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Phenolic, Antioxidant and Free Radical-Scavenging Properties of Various Parts of Indian Moringa (*Moringa Oleifera*) during the winter season

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Abstract

The present investigation was conducted to compare Phenolic, Antioxidant, and Free Radical-Scavenging Properties of Various Parts of Indian Moringa (Moringa Oleifera) during the winter season collected from various locations. Three districts viz Jaipur, Dehra Dun, and Gwalior were selected randomly (one from each state of Rajasthan, Madhya Pradesh, and Uttarakhand) for collection of the samples. The samples of the fresh flowers, tender, and mature leaves, and seeds of Moringa oleifera, were collected from three different agroforest locations selected randomly from each district in January 2022. The samples were extracted and analyzed for total phenolic antioxidant-free radical-scavenging properties. The two-way ANOVA with the replication technique of statistical analysis was used to draw a valid conclusion. It can be concluded on behalf of the results that the Indian moringa plant has rich phenolic and antioxidant and free radical-scavenging properties. The mature leaves were superior followed by tender leaves, flowers, and seeds in this respect.

Keywords: Antioxidant, Free Radical-Scavenging, Moringa flower, Moringa leaves, Moringa Oleifera, Moringa seed, Phenolic.

Introduction

Indian moringa *(Moringa oleifera)* is extensively scattered and utilized in tropical and sub-tropical regions of the world and is mainly native to India and Africa. The tree is honored as the "miracle tree", "natural gift", or "mother's best friend", due to the high nutrients in leaves with protein, minerals, β-carotene, and other properties (Leone et al 2015). On behalf of usefulness, almost all parts of this plant can be used as food, in medicines and for industrial purposes, Indian moringa is considered one of the most valuable trees on the planet. It protects living beings against different types of diseases and infections. In India, the plant is commonly used in traditional medicine for a wide range of various sicknesses and disorders. The consumption of a diet supplemented with Indian moringa has the sufficient capacity to provide necessary protection against diseases

induced by oxidative stress (Nascimento et al 2017). Indian moringa leaf was approved as a new food resource in China for its high nutritional value and vitamin E content (Ningli et al 2017).

Antioxidation is an important property in preventing and scavenging free radicals. The leaf extracts of Indian moringa have potent antioxidant activity against free radicals, prevent oxidative damage to major biomolecules and afford significant protection against oxidative damage (Sreelatha and Padma 2009). The antioxidant activities of leaf extracts of thirteen Indian moringa cultivars from Thailand, South Africa and the United States of America, etc. (Ndhlala et al 2014) and leaves grown in three different agroclimatic regions (India, Nicaragua, and Niger, respectively) (Siddhuraju et al 2003) have been reported.

Ndhlala et al (2014) reported that the Indian moringa leaves are rich in flavonoids and phenolic compounds with high anti-inflammatory activities, whereas there is no such characterization of the plant collected in Kenya, let alone a systematic comparison of its phytochemicals of three different organs (leaves, seeds, and roots) as well as the correlation to their different biological activities (Coppin et al 2013).

The leaves of Indian moringa have been reported to have better potential as a natural source of antioxidants and anti-inflammatory agents and are found very promising to develop health-promoting dietary supplements (Xu et al 2019). The strong radical scavenging activity has been shown in the different extracts of leaves like aqueous 70% methanol, and 80% ethanol extract. The compound called kaempferol has been identified for its high antioxidant properties in the leaves (Ganatra et al 2012) and can be used to prevent damage caused by a high-fat diet (Paikra 2017). Flavonoids are potent antioxidants with innumerable pharmacological properties showing antidiabetic, hypotensive, and hypolipidemic properties and diminishing hyperlipidemia and atherosclerosis. Quercetin is commonly known to protect insulin-producing pancreatic β cells from oxidative stress induced by streptozotocin (Sekhar et al 2018).

Indian moringa dried leaves are a rich source of polyphenols such as flavonoids and phenolic acids having a common structure like the benzo-pyrone ring, which response to microbial infection in plants. Consumption of these flavonoids has been reported to prevent chronic diseases like cardiovascular diseases and cancer caused by oxidative stress. The concentration of the flavonoid compounds in leaves has been determined to be 5.8 mg/g myricetin, 0.207 mg/g quercetin, and 7.5 mg/g kaempferol respectively. Dried leaves contain quercetin of concentration100mg/100g available in 3-o-β-d-glucoside quercetin form (Vergara-Jimenez et al 2017).

Phenolic acids are also the phenolic compounds that naturally occur in plants derived from hydroxybenzoic acid and hydroxycinnamic acid showing antimutagenic, antioxidant, anti-cancer, and anti-inflammatory properties. Dried leaves of moringa tree leaves are the most plentiful source of Gallic acid with a content of around 1.034 mg/g dry weight and chlorogenic acid and caffeic acid ranging between 0.018 and 0.489 mg/g and 0.409 mg/g respectively (Vergara-Jimenez et al 2017, Gandhi et al 2018, Milla et al 2021).

The present investigation was conducted to compare Phenolic, Antioxidant, and Free Radical-Scavenging Properties of Various Parts of Indian Moringa (*Moringa Oleifera*) during the winter season collected from various locations.

Material and methods

Three districts viz Jaipur, Dehra Dun, and Gwalior were selected randomly (one from each state of Rajasthan, Madhya Pradesh, and Uttarakhand) for collection of the samples. The samples of the fresh flowers, tender, and mature leaves, and seeds of Moringa oleifera, were collected from three different agroforest locations selected randomly from each district in January 2022. The samples were extracted using the method of Swain and Hills (1959); with the necessary modifications (Torres et al 2002). The total phenolic content was assessed following the Folin-Ciocalteu assay method (Singleton and Rossi 1965) with minor modifications (Quettier-Deleu *et al.,* 2000). The results were expressed as gallic acid equivalents. The antioxidant capacity was determined according to the DPPH method (Maria do Socorro et al 2010), based on the quantification of free radical scavenging. The per cent FRS of each sample was calculated following the equation hereunder:

% Free radical scavenging = ((AC-AA) x 100)/AC

[Ac is absorbance values of blank and AA absorbance values of the sample].

For comparing phenolic, antioxidant, and free radical scavenging properties of various parts of Indian moringa from different locations, two-way ANOVA with the replication technique of statistical analysis was implemented (Snedecor, and Cochran 1994) to compare the results. The analysis pack of MS Office Excel, 2016 (UQ Library 2016) was used for the purpose.

Results and discussion

The phenolic properties expressed as mg/100g of gallic acid in various parts of moringa (Table 1; Figure 1) collected from three various locations viz. flower, tender, and mature leaves, and the seed was not different ($P>0.05$). In mature leaves, phenolic properties (168.18±1.77) were highest followed by tender leaves (140.05±2.54) and flowers (111.87±0.91) whereas in seeds (24.69±0.50) it was lowest ($P<0.05$). Nascimento et al (2017) reported the highest phenolic properties in leaves followed by flower and seeds, whereas, Fakurazi et al (2012) reported that among edible parts of moringa the flower extracts contain the highest total phenolic content followed by leaves extract. As far as the numerical values of the phenolic properties in various parts of moringa are concerned, the values confirmed the findings of Nascimento et al (2017).

Table 1: Phenolic properties (mg/100g of gallic acid) in *Moringa oleifera*

Location	Flower	Tender leaf	Mature Leaf	Seed
Gwalior	111.53±0.55	138.15±5.62	167.63±2.16	24.18±0.79
Jaipur	114.83±1.51	139.58±5.18	162.83±0.74	25.83±0.35
Dehra Doon	109.25±1.18	142.43±3.08	174.08±2.80	24.08±1.14
Overall	111.87±0.91	140.05±2.54	168.18±1.77	24.69±0.50

P Value-Flower parts 0.00 and Locations 0.51 and Interaction 0.11.

The antioxidant capacity expressed as of µM Eq Trolox/g in various parts of moringa (Table 2; Figure 2) collected from three various locations viz. flower, tender, mature leaves, and seed were not different ($P>0.05$). In mature leaves, antioxidant

capacity (28.26±0.47) was highest followed by tender leaves (26.89±0.42) and flowers (24.28±0.46) whereas in seeds (20.84±0.47) it was lowest (P<0.05). These results verified the observations of Manju et al (2021) and Nascimento et al (2017) reporting freeze-dried Moringa leaves and flowers had better retention in terms of nutrition and antioxidant activities, whereas, Fakurazi et al (2012) reported that among edible parts of moringa the flower extracts contain the antioxidant capacity followed by leaves extract. Fitriana et al (2016) studied that moringa leaves possess antioxidants. As far as the numerical values of the antioxidant capacity in various parts of moringa are concerned, the values confirmed the findings of Nascimento et al (2017).

Figure 1: Phenolic (mg/100g of gallic acid) in Moringa oleifera

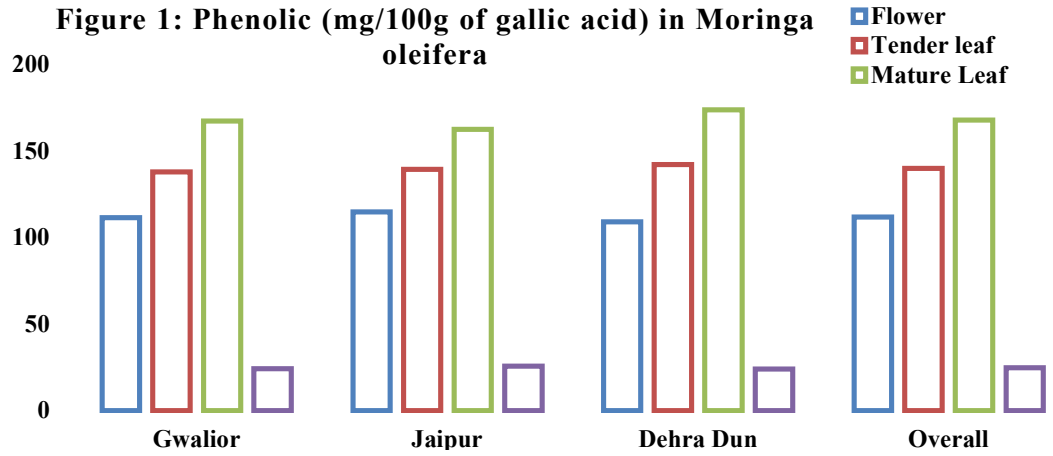
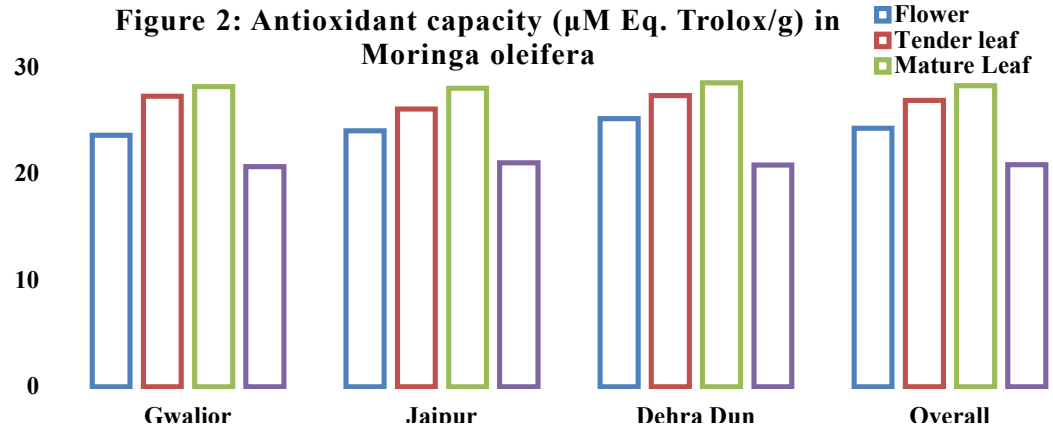


Table 2: Antioxidant capacity (µM Eq. Trolox/g) in *Moringa oleifera*

Location	Flower	Tender leaf	Mature Leaf	Seed
Gwalior	23.60±0.60	27.28±0.99	28.18±1.13	20.68±1.12
Jaipur	24.03±0.89	26.08±0.64	28.05±1.00	21.05±0.85
Dehra Doon	25.20±0.83	27.33±0.45	28.55±0.31	20.80±0.63
Overall	24.28±0.46	26.89±0.42	28.26±0.47	20.84±0.47

P Value-Flower parts 0.00 and Locations 0.49 and Interaction 0.88.

Figure 2: Antioxidant capacity (µM Eq. Trolox/g) in Moringa oleifera



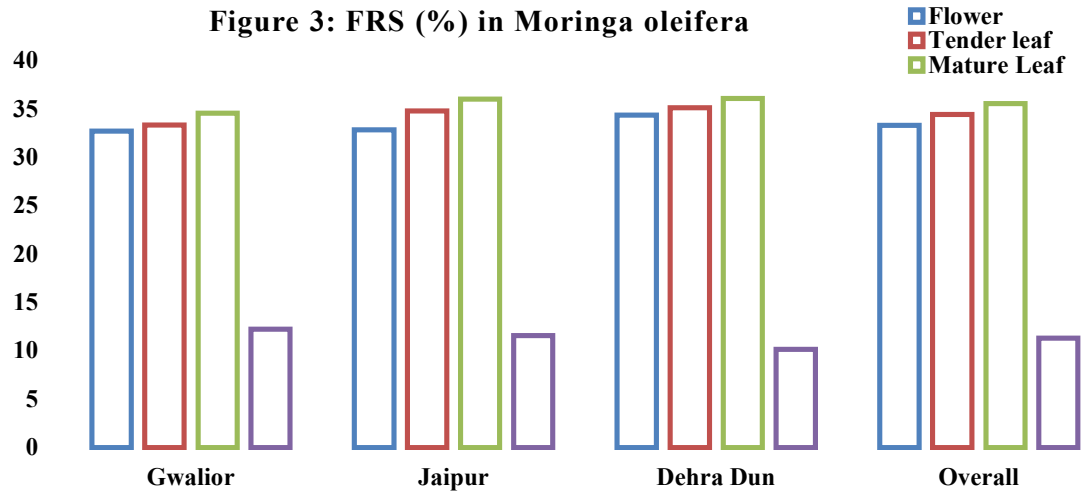
The free radical-scavenging properties in various parts of moringa (Table 3; Figure 3) collected from three various locations viz. flower, tender, mature leaves, and seed were not different (P>0.05). In mature leaves, free radical-scavenging properties (35.58±0.49) were highest followed by that in tender leaves (34.44±0.47) and flowers (33.33±0.41) whereas in seeds (11.33±0.34) it was the lowest (P<0.05). Nascimento et al (2017) reported the highest free radical-scavenging properties in leaves followed by flowers and seeds. As far as the numerical values of the free radical-scavenging properties (%) in various parts of moringa are concerned, the values confirmed the findings of Nascimento et al (2017).

Table 3: Free radical-scavenging properties (%) in *Moringa oleifera*

Location	Flower	Tender leaf	Mature Leaf	Seed
Gwalior	32.75±0.67	33.36±0.92	34.58±0.59	12.25±0.42
Jaipur	32.85±0.48	34.83±0.64	36.05±0.62	11.60±0.46
Dehra Doon	34.38±0.77	35.15±0.75	36.10±1.20	10.15±0.36
Overall	33.33±0.41	34.44±0.47	35.58±0.49	11.33±0.34

P Value-Flower parts 0.00, Locations 0.0.31 and Interaction 0.07.

Figure 3: FRS (%) in Moringa oleifera



It can be concluded on behalf of the results that the Indian moringa plant has rich phenolic and antioxidant and free radical-scavenging properties. The mature leaves were superior followed by tender leaves, flowers, and seeds in this respect.

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