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# DIETARY MICRONUTRIENT CONTENT IN PEA (*PISUM SATIVUM* L.) AND BUCKWHEAT (*FAGOPYRUM ESCULENTUM* M.) FLOUR

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**Abstract**

Micronutrient (Fe, Zn etc.) malnutrition is a major public health problem in the most parts of the world. The attempt to solve micronutrient malnutrition could be to increase the consumption of nutri-dense products, like pseudo-cereals or legumes. This study was carried out to determine the mineral (P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, Mo and B) and vitamin ($B_1$ and $B_2$) content of pea (conventional and organic) and buckwheat (raw, roasted, white and dark) flour. Conventional and organic pea flour (PF) was naturally rich in Fe (36.0 mg $kg^{-1}$ and 64.0 mg $kg^{-1}$, respectively). Iron content in buckwheat flour (BF) ranged from 7.2 mg $kg^{-1}$ (white-BF) to 260 mg $kg^{-1}$ (dark-BF). Zinc content of BF was between 7.0 mg $kg^{-1}$ (white-BF) and 24 mg $kg^{-1}$ (raw- and roasted-BF) while that of pea flour ranged from 20.0 mg $kg^{-1}$ in organic-PF to 24.0 mg $kg^{-1}$ in conventional-PF. There were small differences in the content of P, K, Ca, Mg, S, Fe, Mn, Cu, Mo and B between raw- and roasted-BF. Ca : P ratio in PF and BF revealed a high concentration of phosphorus compared to calcium. This ratio was less than 1.0. The pea and buckwheat flour showed a good content of vitamins $B_1$ and $B_2$. The highest quantity of vitamins $B_1$ and $B_2$ was observed in roasted-BF under buckwheat flour samples (1.39 mg 100 $g^{-1}$ and 1.35 mg 100 $g^{-1}$, respectively) and in conventional-PF under pea flour samples (1.11 mg 100 $g^{-1}$ and 0.71 mg 100 $g^{-1}$, respectively).

***Keywords***: minerals, vitamins, pea, buckwheat, flour

## Introduction

Micronutrient (Fe, Zn etc.) malnutrition is a major public health problem in the most parts of the world. The attempt to solve micronutrient malnutrition could be to increase the consumption of nutri-dense products, like pseudo-cereals or legumes.

Vitamins and minerals are required in small amounts but they are essential micronutrients for regulation of physiological functions in the body. According to World Health Organization, 2 billion people suffer from anaemia of various types where iron deficiency anaemia is the most prevalent type (McLean et al., 2008). Iron is an essential trace element which is involved in metabolic functions by being an important component of hemoglobin, myoglobin and cytochromes (Hemalatha et al., 2007).

Buckwheat is a nutritional food product rich in vitamins $B_1$ and $B_2$ and good source of minerals (Préstamo et al., 2003). Buckwheat contains more minerals except calcium than many cereals and is rich source of zinc, copper, manganese, magnesium, potassium and phosphorus (Steadman et al., 2001; Ikeda et al., 2001).

Legumes are good sources of protein, carbohydrates, dietary fibre, vitamins, carotenoids, macronutrients, micronutrients and phytochemicals (Zia-ul-haq et al., 2011; Kotlarz et al., 2011). Iqbal et al. (2006) indicated that legumes may provide sufficient amounts of minerals to meet the human mineral requirement. Field peas are good source of iron, zinc and magnesium where iron content ranged from 46 mg $kg^{-1}$ to 54 mg $kg^{-1}$, zinc: 39-63 mg $kg^{-1}$ and magnesium: 1350-1427 mg $kg^{-1}$ (Amarakoon et al., 2012). The vitamins present in appreciable quantities in legumes are thiamin, riboflavin, pyridoxine, niacin and folic acid (Suliburska, Krejpcio, 2014; Ofuya, Akhidue, 2005).

The use of buckwheat and pea flours as ingredients in gluten-free products could improve the mineral and vitamin profile of these speciality products and of gluten-free diet in general (Alvarez-Jubete et al., 2009). The purpose of this research was to determine and compare mineral (P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, Mo and B) and vitamin ($B_1$ and $B_2$) contents of buckwheat (raw, roasted, white, and dark) and pea flours (conventional and organic).

## Materials and Methods

*Materials*

Two pea (*Pisum sativum* L.) flours: conventional (Fasma, Lithuania) and organic (Farm "Kaņepītes", Latvia) and four buckwheat (*Fagopyrum esculentum*) flours: raw, roasted, white and dark (Farm "Bebri", Latvia) were analysed (Table 1). Fine wheat flour as control was purchased from "Dobeles Dzirnavnieks", Latvia.

Table 1

**Description of flour**

| Code | Sample |
|---|---|
| WF | Wheat flour |
| Conventional-PF | Conventional pea flour |
| Organic-PF | Organic pea flour |
| Raw-BF | Raw buckwheat flour |
| Roasted-BF | Roasted buckwheat flour |
| White-BF | White buckwheat flour |
| Dark-BF | Dark buckwheat flour |

*Mineral analysis*

Pea and buckwheat flour samples were dry-ashed in concentrated $HNO_3$ vapours and re-dissolved in 3% HCl for K, P, Ca, Mg, Fe, Cu, Zn, Mn and Mo detection.Ca, Mg, Fe, Cu, Zn and Mn contents were measured by Atomic Absorption Spectrophotometry (AAS) AAnalyst 700 (Perkin-Elmer, Singapore) and acetylene-air flame (Methods of Soil Analysis, 1982). K was detected with the flame photometer JENWAY PFPJ. The contents of P, Mo, N, S and B were determined with a spectrophotometer JENWAY 6300 (Rinkis et al, 1987). Each sample was analysed thrice.

*Vitamin analysis*

Vitamin $B_1$ content was determined according to AOAC Official Method 986.27; vitamin $B_2$ was measured by AOAC Official Method 970.65.

*Statistical analysis*

The results were analysed using the analysis of variance (ANOVA). T-test was applied to compare the mean values, and p-value at 0.05 was used to determine the significant differences.

## Results and Discussion

Table 2 shows the composition of five macro-elements, i.e., calcium, phosphorus, potassium, magnesium and sulphur, and calcium phosphorus rate in pea and buckwheat flour.

There were variations in the contents of some minerals between pea and buckwheat flour, and among the varieties of buckwheat flour. A relatively higher content of macro-elements, except magnesium and sulphur, was found in pea flour than in buckwheat flour. These conclusions are confirmed by Suliburska and Krejpcio (2014) that the best sources of bioaccessible minerals seem to be leguminous grains. However the results of macro-elements in pea flours were lower than those reported by Iqbal et al. (2006) and Amarakoon et al. (2012). Generally the highest contents of these minerals were determined in organic-PF, followed by conventional-PF, roasted-BF, raw-BF, WF, dark-BF, while they were the lowest in white-BF.

Within buckwheat flour samples the concentrations of Ca, P, K, Mg and S showed a wide range of value, reflecting the influence of processing conditions applied during the production of flour. Roasted-BF had the highest content of phosphorus, potassium, magnesium and sulphur while dark-BF – calcium. However, the concentrations of calcium in buckwheat flour were insignificant. Research data confirmed the results of Ikeda et al. (2001) that buckwheat flour was poor in calcium. Acquired data for Ca, P, K and Mg in buckwheat flour were lower than those given in literature (Mota et al., 2016; Ikeda et al., 2005; Ikeda et al., 2001). It could be explained by conclusions reported by Suliburska and Krejpcio (2014) and by Koplík et al. (2004) that minerals content of cereals and leguminous grain products depend on a particular plant variety, cultivars, agriculture practices, soil, climatic conditions, and technological practices applied.

Ca : P ratios in PF and BF were greatly low (from 0.06 for raw-BF to 0.19 for white-BF) except dark-BF (0.69). It revealed a high concentration of phosphorus compared to calcium in PF and BF. Ca : P ratio should not be less than 1.0.

Evaluating the contents of trace elements in pea and buckwheat flour (Figure 1) the highest sums of trace elements were determined for raw-BF and roasted-BF.

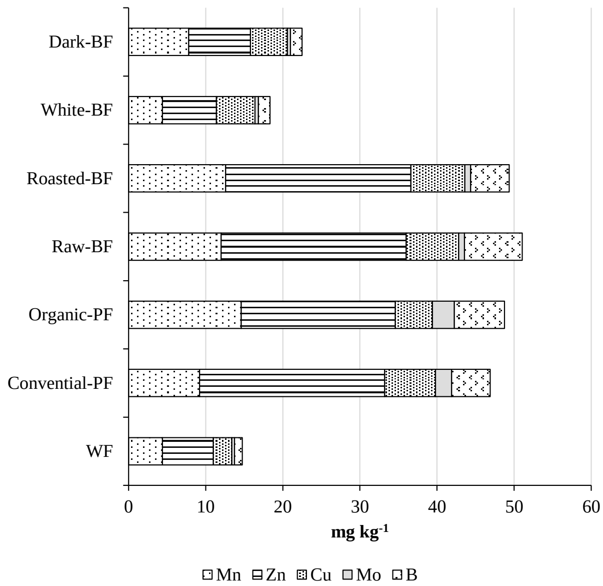


**Figure 1. Content of trace elements in pea and buckwheat flour**

Manganese content in pea flour ranged between 9.2 mg kg$^{-1}$ for conventional-PF and 14.6 mg kg$^{-1}$ for organic-PF, in buckwheat flour – 4.4 mg kg$^{-1}$ for white-BF and 12.6 mg kg$^{-1}$ for roasted-BF. The results for raw-BF and roasted-BF were similar to those reported by Mota et al. (2016) for raw buckwheat, whereas the results for pea flour were lower than those reported by Iqbal et al. (2006) for peas.

Table 2

**Contents of certain macro-elements in pea and buckwheat flour**

| Samples | Ca | P | K | Mg | S | Ca:P ratio |
|---|---|---|---|---|---|---|
| | mg 100 g$^{-1}$ | | | | | |
| WF | 0.15 | 0.65 | 1.80 | 0.26 | 0.75 | 0.23 |
| Conventional-PF | 0.45 | 4.01 | 12.20 | 1.20 | 0.94 | 0.11 |
| Organic-PF | 0.58 | 3.23 | 12.40 | 1.26 | 0.81 | 0.18 |
| Raw-BF | 0.13 | 2.35 | 5.80 | 1.98 | 1.25 | 0.06 |
| Roasted-BF | 0.16 | 2.44 | 6.00 | 2.18 | 1.31 | 0.07 |
| White-BF | 0.10 | 0.54 | 1.76 | 0.46 | 0.63 | 0.19 |
| Dark-BF | 0.35 | 0.51 | 1.78 | 0.48 | 0.56 | 0.69 |

Zinc content in pea flour ranged between 20.0 mg kg$^{1}$for organic-PF and 24.0 mg kg$^{-1}$ for conventional-PF, while in buckwheat flour – 7.0 mg kg$^{-1}$ for white-BF and 24.0 mg kg$^{-1}$ for raw- and roasted-BF. Comparing zinc content in PF in this research with literature data, these results showed lower contents than those mentioned by Amarakoon et al. (2012) – 32–35 mg kg$^{-1}$for zinc in field peas. Results of raw- and roasted-BF were higher than those reported by Mota et al. (2016) but similar to those indicated by Ikeda et al. (2001).

Copper content in pea flour ranged from 4.8 mg kg$^{-1}$ in organic-PF to 6.6 mg kg$^{-1}$in conventional-PF, while in buckwheat flour – from 4.8 mg kg$^{-1}$ in dark-BF to 7.0 mg kg$^{-1}$ in roasted-BF. These results for pea flour were lower compared to literature (Iqbal et al., 2006) whereas results for buckwheat flour were similar to literature data (Mota et al., 2016).

Molybdenum concentrations in pea flour were 2.1 mg kg$^{-1}$ for conventional-PF and 2.85 mg kg$^{-1}$ for organic-PF, while values of buckwheat flour ranged between 0.4 mg kg$^{-1}$ for dark-BF and 0.75 mg kg$^{-1}$ for raw- and roasted-BF. Results of molybdenum content in pea flour were similar to those given in literature by Koplík et al. (2004) for peas.

Boron content in pea flour was determined 5.0 mg kg$^{-1}$ for conventional-PF and 6.5 mg kg$^{-1}$ for organic-PF, while in buckwheat flour it ranged from 1.5 mg kg$^{-1}$ for white- and dark-BF to 7.5 mg kg$^{-1}$ for raw-BF.

Pea and buckwheat flour showed significantly higher content of trace elements compared to wheat flour, except white-BF for Mn, Zn, Mo, B, and dark-BF for Mo and B.

The highest sum of trace elements among pea flour was determined for organic-PF. However organic-PF had significant higher content of manganese compared to conventional-PF ($p<0.05$).

Statistical analysis showed that there were insignificant ($p>0.05$) differences in the contents of Mn, Zn, Cu, Mo and B between raw- and roasted-BF. However they were rich in above mentioned trace elements compared to white- and dark-BF.

Comparing Latvian recommended dietary intakes (RDI) for essential minerals (established by Latvia Ministry of Health) with trace element content in raw- and roasted-BF it could be concluded that 100 g of buckwheat flour can provide about 40 to 42% for manganese, about 17% for zinc, about 23% for cooper and about 30% for molybdenum of RDI for adults. Evaluating organic- and conventional-PF 100 g of them can provide about 31 to 49% for manganese, about 14 to 17% for zinc, about 16 to 23% for cooper and about 84 to 114% for molybdenum of RDI.

Iron content in pea and buckwheat flour is presented in Figure 2.

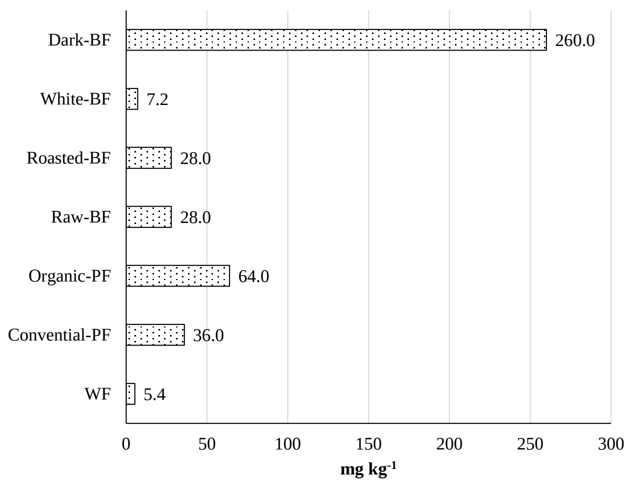


**Figure 2. Iron content of pea and buckwheat flour**

Iron content for pea flour ranged between 36.0 mg kg$^{1}$ for conventional-PF and 64.0 mg kg$^{-1}$for organic-PF while for buckwheat flour – between 7.2 mg kg$^{-1}$ for white-BF and 260.0 mg kg$^{-1}$ for dark-BF. Results of iron content in pea flour were close to those reported by Amarakoon et al. (2012). These data clearly showed that pea flour is substantial source of iron and 100 g of organic-PF can provide 64% for iron of Latvian RDI for males and 36% for females. Similar conclusions are indicated by Amarakoon et al. (2012).

Evaluating iron content among buckwheat flour there were determined significant ($p<0.05$) differences between raw-, roasted-BF and white-BF as well as raw-, roasted-, white-BF and dark-BF. Iron content of raw- and roasted-BF (28.0 mg kg$^{-1}$) was close to those reported by Mota et al. (2016) and Suliburska and Krejpcio (2014) for raw buckwheat. Surprising result was showed by dark-BF with iron content 260.0 mg kg$^{1}$. It could be explained by the presence of bran in buckwheat flour. Bonafaccia et al. (2003) indicated that buckwheat bran exhibited the properties of an excellent food material.

Results indicated that buckwheat flour could be good source of iron, especially dark-BF. 100 g of raw- and roasted-BF can provide 28% of iron of Latvian RDI for males and 16% for females whereas 100 g of dark-BF – 260% for males and 144% for females.

Figure 3 shows B group vitamin concentration in pea and buckwheat flour.

$B_1$ vitamin content in pea flour was 0.80 mg 100 g$^{-1}$for organic-PF and 1.11 mg 100 g$^{-1}$for conventional-PF while the highest content of $B_1$ vitamin among buckwheat flour was determined in roasted-BF followed by raw-BF, white- and dark-BF.

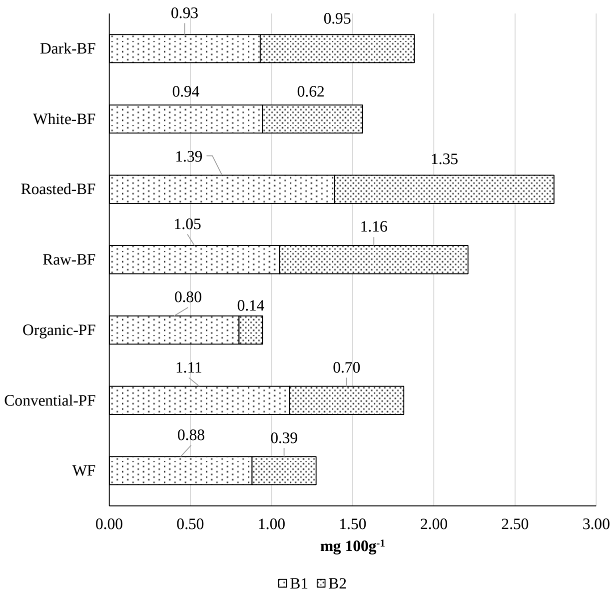


**Figure 3. Contents of vitamins $B_1$ and $B_2$ in pea and buckwheat flour**

All studied samples showed higher concentration of vitamin $B_1$ except organic-PF compared to wheat flour (0.88 mg 100 $g^{-1}$). It could be concluded that buckwheat flour and conventional-PF are excellent source of vitamin $B_1$. Latvian RDI for vitamin $B_1$ is 1.2 mg per day therefore 100 g of raw-BF can provide 87.5%, roasted-BF – 116%, white-BF – 78%, dark-BF – 77.5% and conventional-PF – 92.5%.

Evaluating vitamin $B_2$ content there was determined significantly higher ($p<0.05$) content of this vitamins in pea and buckwheat flour except organic-PF compared to wheat flour. In addition roasted-BF showed the highest content ($p<0.05$) similar to vitamin $B_1$. Buckwheat flour except white-BF showed higher concentration of vitamin $B_2$ compared to pea flour. Latvian RDI for vitamin $B_2$ is 1.6 mg per day therefore 100 g of raw-BF can provide 72.5%, roasted-BF – 84%, dark-BF – 59%.

Results of both vitamins in buckwheat flour were higher than those reported by Bonafaccia et al. (2003) for common and tartary buckwheat flour.

## Conclusions

Pea flour had low macro-element content but they are rich in trace elements and can provide substantial part of recommended di intake for iron, manganese, copper and molybdenum. Conventional-PF was a good source of vitamins $B_1$ and $B_2$ compared to wheat flour.

Substantial indicator which influences mineral and vitamin content in buckwheat flour was the type of flour (raw, roasted, white or dark). Buckwheat flour was poor in content of macro-elements but rich in trace elements. Dark-BF was excellent source of iron and roasted-BF – of vitamins $B_1$ and $B_2$.

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