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Quality profiling of Indian walnut (*Juglans regia*) from Kashmir valley

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ABSTRACT

The aim of this study was to know the nutritional composition of walnuts grown in Kashmir valley of north western Himalayan region for their commercial exploit at farm and consumer level. Samples were collected from earmarked trees growing in major walnut producing areas of Kashmir valley. The research work was conducted during 2002–18 at ICAR-CITH, Srinagar. The observations were assessed in 11 walnut (*Juglans regia* L.) genotypes (BHU-01, ZC-05, NU-03, SPS-02, BPP-05, MPU-04, NU-05, CSB-02, DU-07, NU-02 and BPP-07). Mineral content: zinc (Zn), magnesium (Mg), manganese (Mn), selenium (Se), copper (Cu), aluminium (Al), cobalt (Co), molybdenum (Mo), and iron (Fe), were determined by atomic absorption spectrophotometry. Fat content was determined by standard Association of Official Analytical Chemists (AOAC) methods. Nut and kernel exterior quality traits were recorded as per the IBPGR descriptor. Results revealed that micro-mineral nutrient contents expressed in mg/100 g dry weight ranged between 147.39-68.07 (Mg), 19.71-74.16 (Mo), 7.32-15.57 (Mn), 2.25-9.03 (Cu), 2.90-3.53 (Zn), 1.99-3.81 (Fe), 0.11-0.93 (Al), 0.007-0.069 (Co) and 0.00-0.006 (Se). The fats accounted for more than 60% of the walnut kernel weight and it was ranged from 53.54-74.93%. Significant variability ($P<0.05$) recorded for physical properties can be attributed to quality criteria of nuts and kernel in walnut.

Key words: Mineral nutrients, Nut and kernel quality, Walnut

Walnut (*Juglans regia* L.) is one of the most nutritious nut crop grown around the world in temperate climates. India is one of the major producer as well as exporter of walnuts. It enjoys good demand in the international market due to its superior quality. North western Himalayan in general and Kashmir valley in particularly is the bowl of walnut production. It has a special value in Indian foods, and medicine as well as in traditional sweets (Uniyal *et al.* 2002). Walnut is a rich source of healthy fats that vary from 50–70% depending on the cultivar and location (Greve 1992). It is also considered as the power house of the essential nutrients (Venkatachalam and Sathe 2006). In modern era of busy lifestyles, tree nuts are convenient, tasty, nutritious and easy snack and, therefore, contribute significantly towards a healthy lifestyle (Spiller and Bruce 1997). Several health beneficial minerals are also abundantly present in walnuts (Anderson *et al.* 2001) and work synergistically in the body for the health benefits. The variations in mineral nutrient composition among walnut cultivars/genotypes have been reported by several workers from Iran (Aryapak and Ziarati 2014, Gharibzahedi *et al.* 2014), Italy, New Zealand, Romania (Cosmulescu *et al.* 2009), Serbia, Spain (Tapia *et al.* 2013) and Turkey (Ozcan *et al.* 2010, Polat *et al.* 2015). However, it is lacking for Indian walnut varieties or genotypes.

The morpho-physical qualities of nuts as well as kernel of walnuts are also very important for trade purpose. Several reports have been published from India (Pandey *et al.* 2004, Rana *et al.* 2007), Iran (Aryapak and Ziarati 2014), Pakistan (Ali *et al.* 2010), Romania (Cosmulescu *et al.* 2009), Turkey (Ozcan *et al.* 2010, Polat *et al.* 2015). Therefore, this study was conducted with the objective to characterize the walnut genotypes for micronutrient profile, fat recovery and morpho-physical quality traits.

MATERIALS AND METHODS

Eleven walnut genotypes (BHU-01, ZC-05, NU-03, SPS-02, BPP-05, MPU-04, NU-05, CSB-02, DU-07, NU-02 and BPP-07) were collected from the different location of Kashmir valley. The research work was conducted at ICAR-CITH, Srinagar in 2002–18. For each genotype, 5 kg of the walnuts were received. The samples were packed in air tight packets and stored at 4°C in the dark until analysis. Copper (Cu), iron (Fe), zinc (Zn), magnesium (Mg), manganese (Mn), selenium (Se), aluminium (Al), cobalt (Co), and molybdenum (Mo) concentrations in the digisted samples were determined. An Analytik Jena AAS Vario-6 Graphite furnace spectrometer (Made in Germany), furnished with PC-controlled 6-piece lamp turret, where hollow cathode lamps are mounted as line radiator along

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with a deuterium hallow cathode lamp for compensation of the background absorption and argon gas supply, was used for all of the absorption measurements. The hollow cathode lamps fitted for specific element that has to be analyzed with their respective wavelength and the slit width adjusted accordingly. Signal measurement was done in peak area/ peak height and calibration was in linear mode. The sample injection volume is 20 µL. The typical heating programme of GF-AAS is drying, atomization, and cleansing. The concentration of minerals was calculated with a standard curve for each element. Fat content was measured by the Soxhlet extraction method by exhaustively extracting 5.0 g of each sample in a Soxhlet apparatus using n-hexane (boiling point range 55–60°C) as the extractant (AOAC 1990). Exterior quality traits related to nut and kernels were measured after drying in the shade. The traits like nut weight, nut diameter at suture, nut diameter at cheek, nut length, nut shape, shell texture, shell colour, shell thickness, packing tissue thickness, kernel weight, kernel recovery, kernel vein and kernel colour were determined (IPGRI 1994). While weighing 0.001 g was performed with sensitive precision scales, measuring was made with 0.01 mm precision digital calliper. Mean values and standard errors are reported. Genotypes differences were analysed using the Analysis of Variance (ANOVA) procedure of OPSTAT software (http://www.hau.ernet.in/opstat). The degree of significance was set at $P<0.05$. Correlation analysis was carried out employing Pearson's test.

Table 1 Fat content (%) and concentrations (mg/100 g) of zinc, magnesium, manganese, selenium of 11 walnut genotypes

Genotype	Fat content (%)	Zinc	Mg	Mn	Se
BHU-01	63.67 ± 1.18	3.53 ± 0.03	168.07 ± 4.08	14.70 ± 0.09	0.003 ± 0.00
ZC-05	69.33 ± 2.07	3.15 ± 0.04	166.49 ± 2.35	15.57 ± 0.18	0.002 ± 0.00
NU-03	74.93 ± 1.64	2.90 ± 0.04	161.82 ± 2.78	12.06 ± 0.12	0.000 ± 0.00
SPS-02	67.00 ± 1.83	2.92 ± 0.04	151.86 ± 1.67	7.32 ± 0.08	0.000 ± 0.00
BPP-05	53.54 ± 2.06	3.34 ± 0.04	165.06 ± 2.23	15.27 ± 0.22	0.006 ± 0.00
MPU-04	68.67 ± 2.35	3.44 ± 0.08	148.56 ± 2.72	10.77 ± 0.09	0.000 ± 0.00
NU-05	73.19 ± 1.00	3.43 ± 0.04	152.01 ± 1.42	15.33 ± 0.10	0.000 ± 0.00
CSB-02	73.00 ± 1.56	3.30 ± 0.02	154.86 ± 1.41	15.54 ± 0.19	0.000 ± 0.00
DU-07	69.80 ± 2.45	3.49 ± 0.04	159.96 ± 1.47	10.98 ± 0.15	0.000 ± 0.00
NU-02	67.80 ± 1.65	3.27 ± 0.03	147.39 ± 1.26	12.94 ± 0.14	0.001 ± 0.00
BPP-07	58.33 ± 2.28	3.40 ± 0.01	162.90 ± 2.10	9.57 ± 0.06	0.001 ± 0.00
C.D. (P<0.05)	4.34	0.12	6.98	0.39	0.001

RESULTS AND DISCUSSION

Mineral content of eleven walnut genotypes: The micro-mineral composition showed significant differences ($P<0.05$) among the 11 walnut genotypes (Table 1, 2, 3). The order of the micro mineral nutrient concentrations among all the genotypes kernel samples are found to be in order of Mg>Mo>Mn>Cu>Zn>Fe>Al>Co>Se. Very little or no Se was detected in most of genotypes. Similarly, Aluminium (Al) levels were also found low in all the genotypes. These levels are below the tolerable limit for Se and Al in most adults. In general, in eleven genotypes, zinc ranged between 2.90 and 3.53 mg/100 g, Mg from 147.39 to 168.07 mg/100 g, Mn from 7.32 to 15.57 mg/100 g, Cu from 2.25 to 9.03 mg/100 g, Al from 0.11 to 0.93 mg/100 g, Co from 0.007 to 0.069 mg 100/g, Mo from 19.71 to 74.16 mg 100/g and Fe from 1.99 to 3.81 mg/100 g. In general, 4 genotypes showed high levels of micronutrient, viz. BHU-01 (zinc, magnesium, and iron), ZC-05 (manganese, copper), BPP-05 (selenium, aluminium) and NU-05 (cobalt and molybdenum). In contrast, the minimum content of micronutrients was recorded in NU-03 (zinc, cobalt, and selenium), CSB-02 (copper, molybdenum, and selenium), NU-02 (magnesium, aluminium), SPS-02 (manganese, selenium) and ZC-05 (iron).

It has been reported that the walnuts contain variable

Table 2 Concentrations (mg/100 g) of copper, aluminium, cobalt, molybdenum and iron in 11 walnut genotypes

Genotype	Cu	Al	Co	Mo	Fe
BHU-01	3.57 ± 0.05	0.19 ± 0.004	0.016 ± 0.00	45.57 ± 0.51	3.81 ± 0.03
ZC-05	9.03 ± 0.05	0.12 ± 0.001	0.019 ± 0.00	68.71 ± 1.12	1.99 ± 0.02
NU-03	3.51 ± 0.07	0.51 ± 0.006	0.010 ± 0.00	49.89 ± 0.32	2.25 ± 0.02
SPS-02	3.33 ± 0.06	0.77 ± 0.004	0.017 ± 0.00	27.31 ± 0.29	2.29 ± 0.01
BPP-05	4.23 ± 0.01	0.93 ± 0.005	0.019 ± 0.00	60.61 ± 0.85	3.76 ± 0.09
MPU-04	3.66 ± 0.05	0.69 ± 0.008	0.015 ± 0.00	35.51 ± 0.43	3.16 ± 0.05
NU-05	4.95 ± 0.01	0.12 ± 0.001	0.069 ± 0.001	42.34 ± 0.41	2.22 ± 0.01
CSB-02	2.25 ± 0.18	0.15 ± 0.001	0.018 ± 0.00	19.71 ± 0.27	2.59 ± 0.01
DU-07	3.18 ± 0.04	0.12 ± 0.002	0.010 ± 0.00	30.34 ± 0.24	2.58 ± 0.02
NU-02	2.28 ± 0.00	0.11 ± 0.001	0.007 ± 0.00	74.16 ± 0.82	2.21 ± 0.02
BPP-07	2.94 ± 0.05	0.14 ± 0.000	0.019 ± 0.00	20.78 ± 2.07	2.33 ± 0.03
C.D. (P<0.05)	0.21	0.012	0.001	2.45	0.10

Table 3 Nut weight, nut diameter at suture, nut diameter at cheek, nut length, nut shape, shell texture and shell colour of 11 walnut genotypes

Genotype	Nut weight (g)	Nut diameter at suture (mm)	Nut diameter at cheek (mm)	Nut length (mm)	Nut shape	Shell texture	Shell colour
BHU-01	7.67 ± 0.11	27.00 ± 0.23	27.60 ± 0.54	31.00 ± 0.45	Round	Medium	Dark
ZC-05	12.99 ± 0.12	28.99 ± 0.18	33.00 ± 0.12	46.60 ± 0.34	Elliptic	Rough	Medium
NU-03	8.18 ± 0.05	28.00 ± 0.24	30.00 ± 0.64	28.99 ± 0.42	Round	Smooth	Light
SPS-02	15.55 ± 0.31	35.00 ± 0.41	37.50 ± 0.27	40.00 ± 0.59	Round	Medium	Medium
BPP-05	12.29 ± 0.06	34.00 ± 0.52	32.00 ± 0.27	35.00 ± 0.40	Round	Smooth	Light
MPU-04	12.29 ± 0.07	30.99 ± 0.46	32.00 ± 0.55	36.00 ± 0.48	Round	Medium	Light
NU-05	9.83 ± 0.14	29.00 ± 0.24	30.00 ± 0.06	30.99 ± 0.32	Round	Medium	Medium
CSB-02	9.81 ± 0.05	30.00 ± 0.70	29.50 ± 0.44	32.00 ± 0.37	Round	Medium	Medium
DU-07	9.38 ± 0.05	29.89 ± 0.40	30.01 ± 0.68	29.00 ± 0.53	Round	Smooth	Light
NU-02	8.21 ± 0.07	29.00 ± 0.33	27.30 ± 0.21	37.30 ± 0.18	Elliptic	Medium	Medium
BPP-07	17.17 ± 0.05	39.00 ± 0.48	45.00 ± 0.24	44.00 ± 0.73	S. Trapezoid	Medium	Medium
CD ($P<0.05$)	0.36	1.10	1.10	1.42	-	-	-

levels of Mg between 42.09 mg (Kirbaslar *et al.* 2012) to 483.3 mg/100 g (Moodley *et al.* 2007), Mn from 2.33 (Gharibzahedi *et al.* 2014) to 12.88 mg/100 g (Moodley *et al.* 2007), Zn from 1.17 (Ali *et al.* 2010) to 5.43 mg/100 g (Moodley *et al.* 2007), Fe from 2.49 (Kirbaslar *et al.* 2012) to 7.16 mg/100 g (Moodley *et al.* 2007), Se from untraceable (Moodley *et al.* 2007) to 0.30 mg/100 g (Kirbaslar *et al.* 2012), Cu from 0.20 (Ali *et al.* 2010) to 5.91 mg/100 g (Moodley *et al.* 2007) and Al from 0.10 to 0.53 mg/100 g (Cosmulescu *et al.* 2009). The mineral composition of the 11 genotypes (BHU-01, ZC-05, NU-03, SPS-02, BPP-05, MPU-04, NU-05, CSB-02, DU-07, NU-02 and BPP-07) is in line with these values reported by Kirbaslar *et al.* (2012), Ali *et al.* (2010), Cusmulescu *et al.* (2009), Gharibzahedi *et al.* (2014) and Ozcan *et al.* (2010). However, Moodley *et al.* (2007) reported very high values for Mg (483.3 mg/100 g), Zn (5.43 mg/100 g) and Fe (7.16 mg/100 g) and explained by geographical origin, harvest year, climate and methods of cultivation.

The nutritional interest of walnuts is mainly due to micro mineral elements. Mineral element Mg is a constituent of bones, teeth, enzyme cofactor (Murray *et al.* 2000). The low levels of Mg in the diet are associated with heart and brain related diseases. Around the world most people are at least marginally, if not severely, deficient of Mg. Walnut kernels are among the most concentrated sources of magnesium. In the 11 genotypes studied, Mg was the most abundant mineral, and in all genotypes the highest magnesium levels was found in BHU-01 (168.07 mg/100 g) followed by ZC-05 (166.49 mg/100 g) and BPP-05 (165.06 mg/100 g). Their high magnesium content makes them a very suitable food to offset deficiencies in this mineral, particularly BHU-01, ZC-05 and BPP-05, the genotypes with the rich source of Mg, Zn, Fe, Mn, Cu, Se and Mo levels.

Fat content: The high protein and oil contents of the kernels of *Juglans regia* make this fruit indispensable for human nutrition. Fat content in 11 walnut genotypes were analysed (Table 1) and data showed significant variation ($P<0.05$) among the genotypes and it was ranged from 53.54 (BPP-05) to 74.93% (NU-03). The similar variations were also reported from other countries where walnut is important crop like Iran (Akbari *et al.* 2014, Gharibzahedi *et al.* 2014, Aryapak and Ziarali 2014), Spain (Tapia *et al.* 2013) and Turkey (Ozcan and Koyuncu 2005, Ozcan *et al.* 2010, Polat *et al.* 2015). However, the nutritional contents differ from a cultivar to another which is mainly influenced by genotype, cultivar, different ecology and different soil (Caglarirmak 2003, Muradoglu *et al.* 2010).

Exterior nut and kernel quality traits: Thirteen important quality traits were studies and were found significant variable among genotypes. Data revealed that the nut weight ranged between 7.67 (BHU-01) and 17.17 g (BPP-07); nut diameter at suture between 27.00 (BHU-01) and 39.00 mm (BPP-07); nut diameter at cheek between 27.30 (NU-02) and 45.00 mm (BPP-07); nut length between 28.99 (NU-03) and 46.60 mm (ZC-05); nut shape from round to small trapezoid; shell texture from medium to smooth; shell colour from light to dark; shell thickness between 1.40 (BHU-01) and 2.15 mm (SPS-02); packing tissue thickness between 0.15 (NU-03) and 0.70 mm (BPP-05); kernel weight between 2.73 (NU-05) and 10.25 g (SPS-02); kernel recovery between 38.07 (NU-05) and 65.91% (SPS-02); kernel vein between 6.00 (NU-02) and 25.00 (MPU-04); and kernel colour from extra light to light amber. The maximum variability was recorded in nut weight, kernel weight, nut diameter, nut length, kernel recovery and kernel vein. Similar variations were also reported by various workers (Sharma and Sharma 1998, Pandey *et al.* 2004, Ozkan and Koyuncu 2005, Rana *et al.* 2008, Aryapak and Ziarati 2014). In breeding programmes, nuts with smooth, strong, thin shells, with a tight seal, and light kernels are most desirable (McGranahan and Leslie 1990).

Exterior nut and kernel quality traits: Interestingly, the highly significant and negative correlations were found between fat content-selenium (r=-0.79; P<0.01), kernel weight-manganese (r=-0.73; P<0.05) and kernel recovery-manganese (r=-0.79; P<0.01), suggesting diverse genetic factors controlling the accumulation of different minerals or different physiological mechanisms associated with uptake/translocation of these minerals in the kernel. However, the highly significant and positive correlations were also found between Fe-Se (r=0.67; P<0.05), kernel weight-nut weight (r=0.90; P<0.01), kernel recovery-nut weight (r=0.61; P<0.05) and kernel weight-kernel recovery (r=0.87; P<0.01), this suggesting common genetic factors controlling the accumulation of different minerals or similar physiological mechanisms associated with uptake/ translocation of these minerals in the grains. In rest of the combinations, relationship was found non-significant. A significant positive correlation (0.786) between nut weight and kernel weight was also reported by Aryapak and Ziarati (2014).

Based on the above findings, it is concluded that genotypes BHU-01, NU-05, and ZC-05 were found rich in mineral composition, especially magnesium, molybdenum and manganese. Although other elements like Zn, Cu, Co, and Fe were also found in significantly higher concentrations. The fat content of the three genotypes was ranged from 63.67–74.93%. Genotypes, SPS-02 and BPP-07 found promising in terms of exterior quality traits related to nut and kernel, with maximum nut and kernel weight as well as kernel recovery. These genotypes are good for commercial cultivation for market.

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