Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

J P P Journal of Pharmacognosy and Phytochemistry

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(4): 1373-1378
Received: 17-05-2017
Accepted: 18-06-2017

Shabana Askari
Department of Botany,
Jinnah University for Women,
Nazimabad, Karachi. Pakistan

Aisha Siddiqui
Department of Biotechnology,
Jinnah University for Women,
Nazimabad, Karachi. Pakistan

Maria Kaleem
Department of Botany,
Jinnah University for Women,
Nazimabad, Karachi. Pakistan

Correspondence
Shabana Askari
Department of Botany,
Jinnah University for Women,
Nazimabad, Karachi. Pakistan

Potato peel mediated improvement in organic substances of vigna mungo growing under copper stress

Shabana Askari, Aisha Siddiqui and Maria Kaleem

Abstract
Present study was carried out to investigate the potentials of potato peel powder in the improvement of organic substances of Vigna mungo growing under copper stress. Copper is a toxic metal which cause adverse effects in plants, when supplied in high concentrations. Increasing concentration of copper in agricultural soil due to industrialization is an alarming situation for all living organisms. Removal of heavy metals by low cost adsorbents is a resent technique which is more efficient with no side effects. Potato peels were collected free of cost from French fries shops, shade dry and ground. Healthy seeds were surface sterilized and sown in pots containing 1kg soil, each pot was supplied with different concentrations of copper i.e., 0,25,50,75,100 ppm. Treated plants were supplied with 6 gms potato peel powder/kg soil along with different concentrations of copper (0,25,50,75, ppm). Experiment was designed in a randomized block fashion. Photosynthetic pigments regarding chlorophyll a, chlorophyll b, total chlorophyll and carotenoids were examined in experimental as well as treated plants and were compared with control plants. Results were also confirmed with the analysis of carbohydrate, protein and DNA contents. Biophysical parameters like % germination, growth with respect to root, shoot length, leaf area, biomass and relative water contents were also pragmatic to corroborate consequences.

Keywords: Potato peel, copper, chlorophyll, carbohydrates, proteins, carotenoids, DNA, Vigna mungo

Introduction
Species of Solanum like S. tuberosum and S. nigrum are best hyperacuumulater and detoxifier for various heavy metal such as cadmium (Zhou, Q.X. and Song, Y.F., 2004) [45]. Potato Peel Waste is a good source of dietary fibre: primarily insoluble carbohydrates – cellulose, hemicellulose, lignin, pectin, gums, etc. (Al-Weshahy and Rao, 2013) [2]. Dietary fiber is well known as a bulking agent, increasing the intestinal mobility and hydration of the feces (Forsythe WA, Chenoweth WL, Bennink MR 1976) [13] Potato Peel contains high quantities of polyphenols which have a role in the defence mechanism against phytopathogens. Therefore almost 50% of phenolics are located in the peel and adjoining tissues and decrease toward the center of the tuber (Friedman, 1997) [14]. It is believed that binding of bile acids is one of the mechanisms whereby certain sources of dietary fibers lower plasma cholesterol (Lazarov K, Werman MJ 1996) [22]. Potato peel also was able to support the economic growth and production of several extracellular hydrolytic enzymes (Mahmood AU, Greenman J, Scragg AH, 1998) [1]. Heavy metal toxicity is one of the major current environmental health problems and potentially dangerous due to bioaccumulation through the food chain and in plant products for human consumption. Michael, (Wu, *et al*. 2012) [42]. Copper in small concentration is an essential micronutrient for all form of life such as growth, physiological process (Sharma, R. and A. Madhulika, 2005) [36]. However, as a result of the formation of organo copper complexes, excess copper can be consider as a toxic elements leading to reduces shoot and root growth by inhibits cell elongation and cell cycle (Ouzounidou, G., 1993) [30], decrease of chlorophyll content, leaf expansion, disturbance of DNA conformation damage chromatin and the plasma causing ion efflux (Singh, D., K. Nath and Y. Sharma, 2007) [38]. Present study was based on the question that whether free of cost and abundantly available potato peel could improve organic substances of vigna mungo growing under copper stress?

Materials and Methods
Three sets each with 3 replicates of soil bags were prepared, each with 1 kg of garden soil. First set named control plants was provided with distilled water only, second set named experimental plants was provided with different concentrations of copper (0,25,50,75, & 100ppm Cu) and third set of soil bags was provided with different concentrations of copper along with 6gm of potato peel/kg soil. Seeds of vigna mungo were surface sterilized and carefully sown. The plants were harvested after 17 days of germination for biophysical parameters like root/shoot length, leaf area, biomass and relative water content by Jones and

Turner (1978) [18]. Biochemical parameters like chlorophyll content by Arnon (1949) [5] and McKinney (1941) [27] method, Carotenoid by kirk and Allen method (1965) [20], carbohydrate content by yemm and wills (1945) [43] method, protein content by lowry's method (1951) [23] and DNA concentration by Jayaraman (1992) [17] were determined.

Results and Discussion

Biophysical Parameters

Percent Germination: The percentage germination of Vigna mungo seeds was found to be 46.6±2, 44.4±2.00, 35.5±1.57 and 33.3±1.6 at all applied levels of copper whereas it was68.3±3.88 in control. Decrease in percentage germination of Vigna mungo may attribute to the increasing concentrations of copper which cause osmotic stress in seed thus abscisic acid lowers the ability of seed germination (Shun-ying, 2008) [37]. Application of potato peel significantly improved the percentage germination of Vigna mungo seeds up to53.3±2.66, 47.7±2.1, 53.3±2.00 and 38.8±2.00 at all supplied concentrations of copper. Potato peels are the best substitute and have been recommended to neutralize the copper toxicity from contaminated soil, because it is the best hyperaccumulator of heavy metals (Haider S *et al*. 2014) [15].

Shoot length: The shoot length of vigna mungo was found to be17.86±2.30, 18.18±2.17, 13.09±4.33 and 15.82±2.08 at all applied levels of copper whereas it was18.43±3.21 in control. Copper at 25 and 50 ppm concentration exhibit beneficial effects on shoot length of Vigna mungo so these concentrations may consider as essential for optimal growth, Cu was shown to inhibit growth and to interfere with important cellular processes such as photosynthesis and respiration (Prasad and Strzalka, 1999) [31]. Application of potato peel significantly improved the shoot length of Vigna mungo up to18.88±2.50, 19.89±4.54, 13.88±2.79 and 16.86±1.49 at all supplied concentrations of copper. Potato peels contain large amount of carbohydrate constituent, phenolic compound, phosphorus, potassium and other important nutrients (Azadeh M.S. *et al*. 2012) [7].

Root length: The root length of Vigna mungo was found to be 15.96±2.48, 11.94±2.16, 11.7±2.81, and 8.12±0.68 cm at all applied levels of copper whereas it was 18.16±0.73 in control. Decrease in root growth may attribute to the reduction in cell division. (Souguir *et al*. 2008) [40]. Application of potato peel significantly improved the root length of Vigna mungo up to16.14±1.88, 14.51±2.28, 12.74±1.70 and 10.10±2.97cm at all supplied concentrations of copper. Being an essential micronutrient copper promoted the growth of plants at lower concentration but reduced growth if present in high level interfering metabolic processes. Root is the main important and first contact part from soil contamination (Azmat, *et al*. 2006c) [46]. Potato peel contains polysaccharides, vitamins and minerals, as well as macro and micro nutrients which may overcome the toxicity of copper.

Leaf area: The leaf area of Vigna mungo was found to be 5.82±1.07, 4.87±0.64, 5.58±2.04 and 4.34±1.35 at all applied levels of copper whereas it was 7±1.53 in control. The leaf area of Vigna mungo showed a gradual decline with an increase in copper level in the soil. Similar observations were reported by McBride (2001) [26]. Application of potato peel significantly improved the leaf area of Vigna mungo up to7.22±1.63, 7.22±0.83, 6±0.44 and 6.05±1.13at all supplied concentrations of copper. Potato peels not only provide organic substances, macro and micro nutrients to the plant but also grab toxic metal copper from the soil forming complexes, leaving the plant in a relaxed state (Haider S *et al*. 2014) [15].

Biomass: The biomass of Vigna mungo seeds was found to be1.11±0.40, 1.16±0.11, 1.08±0.05 and 0.8±0.09 at all applied levels of copper whereas it was 1.21±0.50 gm in control. The copper has expressed

an improvement in fresh weight and dry weight of Vigna mungo to some extent (50 ppm) at lower concentrations as it is included in micronutrients, but the biomass was significantly reduced with increasing concentrations of copper (Radha solanki and Rajesh dhankhar 2011) [32]. Application of potato peel appreciably improved the biomass of Vigna mungo up to1.16±0.19, 1.28±0.21, 1.16±0.08 and 0.88±0.16gm at all supplied concentrations of copper. Increment in biomass of Vigna mungo in the presence of potato peels under Cu stress may attribute to the ligand formation between polysaccharides of potato peels and Cu.

Relative water content (R.W.C): The relative water content of Vigna mungo was drastically decreased upto be78.5±0.70, 63±5.65, 73±4.24 and 62±2.82at all applied levels of copper whereas it was 81±1.41 in control (Table 2). Data showed that relative water content of Vigna mungo decreased slightly with low moisture in soil and was reduced even more under stressed conditions (Rodríguez, L 2001) [47]. A huge reduction in relative water content may attribute to the adverse effects of copper on the roots of Vigna mungo (Table 2). Application of potato peel significantly improved the relative water content of Vigna mungo up to 82.5±2.12, 66±2.82, 77.5±3.53, and 66.5±6.36 at all supplied concentrations of copper. The high relative water content is a resistant mechanism to stress (Morales *et al*. 1991 and Dell´Amico *et al*. 1991) [29, 9]. Organic and inorganic substances of potato peels not only supplies nutrients to the young seedlings but also efficiently adsorb copper ions (Haider S *et al*. 2014) [15].

Biochemical Parameters

Chlorophyll a: According to the data obtained in the present study chlorophyll a of Vigna mungo was found to be inhibited upto 0.25±0.04, 0.20±0.19, 0.22±0.11 and 0.20±0.09at all applied levels of copper whereas it was 0.37±0.07mg/gm f.wt in control. Chlorophyll a contents declined progressively with increasing concentrations of copper in comparison with control. Heavy metals like copper are famous as the direct inhibitor of an enzymatic step (Van Assche and Clijters, 1990; Sharma *et al*., 2005) [12, 36]. Heavy metals like copper replaces magnesium of porhyrin ring of chlorophyll molecule and hence make it non-functional. Application of potato peel significantly improved the chlorophyll a contents of Vigna mungo up to 0.32±0.02, 0.28±0.10, 0.34±0.01 and 0.21±0.09mg/gm f.wt at all supplied concentrations of copper. Potatoes peels contain large amount of carbohydrate constituents, and phenolic compounds which may adsorb copper hence may stop entry of salt to the plant (Azadeh, *et al*. 2012) [7]

Chlorophyll b: Data showed in Table 3 revealed that chlorophyll b of Vigna mungo was found to be decreased as 0.30±0.05,0.22±0.18, 0.20±0.21 and 0.21±0.20at all applied levels of copper whereas it was 0.30±0.17mg/gm/f.wt in control. Excessive Cu induces leaf chlorosis which is due to peroxidative breakdown of pigments and membrane lipids and in reduction of pigment content (Maksymiec, 1997; Shainberg *et al*., 2001) [25, 35]. Application of potato peel significantly improved the chlorophyll b of Vigna mungo up to0.18±0.10, 0.33±0.02, 0.37±0.01 and 0.21±0.20mg/gm/f.wt at all supplied concentrations of copper. Potato peels contain a variety of valuable compounds, including phenols, dietary fibres, unsaturated fatty acids, amides, etc. (Schieber and

Saldaña, 2009; Wu *et al*., 2012) [34, 42].
Carotenoid: The data of the present study revealed a drastic decrease in carotenoid of Vigna mungo upto 0.22±0.08, 0.24±0.06, 0.1±0.07 and 0.07±0.08at all applied levels of copper whereas it was0.35±0.13mg/gmf.wt in control. High concentrations of copper have important effects on plant growth and inhibit the development of various aspects of physiological, biochemical and even cell functions of the crop (Hegedus *et al*., 2001) [16]. Application of potato peel significantly improved the carotenoid of Vigna mungo up to 0.35±0.03, 0.28±0.03, 0.24±0.02, and 0.21±0.007mg/gm f.wt at all supplied concentrations of copper. The potato peel contains vitamins and minerals, as well as macro and micro nutrients, and natural phenols that overcome the toxicity of copper.
Total chlorophyll: The total chlorophyll of Vigna mungo found to be inversely proportional to the increasing concentrations of copper upto 0.63±0.08, 0.50±0.29, 0.42±0.33 and 0.40±0.29 at all applied levels of copper whereas it was 0.67±0.10 mg/gm f.wt in control. Decrease in total chlorophyll content may attribute to the inactivation of various proteins which are involved in maintenance of chloroplast bilayer membranes it may also due to replacement of magnesium by copper in porphyrin ring of chlorophyll, inhibition of pigment accumulation and chlorophyll assimilation into photosystems (Kupper *et al*.; 2003) [21]. Application of potato peel significantly improved the carotenoid of Vigna mungo up to0.71±0.02, 0.53±0.22, 0.44±0.14 and 0.47±0.06mg/gm f.wt at all supplied concentrations of copper. Potato peels are a potential source of dietary fiber. Potato peel is a nutrient rich waste and it contains adequate amount of nutrients such as carbohydrate and proteins. It also contains alcohol-insoluble solids (pectin, cellulose, and starch), soluble sugars and minerals (mainly Ca, K, P, and Si) which can efficiently adsorb copper ions (Al-Weshahy and Rao, 2012) [3]. Data present in Table 3 exhibited toxicity of copper at higher concentration (75 & 100 ppm) where Potato peel failed to overcome its drastic effects efficiently.
Carbohydrate content: Data presented in (Table 4) revealed that carbohydrate of Vigna mungo was inversely proportional to the concentrations of copper and reduced upto 37.63±16.76, 29.46±2.99, 20.5±4.40, and 16.03±12.16 at all applied levels of copper whereas it was62.4±18.40 mg/gm f.wt in control. Inhibition in carbohydrate contents may attribute to the affinity of copper to replace magnesium from the porphyrin ring of chlorophyll, it may also cause damage in the membranes of chloroplast and inhibiting photolysis of water and obstruct both photosynthesis and carbohydrate metabolism (Yruela *et al*., 1996, Azmat&Askari2013) [44, 6]. Data presented in (Table 4) showed that application of potato peel significantly improved the carbohydrate contents of Vigna mungo at lower concentrations (25 & 50 ppm) up to42.63±22.7 and 35.8±10.36mg/gm f.wt whereas it did not showed any significant improvement at higher concentrations as (75 & 100 ppm) as 18.43±6.36 and 16.73±9.01mg/gm f.wt. Potato peels have high moisture, organic and inorganic contents which makes it a good basis for fertilizer as well as an efficient adsorbent (Arapoglou *et al*., 2009) [4].
Protein content: Data of current study revealed that protein content of Vigna mungo drastically reduced under the stress of copper upto 19.4±4.44, 18.3±5.46, 18.2±5.94 and 23.5±6.07at all applied levels of copper whereas it was40.1±29.8mg/gm f.wt in control. Reduction in protein may attribute to the affinity of heavy metal copper for protein and enzymes, which contain several mercapto ligands to form chelate structure with the metals and hence losing their functional property (Prasad and Freitas. 1999) [31]. Decrease in protein may also attribute to the breakdown of protein under stress. (Dutta *et al*. 2012) [11]. Proteins are most important organic substances of living organisms, exhibit reversible and irreversible changes in physiological functions, are known to respond to a variety of stressors such as natural and xenobiotic (Singh and Tewari, 2003) [39]. Application of potato peel significantly improved the Protein of Vigna mungo up to21.4±2.22, 21.1±5.99, 24.2±8.59 and 30.6±4.52mg/gm f.wt at all supplied concentrations of copper. Since proteins were newly synthesized under Copper-stress, it appears to have a role in the mechanism of Copper tolerance which allows making biochemical and structural adjustments that enable the plant to cope with stress conditions as appeared at 100ppm in (table 4) (Jyoti *et al*. 2013) [19].
DNA concentration: Deoxyribonucleic acid is the most significant molecule that hold the genetic information used in the growth and development of all known living organisms and viruses. In plants DNA is enclosed within the nucleus, mitochondria, and chloroplasts. DNA has several properties that are unique among chemical molecules. Data presented in Table 4revealed that the DNA of Vigna mungo significantly reduced under the copper stress upto9.8±0.28, 7.24±0.11, 6.7±0.56, and 4.25±0.91at all applied levels of copper whereas it was 10.44±0.16 mg/ml in control. High concentration of copper badly effect DNA synthesis or may even block the cells in the G2 phase of the cell cycle preventing the cells from entering mitosis (Sudhakar *et al*., 2001) [48]. Application of potato peel significantly improved the DNA concentration of Vigna mungo by adsorbing toxic metal copper up to10.8±0.42, 8.07±0.42, 10.15±0.91and 8.45±1.48mg/mlat all supplied concentrations of copper. Potato peel not only efficiently adsorbs toxic metals on their surfaces but also provides a variety of valuable compounds.

Table 1: Effect of copper and its adsorption by potato peel powder on Shoot length, Root length, leaf area in cms of Vigna mungo.

		Shoot Length		Root Length		Leaf Area	
S.NO	Cu[ppm]	Experimental	Treated	Experimental	Treated	Experimental	Treated
1	0	18.43±3.21	18.43±3.21	18.16±0.73	18.16±0.73	7±1.53	7±1.53
2	25	17.86±2.30	18.88±2.50	15.96±2.48	16.14±1.88	5.82±1.07	7.22±1.63
3	50	18.18±2.17	19.89±4.54	11.94±2.16	14.51±2.28	4.87±0.64	7.22±0.83
4	75	13.09±4.33	13.88±2.79	11.7±2.81	12.74±1.70	5.58±2.04	6±0.44
5	100	15.82±2.08	16.86±1.49	8.12±0.68	10.10±2.97	4.34±1.35	6.05±1.13

Results expressed as Mean ± SEM of triplicates.

Table 2: Effect of copper and its adsorption by potato peel powder on Biomass and Relative water content of Vigna mungo.

		BIOMASS (gm)		R.W.C (%)	
S. No	Cu [ppm]	Experimental	Treated	Experimental	Treated
1	0	1.21±0.50	1.21±0.50	81±1.41	81±1.41
2	25	1.11±0.40	1.16±0.19	78.5±0.70	82.5±2.12
3	50	1.16±0.11	1.28±0.21	63±5.65	66±2.82
4	75	1.08±0.05	1.16±0.08	73±4.24	77.5±3.53
5	100	0.8±0.09	0.88±0.16	62±2.82	66.5±6.36

Results expressed as Mean ± SEM of triplicates.

Table 3: Effect of copper and its adsorption by potato peel powder on photosynthetic pigments of Vigna mung in mg/gmf.wt.

		Chlorophyll a		Chlorophyll b		Total chlorophyll		Carotenoid	
S. No	Cu(ppm)	Experimental	Treated	Experimental	Treated	Experimental	Treated	Experimental	Treated
1	0	0.37±0.07	0.37±0.07	0.30±0.17	0.30±0.17	0.67±0.10	0.67±0.10	0.35±0.13	0.35±0.13
2	25	0.25±0.04	0.32±0.02	0.30±0.05	0.18±0.10	0.63±0.08	0.71±0.02	0.22±0.08	0.35±0.03
3	50	0.20±0.19	0.28±0.10	0.22±0.18	0.33±0.02	0.50±0.29	0.53±0.22	0.24±0.06	0.28±0.03
4	75	0.22±0.11	0.34±0.01	0.20±0.21	0.37±0.01	0.42±0.33	0.44±0.14	0.1±0.07	0.24±0.02
5	100	0.20±0.09	0.21±0.09	0.21±0.20	0.21±0.20	0.40±0.29	0.47±0.06	0.07±0.08	0.21±0.007

Results expressed as Mean ± SEM of triplicates.

Table 4: Effect of copper and its adsorption by potato peel powder CHO, Protein and DNA of Vigna mungo.

		CHO (mg/gmf.wt.)		PROTEIN(mg/gmf.wt)		DNA(mg/ml)	
S. No	Cu[ppm]	Experimental	Treated	Experimental	Treated	Experimental	Treated
1	0	62.4±18.40	62.4±18.40	40.1±29.8	40.1±29.8	10.44±0.16	10.44±0.16
2	25	37.63±16.76	42.63±22.7	19.4±4.44	21.4±2.22	9.8±0.28	10.8±0.42
3	50	29.46±2.99	35.8±10.36	18.3±5.46	21.1±5.99	7.24±0.11	8.07±0.24
4	75	20.5±4.40	18.43±6.36	18.2±5.94	24.2±8.59	6.7±0.56	10.15±0.91
5	100	16.03±12.16	16.73±9.01	23.5±6.07	30.6±4.52	4.25±0.91	8.45±1.48

Results expressed as Mean ± SEM of triplicates.

Conclusion

Contamination of agricultural soil by toxic metals due to industrial effluents and other anthropogenic sources has become a universal problem, which not only reducing agricultural productivity but also causing severe human diseases. Detoxification of agricultural soil by green technology is a recent and efficient strategy that involves the use of waste agronomic by-products to adsorb heavy metal contamination from the soil.

Present study revealed that potato peel powder is an efficient and cost effective adsorbent, as it contains large amount of carbohydrates contents and phenolic compounds which have attribute to form metal complex. Beside these, glycoalkaloids, phosphorus, potassium, sulfur and other important nutrients which may act as functional group for adsorption of toxic metal copper are also present (Azadeh *et al*., 2012; Chaney et.al., 2000; Dunbar, 2003) [7-10]. Potato peels are already been using as a low cost and abundantly available organic fertilizer in various countries, as potatoes are daily diet of poor man of Indo-Pak due to its high nutrition values and low cost. It can be collected free of cost from hotels, restaurants, French fries shops and from residential areas. Daily use of potatoes makes tons of garbage which has to collect by Municipal Corporation daily, so use of potato peels as an adsorbent and as organic fertilizer may also reduce pollution and help directly or indirectly Municipal Corporation in collection garbage or pollutants. It is also concluded that, efficiency of potato peel powder should also be investigated for the adsorption of other heavy metals in major crops and cereals.

References

1. Mahmood AU, John Greenman AH, Scragg. Orange and potato peel extracts: Analysis and use as Bacillus substrates for the production of extracellular enzymes in continuous culture. Enzyme and Microbial Technology. 1998; 22:130-137.
2. Al-Weshahy A, El-Nokety M, Bakhete M, Rao VA. Effect of storage on antioxidant activity of freeze-dried potato peels. Food Research International. 2013; 50:507-512.
3. Al-Weshahy A, Rao VA. Potato peel as a source of important phytochemical antioxidant nutraceuticals and their role in human health – A review. Available at: - http://www.intechopen.com/books/ phytochemicals-as-nutraceuticals-global-approaches-to-their-role-in-nutrition-and-health/potato-peel- as-a-source-of-important-phytochemical-antioxidant-nutraceuticals-and-their-role-in-huma, 2012.
4. Arapoglou D, Varzakas T, Vlyssides A, Israilides C. Ethanol production from potato peel waste (PPW). Waste Management. 2010; 30:1898-1902.
5. Arnon DI. Copper enzymes in isolated chloroplasts, polyphenoxidase in beta vulgaris. Plant physiology, 1949; 24:1-15.
6. Askari S, Azmat R. Repairing of epidermal layer of leaves through nutrients of seaweeds in Hg distorted seedlings of Cicerarietinum. Pak. J. Bot. 2013; 45:1721-1727.
7. Azadeh MS, Hashem P, Nima H, Amirhosein E. Phenolics in Potato Peels: Extraction and Utilization as Natural Antioxidants. World Appli. Sci. J. 2012; 18:191-195.
8. Chaney RL, Brown SL, Li YM, Angle JS, Stuczynski TI, Daniels WL *et al*. Progress in risk assessment for soil metals, and in-situ remediation and phytoextraction of metals from hazardous contaminated soils. U.S-EPA Phytoremediation: State of Science, Boston, MA, 2000.
9. Dell'Amico J, Morales D, Jeréz E, Soto F, Sam O. Evaluation of the water status of coffee in different growing conditions. Tropical. 1991; 12:64-67.

10. Dunbar KR, McLaughlin MJ, Reid RJ. The uptake and partitioning of cadmium in two cultivars of Potato (Solanum tuberosum L.), J Exp. Bot. 2003; 54:349-54.
11. Dutta A, Dutta S, Kumari S. Growth of poultry chicks fed on formulated feed containing silk worm pupae meal as protein supplement and commercial diet. Online J. Anim. Feed Res. (OJAFR). 2012; 2:303-30.
12. Van Assche H, Clijsters. Effects of metals on enzyme activity in plants. Plant, cell and environment, ISI Journal. 1990; 13:195-206.
13. Forsythe WA, Chenoweth WL, Bennink MR. The effect of various dietary fibres on serum cholesterol and laxation in the rat. Journal of Nutrition. 1976; 106:26-32.
14. Friedman M. Chemistry, biochemistry, and dietary role of potato polyphenols. A review. Journal of Agricultural and Food Chemistry. 1997; 45:1523-1540.
15. Haider S, Azmat R, Iqbal A, Nasreen H, Wasti AZ. Impact of Low Cost Biosorbent Potatoes Peels for Biosorption of Lead on Two Important Pulses. International Research Journal of Environment Sciences. 2014; 3:15-19.
16. Hegedüs A, Erdei S, Horváth G. Comparative studies of H_2O_2 detoxifying enzymes in green and greening barley seedings under cadmium stress. Plant Sci. 2001; 160:1085-1093.
17. Jayaraman j. laboratory manual in biochemistry, wiley eastern ltd, 1992.
18. Jones MM, Turner NC. Osmotic adjustment in leaves of sorghum is response to water deficits. Plant physiology. 1978; 61:122-126
19. Jyoti R Rout, Shidharth S Ram, Ritarani Das, Anindita Chakraborty, Mathummal Sudarshan, Santi L Sahoo. Copper-stress induced alterations in protein profile and antioxidant enzymes activities in the *in vitro* grown Withaniasomnifera L.US National Library of Medicine National Institutes of Health. 2013; 19:353-361.
20. Kirk JTO, Allen RL. Dependence of chloroplast pigments synthesis on protein synthetic effects on actilione. Biochem. Biophysics Res. J. Canada. 1965; 27:523-530.
21. Kupper H, Setlik I, Setlikova E, Ferimazova N, Spiller M, Kupper FC. Copper induced inhibition of photosynthesis: Limiting steps of *in vivo* copper chlorophyll formation in Scenedesmusquadricauda. Functional Plant Biology. 2003; 30:1187-1196.
22. Lazarov K, Werman MJ. Hypocholesterolemic effect of potato peels as a dietary fibre source. Med. Sci. Res. 1996; 24:581-582.
23. Lowry OH, Rosebrough NJ, Farr AL, Randall RJ. Protein measure- ment with the Folin phenol reagent. J Biol. Chem. 1951; 193:265-275.
24. Prasad MNV, Freitas H. Removal of toxic metals from solution by leaf, stem and root phytomass of Quercus ilex L. (holly oak). Environmental Pollution. 1999, 277-283.
25. Maksymiec W. Effect of copper in higher plants. Photosynthetica, 1997; 34:321-342.
26. McBride MB. Cupric ion activity in peat soil as a toxicity indicator for maize. Journal of Environmental Quality. 2001; 30:78-84.
27. McKinney G. Absorption of light by chlorophyll solutions. J Biol. Chem. 1941; 140:315-322.
28. Michael WH, Evangelou A, Hockmann K, Pokharel R, Jako A, Schulin R. Accumulation of Sb, Pb, Cu, Zn and Cd by various plants species on two different relocated military shooting range soils. Journal of Environmental Management. 2012; 108:102-107.
29. Morales D, Jeréz E, Dell´Amico J, Torres W, Álvarez F. Comportamiento de algunosindicadoresfisiológicosdelestadohídrico de lasplantasendiferentescondiciones de cultivo. Cultivos Tropicales. 1991; 12(3):31-37.
30. Ouzounidou G. Changes in variable chlorophyll fluorescence as a results of Cu-treatment: Dose response relations in Scilene and Thlaspi. Photosynthetica. 1993; 29:455-462.
31. Prasad MNV, Freitas H. Feasible biotechnological and bioremediation strategies for serpentine soils and mine spoils. Electronic Journal of Biotechnology. 1999; 2:35-50.
32. Radha Solanki, Rajesh Dhankhar. Biochemical changes and adaptive strategies of plants under heavy metal stress. Biologia. 2011; 66:195-204.
33. Ritchie SW, Nguyan HT, Holaday AS. leaf Water content and gas exchange parameters of two wheat genotypes differing in drought resistance. Crop sci. 1990; 30:105-111.
34. Schieber A, Saldaña MDA. Potato peels: A source of nutritionally and pharmacologically interesting compounds. 2009; 3:23-29.
35. Shainberg O, Rubin B, Rabinowitch HD, Tel-Or E. Loading beans with sublethal levels of copper enhances conditioning to oxidative stress. J Plant Physiol. 2001; 158:1415-1421.
36. Sharma R, Madhulika A. Biological effects of heavy metals: An overview. Journal of Environmental Biology. 2005; 26:301-313
37. Shun-yingchen, Singh-rongkuo, ching-techien. Roles of gibberellins and abscisic acid in dormancy and germination of red bayberry (Myricarubra) seeds. Tree Physiology. 2008; 28:1431-1439.
38. Singh D, Nath K, Sharma YK. Response of wheat seed germination and seedling growth under copper stress. J Environ Biol. 2007; 28:409-14.
39. Singh PK, Tewari RK. Cadmium toxicity induced changes in plant water relations and oxidative metabolism of Brassica juncea L. plants. J Environ. Biol. 2003; 24:107-112.
40. Souguir D, Ferjani E, Ledoigt G, Gopupil P. Exposure of Viciafaba and Pisumsativum to copper induced genotoxicity. Protoplasma. 2008; 233:203-207.
41. Srivastava Priya, Anjana Pandey, Diamond Prakash Sinha. Journal of Plant Breeding and Crop Science. 2011; 3:53-59.
42. Wu ZG, Xu HY, Ma Q, Cao Y, Ma JN, Ma CM. Isolation, identification and quantification of unsaturated fatty acids, amides, phenolic compounds and glycoalkaloids from potato peel. Food Chemistry. 2012; 135:2425-2429.
43. Yemm EW, Willis AJ. The estimation of carbohydrate in the plant extract by anthrone reagent. J Biochem. 1954; 57:508-514.
44. Yruela I, Pueyo JJ, Alonso PJ, Picorel R. Photo inhibition of photo system II from higher plants: effect of copper inhibition. J Biol. Chem. 1996; 271:27408-27415.
45. Zhou QX, Song YF. Principles, Methods of Contaminated Soil Remediation, Beijing: Science Press. 2004, 135-141.
46. Azmat R, Haider S, Askari S. Phytotoxicity of Pb:I Effect of Pb on germination, growth, morphology and histomorphology of *Phaseolus mungo* and *Lens culinaris.* Pak. J Biol. Sci. 2006a; 9(5):979-984.

47. Rodríguez L, Valdés R, Verdecia J, Arias L, Medina R, Velasco E. Growth, relative water content, transpiration and photosynthetic pigment content in coffee trees (coffea arabica l.) growing at different sunlight regimes. Cultivos Tropicales. 2001; 22(4):37-41.
48. Sudhakar R, Ninge Gowda KN, Venu G. Mitotic abnormalities induced by silk dyeing industry effluents in the cell of Allium cepa. Cytologia. 2001; 66:235-239.