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professional paper

Dietary Fiber in Whole Grain and Enriched Bread

Dijetna vlakna punozrnatog i obogaćenog kruha

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Summary

The aim of this research was to evaluate the whole grain bread and the enriched bread with the stress on the amount of dietary fiber: total, soluble and insoluble. In twelve repetitions there were analysed five sorts of whole grain bread among which there were two enriched ones. The samples were analysed for the content of water, ash, starch, protein and fat by the standard methods. The dietary fiber was defined on the basis of modified AOAC method of Prosky. It was established that the analysed samples contain from 7.11–9.40 g/100 g of total dietary fiber and 1.16–3.1 g/100 g of soluble dietary fiber. The enriched sorts of whole grain bread contain the highest amount of dietary fiber. All analysed sorts of bread are appropriate for the nutrition of diabetics as well as for the everyday protective human nutrition because of their chemical composition, whole grain structure and high amount of dietary fiber.

Sažetak

Cilj je ovog rada ocijeniti punozrnati i obogaćeni kruh, osobito prema količini dijetnih vlakana: ukupnih, topljivih i netopljivih. Tri uzorka punozrnatog kruha i dva uzorka obogaćenog punozrnatog kruha analizirani su u 12 ponavljanja. U uzorcima je određena količina vode, pepela, škroba, proteina i masti standardnim metodama. Dijetna vlakna određena su AOAC–metodom po Proskyu. Utvrđeno je da ispitivani uzorci sadržavaju 7,11–9,40 g/100 g ukupnih dijetnih vlakana i 1,16–3,1 g/100 g topljivih dijetnih vlakana. Obogaćene vrste punozrnatog kruha sadržavaju najveću količinu dijetnih vlakana. Svi ispitivani uzorci kruha pogodni su za prehranu dijabetičara, kao i za svakodnevnu »zdravu« prehranu ljudi zbog svog kemijskog sastava, punozrnate strukture i velike količine dijetnih vlakana.

Introduction

The dietary importance of fiber is well documented and recognized all over the world. In recent years, dietary fiber has become a buzz word among the general public food processors and ingredient suppliers because of its role in nutrition and in reduced-calorie foods. Originally the term dietary fiber has been proposed to describe the *»remnants of plant cells (to be found in human food) which are resistant to hydrolysis by alimentary enzymes of man.«* Dietary fiber is neither a single nor a simple entity that can be defined as a chemical. Dietary fiber is a generic term in the biological sense, which refers to a class of structurally related compounds exhibiting unique properties *(1)*. Structurally, dietary fibers are composed of carbohydrates or oxidized carbohydrates of plant origin. First the term of dietary fiber comprised lignin, cellulose, and other nonstarch, noncellulose polysacharides. The latter group includes pectins, β-glucans, and various hemicelluloses. Being chemically heterogenous, dietary fiber has different chemical and physical properties. Some components are soluble, whereas others are insoluble, some have a high water-holding capacity, whereas others have a low or no water-holding capacity. Some fiber sources yield larger proportions of soluble fiber than others. The main physiological effects of dietary fiber are primarily on gastric emptying and small intestinal transit time, resulting in an improved glucose tolerance and a decreased digestion of starch; second, on colonic transit time and large bowel functions due to fermentation by ceco-colonic microbial flora or bulking action. The soluble dietary fiber is fermented to a large ex-

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tent by a wide variety of anaerobic bacteria that result in an increase in bacterial biomass, an increase in fecal mass, a change in intracolonic pH, and production of short chain fatty acids and various gases as metabolic end products. The insoluble fibers are only marginally fermented; they serve almost exclusively as bulking agents that result in shorter transit time and increased fecal mass *(1)*.

There are several methods of dietary fiber analysis, some of them are gravimetric whereas others are chemical methods. Both types of methods employ a series of steps to selectively extract nonfiber component from the test material. The fiber residues are then measured by gravimetric procedures or with a series of specific assays. The essential differences of all methods are: measurement of soluble and insoluble fiber from the same sample and calculation the of total dietary fiber or measurement of total dietary fiber from a separate sample from that used to measure soluble dietary fiber. Vollendorf and Marlett *(2)* established that gravimetric and chemical methods, with some exceptions, generally measure similar amounts of dietary fiber in oats. They suggested that, when detailed information about chemical components is not required, the quicker gravimetric methods are acceptable methods for measurement of dietary fiber.

Many new food sorts on the market today are high in fiber. High-fiber breads are being produced by several companies, and some new cereals contain corn bran. Diabetic patients can exploit the findings that high-carbohydrate, high-fiber diets often can lower postprandial glucose swings and thus reduce the need for insulin *(3)*. In future high-fiber products – such as bread, waffles, meat-loaf mix, pasta, snack crackers, sugarless syrup and jams could possibly lead to better glucose tolerance and lower cholesterol. Bakery products, particularly breads, are considered the best vehicle to increase dietary fiber content. Attempts have been made to utilize wheat bran, corn bran, oat bran, soybean bran or hulls, triticale bran, alpha-cellulose, guar-gum, coconut residues, potato peels, field pea hulls and edible brewers spent grains for increasing the dietary fiber content of breads.

Eksperimental

Five samples of bread intended for the nutrition of diabetics as well as for the everyday protective human nutrition were chosen from the market: three samples of whole grain bread were denoted as $\mathbf{a}_1$ $\mathbf{a}_2$ and $\mathbf{a}_3$, two samples of enriched bread were denoted as $\mathbf{b}_1$ and $\mathbf{b}_2$ and analysed them in twelve repetitions for:

- water: by drying at 105 °C,
- ash: by burning at 600 °C,
- fat: by Soxhlet,
- protein: by Kjeldahl,
- starch: by Baumann-Grossfeld, and
- dietary fiber, by an enzymatic-gravimetric method, recently modified to allow the determination of the soluble (SDF) and insoluble (IDF) fractions *(4)*. The principle of this method is an enzymatic removal of starch and protein and gravimetric determination of fiber residues as soluble and as insoluble dietary fiber. Total dietary fiber was calculated as the sum of the soluble and insoluble fractions.

Results and Discussion

Table 1 presents results for the analysis of chemical components carried out in five bread samples.

Table 1. Chemical compositions of the whole grain bread and enriched bread (g/100 g)
Tablica 1. Kemijski sastav punozrnatog i obogaćenog kruha (g/100 g)

Sample Uzorci n = 12	Water Voda	Starch Škrob	Total fiber Cijel.vlak.	Protein Bjelanč.	Fat Masti	Ash Pepeo
$\mathbf{a}_1$	45.74	34.66	7.41	8.48	0.52	1.86
$\mathbf{a}_2$	39.63	40.62	7.58	8.94	0.56	1.74
$\mathbf{a}_3$	38.57	40.17	7.11	10.16	0.61	1.71
$\mathbf{b}_1$	36.82	35.44	8.74	15.89	0.50	2.11
$\mathbf{b}_2$	37.20	33.52	9.40	16.33	0.48	2.26

$\mathbf{a}_1$, $\mathbf{a}_2$ and $\mathbf{a}_3$ – whole grain bread
$\mathbf{a}_1$, $\mathbf{a}_2$ and $\mathbf{a}_3$ – punozrnati kruh
$\mathbf{b}_1$, and $\mathbf{b}_2$ – enriched whole grain bread
$\mathbf{b}_1$, and $\mathbf{b}_2$ – punozrnati obogaćeni kruh

The water content varied from 36.82 g/100 g in sample $\mathbf{b}_1$ to 45.74 g/100 g in sample $\mathbf{a}_1$. The starch ranged from 33.52 g/100 g in sample $\mathbf{b}_2$ to 40.62 g/100 g in sample $\mathbf{a}_2$. Both samples of enriched whole grain bread had the highest content of total dietary fiber (8.74 and 9.40 g/100 g) and the highest content of protein (15.89 and 16.33 g/100 g). All analysed samples had the fat content below 1 g/100 g and the ash content between 1.71 – 2.26 g/100 g.

Table 2. The results of dietary fiber analyses in the whole and enriched bread (g/100 g)
Tablica 2. Rezultati dijetnih vlakana punozrnatog i obogaćenog kruha (g/100 g)

	$\mathbf{a}_1$	$\mathbf{a}_2$	$\mathbf{a}_3$	$\mathbf{b}_1$	$\mathbf{b}_2$
Total fiber Cjelokupna vlakna	7.41	7.58	7.11	8.74	9.40
Insoluble fiber Netopljiva vlakna	6.25	5.30	4.62	6.43	6.22
Soluble fiber Topljiva vlakna	1.16	2.28	2.49	2.31	3.18

The results of dietary fiber analyses are summarized in Table 2. Total dietary fiber of the whole grain bread samples ranged from 7.11 g/100 g to 7.58 g/100 g, while in enriched whole grain bread it was between 8.74 g/100 g and 9.40 g/100 g. The soluble fiber in the whole grain bread samples was from 1.16 g/100 g to 2.49 g/100 g, and in enriched bread between 2.31 g/100 g and 3.18 g/100 g. The calculated percent of soluble dietary fiber in the total dietary fiber were: 15.65 % (sample $\mathbf{a}_1$) 26.43 % (sample $\mathbf{b}_1$), 30.08 % (sample $\mathbf{a}_2$), 33.83 % (sample $\mathbf{b}_2$) and 35.02 % (sample $\mathbf{a}_3$). These proportions corresponded with the statements of Vollendorf and Marlett *(5)* that soluble fiber in the grain products comprised (21 ± 7) % of the total dietary fiber and that the content of soluble dietary fiber was higher in remarked and cooked foods *(6)*.

Table 3. Statistic parameters of the results of total fiber analyses in the whole grain and enriched bread
Tablica 3. Statistički parametri za cjelokupna vlakna punozrnatog i obogaćenog kruha

	a_1	a_2	a_3	b_1	b_2
$\bar{x}$ (n = 12)	7.41	7.58	7.11	8.74	9.40
SD	0.50	0.59	1.26	1.13	1.01
CV/ %	6.75	7.79	17.72	12.93	10.74
L_{min}	6.89	6.95	5.79	7.56	8.43
L_{max}	7.93	8.19	8.43	9.92	10.46

$F_{tab}\left(\frac{4,25}{0,05}\right) = 2.76$ $F_{izr} = 6.39$ $F_{izr} > F_{tab}$

Table 4. Statistic parameters of the results of soluble fiber analyses in the whole and enriched bread
Tablica 4. Statistički parametri za topljiva vlakna punozrnatog i obogaćenog kruha

	a_1	a_2	a_3	b_1	b_2
$\bar{x}$ (n = 12)	1.16	2.27	2.49	2.31	3.18
SD	0.20	0.90	0.93	0.98	1.43
CV/ %	17.24	39.65	37.35	45.42	44.97

Table 5. The results of total dietary fiber analyses in the whole and enriched bread (g/100 g dry matter)
Tablica 5. Rezultati cjelokupnih vlakana punozrnatog i obogaćenog kruha (g/100 g suhe tvari)

	a_1	a_2	a_3	b_1	b_2
$\bar{x}$ (n = 12)	13.58	12.55	11.30	14.01	14.99
SD	0.67	0.97	2.24	1.81	1.72
CV/ %	4.94	7.74	19.85	12.94	11.46
L_{min}	12.88	11.53	8.95	12.11	13.19
L_{max}	14.28	13.57	13.65	15.91	16.80

$F_{tab}\left(\frac{4,25}{0,05}\right) = 2.76$ $F_{izr} = 11.18$ $F_{izr} > F_{tab}$

The statistic F-test showed that there were statistically significant differences among the contents of total dietary fiber in analysed bread samples. The variability coefficients (CV) between the results of total dietary fiber were from 6.75 % to 17.72 %.

Statistic analysis showed that the soluble dietary fiber was more variable than total dietary fiber. The lowest CV was 17.24 % and the highest CV was 45.42 %. So we can confirm the statements (Vollendorf and Marlett 1991) about unacceptable variable fiber measurements of Prosky.

It was established that the differences among the content of water of analysed bread samples were statistically significant, so we calculated the total dietary fiber on the dry matter.

The results in Table 5 and calculated F-test showed that all analysed bread samples were statistically significantly differentiated with respect to the content of total dietary fiber when they are calculated on the dry matter base. In 100 g of dry matter of analysed bread samples from 11.30 g/100 g to 14.98 g/100 g of total dietary fiber was found. Coeficients of variation (CV) were between 4.94 and 19.85 %.

Conclusions

The amount of dietary fiber in the discussed whole grain and enriched breads was between 7.11 and 9.40 g/ /100 g, which corresponds with the data in nutritional Tables. Southgate (7), e.g., found 8.5 g of dietary fiber in 100 g of whole grain bread. The soluble fiber determined (between 1.16 and 3.18 g/100 g) has special meaning as it binds water and makes the contents of small intestine more viscose and therefore slows down the absorption of carbohydrates and other components. The protein content varies considerably (8.48 to 16.33 g/100 g) while all analysed samples contain very little fat, less than 1 g/100 g and inorganic residues (1.71–2.6 g/100 g). On the basis of these results and the physical bread structure itself, which is rough grained, it can be concluded that the discussed breads are suitable for diabetics as well as for protective human diet in general.

The cited authors mentioned that it is possible that the total dietary fiber values determined by AOAC method were greater than those determined by another chemical method. Two reasons can be cited for this. One is the incomplete removal of starch from the fiber residue. Second are simple sugars which may coprecipitate with the fiber in 80 % ethanol. However, differences in the fiber contents are due to analytical differences rather than to differences in food variety.

References

1. M. Roberfroid, *Food Sci. Nutr. 33* (1993) 103.
2. N. W. Vollendorf, J. A. Marlett, *Cereal Foods World, 36* (1991) 565.
3. D. F. Owen, R. H. Cotton, *Cereal Foods World, 27* (1982) 519.
4. L. Prosky, N. G. Asp, T. F. Schweizer, J. W. Devries, I. Fruda, *J. Assoc. Off. Anal. Chem. 71* (1988) 1017.
5. N. W. Vollendorf, J. A. Marlett, *J. Food Compos. Anal. 6* (1993) 203.
6. J. L. Rosado, P. Lopez, Z. Huerta, E. Munos, L. Mejla, *J. Food Compos. Anal. 6* (1993) 215.
7. A. A. Paul, D. A. T. Southgate, *The Composition of Foods*, Elsevier, London (1982) p. 42.