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Short Note

Biochemical evaluation of some important pseudocereals of Himachal Pradesh

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Abstract

The dry mature grains of twelve promising amaranth and eleven promising buckwheat varieties/genotypes procured from NBPGR, Regional Station, Phagli, Shimla were analysed for proximate composition and important minerals content. Variation in moisture, oil, crude protein, ash, crude fibre, carbohydrate, calcium, iron, zinc and phosphorus was observed to range from 9.3 to 10.8, 5.0 to 7.5, 11.3 to 12.5, 3.0 to 3.7, 2.4 to 3.3, 64.6 to 67.3 *per cent*, 217.5 to 312.0, 4.6 to 7.2, 2.0 to 4.5 and 521.4 to 678.2 mg/100 g, respectively in amaranth varieties/genotypes, whereas variation in these parameters in buckwheat varieties/genotypes was noticed from 9.4 to 11.6, 2.1 to 2.8, 11.5 to 12.9, 2.0 to 2.8, 8.3 to 10.0, 61.8 to 64.8%, 43.8 to 95.5, 3.5 to7.6, 1.9 to 3.6 and 349.4 to 460.3 mg/100 g in that order. The study indicated that among various genotypes PRA-3 in moisture (exhibiting lowest value); IC-0423152 in oil; IC-042328 and PRA-2007-2 in crude protein; IC-0423152 and PRA-2008-2 in ash; IC-0423152 in crude fibre; PRA-3 and Annapurna in carbohydrate; IC-35407 in calcium; IC-35407 and IC-042328 in iron; IC-0423152 and PRA-2008-2 in zinc and PRA-2008-2 in phosphorus content emerged promising amaranth genotypes, whereas, IC-109314 in moisture (exhibiting minimum value); IC-108499 in oil; IC-109314 in crude protein; IC-108500 in ash and IC-108500 in crude fibre; Shimla B-1in carbohydrate; PRB-1 in calcium; IC-109314 in iron; IC-109549 in zinc and PRB-1 in phosphorus were adjudged to be superior buckwheat genotypes for individual quality attribute(s). Moreover, on the basis of cumulative varietal grading in respect of desirable nutritional quality attributes taken altogether PRA-2008-2, IC-35407, PRA-2 and PRA-2007-1 genotypes of amaranth and IC-109314, IC-109549 and IC-108499 buckwheat genotypes were found superior over others.

Key words: Amaranth, moisture, oil, protein, ash, crude fibre, carbohydrate, calcium, iron and zinc.

The food grains comprising grain amaranth and buckwheat belonging to two different families *viz.,* Amaranthaceae and Polygonaceae are referred to as pseudo cereals. Major cereals *viz.,* rice, wheat and maize are reported to provide only 60% of the world's total food requirement (Harlan, 1992). This narrow level of food base may imperil the existence of mankind during the time of impending crisis in unforeseen times to come. Therefore, there is a need to enlarge our food basket with alternative food crops to safeguard against such a catastrophe. Consequently, in recent years, there has been a global concern to collect, introduce, evaluate and utilize the vast array of lesser known, under-exploited, alternative crop plants to diversify the agricultural system. Of these crop plants amaranth and buckwheat form prominent pseudo cereal grains with enormous nutritional and nutraceutical potential.

Amaranth is widely distributed throughout the Old and New World. The crop is mainly cultivated in mid and high hills of the Himalayan region as a pure as well as mixed crop. The tiny seeds of grain amaranth compare favourably with maize and other true cereals in nutritional value and yield (Sauer, 1967). The grain yield of amaranth and maize grown during Kharif 2009 in the university research station at Palampur has been recorded as 16.10 and 18.14 q/ha, respectively. Its seeds and edible leaves have very high nutritional value (Saunders and Becker, 1983; Joshi and Rana, 1991). On the other hand, buckwheat commonly known as *kathu, fafra, ogla or bharesh* are distributed in mountainous regions extends from Pakistan to India, Nepal, Bhutan and Myanmar. It is not only rich in many nutrients, but it is reported to be useful in the treatment of capillary fragility, retinitis, and rheumatic fever and also helpful against cardiovascular ailments (Kreft *et al.,* 2003). Since, amaranth and buckwheat are valuable pseudo cereals enriched with several dietary nutrients and possess satisfactory yield potential to be harnessed by adopting appropriate cultural practices, an effort has been made in the present study to evaluate some important biochemical constituents to be useful in human nutrition.

The grain samples of twelve varieties/genotypes of amaranth and eleven varieties/genotypes of buckwheat procured from NBPGR, Regional Station, Phagli, Shimla during the year 2008 were evaluated for various biochemical parameters by following standard procedures. The finely ground samples of various genotypes were analysed in triplicate for moisture, crude protein, ash, crude fibre by following the AOAC method (1970), oil by AOAC method (1965). Carbohydrate content was computed as a difference of 100 – (moisture + crude protein + oil + ash + crude fibre) in amaranth and buckwheat grains. To evaluate the crop specific important trace elements *viz.* calcium, iron and zinc the ground grain samples were digested using the di-acid wet digestion (HNO_3:$HClO_4$) (3:1) and were estimated by using atomic spectrophotometer (Model-ContrAA 700). However, the phosphorus content in the digested samples was estimated by vanado-molybedo phosphoric acid yellow colour method as described by Jackson (1967). The data was analyzed statistically by using analysis of variance as given by Panse and Sukhatme (1984).

The data on variation in biochemical constituents of various varieties/genotypes of amaranth and buckwheat are depicted in Table 1 and 2.

Determination of moisture content is an important criterion contributing towards maturity, shelf life, storage behaviour and acceptability of the crop harvest. As such the moisture content in the sun dried grains of amaranth and buckwheat was evaluated. It is evident that among amaranth varieties/genotypes the moisture content was found to vary significantly from 9.3 to 10.8 per cent with the lowest and highest value for this parameter noticed in PRA-3 (released variety) and PRA-2008-2 respectively. In buckwheat varieties/genotypes the moisture content varied significantly from 9.4 (IC-109314) to 11.6 (Himpriya) per cent. The range of variation in moisture content in the present study was in accordance with the findings of Gopalan *et al.* (2004) reporting 10 per cent moisture in amaranth and 11.3 per cent moisture in buckwheat genotypes.

Proteins are important for growth, development and immune response of body. Crude protein content ranged from 11.3 (IC-0423152) to 12.5 (IC-042328, PRA-2007-2) *per cent* in amaranth varieties/genotypes. The released varieties *viz.*, PRA-2, PRA-3 and Annapurna contained 11.9, 12.3 and 11.5 per cent crude protein content in that order. The findings of the study on this aspect were close with the observations of Osuntogun and Oke (1983), Pedersen *et al.* (1987) and Gopalan *et al.* (2004) who have reported overall variation in this parameter from 13.1 to 14.7 per cent. In buckwheat genotypes the crude protein content varied from 11.5 (PRB-1, IC-107989, Reshwal) to 12.9 (IC-109314) per cent. The released varieties *viz.*, Himpriya and Shimla B-1 exhibited 11.8 and 11.9 per cent crude protein content, respectively. The results of the present study are very close to those reported by Lal *et al.* (2003) and Gopalan *et al.* (2004) reporting variation on this aspect from 8.1 to 13.9 per cent in buckwheat genotypes.

Fats and oils form an important component of human diet and involved in large number of metabolic functions of the body besides serving as concentrate source of energy. Although cereals and pseudo cereals contain relatively less amount of fats, however, they offer essential fatty acids in the diet essentially required for optimum human nutrition and therefore, the status of the oil (ether extract) among various amaranth and buckwheat genotypes was evaluated. Significant variation in oil content was observed from 5.0 (PRA-2008-2) to 7.5 (IC-0423152) per cent in amaranth varieties/genotypes. The genotype IC-35407 and PRA-2007-2 showed the next highest value for this parameter. However, the released varieties *viz.*, PRA-2, PRA-3 and Annapurna exhibited 5.9, 5.3 and 5.6 per cent oil content, respectively. Pedersen *et al.* (1987) reported 10 per cent oil content in *Amaranthus caudatus* seeds. In buckwheat varieties/genotypes oil content varied from 2.1 (Reshwal) to 2.8 (IC-108499) per cent. The released varieties *viz.*, PRB-1, Himpriya and Shimla B-1 exhibited 2.5, 2.7 and 2.4 per cent oil content in that order. The results of the present study were in agreement with those reported by Gopalan *et al.* (2004) in buckwheat genotypes i.e. 2.4 per cent. Values in respect of ash, which is the sum total of the minerals as well as crude fibre content, which is reported to add bulk in the diet and also help in normal elimination of the

Table 1. Variation in biochemical constituents of amaranth varieties/genotypes

Parameters	PRA-2*	PRA-3*	PRA-2007-1	PRA-2007-2	PRA-2008-1	PRA-2008-2	IC-35407	IC-107197	IC-042328	IC-0423152	IC-540862	Annapurna*	S.E.	C.D. (5%)
Moisture (%)	9.6	9.3	10.1	9.9	10.1	10.8	9.4	10.3	10.1	9.7	10.0	9.6	0.14	0.42
Crude protein (%)	11.9	12.3	12.3	12.5	11.9	11.6	12.4	11.8	12.5	11.3	12.2	11.5	0.15	0.43
Oil (%)	5.9	5.3	6.0	6.1	5.6	5.0	6.3	5.6	6.0	7.5	5.7	5.6	0.11	0.33
Crude fibre (%)	2.8	2.4	2.4	2.7	2.5	2.9	2.5	2.6	2.8	3.3	2.7	2.9	0.04	0.13
Ash (%)	3.2	3.4	3.2	3.2	3.3	3.7	3.3	3.0	3.0	3.7	3.2	3.0	0.05	0.14
Carbohydrates (%)	66.6	67.3	66.0	65.6	66.5	66.6	66.0	66.7	65.6	64.6	66.3	67.3	0.27	0.79
Calcium (mg/100 g)	268.0	261.7	249.2	247.8	297.5	281.0	312.0	217.5	233.3	301.4	246.5	230.5	2.64	7.72
Iron (mg/100 g)	5.2	5.4	6.9	6.6	6.0	6.7	7.2	5.7	7.2	5.4	5.7	4.6	0.07	0.21
Zinc (mg/100 g)	3.4	3.2	3.6	3.2	3.1	4.5	2.9	2.0	3.1	4.5	3.0	2.6	0.08	0.23
Phosphorus (mg/100 g)	642.4	609.8	614.6	626.9	648.9	678.2	534.7	600.8	633.9	598.9	574.7	521.4	0.88	2.57

*Released varieties
Values on dry weight basis

Table 2. Variation in biochemical constituents of buckwheat varieties/genotypes

Parameters	PRB-1*	VL-7	IC-107989	IC-108499	IC-108500	IC-109314	IC-109549	Himpriya*	Reshwal	Sangla B-124	Shimla B-1*	S.E.	C.D. (5%)
Moisture (%)	11.2	10.3	11.1	11.1	10.8	9.4	10.9	11.6	11.1	9.8	10.1	0.20	0.58
Crude protein (%)	11.5	12.3	11.5	12.3	12.0	12.9	12.1	11.8	11.5	12.3	11.9	0.26	0.75
Oil (%)	2.5	2.3	2.4	2.8	2.5	2.7	2.6	2.7	2.1	2.6	2.4	0.02	0.06
Crude fibre (%)	9.5	9.0	8.3	9.4	10.0	9.4	9.4	9.0	9.8	8.9	8.6	0.06	0.19
Ash (%)	2.7	2.0	2.5	2.3	2.8	2.7	2.3	2.4	2.4	2.4	2.2	0.05	0.16
Carbohydrates (%)	63.1	63.4	64.2	61.9	61.8	63.6	62.7	62.3	63.1	63.8	64.8	0.36	1.07
Calcium (mg/100g)	95.5	60.5	74.2	88.4	54.9	63.4	81.7	52.5	72.3	43.8	59.1	1.79	5.25
Iron (mg/100 g)	3.6	3.7	5.0	5.5	7.0	7.6	4.3	4.2	4.3	3.5	4.4	0.10	0.30
Zinc (mg/100 g)	2.1	2.2	2.3	2.1	1.9	2.9	3.6	2.5	2.6	2.1	3.4	0.07	0.19
Phosphorus (mg/100 g)	460.3	433.1	384.2	349.4	402.7	409.8	450.5	429.9	416.8	402.1	425.0	1.36	3.99

*Released varieties
Values on dry weight basis

Table 3. Varietal grading of amaranth and buckwheat varieties/genotypes in search of versatile multipurpose genotypes

Genotypes/ Parameters (Amaranth)	PRA-2	PRA-3	PRA-2007-1	PRA-2007-2	PRA-2008-1	PRA-2008-2	IC-35407	IC-107197	IC-042328	IC-0423152	IC-540862	Annapurna
Crude protein (%)	4	5	3	2	6	7	2	3	1	9	4	8
Oil (ether extract) (%)	10	10	3	1	2	4	7	8	4	6	5	9
Carbohydrates (%)	3	1	6	7	4	3	6	2	7	8	5	1
Calcium (mg/100 g)	5	6	7	8	3	4	1	12	10	2	9	11
Iron (mg/100 g)	8	7	2	4	5	3	1	6	1	7	6	9
Zinc (mg/100 g)	4	5	3	5	6	2	8	10	6	1	7	9
Total*	27	28	27	28	28	20	24	41	28	28	35	40
Cumulative grading	**3**	**4**	**3**	**4**	**4**	**1**	**2**	**7**	**4**	**4**	**5**	**6**
Genotypes/Parameters (Buckwheat)	PRB-1	VL-7	IC-107989	IC-108499	IC-108500	IC-109314	IC-109549	Himpriya	Reshwal	Sangla B-124	Shimla B-1	
Crude protein (%)	7	2	7	2	4	1	3	6	7	2	5	
Oil (ether extract) (%)	5	7	6	1	4	2	3	2	8	3	6	
Carbohydrates (%)	6	5	2	9	10	4	7	8	6	3	1	
Calcium (mg/100 g)	1	7	4	2	9	6	3	10	5	11	8	
Iron (mg/100 g)	9	8	4	3	2	1	6	7	6	10	5	
Zinc (mg/100 g)	8	7	6	8	9	3	1	5	4	8	2	
Total*	28	30	25	17	28	13	16	29	28	34	24	
Cumulative grading	**6**	**8**	**5**	**3**	**6**	**1**	**2**	**7**	**6**	**9**	**4**	

*Genotypes graded in the descending order for nutritionally desirable characters

body was determined. The data presented on this aspect in the Table 1 and 2 showed significant variation from 3.0 (Annapurna) to 3.70 (PRA-2008-2) per cent and 2.4 (PRA-3, PRR-2007-1) to 3.3 (IC-0423152) per cent in amaranth varieties/genotypes, accordingly. The released varieties i.e. PRA-2, PRA-3 and Annapurna showed 3.2, 3.4 and 3.0 per cent ash content and 2.8, 2.4 and 2.9 per cent crude fibre in that order. The findings of the study in this context are in conformity with the values reported by Pedersen *et al.* (1987) and Gopalan *et al.* (2004). In buckwheat varieties/genotypes ash and crude fibre content ranged from 2.0 (VL-7) to 2.8 (IC-108500) and 8.3 (IC-107989) to 10.0 (IC-108500) per cent, respectively. The released varieties *viz.*, PRB-1, Himpriya and Shimla B-1 possessed 2.7, 2.4 and 2.2 per cent ash content and 9.5, 9.0 and 8.6 per cent crude fibre, accordingly. The range of variation in ash and crude fiber content in the present study was in agreement with the values quoted by Copalan *et al.* (2004) i.e. 2.3 per cent for ash and 8.6 per cent for crude fibre in buckwheat grains.

Carbohydrates are the readily available source of energy and also involve in various important structural and metabolic functions. Variation in carbohydrate content of amaranth varieties/genotypes was noticed from 64.6 (IC-0423152) to 67.3 (PRA-3 and Annapurna) per cent, while 61.8 (IC-108500) to 64.8 (Shimla B-1) per cent in buckwheat varieties/genotypes. Similar pattern for carbohydrate content in amaranth and buckwheat genotypes have also been reported by Gopalan *et al.* (2004) i.e. 60.7 and 65.1 *per cent,* respectively.

Calcium, iron, zinc and phosphorus play an important role in the regulation of the metabolism in the body. Literature further revealed that calcium makes the bones and teeth strong and also plays an important part in nerves function, blood clotting, regulation of blood pressure and contraction of muscles. Iron plays an important role in the formation of haemoglobin in the body, whereas zinc helps in cell division, healing of wounds and also assists in liver function. Phosphorus plays an important role in the body's utilization of carbohydrates and fats and in the synthesis of protein, nucleic acid etc. for the growth, maintenance, and repair of cells and tissues. It is also crucial for the production of ATP, a molecule the body uses to store energy. Therefore, the status of these minerals was determined in various amaranth and buckwheat genotypes and pertinent data are presented in Table 1 and 2. The calcium content of amaranth varieties/genotypes ranged from 217.5 (IC-107197) to 312.0 (IC-35407), iron content from 4.6 (Annapurna) to 7.2 (IC-35407, IC-042328), zinc content from 2.0 (IC-107197) to 4.5 (PRA-2008-2, IC-0423152) and phosphorus content from 521.4 (Annapurna) to 678.2 mg/100g (PRA-2008-2). The released varieties *viz.* PRA-2, PRA-3 and Annapurna exhibited 268.0, 261.7, 230.5 mg/100 g calcium, 5.2, 5.4, 4.6 mg/100 g iron, 3.4, 3.2, 2.6 mg/100 g zinc and 642.4, 609.8, 521.4 mg/100 g phosphorus, respectively. Czerwinski *et al.* (2004) and Gopalan *et al.* (2004) also observed similar pattern in mineral content of amaranth genotypes. In buckwheat varieties/genotypes calcium content varied from 43.8 (Sangla B-124) to 95.5 (PRB-1), iron content from 3.5 (Sangla B-124) to 7.6 (IC-109314), zinc content from 1.9 (IC-108500) to 3.6 (IC-109549) and phosphorus content from 349.4 (IC-108499) to 460.3 mg/100 g (PRB-1), accordingly. The released varieties *viz.* Himpriya and Shimla B-1 exhibited 52.5 and 59.1 mg/100 g calcium, 4.2 and 4.4 mg/100 g iron, 2.5 and 3.4 mg/100 g zinc and 429.9 and 425.0 mg/100 g phosphorus, respectively. Gopalan *et al.* (2004) also observed similar pattern in mineral content of buckwheat genotypes i.e. 64 mg/100 g calcium, 15.5 mg/100 g iron, 355 mg/100 g phosphorus. The data presented in the Annual Report of All India Coordinated Research Network on Underutilized Crops for the year 2009 revealed that the moisture, crude protein, oil, calcium, iron and zinc content in amaranth grains procured from Shimla centre varied from 11.20 to 12.20 per cent, 10.40 to 13.60 per cent, 6.50 to 11.10 per cent, 251.00 to 298.00 mg/100 g, 2.10 to 8.70 mg/100 g, and 2.10 to 3.70 mg/100 g, respectively, whereas values for these parameters in buckwheat genotypes were observed to range from 12.22 to 13.90 per cent, 10.03 to 12.15 per cent, 48.90 to 96.75 mg/100 g, 3.45 to 6.90 mg/100 g and 1.90 to 3.45 mg/100 g, accordingly (Bhandari, 2009).

The study thus showed significant variation among various genotypes of amaranth and buckwheat for individual quality parameters for further breeding and crop improvement. Besides identifying genotypes superior in individual quality trait(s) attempts were made to carry out

genotypic rating in respect of various nutritionally quality attributes *viz.*, protein, oil, carbohydrates, calcium, iron and zinc taken together in order to identify overall nutritionally superior multipurpose amaranth genotypes to be useful for food enrichment and value addition. Accordingly, the genotypes PRA-2008-2, PRA-2007-1 and IC-35407 were identified as overall nutritionally superior/versatile genotypes in that order. Similarly, among buckwheat varieties/genotypes, IC-109314, IC-109549 and IC-108499 exhibited their excellence over others as multipurpose genotypes (Table 3).

In all the study indicated wide range of variability in individual biochemical parameter(s) of nutritional significance to be useful to the plant breeders and those engaged in amaranth and buckwheat quality improvement. Moreover, the multipurpose genotypes identified in the study based on genotypic rating might be used for further dietary intake/supplementation purpose for optimum human nutrition.

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