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Morpho-chemical characteristics of cultivated genotypes of leafy chenopod (*Chenopodium album* L.) developed at ICAR-IIVR, Varanasi, Uttar Pradesh

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Abstract

Cultivated genotypes of leafy chenopod evaluated for plant growth; yield potential; dry matter; and concentration of phytochemicals such as total carotenoids, vitamin C, total phenolics and antioxidant ability expressed in the form of CUPRAC activity which is developed at ICAR-IIVR, Varanasi, Uttar Pradesh, India. Plant height at flowering stage, biomass yield potential and dry matter content ranged from 169.8-214.1 cm, 31.2-43.3 t/ha and 13.4-16.3%, respectively. The content of phytochemicals i.e. total carotenoids (26.7-71.3 mg/100 g FW), vitamin C (108.4-149.7 mg/100 g FW), total phenolics (191.8-292.6 mg GAE/100 g FW) and CUPRAC antioxidant ability (27.4-43.2 ìmol TE/g FW) is higher in green leafed genotypes than purplish-green genotypes to the tune of 99.2%, 15.1%, 23.5%, 31.8%, respectively. In Amaranthaceae family, red/purple colour of plant parts is due to presence of betalain pigments and their presence in purplish-green leafed genotypes of leafy chenopod might be possible reason for lower values of phytochemicals/ antioxidants; and hence, green leafed cultivars should be promoted for commercial utilization.

Keywords: Bathua; *Chenopodium album*; leafy vegetable; nutrient; carotenoids; phenol; antioxidants

Introduction

Leafy chenopod (*Chenopodium album* L.), a fast-growing annual herb, is also known as fat hen, lamb's quarters, Nawai grass, silver grass, giant fat-hen, goosefoot, white goosefoot, pigweed, dungweed or melde. However, In India, it is known by various names such as bathua in Hindi and Odia, vastuka in Sanskrit, lunak in Punjabi, paruppukkirai in Tamil, chandanbethu in Bengali, jilmil in Assamese, monsaobi in Manipuri, chakkavatta/kaduoma in Kannada, pappukura in Telugu, vastuccira in Malayalam, chakvit in Konkani and chilani in Gujarati (Singh et al. 2018). Though cultivated in some regions only, generally it is a potentially serious weed of almost all cultivated crops, gardens, horticultural crops and orchards in almost all winter-sown crops of the subtropics and tropics. It is also found on wasteland, in pastures, and along roadsides and riverbanks. Usually, the leaves are cooked in form of saag (leafy vegetable) and mixed with dal/puri/paratha. Leafy chenopod belongs to family Amaranthaceae, sub-family Chenopodiaceae, genus *Chenopodium*, and species *album* which has a wide distribution globally and comprises of about 250 species (Risi and Galwey 1984). The other important relatives of this genus are quinoa (*Chenopodium quinoa*), kaniwa (*Chenopodium pallidicaule*), epazote (*Chenopodium ambrosides*) and good king henry (*Chenopodium bonushenricus*). It is originated in the Andean region of Bolivia and Peru; widely distributed in both the northern and southern hemispheres; and occurring in Asia, North America, Europe, South Africa, Australia and South America (Brenan and Akeroyd 1993).

Chenopodium album occurs from sea level to altitudes of 3600 m, and from latitudes 70°N to 50°S. Commonly, bathua is being grown/cultivated for soft leaves and shoots in the various countries like USA, Japan, Chile, Africa, India, Sri Lanka, Pakistan and Bangladesh. Generally, it is tolerant of a wide range of cultural conditions, climates, soil types, fertility and pH, and have potential for cultivation in marginal lands (Sood 2011). *Chenopodium album* plant is extensively consumed in Northern India as a leafy vegetable and as animal feed too in many Asian countries. The succulent soft leaves are very good sources of dietary fibre; protein; minerals such as Ca, Fe, P, K, Mg, Zn, Mn, Se and Na; vitamins i.e. vitamin-C, â-carotene, niacin, folic acid and

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riboflavin; antioxidatns; and omega-6-fatty acid (Yadav et al. 2013, Poonia and Upadhayay 2015, Kole et al. 2016; Singh and Singh 2017; and Singh et al. 2018). The effect of feeding chenopodium cultivar on blood lipid profile of rats confirmed the hypochloesterolemic effect by lowering total blood cholesterol, LDL, VLDL and triglycerides, and increasing HDL content (Sood 2011). Now-a-days, the importance of antioxidant rich food items is in discussion because of their wide range of health beneficial properties such as anti-aging, anti-inflammatory, hepato-protective, anti-atherosclerotic, anti-thrombotic, anti-bacterial and anti-carcinogenic.

Being an important leafy vegetable with respect to its tremendous nutritional importance; ICAR-IIVR felt its responsibility and initiated research work to develop high yielding and nutritionally rich genotypes for greater benefit to the growers and consumers. These nutritionally rich high yielding genotypes have very much scope to be used as a potential leafy vegetable and could be utilized for manufacturing of leaf concentrate and dry leaf powder which will eventually help in combating the nutritional deficiency of masses.

Materials and Methods

Eight high yielding cultivated genotypes developed at ICAR-Indian Institute of Vegetable Research, Jakhini, Varanasi, Uttar Pradesh and a released variety (Pusa Bathua-1) comprised the basic experimental materials. Morphologically, the genotypes were categorized in two groups (i) purplish-green leaved (VRCHE-1, VRCHE-3, VRCHE-4, VRCHE-5 and Pusa Bathua-1); and (ii) green leaved (VRCHE-2, VRCHE-6 and VRCHE-10). In 2019, two genotypes i.e. VRCHE-2 and VRCHE-4 have been notified and released in the name of Kashi Bathua-2 and Kashi Bathua-4, respectively for commercial cultivation. All eight genotypes/variety were evaluated for morphological and phytochemical parameters at the Research Farm, ICAR-IIVR, Varanasi, UP, India during five consecutive years (2013-2018). Seeds were sown during mid-October every year and all agronomic practices were carried out uniformly to get normal crop growth. The experimental site of ICAR-IIVR is located at 25°10’55’’ N latitude, 82°52’36’’ E longitude and 85 m altitude which receives usually an annual rainfall of 1050-1100 mm. The soil of the research Farm was of silt-loam in texture, having pH 7.3 and electrical conductivity of 0.28 dSm-1.

Each genotype was harvested at marketable stage, generally 5-6 cuttings were made during cropping period, and total biomass yield was calculated (t/ha). To observe the differential plant growth, total plant height (without cutting) was measured at two stages, namely 40 and 160 days after sowing (DAS) i.e. first cutting and flowering, respectively. A representative of the fresh leaves of 2nd cutting was taken for dry matter content and biochemical estimation on fresh weight (FW) basis. Moisture was evaporated from the 200 g of fresh sample by oven-drying, and dry matter (%) was determined gravimetrically as the residue remaining after drying. Moreover, vitamin C was determined by the direct colorimetric method as mentioned by Ranganna (1986) which is based on measurement of the extent to which 2, 6-dichlorophenol indo-phenol solution (dye) is decolorized by ascorbic acid in sample extracts and in standard ascorbic acid solution. The estimation of total carotenoids is based on the extraction of crude pigment mixture in lipid solvent as described by Ranganna (1979) and the pigment content was determined by measuring its optical density at 452 nm. The water-soluble phytochemicals were extracted according to the method reported previously (Chu et al. 2002) with slight modification for analysis of total phenolics and cupric reducing antioxidant capacity (CUPRAC) activity. Total phenol was estimated spectrophotometrically using Folin–Ciocalteu reagent (Singleton et al. 1999). Moreover, antioxidant value in terms of CUPRAC activity was analysed according to the procedure described by Apak et al. (2008). The pooled data of five years were used for making histograms to compare mean differences among genotypes of leafy chenopod by using standard error bars with $p<0.05$ through Microsoft Excel.

Results and Discussion

The economic traits such as plant height at 40 and 160 DAS, biomass yield, dry matter, total carotenoids, vitamin C, total phenolics and antioxidant ability in terms of CUPRAC activity are presented in various figures. Among five experimental years, there were no considerable differences observed within various high yielding genotypes (data not sown); but significant variations were comprehended between purplish-green and green leafed genotypes especially for phytochemical traits. Hence, the pooled data of five years are presented in various 8 Figures and mean value compared with standard error bars. Since the crops were raised in almost similar climatic conditions during five years, it is obvious to get least differences over the year and lack any interactions between years for various biochemical estimates. The significant variability among genotypes; and non-significant differences between experimental years for various phytochemicals and antioxidants were also reported by Leja et al. (2013) and Singh et al. (2018) in different coloured carrots, and Singh et al. (2017) in white, red and purple radishes.

Crop growth in terms of plant height is one of the most important yield contributing factors in leafy chenopod that ranged 16.7-20.3 cm at 40 DAS and 169.8-214.1 cm at 160 DAS (Figure 1 and 2). In both stages, it was maximum for VRCHE-4 i.e. 8% and 22.9% higher than standard check, respectively at 1st cutting and flowering stage. Yadav et al. (2013) reported a wider range (111-227 cm) of plant height at flowering stage among 15 genotypes developed at ICAR-IARI, New Delhi. The purplish-green and green leafed genotypes did not differ significantly for plant growth. The cultivated genotypes of leafy chenopod exhibited significant variations for total biomass yield (Figure 3) which ranged from 31.2 t/ha (VRCHE-6) to 43.3 t/ha (VRCH-4). The standard cultivar Pusa Bathua-1 realized yield potential of 33.9 t/ha. Yielding ability of best genotype VRCHE-4 is 27.9% higher than standard check. Also, purplish-green genotypes produced higher yield by 11% than green leafed genotypes because of higher plant growth. Dry matter, refers to materials remaining after removal of water, is an indicator of the amount of nutrients that are available in a particular material, which was maximum in VRCHE-4 (16.3%) followed by Pusa Bathua-1 (15.7%) and VRCHE-6 (15.6%), and minimum in VRCHE-5 (13.4%, Figure 4). Further, there is no significant differentiation between purplish-green and green leafed genotypes. A wide range of dry matter content in leaves have also reported by various researchers such as 8.6-16.5% by Yadav et al. (2013), 12.5% by Singh et al. (2007) and 17% by Yadav et al. (2007).

Total carotenoids content (mg/100 g FW) varied considerably from 26.7-71.3 mg among genotypes with a general mean value of 46.8 mg (Figure 5) which was highest in VRCHE-2 (71.3 mg) followed by VRCHE-6 (69.2 mg), VRCHE-10 (63.5 mg) and lowest in Pusa Bathua-1 (26.7 mg). Very interestingly, it is greatly higher (99.2%) in green leafed genotypes (68.0 mg) than purplish-green leafed lines (34.1 mg). Similarly, Yadav et al. (2013) also quantified total carotenoids ranged from 24.7-89.2 mg/100 g in the fresh leaves of bathua. In Amaranthaceae family, red and purple colour of plant parts is due to presence of betalains content which might be reducing the carotenoids synthesis in the leaves. Moreover, vitamin C content (mg/100 g FW) in the fresh leaves of high yielding bathua genotypes varied from 108.4-149.7 mg (Figure 6). It was analyzed maximum in VRCHE-2 (149.7 mg) followed by VRCHE-6 (139.7 mg), VRCHE-4 (130.5 mg), VRCHE-10 (128.3 mg), VRCHE-1 (124.1 mg), Pusa Bathua-1 (122.0 mg), VRCHE-3 (119.8 mg), and lowest in VRCHE-5 (108.4 mg). Additionally, vitamin C content is significantly higher (15.1%) in green leafed genotypes (139.2 mg) than purplish-green genotypes (121.0 mg).

Total phenolics (mg GAE/100 g FW) in the leaves of 8 genotypes ranged from 191.8-292.6 mg (Figure 7). The genotype VRCHE-2 possessed highest content followed by VRCHE-6, VRCHE-10, VRCHE-4, Pusa Bathua-1, VRCHE-3, VRCHE-1, and lowest in VRCHE-5. As like carotenoids, phenolics content was estimated significantly higher i.e. 23.5% more in green leaf genotypes (267.6 mg) than the purplish-green genotypes

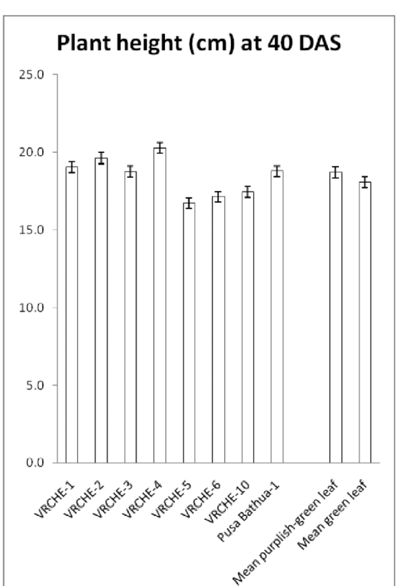

Figure 1: Plant height at 40 DAS in the genotypes of leafy chenopod (Standard error bars with $p<0.05$).

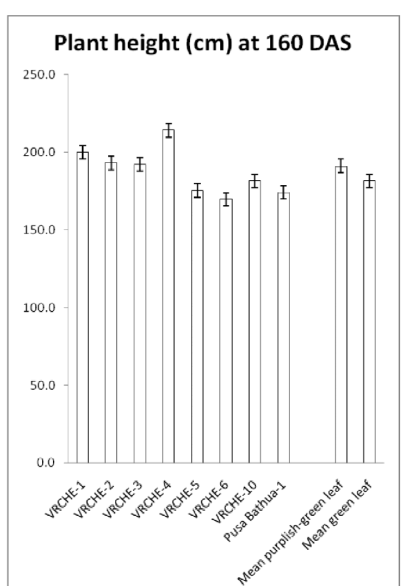

Figure 2: Plant height at 160 DAS in the genotypes of leafy chenopod (Standard error bars with $p<0.05$).

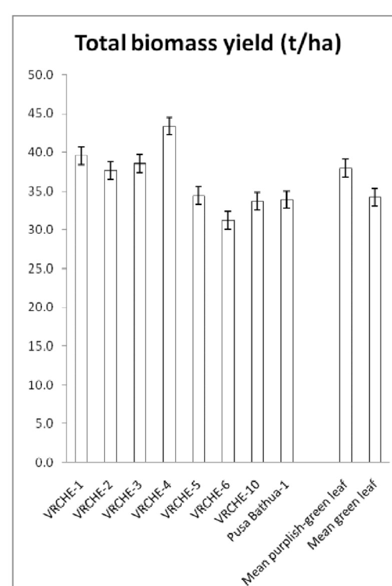

Figure 3: Biomass yield in the genotypes of leafy chenopod (Standard error bars with $p<0.05$).

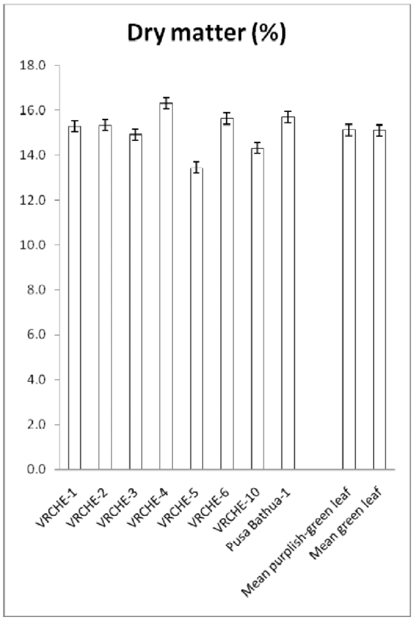

Figure 4: Dry matter content in the genotypes of leafy chenopod (Standard error bars with $p<0.05$).

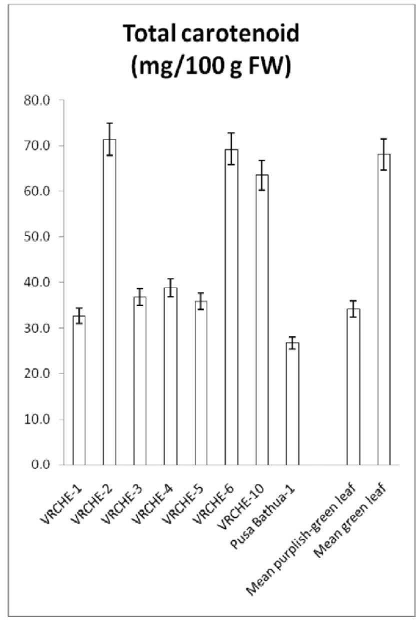

Figure 5: Total carotenoid content in the genotypes of leafy chenopod (Standard error bars with $p<0.05$).

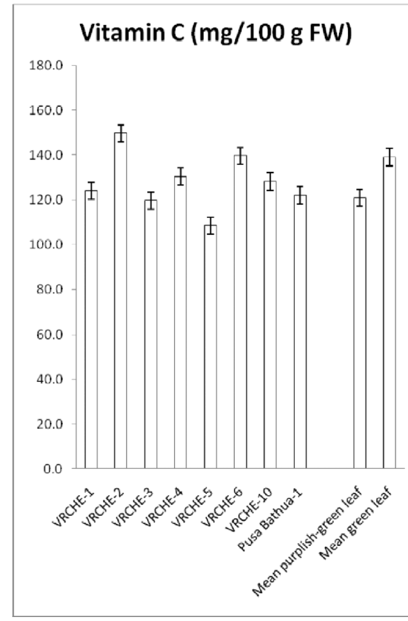

Figure 6: Vitamin C content in the genotypes of leafy chenopod (Standard error bars with $p<0.05$).

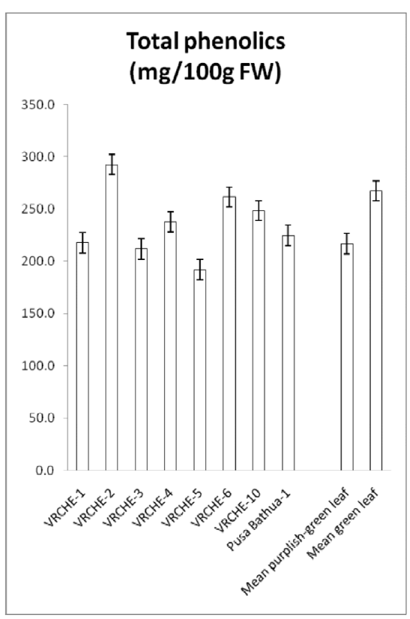

Figure 7: Total phenolics content in the genotypes of leafy chenopod (Standard error bars with $p<0.05$).

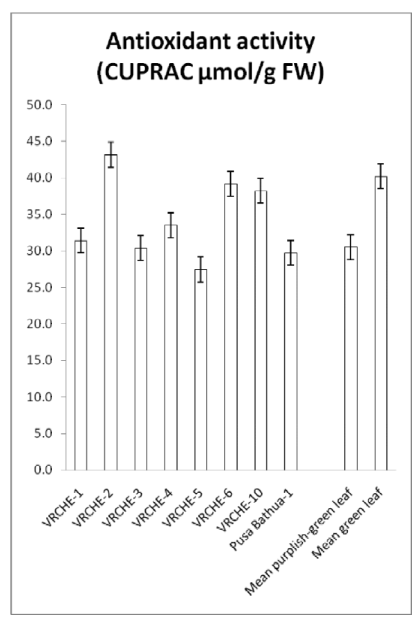

Figure 8: Antioxidant activity (CUPRAC value) in the genotypes of leafy chenopod (Standard error bars with $p<0.05$).

(216.7 mg). However, Yadav et al. (2013) estimated 27.7-91.1 mg GAE/100g FW of phenolics in the leaves of cultivated leafy chenopods.

The dietary antioxidants are biochemical molecules (vitamin C, carotenoids, phenolics, pigments, etc.) inhibit the process of oxidation. In nutritional research of food items, the evaluation of antioxidant activity is becoming more important as it provides useful information with regard to health promoting functional quality of food items. In the present study, antioxidant potential in terms of CUPRAC activity (ìmol TE/g FW) has been estimated which varied significantly from 27.4-43.2 ìmol. The green leafed genotypes. Interestingly, antioxidant potential is higher (31.8% more) in green leafed genotypes (40.2 ìmol) than purplish-green leafed genotypes (30.5 ìmol). Yadav et al. (2013) have also reported CUPRAC activity ranged from 17.4-34.1 ìmol TE/g FW in the leaves of bathua. Two bioactive pigments anthocyanins and carotenoids responsible for various colours (red, purple, black) of the vast majority of vegetables, fruits and foods, and their colour intensity is directly correlated with antioxidant activity such as radish (Singh et al. 2017), carrot (Singh et al. 2018), French bean and legumes (Singh et al. 2011; Koley et al. 2019). Higher antioxidant ability of green leafed genotypes has been attributed because of presence of higher quantity of antioxidant phytochemicals such as carotenoids, vitamin C and phenolics. In Amaranthaceae family, red/purple colour of plant parts is due to presence of betalain pigments and their presence in purplish-green leafed genotypes of leafy chenopod might be possible reason for lower antioxidant ability. Further, it is very interesting to note that anthocyanins containing black carrots possessed >500% higher antioxidant ability than betalains rich dark red beetroot (Singh et al. 2018). Realizing the beneficial impacts of phytochemicals in managing the human health, green leafed cultivars of leafy chenopod should be promoted for commercial utilization.

सारांश

कृष्य योग्य पत्तीदार बथुआ (*चिनोपोडियम एल्बम* एल.) का मूल्यांकन पौध वृद्धि, उपज क्षमता, शुष्क पदार्थ एवं पादप रसायनों जैसे– कुल कैरोटीनोयड्स, विटामिन सी, कुल फिनोलिक्स तथा प्रति ऑक्सीकारक क्षमता की अभिव्यक्ति सी.यूपी.आर.ए.सी. प्रक्रिया के माध्यम से भा.कृ. अनु.प.–भारतीय सब्जी अनुसंधान संस्थान, वाराणसी (उत्तर प्रदेश) में किया गया। पुष्पन अवस्थान में पौध ऊँचाई, जैव भार, उपज क्षमता तथा शुष्क पदार्थ की मात्रा का मध्य विस्तार 169.80–214.10 सेंमी., 31.20–43.3 टन/हे. तथा 13.40–16.30 प्रतिशत क्रमशः पाया गया। पादप रसायनों की मात्रा जैसे–कुल कैरोटीनायेड्स (26. 70–71.30 मिग्रा./100 ग्राम ताजे भार), विटामिन सी (108.40–149. 70 मिग्रा./100 ग्राम ताजे भार), कुल फिनोलिक्स (191.80–292.60 मिग्रा. जी.ए.ई./100 ग्राम ताजे भार) तथा सी.यू.पी.आर.ए.सी. प्रति ऑक्सीकारक क्षमता (27.40–43.20 माइक्रोमोल टी.ई./ग्राम ताजे भार), हरी पत्तियों वाली प्रभेदों में बैगनी हरे पत्तियों वाली की तुलना में 99.20 प्रतिशत, 15.10 प्रतिशत, 93.50 प्रतिशत व 31.80 प्रतिशत क्रमशः पाया गया। एमारेन्थेसी कुल की लाल बथुआ में बैगनी रंग पौधों में बेटालेन रंजक की उपस्थिति एवं उनकी उपस्थिति बैगनी हरे रंग वाली पत्तियों के प्रभेदों में सम्भवतः कम मात्रा में पादप रसायनों/प्रति आक्सीकारक स्पष्ट करता है कि सफेद पत्ती वाली किस्मों को व्यवसायिक खेती के लिए प्रोत्साहित करना चाहिए।

References

Apak R, Guclu K, Ozyurek M and Celik SE (2008) Mechanism of antioxidant capacity assays and the CUPRAC (cupric ion reducing antioxidant capacity) assay. Microchim Acta 160: 413–419.

Brenan JPM and Akeroyd JR (1993) *Chenopodium* L. In: Tutin TG, Burges NA, Chater AO, Edmondson JR, Heywood VH, Moore DM, Valentine DH, Walters SM, Webb DA (Eds) Flora Europaea Vol-1, Psilotaceae to Platanaceae. 2nd Edition, Cambridge University Press, Cambridge, UK, pp 111–114.

Chu YF, Sun J, Wu X and Liu RH (2002) Antioxidant and anti-proliferative activities of common vegetables. J Agr Food Chem 50: 6910–6916.

Koley TK, Maurya A, Tripathi A, Singh BK and Singh B (2016) Nutritive vegetables for healthy life. Indian Hort 61(1): 38–41.

Koley TK, Maurya A, Tripathi A, Singh BK, Singh M, Bhutia TL, Tripathi PC and Singh B (2019) Antioxidant potential of commonly consumed underutilized leguminous vegetables. Int J Veg Sci 25(4): 362–372.

Poonia A and Upadhayay A (2015) *Chenopodium album* L.: review of nutritive value and biological properties. J Food Sci Technol 52(7): 3977–3985.

Ranganna S (1979) Manual of Analysis of Fruits and Vegetable Products. Tata McGraw Hill Book Company, New Delhi.

Risi J and Galwey NW (1984) The Chenopodium grains of the Andes: Inca crops for modern agriculture. In: Coaker TH (ed) Advances in applied biololgy. Academic Press, Landon, pp 145–216.

Singh BK, Koley TK, Karmakar P, Tripathi A, Singh B and Singh M (2017) Pigmented radish (*Raphanus sativus* L.): genetic variability, heritability and inter-relationships of total phenolics, anthocyanins and antioxidant activity. Indian J Agric Sci 87(12): 1600–1606.

Singh BK, Koley TK, Maurya A, Singh PM and Singh B (2018) Phytochemical and antioxidative potential of orange, red, yellow, rainbow and black coloured tropical carrots (*Daucus carota* subsp. *sativus* Schubl. & Martens). Physiol Mol Biol Plants 24(5): 899–907.

Singh BK, Pathak KA, Ramakrishna Y, Verma VK and Deka BC (2011) Purple-podded French bean with high antioxidant content. ICAR News: A Sci Techn Newsl 17 (3): 9.

Singh BK, Pragya, Chaurasia SNS, Singh B and Singh PM (2018) Kashi Bathua-2: A bathua variety for higher nutrient and yield. Veg Sci 45(2): 291–293.

Singh BK and Singh B (2017) IC0619019 (VRCHE-2): A bathua genotype for higher nutrient and yield. Veg Newsl 4(2):3.

Singh L, Yadav N, Kumar AR, Gupta AK, Chacko J, Parvin K and Tripathi U (2007) Preparation of value-added products from dehydrated bathua leaves (*Chenopodium album* L.). Natural Product Radi 6: 6–10.

Singleton VL, Orthofer R and Lamuela-Ranventos RM (1999) Analysis of total phenols other oxidation substrates and antioxidants by means of Folin–Ciocalteu reagent. Methods Enzymol 299: 152–178.

Sood P (2011) Physico-chemical, nutritional, biological quality evaluation and value addition of chenopodium (bathua) cultivars. PhD Thesis, Department of Food Science and Nutrition, CSKHPKV, Palampur-176062, HP.

Yadav N, Vasudeva N, Singh HS and Sharma SK (2007) Medicinal properties of genus *Chenopodium* L. Natural Product Radi 6:131–134.

Yadav RK, Joshi S, Kumar R, Kalia P, Varshney R and Jain V (2013) Studies on different genotypes of Indian bathua (*Chenopodium album*) for their yield, quality and antioxidant activities. Indian J Agric Sci 83(1): 26–30.