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SCIENCE DIRECT®

Food Chemistry 95 (2006) 116–122

Food Chemistry

www.elsevier.com/locate/foodchem

Vitamins B in grain and cereal–grain food, soy-products and seeds

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Received 30 August 2004; received in revised form 6 December 2004; accepted 6 December 2004

Abstract

The present study provides information about the concentrations of vitamins B (thiamine, riboflavin, pyridoxine and niacin) in cereal and soy-products, grain and seeds. The concentrations of vitamins were determined by microbiological analytical methods. The results demonstrated that there are great differences in vitamin B composition within varieties of the analysed products. Whole grain products and seeds, are better sources of the vitamin B group than technologically processed products, and therefore more nutritionally efficacious.

Keywords: Vitamins B (thiamine, riboflavin, pyridoxine and niacin); Grain; Cereal foods; Soy-products; Seeds

1. Introduction

Grain and cereal–grain food products constitute an important part of the human diet, providing a high proportion of carbohydrates, proteins, fats, dietary fibres, B-group vitamins and minerals. In many countries they find increasing use in dietetic formulations for treatment and prevention of diabetes, cardiovascular diseases, cancer of colon and lowering of blood cholesterol levels, which indicates their possible therapeutic value for humans. They are essential material for the modern food industry in the production of functional food ingredients (Gawęcki & Hryniewiecki, 1998).

The most recent European guidelines on cardiovascular disease prevention in clinical practice were announced in 2003 (De Backer et al., 2003). It was emphasised then that making healthy food choices is an integral part of total risk management. Everyone should receive professional advice on food and food choices to compose a diet associated with the lowest risk of cardiovascular disease. General recommendations are to encourage people to consume fruits and vegetables, whole grain cereals and bread, low fatty products and fish. In a traditional Polish diet, the greatest components are groats and whole grain products. Cereal products are an important source of a variety of nutrients, including vitamins B (De Backer et al., 2003).

The aim of the study was to determine the contents of thiamine, riboflavin, vitamin B_6 and niacin in grain, cereal, grain and cereal products and seeds, by considering percentages of realization of the recommended allowances (RDA) of the vitamins B by adult persons.

2. Materials and methods

Food samples analysed in this study were randomly obtained from the local market in Gdansk (Poland).

Various (2 g) samples were finely homogenised. A single extraction procedure for thiamine, riboflavin and niacin was carried out using 0.1 N HCl (30 min, 121 °C), while for vitamin B_6 extraction involved 0.055 N HCl (4 h, 121 °C) and enzymatic digestion with diastase by a mixture of papain. Concentrations of vitamins were determined by a microbiological analytical

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0308-8146/$ - see front matter
doi:10.1016/j.foodchem.2004.12.024

Table 1
Accuracy and precision achieved for the analysed vitamins B

Vitamin	Recovery (%)	Relative error (%)	Standard deviation (%)
Thiamine	89.5	−10.5	9.7
Riboflavin	96.9	−3.1	1.0
Pyridoxine	101	+1.3	8.1
Niacin	90.2	−9.8	9.2

procedure based on the following test organisms: *Lactobacillus fermentum* ATCC 9338 for thiamine (Freed, 1966), *Lactobacillus casei* ATCC 7469 for riboflavin (AOAC, 1993), *Saccharomyces uvarum* ATCC 9080 for vitamin B_6 (Eitenmiller & Landen, 1999; Kall, 2003) and *Lactobacillus plantarum* ATCC 8014 for niacin (AOAC, 1980) using Thiamine Assay Medium, Riboflavin Assay Medium, Pyridoxine Y Medium and Niacin Assay Medium (Difco, Becton Dicenson Co.), respectively. Standards for vitamins, such as thiamine hydrochloride, riboflavin, pyridoxine hydrochloride and nicotinic acid, were purchased from Fluka (Biochemica Co.). All other chemicals and reagents were purchased from Merck and Fluka. All analyses were performed in duplicate and the data obtained were expressed as means ± SD and range. The methods were validated during analyses with respect to accuracy and precision (Table 1). The accuracy was determined as recovery of thiamine hydrochloride, riboflavin, pyridoxine hydrochloride and nicotinic acid, added to samples prior to extraction and calculated as the total vitamin.

3. Results and discussion

3.1. General

The analysed products were characterised by a variable content of vitamins: B_1, B_2, B_6 and niacin (Tables 2 and 3).

3.2. Thiamine

The highest contents of thiamine were determined in dry sunflower seed, roasted sunflower seed and dry sesame seed (1.05, 0.550 and 0.716 mg/100 g, respectively). Thiamine contents of soybean, soybean sprouts, soy flour and soy chops were 0.912, 0.415, 0.711 and 0.418 mg/100 g of product, respectively (Table 3). Grain–cereal products were rich in thiamine, especially barley, buckwheat groats and millet (0.356, 0.388, 0.307 mg/100 g, respectively). Thiamine content in roasted buckwheat groats is lower by about 60% than in unroasted buckwheat groats (Table 2).

Rice is a good source of vitamin B_1, especially brown rice, long-grained brown rice, wild rice and parboiled rice containing 0.216, 0.264, 0.226 and 0.182 mg/100 g, respectively (Table 2). In other kinds of rice and rice products, the thiamine content decreases significantly. Only enriched rice groats are a very good source of thiamine (0.938 mg/100 g).

The concentrations of thiamine in corn and corn products were different. Its lowest content was observed in canned corn (0.008–0.020 mg/100 g), and highest in puffed roasted corn and corn flour (0.279 and 0.173 mg/100 g). Thiamine content decreased sharply in processed products, in contrary to whole grain–cereal products.

Vitamin B_1 was the vitamin most sensitive to canning. Martin-Belloso and Lianos-Barriobero (2001) have reported that the vitamin B_1 content, during the canning process, decreased to 53%. Part of the variability is also due to differences in techniques, such as methods of collecting samples and styles of cooking; Lisiewska, Korus, and Kmiecik (2002) have proved that, after cooking, frozen seeds, prepared from the raw material at the same maturity degree as the canned product, contained 40–97% more thiamine.

Thiamine deficiency is rare in developing countries except for patients who take total parenteral nutrition without any thiamine supplementation or have an eating disturbance or suffer alcoholism. However, Ozawa, Homma, Arisawa, Fukuuchi, and Handa (2001) have suggested that thiamine deficiency should be considered in the differential diagnosis of a patient with congestive heart failure who leads a normal life.

3.3. Riboflavin

Riboflavin (vitamin B_2) concentration is higher in dry linseed, roasted linseed, sunflower seed, roasted sunflower seed, pumpkin seed and roasted pumpkin seed containing 0.567, 0.260, 0.272, 0.449, 0.833 and 1.59 mg/100 g, respectively. Soybean, as well as some soy-products (soybean sprouts, soy flour, soy flakes and soy chops) are also rich in riboflavin. Similarly to thiamine, vitamin B_2 content in canned products was also lowered about 20%, as observed by Lisiewska et al. (2002). Riboflavin is very sensitive to processing conditions, especially light and heat (Rachmani & Muller, 1996). Prodanov, Sierra, and Vidal-Valverde (2004) have studied the effects of soaking in different solutions, and cooking, on thiamine, riboflavin and niacin contents of legumes. The authors have proved that vitamin losses depend on conditions in which technological process is conducted. The vitamin losses can reach 51–61% for thiamine, 66% for riboflavin and 61–78% for niacin in different kinds of legumes.

The contents of vitamin B_2 in the analysed grains and groats were variable but the highest ones were noticed in buckwheat flour and groats (0.210 and 0.132 mg/100 g, respectively). A similar level of this vitamin in

Table 2
The concentrations of B vitamin in grain, grain and cereal products in mg/100 g (means ± SD and range)

Variety	*N**	Vitamin B_1 (thiamine)	Vitamin B_2 (riboflavin)	Vitamin B_6 (pyridoxine)	Niacin
Sweet corn, frozen	6 × 21	0.058 ± 0.041 (0.053–0.065)	0.055 ± 0.003 (0.043–0.062)	0.148 ± 0.01 (0.137–0.157)	1.66 ± 0.33 (1.32–1.97)
Whole canned corn[a]	6 × 20	0.011 ± 0.003 (0.008–0.014)	0.089 ± 0.007 (0.081–0.095)	0.115 ± 0.003 (0.111–0.118)	1.69 ± 0.08 (1.60–1.74)
Whole canned corn[b]	6 × 19	0.018 ± 0.003 (0.015–0.020)	0.039 ± 0.011 (0.028–0.051)	0.064 ± 0.004 (0.060–0.068)	0.75 ± 0.16 (0.58–0.89)
Whole canned corn[c]	6 × 21	0.013 ± 0.001 (0.012–0.013)	0.047 ± 0.01 (0.035–0.054)	0.126 ± 0.018 (0.115–0.146)	0.85 ± 0.04 (0.80–0.87)
Corn groats	4 × 8	0.058 ± 0.005 (0.053–0.063)	0.045 ± 0.018 (0.025–0.058)	0.151 ± 0.009 (0.144–0.161)	1.21 ± 0.01 (1.20–1.22)
Corn grits	6 × 18	0.093 ± 0.004 (0.089–0.096)	0.051 ± 0.004 (0.048–0.055)	0.219 ± 0.011 (0.207–0.221)	0.84 ± 0.02 (0.81–0.85)
Corn groats, "Quick one minute"	4 × 6	0.030 ± 0.004 (0.027–0.034)	0.055 ± 0.009 (0.047–0.064)	0.195 ± 0.018 (0.15–0.22)	0.80 ± 0.04 (0.75–0.83)
Corn flour	6 × 18	0.173 ± 0.003 (0.169–0.175)	0.067 ± 0.008 (0.059–0.075)	0.332 ± 0.014 (0.33–0.347)	1.50 ± 0.07 (1.43–1.57)
Corn puffed, roasted	6 × 23	0.297 ± 0.015 (0.28–0.301)	0.076 ± 0.007 (0.071–0.084)	0.331 ± 0.016 (0.314–0.346)	1.26 ± 0.12 (1.18–1.40)
Corn flakes, enriched[a]	6 × 14	1.37 ± 0.147 (1.28–1.54)	1.68 ± 0.14 (1.53–1.81)	2.19 ± 0.065 (2.12–2.24)	30.6 ± 2.49 (28.41–33.33)
Corn flakes, enriched[b]	6 × 19	1.01 ± 0.011 (0.997–1.02)	1.18 ± 0.11 (1.06–1.28)	1.83 ± 0.11 (1.72–1.94)	16.4 ± 0.53 (15.66–16.95)
Corn flakes, enriched[c]	6 × 24	2.48 ± 0.182 (2.29–2.65)	1.78 ± 0.045 (1.73–1.82)	4.93 ± 0.25 (4.64–5.09)	32.58 ± 1.05 (31.41–33.36)
Corn flakes[a]	6 × 19	0.049 ± 0.007 (0.043–0.057)	0.056 ± 0.001 (0.055–0.057)	0.15 ± 0.017 (0.13–0.16)	1.62 ± 0.03 (1.581–1.64)
Corn flakes[b]	6 × 16	0.044 ± 0.002 (0.043–0.046)	0.056 ± 0.005 (0.051–0.06)	0.14 ± 0.029 (0.11–0.16)	1.05 ± 0.09 (0.95–1.13)
Rice, parboiled	6 × 14	0.182 ± 0.002 (0.180–0.184)	0.021 ± 0.001 (0.02–0.022)	0.183 ± 0.008 (0.178–0.192)	4.06 ± 0.19 (3.93–4.29)
Rice, white basmati	5 × 13	0.053 ± 0.001 (0.052–0.054)	0.026 ± 0.009 (0.016–0.034)	0.104 ± 0.019 (0.088–0.125)	0.97 ± 0.06 (0.91–1.02)
Rice, polished	5 × 21	0.032 ± 0.003 (0.028–0.034)	0.031 ± 0.004 (0.027–0.034)	0.135 ± 0.007 (0.129–0.142)	1.10 ± 0.01 (1.09–1.10)
Rice, long-grained	6 × 20	0.006 ± 0.001 (0.006–0.007)	0.025 ± 0.008 (0.020–0.034)	0.106 ± 0.004 (0.103–0.110)	0.58 ± 0.05 (0.55–0.64)
Rice, brown	6 × 16	0.216 ± 0.008 (0.210–0.226)	0.05 ± 0.004 (0.046–0.053)	0.254 ± 0.013 (0.241–0.267)	4.36 ± 0.09 (4.29–4.46)
Rice, brown, long-grained	6 × 19	0.264 ± 0.006 (0.260–0.271)	0.063 ± 0.002 (0.062–0.065)	0.225 ± 0.002 (0.222–0.226)	5.38 ± 0.16 (5.22–5.54)
Rice, wild	12 × 35	0.226 ± 0.004 (0.221–0.230)	0.192 ± 0.049 (0.149–0.256)	0.461 ± 0.028 (0.44–0.504)	4.68 ± 0.22 (4.34–4.97)
Rice flour	3 × 15	0.043 ± 0.001 (0.042–0.043)	0.028 ± 0.056 (0.016–0.034)	0.086 ± 0.001 (0.085–0.087)	0.89 ± 0.06 (0.86–0.96)
Rice, instant	3 × 16	0.082 ± 0.004 (0.077–0.085)	0.024 ± 0.001 (0.024–0.025)	0.122 ± 0.003 (0.12–0.125)	1.54 ± 0.04 (1.51–1.59)
Rice groats, enriched	3 × 17	0.938 ± 0.04 (0.898–0.978)	0.023 ± 0.002 (0.021–0.025)	0.171 ± 0.014 (0.156–0.182)	7.69 ± 0.53 (7.22–8.27)
Natural rice cakes	6 × 33	nd	0.047 ± 0.008 (0.039–0.057)	0.245 ± 0.016 (0.235–0.263)	4.02 ± 0.37 (3.65–4.45)
Barley	4 × 18	0.356 ± 0.012 (0.344–0.369)	0.136 ± 0.031 (0.109–0.170)	0.262 ± 0.012 (0.250–0.275)	4.07 ± 0.15 (3.92–4.23)
Barley, pearled	4 × 12	0.174 ± 0.013 (0.161–0.188)	0.090 ± 0.008 (0.083–0.099)	0.203 ± 0.009 (0.194–0.210)	3.35 ± 0.21 (3.12–3.53)
Buckwheat groats	4 × 12	0.388 ± 0.005 (0.380–0.392)	0.132 ± 0.03 (0.113–0.151)	0.463 ± 0.032 (0.431–0.495)	4.89 ± 0.44 (4.48–5.36)
Buckwheat groats, roasted	8 × 25	0.185 ± 0.008 (0.178–0.193)	0.106 ± 0.006 (0.096–0.118)	0.347 ± 0.057 (0.292–0.407)	4.41 ± 0.17 (4.25–4.56)
Buckwheat flour	6 × 19	0.268 ± 0.014 (0.248–0.282)	0.210 ± 0.087 (0.162–0.310)	0.416 ± 0.027 (0.384–0.450)	4.22 ± 0.20 (4.04–4.50)
Buckwheat flakes	4 × 16	0.015 ± 0.007 (0.014–0.015)	0.087 ± 0.001 (0.08–0.089)	0.162 ± 0.001 (0.161–0.164)	4.46 ± 0.21 (4.25–4.65)
Millet	4 × 16	0.307 ± 0.004 (0.303–0.311)	0.078 ± 0.003 (0.075–0.082)	0.456 ± 0.002 (0.454–0.459)	4.29 ± 0.05 (4.24–4.34)
Millet groats	8 × 26	0.206 ± 0.013 (0.188–0.216)	0.06 ± 0.017 (0.045–0.085)	0.303 ± 0.078 (0.227–0.392)	4.74 ± 0.06 (4.68–4.8)

[a,b,c] – Products originated from different food companies.
nd – Not detected.
*N** – Number of samples × number of subsamples.

Table 3
The concentrations of B vitamins in soybean, soy-products and seeds in mg/100 g (means ± SD and range)

Variety	N*	Vitamin B_1 (thiamine)	Vitamin B_2 (riboflavin)	Vitamin B_6 (pyridoxine)	Niacin
Soybean, dry	10 × 32	0.912 ± 0.022 (0.886–0.935)	0.320 ± 0.01 (0.31–0.33)	0.523 ± 0.043 (0.50–0.60)	2.16 ± 0.24 (1.87–2.32)
Soybean, canned	6 × 18	0.054 ± 0.005 (0.048–0.057)	0.087 ± 0.011 (0.079–0.1)	0.22 ± 0.055 (0.16–0.26)	0.32 ± 0.13 (0.24–0.48)
Soybean sprouts, raw	4 × 14	0.415 ± 0.004 (0.411–0.42)	0.164 ± 0.004 (0.16–0.168)	0.335 ± 0.005 (0.33–0.34)	0.91 ± 0.01 (0.90–0.92)
Soybean sprouts, canned	6 × 20	0.014 ± 0.002 (0.012–0.017)	0.054 ± 0.003 (0.05–0.057)	0.11 ± 0.011 (0.10–0.12)	0.30 ± 0.05 (0.26–0.36)
Soy flour	6 × 19	0.711 ± 0.015 (0.701–0.722)	0.395 ± 0.015 (0.380–0.410)	0.53 ± 0.055 (0.50–0.60)	1.86 ± 0.09 (1.79–1.97)
Soy flakes	4 × 13	0.114 ± 0.002 (0.112–0.117)	0.275 ± 0.015 (0.260–0.291)	0.36 ± 0.025 (0.33–0.38)	1.13 ± 0.01 (1.13–1.14)
Tofu	6 × 18	0.061 ± 0.006 (0.055–0.067)	0.036 ± 0.003 (0.033–0.039)	0.055 ± 0.06 (0.05–0.06)	0.16 ± 0.01 (0.16–0.17)
Soy milk, powdered	6 × 20	0.25 ± 0.013 (0.235–0.26)	1.04 ± 0.01 (1.03–1.05)	0.300 ± 0.025 (0.285–0.310)	0.51 ± 0.08 (0.42–0.56)
Soy milk, UHT	6 × 18	nd	0.098 ± 0.002 (0.096–0.10)	0.045 ± 0.001 (0.044–0.046)	0.11 ± 0.01 (0.10–0.12)
Soy chops	10 × 33	0.418 ± 0.056 (0.366–0.485)	0.335 ± 0.025 (0.310–0.36)	0.45 ± 0.041 (0.38–0.475)	1.97 ± 0.26 (1.67–2.25)
Linseed, dry	6 × 20	0.095 ± 0.002 (0.087–0.098)	0.567 ± 0.02 (0.544–0.591)	0.395 ± 0.02 (0.375–0.425)	1.88 ± 0.08 (1.75–1.94)
Linseed, roasted	10 × 32	0.231 ± 0.04 (0.200–0.251)	0.260 ± 0.02 (0.225–0.287)	0.406 ± 0.02 (0.375–0.438)	1.78 ± 0.10 (1.68–1.92)
Poppy seed, dry	10 × 31	0.132 ± 0.01 (0.120–0.137)	0.214 ± 0.05 (0.206–0.266)	0.438 ± 0.03 (0.425–0.475)	0.89 ± 0.14 (0.78–1.09)
Poppy seed, dry	8 × 25	0.258 ± 0.03 (0.240–0.305)	0.168 ± 0.01 (0.153–0.175)	0.335 ± 0.01 (0.325–0.338)	0.76 ± 0.03 (0.73–0.81)
Sunflower seed, dry	10 × 36	1.049 ± 0.05 (0.995–1.109)	0.272 ± 0.02 (0.250–0.301)	0.688 ± 0.05 (0.650–0.750)	3.59 ± 0.06 (3.50–3.63)
Sunflower seed, roasted[a]	6 × 18	0.550 ± 0.05 (0.511–0.601)	0.243 ± 0.02 (0.220–0.275)	0.775 ± 0.05 (0.725–0.850)	4.31 ± 0.15 (4.13–4.50)
Sunflower seed, roasted[b]	6 × 20	0.217 ± 0.02 (0.203–0.237)	0.449 ± 0.02 (0.416–0.475)	0.830 ± 0.02 (0.800–0.860)	3.71 ± 0.09 (3.63–3.75)
Sesame seed, dry[a]	16 × 50	0.716 ± 0.06 (0.633–0.775)	0.228 ± 0.01 (0.221–0.233)	0.558 ± 0.01 (0.550–0.575)	6.70 ± 0.18 (6.50–6.84)
Sesame seed, dry[b]	10 × 30	0.627 ± 0.04 (0.575–0.680)	0.168 ± 0.01 (0.162–0.175)	0.317 ± 0.01 (0.310–0.320)	5.54 ± 0.15 (5.44–5.75)
Pumpkin seed,	6 × 21	0.370 ± 0.06 (0.301–0.422)	0.833 ± 0.02 (0.667–0.975)	0.171 ± 0.02 (0.158–0.200)	3.12 ± 0.12 (2.84–3.38)
Pumpkin seed, roasted	8 × 26	0.081 ± 0.01 (0.075–0.088)	1.587 ± 0.09 (1.48–1.656)	0.587 ± 0.03 (0.533–0.600)	3.40 ± 0.09 (3.30–3.50)
Amaranth seed	10 × 26	0.029 ± 0.001 (0.028–0.03)	0.132 ± 0.027 (0.104–0.179)	0.563 ± 0.033 (0.523–0.606)	1.02 ± 0.06 (0.95–1.08)
Amaranth flour	10 × 30	0.021 ± 0.001 (0.02–0.023)	0.100 ± 0.017 (0.081–0.123)	0.615 ± 0.017 (0.587–0.626)	1.14 ± 0.07 (1.10–1.24)
Amaranth seed, expanded	4 × 12	0.019 ± 0.002 (0.016–0.022)	0.143 ± 0.003 (0.14–0.145)	0.586 ± 0.039 (0.543–0.609)	1.20 ± 0.06 (1.12–1.26)

[a, b] – Products originated from different food companies.
nd – Not detected.
N* – Number of samples × number of subsamples.

buckwheat flour was observed by Bonafaccia, Marocchini, and Kreft (2003). Rice and rice products contain small amounts of riboflavin (including wild rice, i.e. 0.192 mg/100 g). Natural brown rice contains twice higher levels of riboflavin than other kinds of rice and rice products, i.e. up to 0.063 mg/100 g.

3.4. Pyridoxine

Vitamin B_6 (pyridoxine) levels were relatively high in all the analysed products. Table 3 shows that the seed samples were rich in vitamin B_6; its average concentrations in roasted sunflower seed and dry sunflower were up to 0.86 and 0.75 mg/100 g, respectively. Soya products such as dry soybean, soy flour, soy chops, soy flakes and soybean sprouts, containing from 0.60 to 0.34 mg/100 g, are also a good source of pyridoxine. Soybeans are unique among the legumes because they are rich in protein, low in saturated fat, high in complex carbohydrates and fiber; they are also a good source of vitamins B and isoflavones (Messina, 1997). The concentrations of B_6 in processed products were generally smaller, as has been observed by other authors (Lassen, Kall, & Ovesen, 2002; Martin-Belloso & Lianos-Barriobero, 2001). The lowest mean concentration of vitamin B_6 (0.055 mg/100 g) was detected in tofu (Table 3). This fact is of great importance to those who are on a diet rich in plant proteins. Soybean and soy-products are the basis for a vegetarian diet. In Poland, as in other countries, there is a growing interest in such types of diet. Ziemlański, Wartanowicz, and Pawlicka (1995) have reported presence of a vitamin deficiency risk, both in the population of vegetarians and in consumers on usual mixed diets. The risk of overall deficiency of vitamin B_6 was higher in a non-vegetarian group than in vegetarians (60% and 48%, respectively).

Among grain–cereal products, high mean levels of vitamin B_6 were determined in buckwheat groats, flour and millet, namely 0.463, 0.416 and 0.456 mg/100 g, respectively. The ranges of pyridoxine levels in corn, corn products, rice and rice products were different. The highest concentrations of this vitamin (up to 0.347 mg/100 g) were observed in corn flour, puffed corn, and roasted and corn grits (Table 2). Cornflakes (enriched) contained an order of magnitude higher levels (2.19, 1.83 and 4.93 mg/100 g, respectively). Corn flakes, similarly to natural corn, contained 0.16 mg/100 g of this vitamin. Rice (wild) and brown rice were also rich in vitamin B_6 (up to 0.504 mg/100 g). Kennedy and Burlingame (2003) have reviewed the literature data on nutrient composition of rice varieties. They have demonstrated that there are large differences in nutrient composition, including the vitamin B group, within varieties of rice.

Pyridoxine deficiency appears to be an independent predictor of coronary artery disease. Pyridoxine is effective (along with folic acid and vitamin B_{12}) in the reduction of blood plasma homocysteine levels and in the decrease of the rate of retenosis after coronary angioplasty. The administration of pyridoxine to the group assigned to folate treatment could have contributed to the improvement seen with folate therapy (Schnyder, Roffi, Pin, & Flammer, 2001; Wartanowicz, 1993).

3.5. Niacin

The term niacin is commonly used relative to the two forms of vitamin B_3, i.e. nicotinic acid and nicotinamide. Tables 2 and 3 indicate that the highest concentrations of this vitamin were detected in sesame seeds, sunflower seeds, pumpkin seeds (up to 6.84 mg/100 g), brown rice and wild rice (up to 5.54 mg/100 g) and in barley, buckwheat and millet groats (up to 5.36 mg/100 g). In the other examined products, the niacin content was rather low.

Niacin is incorporated as nicotinamide adenine dinucleotides, to form the prosthetic group of some enzymes, involving in the electron transfer reactions of the respiratory chain and oxidative phosphorylation. Nicotinic acid protects against cardiovascular disease. Among different treatments, there is an example of simvastatin–niacin therapy used for cardiovascular protection in patients with coronary disease and low plasma levels of high-density lipoprotein (HDL) cholesterol (Brown, Zhao, Chait, & Fisher, 2001). The authors have proved that simvastatin plus niacin provides market clinical and angiographically measurable benefits to patients with coronary disease and low HDL levels.

Table 2 shows data concerning products enriched in vitamins. Their concentrations in enriched corn flakes and rice groats are comparable to the Polish recommended dietary allowance (RDA) of the vitamin group B (Ziemlański, 2001).

Table 4 demonstrates percentage realisation of the dietary allowance (RDA) of vitamins B for adult persons relative to the analysed products which are characterised by the highest vitamin contents. Grain, cereal, soybean and seed products can provide the human organism with contents of vitamins B_1, B_2, B_6 and niacin corresponding to 11.3–48.0%, 5.1–21.9%, 19.2–38.8% and 8.0–31.9% of RDA, respectively.

The vitamin B status in a healthy population is generally satisfactory, but the status among high-risk populations with decreased intake or increased needs, may be low. Both intakes and status of vitamins B have been found to be insufficient in some elderly populations (Deijen, van der Beek, Orlebeke, & van den Berg, 1992). One of their features is susceptibility to heat treatment and technological processing. The human organism has no tendency to accumulate those vitamins and that is why, in order to comply with daily recommendation intake, products enriched in group B vitamins

Table 4
Percentage of realization of the recommended dietary allowance (RDA) of vitamins B calculated for adult persons (Ziemlański, 2001)

Variety (100 g)	Vitamin B_1 (%)		Vitamin B_2 (%)		Vitamin B_6 (%)		Niacin (%)	
	Male	Female	Male	Female	Male	Female	Male	Female
Rice wild	11.3	11.9	7.4	10.6	19.2	23.0	20.3	22.3
Buckwheat groats	19.4	20.4	5.1	7.3	19.3	23.1	21.3	23.3
Soybean	45.6	48.0	12.3	17.8	21.8	26.2	9.4	10.3
Soy flour	35.6	37.4	15.2	21.9	22.1	26.5	8.0	8.9
Sunflower seed, roasted	26.3	28.9	9.3	13.5	32.3	38.8	18.7	20.5
Sesame seed, dry	35.8	37.7	8.8	12.7	23.3	27.9	29.1	31.9

should be included in every meal. Providing the organism with all the vitamins B avoids risk of deficiency (Gawęcki & Hryniewiecki, 1998).

The results of our investigations have demonstrated that there are large differences in vitamin composition within varieties of cereal–grain products. Whole grain products, which besides higher vitamin B content also have low glycemic indices are the most profitable. These products have been reported to control glucose tolerance and reduce insulin problems (Brand-Miller, Holt, Pawlak, & McMillan, 2002; Foster-Powell & Miller, 2002; Hallfrisch & Behall, 2000; Montonen, Knekt, Järvinen, Aromaa, & Reunanen, 2003).

Nutritionists, dietetitians and health educators are partly responsible for a lack of interest and attention to differentiation of diets within crop varieties (Kennedy & Burlingame, 2003). Professional dietary advice, reduction of body weight and increased physical activity should be the first treatments, aiming at good glucose control and keeping the cardiovascular risk low (De Backer et al., 2003).

Tables 2 and 3 confirm other authors' findings that natural products are an incomparably better source of vitamins B than those technologically processed (El, 1999; Hallfrisch, Muller, & Andres, 1996). Most countries promote the enrichment of foods with the purpose of correcting nutritional deficiencies of the population.

The analysed grain products and seeds proved to be an important source of a variety of nutrients, including vitamins B.

Groats, including buckwheat (Bonafaccia, Gambelli, Fabjan, & Kreft, 2003) have potential as functional foods and as ''ethnic'' foods of local traditions in our country. In Poland, and some other European countries, groats as well as bread fortified with buckwheat, whole grains or seeds, constitute the main part of a daily diet (Bonafaccia et al., 2003; Tas & El, 2000). Recently, public interest in such types of functional food products is rapidly increasing.

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