Progressive Agriculture, Vol. 30, Suppl. 1: 10-16, 2019 ISSN: 1017 - 8139

Progressive Agriculture
Journal homepage:http://www.banglajol.info/index.php/PA

Evaluation of morphological traits, phytochemical compositions and antioxidant properties of watercress leaves

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Abstract

Despite the significant nutritional and health values, watercress (*Nasturtium officinale* L.) is still insufficiently known and explored leafy vegetables. Being a native crop of Central Asia ensure possibility of watercress to grow under Bangladesh climate.An experiment was conducted during October 2015 with the aim to evaluate the morphological traits, morphological traits, phytochemical compositions and antioxidant properties of the leaves of watercress. The experiment was designed with Completely RandomizedDesign (CRD) with three replications. The results showed, average watercress shoot biomass was 38.60 ± 3.41 g plant^{-1}. In case of leaf pigment composition the chlorophyll a and b was 70.45 ± 11.97 and28.32 ± 4.37 mg 100 g^{-1} FW. On an average, the increasing order of the nutrients of proximate analysis in fresh sample was fat<ash<carbohydrate<protein<moisture. Besides those, mineral composition and antioxidant properties of watercress leaves were evaluated. Potassium mineral concentration was highest in watercress leaves 278±45% w.b. followed by Calcium 131±13 % w.b. The ascorbic acid was found in highest concentration 70.57±5.78 mg/100g fresh weight. Results also showed 50.42±2.77 mg GAE/g phenols and 0.13±0.03 mg/ml DPPH radicle scavenging activity in watercress.

Key words: Watercress, morphological traits, nutrient content, proximate composition, antioxidant properties

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Introduction

Watercress (*Nasturtium officinale* L.) is an aquatic perennial leafy vegetable belongs to Brassicaceae family usually found in and/or around water. Though, watercress is native in western Asia, India, Europe and Africa (Cruz *et al.,* 2008), today it is cultivated all around the world.The plant is cultivated in lakes, ponds and in slow-moving water in rivers, canals and streamswith slightly alkaline conditions.It offers a sound habitation for many aquatic organisms and protection for young fish and amphibians (Rose *et al.,* 2000) alone with commercial uses in human diets for several thousand years.

The existence of several phytochemicals, minerals and antioxidant properties in watercress make it a healthy and nourishing diet that maintains the immunity and health of the body. Watercress is lobed with chlorophyll which is a safe source of nutrients with anti-inflammatory, wound-healing (Lanfer-Marquz *et al.,* 2005) and antioxidant properties that restrict the binding of carcinogens to DNA (Ferruzzi and Blakeslee, 2007). Besides these,chlorophyll is believed an efficient deliverer of magnesium and helps the blood carry oxygen to the cells and tissue. Watercress was found to contain several phenolic compounds that contributed to the anti-cancer potential (Ozen, 2009).

Watercress is also a rich source of vitamin C which assists normal neurological function (Prior, 2003) and decreases oxidative damage. Watercress is low in fat and calories while it is a rich source of protein, minerals, vitamin and antioxidant.Watercress supplementation in diet has shown to ameliorate the DNA damage and increased the blood antioxidant potential in human subjects (Gill *et al.,* 2007). Watercress consumption also acts as a source of anti-cancer drug (Hecht *et al.,* 1995) and its extract provides protection against the genotoxins at the different cancer stages (Boyd *et al.,* 2006).

But it is a regret that we are behind of watercress cultivation in Bangladesh though it is beneficial for sound health maintenance. So this experiment was carried out to investigate the adaptation and morphological traits alone with determination of phytonutrients, mineral compositions and antioxidant properties of watercress leaves grown in Bangladesh.

Materials and Methods

Seeds of watercress (collected from Japan and Germany) were sown into earthen pots (2.5 × 2.5 cm) on October 2015 at grill house, Department of Crop Botany, Bangladesh Agricultural University. After germination, 20 days old seedlings were transplanted in specialized tray made for watercress cultivation under Completely Randomized Design (CRD) with 3 replications (Figure 1).

Figure 1. Growing of watercress in specialized tray

The transplanted seedlings were grown for 30 days and meanwhile different morphological assessments were performed and after harvesting the nutritional parameters were assayed.

***Determination of chlorophyll*:** Chlorophyll (Chl) concentration was determined from fully expanded leaves (leaf number 8 from base). A leaf sample of 0.1 g was ground and extracted with 5 mL of 80% (v/v) acetone in the dark. The slurry was filtered and absorbance was determined at 645 and 663 nm. Concentration of Chl a, and Chl b were estimated by the equations of Barros *et al.,*(2010).

***Determination of tissue C/N ratio for*:** A 0.01-g sample of freeze-dried watercress shoot tissue was placed in a tin crucible and analyzed for total %N and %C using a Flash EA 1112 series NC Soil Analyzer (Thermo, Waltham, MA). Data generated was used to calculate the C/N ratio for each experimental sample.

***Proximate composition and minerals contents*:** Proximate composition of leaves was determined by adopting procedures depicted by Helrich (1990). Dried microgreens were manually ground into a fine powder and digested in concentrated di-acid mixture to determine minerals and trace elements according to Hassan and Umar (2004).

***Antioxidant properties of watercress leaves (in vitro)*:** Phenolic compounds were determined according to the

procedure depicted by Khoddami *et al.,* (2013). Ascorbic acid content was determined by following a procedure described by Xaio *et al.,* (2012) with 2.6-dichloroindophenl and measuring the content by titrimetric method. 1,1-diphenyl-2-picrylhydrazyl (DPPH) assay was carried out with some modifications depicted in Sanja *et al.,*(2009).

Results

***Evaluation of morphological traits*:** Being an introduced new crop in Bangladesh, the morphological traits evaluation of watercress is very important for its commercial cultivation. The morphological traits of watercress grown in soil were shown in Table 1.

Table 1. Maximum, minimum, average, and the variance of measured quantitative traits in watercress grown in Bangladesh.

Measured traits	Abbreviation	Unit	Maximum	Minimum	Average	CV (%)
Leaf length	LL	cm	18.4	4.73	9.27	31.98
Leaf width	LW	cm	13.0	2.04	4.71	45.88
Leaf thickness	LT	mm	0.88	0.24	0.43	24.59
Leaf number	NL	-	45.59	14.13	25.19	45.74
No of leaflet in leaf	NLL	-	9	5	7	14.57
Plant height	PH	cm	122.6	13.99	41.78	45.58
Lateral branch number	NLB	-	10.33	1.55	4.6	42.43
Node number		-	44.57	15.35	22.73	42.57
Fresh weight	FW	g	50.73	9.66	19.81	52.04

***Assessment of tissue biomass*:** Table 2 showed shoot tissue biomass, tissue nitrogen (N), carbon (C) and C/N ratio. Average watercress shoot biomass was (38.60 ± 3.41 g plant^{-1}) collected in transplanting plants. Shoot tissue %N was recorded at 4.75±0.79 while shoot tissue %C was 39.91±0.77. The C/N ratio in watercress shoot tissues was 8.40±1.70.

Table 2. Shoot biomass, leaf tissue nitrogen (N), carbon (C), and the C/N Ratioon a dry mass basis of watercress.

Treatment	Shoot biomass (g plant^{-1})	Tissue % N	Tissue % C	C/N ratio
Transplant	38.60 ± 3.41	4.75 ± 0.79	39.91 ± 0.77	8.40 ± 1.70

Values represented as mean±SE @ 5% level of probability

***Chlorophyll content*:** Chl-a concentrations in the watercress leaf tissues was 70.45 ± 11.97mg100 g^{-1}fresh weight (FW) while Chl-b concentration was 28.32 ± 4.37mg 100 g^{-1} FW with total Chl content at 98.77 ± 15.88mg 100 g^{-1} FW (Table 3).

***Proximate composition of watercress leaves*:** The proximate composition of the water cress leaves is given in Table 4. On the average, the increasing order of these nutrients in fresh sample is fat → ash→ protein → carbohydrate → moisture. The mean moisture content was found the highest while mean fat content was the lowest. Protein content was approximately eight fold of ash.

***Minerals in watercress leaves*:** From the results presented in Table 5, it is apparent that watercress leaves could be regarded as important source of essential macro elements (K, Ca, Mg, Na, P) and trace minerals (Zn, Fe, Cu, I). Potassium is the most abundant mineral in the leaves (287 ± 45% w.b.) followed by Ca content (131 ± 13 % w.b.). The magnesium content of watercress leaves was low among the macroelements (21 ± 3.5 % w.b.). On the average, the decreasing order of the trace minerals was Fe→Zn→Cu→I.

Table 3. Chlorophyll content in watercress leaves on Fresh Weight basis.

Treatments	Pigment concentration mg 100 g^{-1} FW			
	Chlorophyll a	Chlorophyll b	Total Chlorophyll	Chlorophyll a/b ratio
Transplant	70.45 ± 11.97	28.32 ± 4.37	98.77 ± 15.88	2.49 ± 0.23

Values represented as mean±SE @ 5% level of probability

Table 4. Proximate composition of watercress leaves

Component	Per cent (%) of dry weight
Moisture	87.50 ± 3.76
Ash	0.36 ± 0.05
Protein	2.85 ± 0.06
Fat	0.81 ± 0.07
Carbohydrates	7.40 ± 0.86
Fiber	1.06 ± 0.01
Caloric value (Kcal)	32.29 ± 1.02

Values represented as mean ± SE @ 5% level of probability

Table 5. Mineral content of water cress leaves (% w.b.).

Minerals	% w.b.
P	54 ± 10
Ca	131 ± 13
K	287 ± 45
Na	52± 9
Mg	21 ± 3.5
Zn	0.15 ± 0.05
Fe	1.2 ± .1
Cu	0.077± 0.01
I	0.015±0.02

Values represented as mean ± SE @ 5% level of probability

***Antioxidant properties*:** The antioxidant properties of watercress leaves were determined and the results were shown in the Table 6. The antioxidant properties were attributed to their phenolic compounds (50.42±2.77 mg GAE/g extract), ascorbic acid (70.57± 5.78mg/100g FW) and 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity with an IC_{50} value of 0.13±0.03 mg/ml.The lowest IC_{50} value indicates the highest radical scavenging activity.

Table 6. Antioxidant properties of watercress leaves

Components	**% w.b.**
Phenolics (mg GAE/g extract)	50.42±2.77
Ascobic acid (mg/100g)	70.57± 5.78
DPPH scavenging activity (mg/ml)	0.13±0.03

Values represented as mean±SE @ 5% level of probability

Discussion

Since the vegetative parts are used for human consumption, the morphological traits (leaf & stem characteristics) evaluation could be economically useful and practical markers in both food industry and agricultural applications. Therefore, vegetative traits were evaluated in the present study (Table 1). Moreover, this plant exists as evergreen beside the water stream and as vegetative phase. Its propagation is

often asexual, so that every part of plant in contact with the water produces adventitious root and develop a complete plant. The plant had the compound leaves and glabrous organs, hollow stem with anthocyanin rich colour both in petiole and stem (Palaniswamy and McAvoy, 2003).

Watercress is an excellent source of Chl-a and Chl-b, found in the present study (Table 2). Chlorophyll is a good source of antioxidant nutrients with anti-inflammatory, wound-healing (Lanfer-Marquz*et al.,* 2005) and antioxidant properties that reduces the binding of carcinogens to DNA (Ferruzzi and Blakeslee, 2007) Again, Chl is an efficient deliverer of magnesium and helps the blood carry oxygen to the cells and tissue. Chlorophyll also assists in the chelation of heavy metals.

Watercress is low in fat and calories (Table 4) with sufficient amount of protein. Like most vegetables it has a high water content (93%) and low energy density. All the features from proximate composition are associated with weight control of an adult. Research carried out at Pennsylvania State University found that eating a large, mixed low fat salad as a starter resulted in subjects eating 12% fewer calories (a saving of more than 100 calories) overall at that meal, compared to when they didn't start their meals with the salad. Watercress has a low energy density, which can contribute to feelings of fullness and may help with weight control. Optimum intake of watercress vegetable has been associated with better body weight control in women.

Watercress is an outstanding source of iodine that is important for protection against radiation and maintaining a healthy thyroid gland. Naturally occurring iodine in watercress is so high that it is not advised for anyone with hyperthyroidism. Potassium helps in maintaining normal physiological function of the body, normal water balance in the body and in balancing the pH of the body (Tazoe *et al.,* 2007).Sodium helps in regulating blood pressure and in maintaining proper function of muscle and nerves (Hassan and Umar, 2004). The importance of calcium on bone health is well known, and deficiencies in this mineral can lead to osteoporosis. Magnesium is involved in calcium metabolism in bones and helps to prevent heart diseases (Hassan and Umar, 2006). Iron is essential in the formation of haemoglobin and oxidation of carbohydrates, protein and fats (Adeyeye and Otokiti, 1999).

Watercress is lobed with phenols. They act as a reducing agent and singlet oxygen quencherswhich lead to antioxidant activity (Nisha *et al.,* 2009; khoddami *et al.,* 2013). Phenolic compounds also assist in heavy metal chelation. Watercress is a rich source of vitamin C (Table 6). Vitamin C is necessary for the normal structure and function of blood vessels and connective tissues (as required for normal gums, skin, bones, cartilage and wound healing). Generally, young edible seedlings are a super source of vitamin C, an antioxidant that helps protect our body from the harmful effects of free radicals thus cancer (Stratton and Godwin, 2011). It also use against common cold and skin infection **(**Hodges *et al.,* 1969; Heimer *et al.,* 2009**)**. Vitamin C is needed to synthesize neurotransmitters making it essential for normal neurological function (Prior, 2003). Higher plasma vitamin C levels may benefit cardiovascular health. Watercress also shows highest DPPH radicle scavenging activity. DPPH itself a radical that binds with other free radicals and lead the free radical remove from body thus ensure healthy life and longevity.

Based on the findings of the present study, it may be concluded that cultivation of watercress could be possible in our country by transplanting method.In nutritional aspects watercress possess the maximum Chl, phytochemicals, minerals and antioxidant activity which not only providesadequate nutrition but also decreases the oxidative damage leads to maintain a sound health.

Acknowledgements

The Ministry of Science and Technology, Government of the Peoples Republic of Bangladesh is gratefully acknowledged for the financial support of the research work.

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