Tartary buckwheat (*Fagopyrum tataricum* Gaertn.) is an important underexploited pseudocereal belonging to the Polygonaceae family. Considering the nutraceutical significance of various plant species including underutilized tartary buckwheat in sustaining human health extensive efforts are being made to standardise/improve production technology and development of enriched functional foods for human health care both at the national and international level. However, systematic information on the genotypic variability in relation to biochemical constituents among different buckwheat genotypes grown under North-Western Himalayan conditions appears to be limited. The literature reviewed so far further revealed inadequate information with regard to status of biochemical parameters of nutritional significance in the fresh leaves of tartary buckwheat genotypes. Keeping these aspects in view the research work, which has mostly been carried out abroad and that too in India is reviewed briefly under following sub-heads:

2.1 **Variability in biochemical constituents in grains**

2.1.1 Variations in proximate composition

2.1.2 Protein fractionation and protein quality indexing

2.1.3 Variation in minerals and dietary fibre content of tartary buckwheat

2.2 **Variation in biochemical constituents in leaves**

2.2.1 Variation in proximate composition

2.2.2 Variation in minerals and dietary fibre

2.3 **Variation in total phenols and rutin in grains and leaves**

2.4 **Comparison of tartary buckwheat quality attributes with Major cereals** (Wheat, Barley and Oat)

**2.1 Variability in biochemical constituents of tartary buckwheat grain**

2.1.1 **Variation in proximate composition**

The proximate composition of food stuffs including pseudocereals represents the moisture, crude protein, fat, minerals, crude fibre and carbohydrates, when taken
together on per cent basis and the extent of variability in proximate composition of tartary buckwheat grains evaluated so far is reviewed appropriately as follows:

Prakash et al. (1987) evaluated seven varieties of buckwheat, two Indian selections *Fagopyrum esculentum*, *Fagopyrum tataricum* and five from Poland cultivated under Northern Indian conditions and observed value for protein content as 9.2, 11.23, 9.7, 10.4, 11.0, 13.8 and 12.5 per cent, respectively in these varieties/selections.

Wende Li et al. (1996) reported protein and lipid content in tartary buckwheat grains (dry weight basis) to range from 11.3 to 15.9 per cent and 2.4 to 2.7 per cent, respectively.

Sato et al. (2001) estimated the contents of moisture, protein and fat in the tartary buckwheat flour and reported variation in these parameters from 11.15 to 11.73, 10.32 to 13.84 and 2.26 to 2.57 per cent, accordingly.

Li and Zhang (2001) reported protein, carbohydrate, fat, fiber and ash content in grains of tartary buckwheat as 12.3, 73.3, 2.3, 10.9 and 2.1 g/100g in that order.

Gupta et al. (2002) evaluated the nutritive value of hulled and dehulled buckwheat grains and reported that protein, crude fibre, fat, total minerals ranged from 10.81 to 12.86, 4.38 to 16.96, 2.11 to 2.62 and 2.07 to 2.39 g/100g dry matter basis, accordingly.

Bonafaccia et al. (2003) analysed the chemical composition of grain, bran and flour of tartary buckwheat. They reported protein, ash and fat content as 11.1, 2.81 and 2.8 per cent in the grains, 25.3, 4.97 and 7.35 per cent in the bran and 10.3, 1.8 and 2.4 per cent in the flour in that order (value given on dry weight basis).

Bonafaccia and Fabjan (2003) studied the chemical composition of flour (dry matter basis) of tartary buckwheat and reported protein content as 10.3 per cent, ash 1.8 per cent, lipids 2.5 per cent and fibre 6.3 per cent.

Gopalan et al. (2004) reported protein, fat, minerals, crude fibre and carbohydrate content in buckwheat grains as 10.3, 2.4, 2.3, 8.6 and 65.1 per cent, respectively on dry weight basis.

Ikeda et al. (2005) reported protein content to range from 4.2 to 13.6 g/100g in buckwheat groats grown in Japan, Europe and Canada. In the following studies Ikeda et al. (2006) evaluated the total protein content in buckwheat, wheat,
rice and maize flour and reported its value as 7.86, 9.50, 4.40 and 7.46 g/100g, respectively on dry matter basis.

Tang et al. (2007) determined the protein content in seeds of five buckwheat species viz. *F.esculentum, F.tataricum, F.cymosum, F.gracilipes* and *F.urophyllum* and reported 11.5, 10.6, 14.1, 11.8 and 12.9 per cent protein content in that order.

Awasthi and Thakur (2010) evaluated eleven varieties of common buckwheat grains and reported that moisture, crude protein, ash, fat, crude fibre, carbohydrates ranged from 9.4 to 11.6, 11.5 to 12.9, 2.0 to 2.8, 2.1 to 2.8, 8.3 to 10.0 and 61.8 to 64.8 g/100g dry matter basis, accordingly.

Dogra (2010) reported moisture, crude protein, soluble protein, ash, fat, fiber and carbohydrate content in the grains of common buckwheat as 10.2 to 10.9, 10.4 to 15.1, 9.4 to 13.3, 1.5 to 2.5, 1.7 to 2.8, 6.1 to 9.2 and 62.0 to 67.9 per cent in that order.

### 2.1.2 Protein fractionation and protein quality indexing

Based on solubility characteristics the seed proteins are broadly characterized as: albumins (soluble in water and dilute buffers at neutral pH), globulins (soluble in salt solutions, but insoluble in water), glutelins (soluble in dilute acid or alkali solutions), and prolams (soluble in aqueous alcohols of 70 – 90%). The pertinent information related to variability in various grain protein fractions of tartary buckwheat have been reviewed and presented as under-

#### 2.1.2.1 Protein fractionation


Bonafaccia *et al.* (1994) evaluated the protein fractions in buckwheat cultivated in Italy. The study indicated that almost half of the protein content in the five samples analysed was constituted by globulin with its values over 44 per cent, while prolams represented the smallest fraction (0.7%). The albumin (18%) and glutelin (22%) contents were constant in all the samples.

Wei *et al.* (2003) reported that proportions of albumin, globulin, prolamin, and glutelin were 16.8–30.3%, 4.96–21.6%, 3.08–7.01% and 11.5–16.0%, respectively, for four buckwheat species.
Guo et al. (2006) fractionated and characterized the tartary buckwheat flour proteins and reported that albumin was the predominant protein fraction (43.8%) followed by glutelin (14.6%), prolamin (10.5%), and globulin (7.82%).

Dogra (2010) evaluated protein fractions in common buckwheat and reported that globulins (5.9%) constituted the major grain protein followed by albumins (2.7%), glutelins (3.1%) and prolamins (0.12%) based on solubility characteristics.

2.1.2.2 Limiting amino acids (Methionine and Tryptophan)

Prakash et al. (1987) evaluated amino acid profile of seven varieties of buckwheat, two Indian selections F. esculentum, F. tataricum and five from Poland and reported methionine content to vary from 0.4-0.7 g/100g protein, lysine 4.6-4.8 g/100g protein, leucine 6.4-6.9 g/100g protein, valine 5.4-5.8 g/100g protein in two Indian selections.

Bonafaccia et al. (1994) determined methionine content in five different samples of buckwheat grown at five different geographical areas, and observed its value to vary from 2.15 to 2.73 g/100g of protein.

Zheng et al. (1998) noticed that methionine content in groat of buckwheat grains was 1.9 per cent on dry weight basis.

Bonafaccia et al. (2003a) reported further that the methionine content in bran and flour of tartary buckwheat as 1.33 and 1.42 g/100g protein, respectively.

Wei et al. (2003) evaluated amino acid profile and found very low amount of prolamin in tartary buckwheat kernel. Leucine was the first limiting amino acid and tartary buckwheat protein was assessed to be a semi-nutritional protein.

Gopalan et al. (2004) reported methionine and tryptophan content of common buckwheat seeds as 100 and 80 mg/g N, respectively.

Tomotake et al. (2006) reported methionine content in buckwheat grains as 2.3 per cent and tryptophan content as 2.0 per cent.

Tang et al. (2007) evaluated amino acid profile of tartary buckwheat seeds and reported methionine content as 0.29 per cent and tryptophan content as 0.08 per cent.

Dogra (2010) reported methionine content in buckwheat grains as 57.9 to 103.4 mg/g N and tryptophan content as 62.2 to 79.2 mg/g N.
2.1.2.3  *In vitro* protein digestibility

Dietryoh-szostak and Ploszynski (1986) reported *in vitro* protein digestibility in five different fractions of buckwheat groat to range from 78.9 to 88.3 per cent of dry matter.

Gupta and Sehgal (1991) reported that *in vitro* protein digestibility of cereals and pulse mixtures varied from 80.22 to 84.43 per cent. Processing of cereals and pulses brought about 24.93 to 28.29 per cent increase in protein digestibility (*in vitro*) of weaning mixtures.

Ikeda and Kishida (1993) evaluated the digestibility of albumin and globulin of buckwheat grains and reported susceptibility of albumin, globulin, haemoglobin and ovalbumin to pepsin action. There was a striking difference in the susceptibility to pepsin action among the protein examined; with hemoglobin being the most digestible by pepsin. Ovalbumin is relatively less digestible by proteases as compared with some other proteins. The two buckwheat proteins were less digestible than ovalbumin. Buckwheat globulin was more digestible by pepsin than buckwheat albumin.

Guo et al. (2006) reported *in vitro* pepsin digestibility of Chinese tartary buckwheat protein fractions viz., albumin, globulin, prolamin and glutelin content as 81.2, 79.6, 67.0 and 58.1 per cent, respectively.

Tang (2007) evaluated the *in vitro* digestibility of buckwheat products and soy protein isolates by TCA-soluble nitrogen release during digestion of pepsin and trypsin, in simulated gastric fluid and reported it to vary from 50.1 to 68.0 per cent by pepsin and 72.5 to 81.3 per cent by pepsin and trypsin in that order.

Dogra (2010) reported *in vitro* protein digestibility in buckwheat grains to range from 66.7 to 79.5 per cent of dry matter.

2.1.3  Variation in minerals and dietary fibre content in tartary buckwheat

2.1.3.1  Variation in mineral composition of grains

Minerals are well known to be essential for optimum human nutrition. Each mineral element has many diverse physiological functions. The interest in nutritional functions of dietary minerals is rapidly growing, thus, mineral nutrition is a major nutritional subject. Buckwheat is reported to contain appreciable amounts of minerals. As such, the status of minerals in food grains in general and buckwheat genotypes in particular is reviewed as follows:
Ikeda and Yamashita (1994) analysed the contents of zinc, copper and manganese in different buckwheat samples. Variation in zinc and copper content among various buckwheat grains was found to range from 1.37 to 2.73 mg/100g flour and 0.41 to 0.68 mg/100g flour, whereas, manganese content was observed to vary from 0.59 to 1.79 mg/100g flour on dry weight basis and values for zinc, copper and manganese content in buckwheat flour were noticed to range from 0.70 to 4.47, 0.35 to 0.64 and 0.46 to 3.34 mg/100g (values presented on dry weight basis).

Wang et al. (1995) reported mineral composition comprising of potassium, sodium, calcium, magnesium, iron, manganese, zinc, copper and phosphorus content in buckwheat as 320, 2.3, 39, 94, 4.4, 1.31, 2.02, 0.89 and 244 mg/100g, in that order.

Ikeda et al. (1999) evaluated mineral content of buckwheat grains i.e., flour and hull on dry weight basis. Calcium, magnesium, phosphorus, potassium, zinc, copper and manganese content in flour were noticed as 14.5, 248, 379, 411, 2.79, 0.63 and 0.89 mg/100g, whereas in the hull the values for the these parameters were found as 97.4, 112, 127, 1267, 1.24, 0.61 and 9.16 mg/100g, respectively.

Gupta et al. (2002) analysed the nutritive value of hulled and dehulled buckwheat grain and reported calcium and phosphorus content to vary from 0.20 to 0.28 and 0.30 to 0.36 g/100g on dry matter basis.

Bonafaccia et al. (2003) observed zinc in different fractions of tartary buckwheat i.e., grain, bran and flour, and noticed values for these parameters as 35, 78.8 and 26.3 mg/kg, whereas iron content was reported as 462, 147 and 149 mg/kg, respectively.

Ikeda et al. (2005) studied the composition of seven important minerals, namely zinc, copper, manganese, calcium, magnesium, potassium and phosphorus in various buckwheat groats. The zinc content (per 100g dry matter) of buckwheat groats ranged from 1.29 to 2.61 mg; copper 0.31 to 0.63 mg; manganese 0.79 to 2.53 mg; calcium 6.7 to 16.9 mg; magnesium 141 to 217 mg; potassium 322 to 518 mg and phosphorus 265 to 510 mg.

Siener et al. (2006) while compiling the data related to potassium, calcium, magnesium, iron and zinc content reported values for these minerals as 484, 214, 308, 9.0 and 3.7 mg/100g in edible portion of buckwheat nuts.
Ikeda et al. (2006) studied the composition of eight essential minerals in buckwheat, wheat, rice and maize flour and reported iron, zinc, copper, manganese, calcium, magnesium, potassium and phosphorus content to range from 0.79 to 4.46, 0.80 to 2.70, 0.16 to 0.52, 0.43 to 1.61, 4.0 to 14.8, 35 to 375, 82 to 450 and 124 to 394 mg/100g, respectively on dry matter basis.

Alvarez-Jubete et al. (2009) studied the mineral content of tartary buckwheat and amaranth seeds and reported calcium, magnesium, zinc, iron content as 60.9, 203.4, 1.0, 4.7 mg/100g, (on dry weight basis) in tartary buckwheat, whereas 180.1, 279.2, 1.6, 9.2 mg/100g in amaranth seeds.

Awasthi and Thakur (2010) studied the mineral content of buckwheat grains and reported calcium, iron, zinc and phosphorus content to range from 43.8 to 95.5, 3.5 to 7.6, 1.9 to 3.6 and 349.4 to 460.3 mg/100g, respectively on dry matter basis.

2.1.3.2 Variations in dietary fibre components in grains

Amarowicz and Fornal (1987) analysed the dietary fibre content and its composition in buckwheat grain and its products i.e., flour, seed coat and groat on per cent dry matter basis. Buckwheat grain, flour, seed coat and groat contained dietary fibre as 24.75, 3.94, 80.31 and 4.51 per cent, whereas 20.39, 3.98, 61.98 and 2.29 per cent acid detergent fibre, respectively. Hemicellulose and cellulose were observed in buckwheat grain, flour, seed coat and groat were found to be 4.36, 0.0, 18.33 and 2.2 per cent, and 9.81, 2.34, 29.93 and 1.81 per cent, whereas lignin content as 10.58, 1.64, 32.05 and 0.48 per cent, accordingly in buckwheat grain and its products.

Bjorkman and Chase (2006) reported that when there is a shortage of hay, buckwheat can be good alternative forage. The forage contained 70 per cent moisture at flowering stage of buckwheat and fibre analysis revealed that it contained 16.4 per cent fibre, acid detergent fibre 32.9 per cent and neutral detergent fibre 41.8 per cent. The buckwheat was picked up when the grains were 30 to 50 per cent brown and grains had mostly filled, but are not yet hard and the analysis showed 9 per cent crude protein, 36 per cent acid detergent fibre and 43 per cent neutral detergent fibre.

Amelchanka et al. (2010) analysed buckwheat fresh, buckwheat ensiled and buckwheat grain meal for dietary fibre composition and noticed that dry matter, crude protein, neutral detergent fibre, acid detergent fibre and lignin to vary
from 142 to 854; 119 to 137; 256 to 555; 154 to 427; 72 to 94.9 g/kg on dry weight basis, respectively.

Dogra (2010) analysed the dietary fibre content of grains of buckwheat and reported cellulose, hemicellulose, acid detergent lignin, acid detergent fibre and neutral detergent fibre varied from 8.1 to 13.9, 10.7 to 21.5, 9.2 to 12.7, 20.2 to 23.9 and 34.4 to 42.8 per cent, respectively. (Values on dry weight basis)

2.2 Variation in biochemical constituents in leaves

2.2.1 Variations in proximate composition

Dietryoh-szostak and Ploszynski (1986) evaluated the chemical composition of buckwheat plant residues and hulls and reported dry matter, ash, crude fibre and fat content as 92.07, 8.54, 13.42 and 4.36 per cent on dry matter basis.

Tahir and Farooq (1985) studied the biochemical composition of leaves of four species of *Fagopyrum* and reported total nitrogen and total sugars as 0.379 and 1.0 per cent, respectively on fresh weight basis in *Fagopyrum tataricum*.

Dietryoh-szostak and Ploszynski (1988) studied chemical composition of buckwheat leaves, inflorescence and unfilled grains. The leaves contained 91.4 dry matter per cent, 8.3 per cent ash, 10.1 per cent fibre and 3.5 per cent fat on dry weight basis.

Raghuvanshi *et al.* (2001) evaluated the biochemical composition of leaves of *Bauhenia purpurea*, *Chenopodium album* and *Fagopyrum* species and reported crude protein, fat, minerals, crude fibre, carbohydrates to range from 1.74 to 4.93 per cent, 0.23 to 1.38 per cent, 0.46 to 3.02 per cent, 0.88 to 5.02 per cent and 1.46 to 14.46 per cent, respectively (values on fresh weight basis).

Lahanov *et al.* (2004) evaluated nitrogen content, crude protein and ash content of leaves of tartary buckwheat and reported values for these parameters as 2.06, 22.3 and 9.74 per cent, accordingly on dry weight basis.

Dogra (2010) evaluated the biochemical composition of leaves of common buckwheat and reported moisture (fresh weight), crude protein, fat, ash, crude fibre, carbohydrates to range from 87.4 to 92.2, 22.4 to 30.4, 1.8 to 3.7, 10.5 to 15.4, 12.0 to 13.9 and 34.8 to 42.4 per cent, respectively on dry weight basis.
2.2.1 Ascorbic acid

Raghavanshi et al. (2001) reported ascorbic acid content in leaves of Bauhenia purpurea, Chenopodium album and Fagopyrum species to range from 3.26 to 173.13 mg/100g.

Gopalan et al. (2004) compiled data pertaining to biochemical constituents of different leafy vegetables including spinach and reported vitamin C content as 28 mg/100g in spinach.

Siener et al. (2006) reported vitamin C content in spinach leaves as 51 mg/100g.

Dogra (2010) reported ascorbic acid content in common buckwheat leaves to vary from 25.0 to 29.2 mg/100g.

2.2.1.2 In vitro protein digestibility

Dietryoh-szostak and Ploszynski (1986) analysed the chemical composition of buckwheat plant residues and hulls and reported 47.5 per cent in vitro digestibility of its leaves and stems.

Ly and Preston (2001) determined in vitro digestibility (pig pepsin/pancreatin) and water-soluble nitrogen (N) in samples from seventeen tropical forage feeds available in Indochina and reported in vitro protein digestibility in Ipomoea aquatica as 68.8 per cent.

2.2.2 Variation in minerals and dietary fibre content in leaves

2.2.2.1 Variation in minerals composition

Dietryoh-szostak and Ploszynski (1988) studied the mineral composition in leaves (inflorescence and unfilled grains) and stems of common buckwheat genotypes and reported phosphorus, potassium, calcium and magnesium content to range from 0.66 to 0.78, 1.49 to 2.74, 3.4 to 4.6 and 0.24 to 0.37 per cent on dry matter basis in that order.

Ikeda et al. (1999) analysed the mineral composition of buckwheat straw and leaves and aqueous extract of ash of buckwheat straw and leaves. Buckwheat straw and leaves contained relatively high levels of some minerals viz., potassium, calcium and manganese when compared to buckwheat flour. Calcium, magnesium, phosphorus, potassium, zinc, copper and manganese content were noticed to be present as 894.2, 305, 1132, 5139, 6.69, 0.27 and 38.81 mg/100g, accordingly on dry weight basis. However, ash aqueous extract of straw and
leaves exhibited values for theses parameters as 1.7, 2, 345, 20399, 0.17, 1.17 and 0.02 mg/l in that order.

Bonafaccia et al. (2003) studied the mineral composition of tartary buckwheat and their milling products and reported values for zinc, iron, cobalt and selenium content as 29.2, 1607, 4.15 and 0.529 mg/kg in leaf flour on dry matter basis.

2.2.2.2 Variation in dietary fibre components in leaves

Dietryoh-szostak and Ploszynski (1986) analysed the chemical composition of buckwheat plant residues and hulls and reported hemicellulose and cellulose content as 19.8 and 13.9 per cent on dry matter basis in the leaves and stems.

Salmon et al. (1996) evaluated forage quality of spring triticale, barley and oat when harvested at the early dough stage and reported values for neutral detergent fibre as 44.0, 46.6 and 48.9 per cent, respectively.

Buntha and Ty (2006) analysed the fresh foliages of guinea grass (Panicum maximum), cassava (Manihot esculenta), stylo (stylo santhesis guiensis) and water spinach (Ipomoea aquatica) to compare the water extractable dry matter of these feeds with neutral detergent fibre values as predictors of whole tract dry matter digestibility and found that neutral detergent fibre for water spinach leaves was 42.8 per cent.

Chumpawadee et al. (2006) reported neutral detergent fibre, acid detergent fibre and acid detergent lignin in Chinese spinach (Amaranthus viridus L.) as 40.06, 19.96 and 4.99 per cent on dry matter basis.

Gang et al. (2006) studied the digestibility of foliages i.e., water spinach, sweet potato vines, mixture of water spinach and sweet potato vines and observed value for neutral detergent fibre and acid detergent fibre of water spinach as 35.6 and 22.9 per cent.

Dong et al. (2008) reported values for neutral detergent fibre and acid detergent fibre as 40.2 and 24.2 per cent on dry matter basis in water spinach leaves.

Dogra (2010) reported values for cellulose, hemicellulose, acid detergent lignin, acid detergent fibre and neutral detergent fibre to range from 12.9 to 17.2, 12.4 to 17.5, 6.1 to 9.6, 19.3 to 23.8 and 34.8 to 38.5 per cent, respectively on dry matter basis in common buckwheat leaves.
2.3 Variation in total phenols and rutin in grains and leaves

2.3.1 Total Phenols

Phenolic compounds are secondary metabolites synthesized in various plant species and these compounds are reported to possess biological properties such as anti-oxidant, anti-apoptosis, anti-aging, anti-carcinogen, anti-inflammation, anti-atherosclerosis, cardiovascular protection, improvement of the endothelial function, as well as inhibition of angiogenesis and cell proliferation activity. Most of these biological actions have been attributed to their intrinsic reducing capabilities (Johnson et al., 2008). Literature reviewed related to variability in the total phenols and rutin content amongst various buckwheat varieties/genotypes is presented as under-

Tahir and Farooq (1985) evaluated chemical composition of grains of tartary buckwheat cultivars and reported phenolics content as 1.87 and 1.52 per cent (on dry weight basis) in the hull and groat.

Farooq and Tahir (1988) studied the leaf composition of *Fagopyrum* species and reported phenolics content as 0.47 per cent on fresh weight basis in *Fagopyrum tataricum*.

Oomah et al. (1996) determined phenolic acid content in grains from five buckwheat cultivars grown at three locations in western Canada for four years and reported 12-16 g/kg of total phenolic acids, about 3 g/kg of esterified phenolic acids, and 8-13 g/kg of etherified phenolic acids. Variation in phenolic acids was mainly due to cultivar, seasonal effects and their interaction, while growing location had no significant effect. Phenolic acid contents of buckwheat were independent of seed color and protein content.

Velioglu et al. (1998) analysed total phenolics compounds of some fruits and vegetables and reported that buckwheat grains contained total phenols content as 726 mg/100g as ferulic acid equivalent.

Dietrych–Szostak and Oleszek (1999) isolated and identified flavonoid content in buckwheat grains and observed its value in the grains and hulls in the order of 18.8 and 74 mg/100g of dry matter, respectively.

Ikeda et al. (2001) reported high levels of polyphenols in common buckwheat and tartary buckwheat groats and suggested that the polyphenol
content might be associated with their colour characteristics and their anti-
oxidative characteristics.

Li et al. (2001) reported that tartary buckwheat seeds contained
flavonoid content as 40 mg/g, whereas common buckwheat seeds exhibited its
value as 10 mg/g, on dry weight basis.

Krkoskova and Mrazova (2005) showed that flavonoids composition in
buckwheat grains was different in different buckwheat species during diverse
growing phases and had slight differences owing to difference among growing
circumstances.

Kim et al. (2008) analysed phenolic compounds in the edible parts of
tartary buckwheat sprouts and reported its value as 24.4 mg/g (DW) after 6-10
DAS (Days after sowing).

Amelchanka et al. (2010) analysed total phenol content in buckwheat
fresh, buckwheat ensiled and buckwheat grain meal and reported its value as
35.7, 34.5 and 7.3 g/kg in that order on dry matter basis.

2.3.2 Rutin

Kitabayashi et al. (1995) estimated rutin content in seed and leaves of
27 cultivars of common buckwheat grown in Japan, China, Nepal and Europe. The
rutin content in seed showed a wide range of variation from 12.6 to 35.9 mg/100g
dry matter basis. Besides, the rutin content in leaves also showed significant
variations to range from 1,880 to 3600 mg/100g.

Oomah and Mazza (1996) reported that rutin content in hulls of four
buckwheat cultivars from Canada was higher than in grains and it value ranged
from 50.5 to 97.4 mg/l00g in hulls and 44.2 to 51.1 mg/100g in grains,
respectively. In buckwheat hulls from these nuts the rutin content was 46 to 80
mg/100g.

The leaves (inflorescence and unfilled grains), stems and seed hulls
contained 3.96, 0.95 and 0.17 per cent rutin on dry matter basis, respectively
(Dietrych-szostak and Ploszynski, 1988).

Fabjan et al. (2003) reported rutin content upto 3% (DW) in tartary
buckwheat herb and its seeds contained 0.8−1.7% rutin (DW).

Dietrych- szostak (2004) studied the flavonoid content in the hulls of
Polish buckwheat and reported rutin as pre-dominant flavonoid in all the analysed
hulls to range from 46.1 to 79.9 mg/100g.
Park et al. (2004) carried out study to compare rutin content in grains and plant parts of 50 tartary buckwheat strains collected from various parts of the world and reported that leaf and grains of *Fagopyrum tataricum* contained rutin content from 2876.0 and 1469.8 mg/100g, respectively. However, strains of *Fagopyrum tataricum* collected from India exhibited rutin content as 4259.6 mg/100g in the leaves and 1199.4 mg/100g in grains, respectively.

Suzuki et al. (2005) analysed the rutin content in different types of leaf discs cut from tartary buckwheat leaves and found to vary from 17.1 (mesophyll) to 53.1 (upper epidermis) per cent on fresh weight basis.

Zhanrong and Xiulian (2006) evaluated the tartary and common buckwheat varieties (strains) for rutin content and reported the range of variation for this parameter in tartary buckwheat from 1.54 to 2.56 per cent and in common buckwheat from 0.19 to 0.92 per cent.

Tang et al. (2007) analysed rutin content in five buckwheat species and reported its value as 1.85 per cent (dry weight basis) in tartary buckwheat seeds.

Brunori et al. (2010) studied rutin content in tartary buckwheat whole flour and reported its value as 1091.43 ± 8.90 mg/100g on dry weight basis.

### 2.4 Nutritional Quality comparison with Major cereals (Wheat, Barley and Oat)

Cereals are cultivated grasses which are extended worldwide. They belong to the large monocotyledonous plant family called the *Gramineae*. They can grow in temperate and tropical regions as well and are the most important source of living. People all over the world eat more cereals than any other kind of food. They strongly influence nutritional balance, because they contain all necessary nutrients including fats and vitamins. They are still very important today because all sorts of cereals are staple food for population. Their world productivity is around three tonnes per hectare in average. People use primarily the grain; the other parts of the plant can be used as animal feed.

Eight major cereal grains viz. wheat, maize, rice, barley, sorghum, oats, rye, and millet provide 56 per cent of the food energy and 50 per cent of the protein consumed on earth. Three cereals wheat, maize and rice together comprise at least 75 per cent of the world’s grain production. It is clear that humanity has become dependent upon cereal grains for the majority of its food
supply. Therefore, it is essential that we fully understand the nutritional implications of cereal grain consumption upon human health and well being. The pertinent information regarding proximate composition of wheat, barley and oat have been reviewed as under:

Joshi and Paroda (1991) reported protein, carbohydrate, fat, crude fiber and ash content in grains of wheat as 12.0, 69.0, 1.7, 1.2 and 2.7 g/100g in that order.

Bhagmal (1994) compiled data on the essential amino acid composition of wheat, barley and maize and reported that methionine, lysine and Isoleucine ranged from 1.5 to 3.4, 2.8 to 3.0 and 3.3 to 4.1 g/100g protein dry matter basis, accordingly.

Mulholland and Preston (1995) studied the dry matter, chemical composition and \textit{in vitro} protein digestibility of wheat and oat grains and reported dry matter 90.1, nitrogen 2.5, ash 1.9, cellulose 2.0 and \textit{in vitro} digestibility 84 per cent in wheat, while oat contained 90.0, 1.3, 4.4, 13.1 and 57 per cent of these values in that order.

Cordain and Simopoulos (1999) studied protein, fat, carbohydrate, methionine, tryptophan, calcium, iron, zinc, phosphorus and magnesium content in different cereal grains and reported values as 12.6, 1.5, 71.3 per cent, 201, 160, 29, 3.19, 2.65, 288 and 126mg/100g for wheat, 12.5, 2.3, 73.3 per cent, 240, 208, 33, 3.60, 2.77, 264 and 133 mg/100g for barley and 16.9, 6.9, 66.0 per cent, 312, 234, 53.9, 4.72, 3.97, 523 and 177 mg/100g for oat (values on dry weight basis) in that order.

Bhuvaneshwari \textit{et al}. (2004) reported \textit{in vitro} protein digestibility in wheat varieties to range from 71.5 to 80.5 per cent on dry weight basis.

Grausgruber \textit{et al}. (2004) evaluated the proximate composition of grains of wheat, barley and oat and reported values for crude protein to vary from 13.19 to 15.03, fat 2.2 to 3.8, ash 2.2 to 2.7 and crude fibre from 3.3 to 12.7 per cent.

Chaudhary \textit{et al}. (2006) studied the mineral composition of wheat grains and reported values for calcium, magnesium, phosphorus, potassium, iron and zinc content from 35 to 63, 62 to 160, 72 to 95, 30 to 51, 1.3 to 8.3 and 1.7 to 7.7 mg/100g, respectively.
Mikulioniene and Balezentiene (2009) studied the composition of organically grown wheat and reported crude protein, crude fat, crude fibre, ash, calcium and magnesium content as 9.6 per cent, 2.0 per cent, 3.4 per cent, 2.3 per cent, 0.46g/Kg and 1.20g/Kg DM in that order.

In view of the literature reviewed it was thought prudent to evaluate the nutritional quality characteristics and nutraceutical attributes of both grains and leaves of promising genotypes of tartary buckwheat grown particularly in Himachal Pradesh and also to find out the comparative performance of tartary buckwheat grains with major cereals for biochemical constituents of quality significance, so that the information generated will be useful to the plant breeders, farmers, food and pharma industries for further crop improvement and value addition purposes.