AOAC International. p. 201. http://dx.doi.org/10.1093/jaoac/76.6.180a

Betawadkar, N., Parikh, P., Patel, J. and Akhani, T.K. 2022. A review on food product development with a flower of *Moringa oleifera*. *J. Emerg. Tech. Innov. Res.* 9(1): 330–333.

Dechasa Jiru, Kai Sonder, Lalisa Alemayehu, Yalemtshay Mekonen and Agena Anjulo 2006. Leaf yield and Nutritive value of *Moringa stenopetala* and *Moringa oleifera* Accessions: Its potential role in food security in constrained dry farming agroforestry system. Work. Moringa other highly Nutr. plant Resour. Strateg. Stand. Mark. a better impact Nutr. Africa, Ghana. 16-18 November, 2006. 14p. https://www.researchgate.net/publication/242208976.

Dessalegn, E. and Rupasinghe, H.P.V. 2021. Phenolic compounds and *in vitro* antioxidant activity of *Moringa stenopetala* grown in South Ethiopia. *Int. J. Food Prop.* 24(1): 1681–1692. http://dx.doi.org/10.1080/10942912.2021.1990943

Doerr, B., Wade, K.L., Stephenson, K.K., Reed, S.B. and Fahey, J.W. 2009. Cultivar effect on *Moringa oleifera* glucosinolate content and taste: A pilot study. *Ecol. Food Nutr.* 48(3): 199–211. http://dx.doi.org/10.1080/03670240902794630

Ebert, A.W. 2014. Potential of underutilized traditional vegetables and legume crops to contribute to food and nutritional security, income and more sustainable production systems. *Sustain.* 6(1): 319–335. http://dx.doi.org/10.3390/su6010319

Fakankun, A.O., Babayemi, O.J. and Utiaruk, J.J. 2013. Variations in the mineral composition and heavy metals content of *Moringa oleifera*. *African J. Environ. Sci. Technol.* 7(6): 372–379. http://dx.doi.org/10.5897/ajest12.228

Gandji, K., Chadare, F.J., Idohou, R., Salako, V.K. and Assogbadjo, A.E. 2018. Status and utilisation of *Moringa oleifera* Lam : A review. *African Crop Sci. J.* 26(1): 137–156. http://dx.doi.org/10.4314/acsj.v26i1.10

Hagos, Z., Yirga Brhane, M., Zenebe Teka, M., Krishna Chaithanya, K. and Gopalakrishnan, V.K. 2018. Proximate analysis of the methanolic and aqueous leaves extracts of *Moringa stenopetala*. *Drug Invent. Today* 10(12): 2577–2582.

Javed, M.S., Amjad, A., Shah, M., Shah, F.U.H., Sardar, H., Sardar, H., Tariq, M.R., Khan, A.A., Sajid, M.W., Ali, U., Amir, M. and Nasir, F. 2021. Isolation and characterization of *Moringa oleifera* L. flower protein and utilization in functional food bars. *Food Sci. Technol.* 41(3): 643–652. http://dx.doi.org/10.1590/fst.24620

Koul, B. and Chase, N. 2015. *Moringa oleifera* Lam.: panacea to several maladies. *J. Chem. Pharm. Res.* 7(6): 687–707. http://jocpr.com/vol7-iss6-2015/JCPR-2015-7-6-687-707.pdf

Kumssa, D.B., Joy, E.J.M., Young, S.D., Odee, D.W., Ander, E.L., Magare, C., Gitu, J. and Broadley, M.R. 2017. Challenges and opportunities for Moringa growers in southern Ethiopia and Kenya. *PLoS One* 12(11): 1–15. http://dx.doi.org/10.1371/journal.pone.0187651

Leone, A., Spada, A., Battezzati, A., Schiraldi, A., Aristil, J. and Bertoli, S. 2015. Cultivation, genetic, ethnopharmacology, phytochemistry and pharmacology of *Moringa oleifera* leaves: An overview. *Int. J. Mol. Sci.* 16(6): 12791–12835. http://dx.doi.org/10.3390/ijms160612791

Lyons, G., Gondwe, C., Banuelos, G., Mendoza, C., Haug, A. Christophersen, O. and Ebert, A.W. 2017. Drumstick tree (*Moringa oleifera*) leaves as a source of dietary selenium, sulphur and pro-Vitamin A. *Acta Hortic.* 1158: 287–292. http://dx.doi.org/10.17660/actahortic.2017.1158.32

Palada, M.C. 2021. The role of *Moringa oleifera* in agro-ecosystems: A review. *Acta Hortic.* 1306 (March): 83–97. http://dx.doi.org/10.17660/actahortic.2021.1306.11

Palada, M.C., Ebert, A.W., Yang, R.Y., Chang, L.C. and Chang, J. 2017. Progress in research and development of moringa at the World Vegetable Center. *Acta Hortic.* 1158: 425–434. http://dx.doi.org/10.17660/actahortic.2017.1158.49

Pike, L.J. 2003. Lipid rafts: Bringing order to chaos. *J. Lipid Res.* 44(4): 655–667. http://dx.doi.org/10.1194/jlr.r200021-jlr200

SAS Institute. 1998. SAS user's guide: Version 9.1. SAS Institute Inc., Cary.

Yang, R. and Chang, L. 2006. Nutritional and functional properties of Moringa leaves– From germplasm, to plant, to food, to health. Moringa leaves Moringa and other highly nutritious plant resources: Strategies, standards and markets for a better impact on nutrition in Africa. Accra, Ghana, November 16-18, 2006, pp. 1–9.