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ORIGINAL ARTICLE

BAKERY PRODUCTS AS A SOURCE OF TOTAL DIETARY FIBRE IN YOUNG ADULTS

Renata Markiewicz-Żukowska[*], *Justyna Moskwa, Krystyna Gromkowska-Kępka, Emilia Laskowska, Jolanta Soroczyńska, Justyna Tomczuk, Maria Halina Borawska*

Medical University of Bialystok, Faculty of Pharmacy with Division of Laboratory Medicine, Department of Bromatology, Białystok, Poland

ABSTRACT

Background. Bakery products are a source of bioactive compounds, such as dietary fibre (DF), whose proper supply plays an important role in prevention of civilisation diseases.

Objective. The aim of the present study was to determine total dietary fibre (TDF) content in bakery products and their contribution to TDF supply.

Material and Methods. The determination of TDF content was performed using enzymatic-gravimetric method in 72 samples of six types of bakery products (wholemeal rye bread, wheat-rye bread, wheat-rye bread with grains, toast bread, crispbread, rolls) included in the young adults diet. Simultaneously, frequency of bakery products consumption and their contribution to TDF supply were assessed based on dietary interview questionnaires carried out among 224 students from Poland. Index of nutritional quality (INQ) of examined bakery products was calculated.

Results. Our data indicate that average TDF content depended on the type of bakery products and ranged from 2.19 g/100 g in rolls to 11.80 g/100 g in wholemeal rye bread. All of the tested types of bakery products, except rolls, were a good source of fibre (INQ≥1), but the richest were wholemeal rye and wheat-rye with grains breads. Analysis of questionnaires data showed that bakery products were regularly consumed by 80% of young adults; however, most of whom preferred rolls. Consumption of bakery products covered current recommendations for dietary fibre in 27%. Daily intake of bakery products and TDF was not correlated with student's BMI, however, women frequently consuming bread had a lower BMI than those who rarely ate it.

Conclusion. Wholemeal rye and wheat-rye with grains breads are the rich source of TDF and they should be consumed by young adults in order to achieve the recommended TDF values.

Key words: *dietary fibre, bakery products, enzymatic-gravimetric method, dietary interview questionnaire, students*

STRESZCZENIE

Wprowadzenie. Pieczywo jest źródłem bioaktywnych składników, w tym również błonnika pokarmowego (DF), którego prawidłowa podaż z dietą odgrywa istotną rolę w prewencji chorób cywilizacyjnych.

Cel. Oznaczenie zawartości całkowitego błonnika pokarmowego (TDF) w różnych rodzajach pieczywa i określenie udziału tych produktów w dostarczaniu błonnika z dietą.

Materiał i Metody. Oznaczenie zawartości TDF metodą enzymatyczno-grawimetryczną wykonano w 72 próbach sześciu rodzajów pieczywa (chleb razowy żytni, chleb mieszany pszenno-żytni, chleb mieszany z ziarnami, chleb tostowy, chleb chrupki i bułki), których konsumpcję deklarowali studenci uczestniczący w badaniu. Częstość i wielkość spożycia poszczególnych rodzajów pieczywa oraz ich udział w dostarczaniu błonnika określono na podstawie wywiadu żywieniowego przeprowadzonego wśród 224 polskich studentów. Wyznaczono również wartość wskaźnika jakości żywieniowej (INQ) badanych produktów.

Wyniki. Wykazano, że zawartość błonnika pokarmowego całkowitego zależała od rodzaju pieczywa i wynosiła średnio od 2,19 g/100 g w bułkach do 11,80 g/100 g w chlebie razowym żytnim. Wszystkie badane rodzaje pieczywa, za wyjątkiem bułek, były dobrym źródłem błonnika (INQ≥1), przy czym najbogatszym był chleb razowy żytni i chleb mieszany z ziarnami. Na podstawie analizy danych ankietowych stwierdzono, że 80% studentów regularnie spożywało pieczywo, ale najczęściej wybierali oni bułki. Spożywane przez badanych studentów pieczywo zapewniało pokrycie zapotrzebowania na błonnik w 27%. Nie stwierdzono korelacji pomiędzy ilością błonnika spożywanego z pieczywem a wartościami BMI studentów, jednak kobiety często spożywające pieczywo miały niższe BMI niż spożywające rzadko.

Wniosek. Chleby razowy żytni i mieszany z ziarnami są bogatym źródłem błonnika i ich spożycie powinno być młodym osobom zalecane w celu pokrycia zapotrzebowania na ten składnik.

Słowa kluczowe: *błonnik pokarmowy, pieczywo, metoda enzymatyczno-grawimetryczna, wywiad żywieniowy, studenci*

[*]**Corresponding author:** Renata Markiewicz-Żukowska, Medical University of Bialystok, Faculty of Pharmacy with Division of Laboratory Medicine, Department of Bromatology, Mickiewicza street 2D, 15-222 Białystok, Poland, Tel./Fax: +48 857485469, e-mail: bromatos@umb.edu.pl

INTRODUCTION

Cereal products are a staple food eaten all over the world and they should constitute a dominant portion of a diet. Statistical data [10] indicate that in Poland bread is consumed in the highest quantity from all cereal-based products. It is an integral part of the human diet as it provides carbohydrates including dietary fibre (DF), protein, minerals, vitamins and many other bioactive compounds.

European Food Safety Authority (EFSA) dietary guideline recommendations for fibre intake are various depending on age [6]. The dietary reference values present established adequate intake (AI) values for women and men 19 years or older as 25 g/day [13]. *Hamulka* et al. [12] evaluated the intake of dietary fibre in Polish households in years 1996-2005. It has been shown that the average intake of dietary fibre in total in the period was about 24 g/day per person and varied over a wide range of 19.9 to 28.5 g/day. According to representative studies of food consumption in Poland conducted by *Szponar* et al. [23], the intake of DF in Polish adults varies from 25 to 34 g/day in men and from 19 to 20 g/day in women. It should be noted that men over 60 years of age consume significantly less DF than men aged 20-30 years. Furthermore, questionnaire survey indicated that among older people with diverticulosis of the colon the consumption of dietary fibre was two times lower (12.6 g/day) than recommended in the standard [27].

Decreased intake of DF is associated with an increased risk of overweight and obesity, diabetes, inflammation, hypertension, cardiovascular diseases, certain cancers and constipation [1, 5, 15, 17, 20, 25, 28]. In accordance with various studies, improved body weight management is linked to higher intake of DF. In an observational study, looking at the effects of overall diet on the body composition in obese and lean subjects, it was demonstrated that lean men and women showed significantly higher fibre intake as opposed to obese men and women (27.0 g/day and 22.7 g/day vs 22.0 g/day and 15.0 g/day, respectively) [18]. *Chuang* et al. [4] in the international research assessed the relation between fibre intake, mortality and cause–specific mortality. Higher fibre intake was connected with lower mortality. The above association was more obvious for fibre from cereals and vegetables than from fruit.

The aim of the present study was to determine TDF content in different types of bakery products and their contribution to TDF supply in young adults diet.

MATERIALS AND METHODS

Dietary interview questionnaires were carried out among 224 students aged between 19 and 26 (mean age 22.2±1.7 years) from Medical University of Bialystok during the period of 2013-2015. Most of them (86%) were women. Respondents represented academic community of Faculty of Pharmacy with the Division of Laboratory Medicine and Faculty of Health Sciences. The participants were required to be free of diet-related health problems and to be consuming their usual mixed diets. Participants were informed about the objectives of the study and the questionnaire was also explained.

TDF was determined in 72 samples collected in the north-east Poland in 2013. Six types of bakery products which consumption was declared by students in their questionnaires were selected (wholemeal rye bread, wheat-rye bread, wheat-rye bread with grains, toast bread, crispbread, rolls). Samples of each bakery product were obtained from different producers and shops on various dates. Each sample was analysed individually by triplicate.

The following standard and chemicals were used: certified reference material (Dried Bran Breakfast Cereal ERM-BD518, IRMM, Geel, Belgium), sulphuric acid, ammonium sulphate, boric acid, sodium hydroxide, hydrochloric acid (Sigma-Aldrich, Steinheim, Germany).

Ethical considerations

This study was carried out with approval from the Local Bioethical Committee of Medical University of Bialystok (R-I-002/8/2015). Participation was voluntary and anonymous. After having received verbal and written information, all students signed an informed consent form.

Dietary interview questionnaires development

A self-administered questionnaire was used to obtain demographic data, anthropometric measurements, data on the frequency of food consumption and three-day-weighted dietary recording.

The demographic data included age and sex. The students were also asked about eating places (at or away from home). Anthropometric variables such as height, weight were measured to the nearest 0.5 cm and 0.1 kg respectively using height-measuring equipment connected to an electronic scale (AXIS B 150L, Seca, Gdańsk, Poland). The students were wearing light clothing and no shoes. Body mass index (BMI) was calculated as the ratio of weight (kg) to height squared (m^2). BMI was used to assess percentage of students with underweight (<18.5 kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight (25-29.9 kg/m^2) and obesity (≥30 kg/m^2) according to WHO criteria [26].

The food frequency questionnaire was designed to assess habitual intake of bakery products by students. Consumption frequency was measured as occasionally, once per week, 2-3 times per week, 4-6 times per week and every day and frequency ≥4 was recognised as regularly.

Three-day-weighted dietary recording (two working days and one day off) was used to obtain information about kind and amount of consumed bakery products (wholemeal rye bread, wheat-rye bread, wheat-rye bread with grains, toast bread, crispbread, rolls). The amount of bakery products portions consumed by the students was estimated based on the "Photography album of products and dishes" [24]. Taking into account the obtained results (TDF content and amount of consumed portions), the quantity of TDF intake was calculated.

TDF intake values were referred to the current recommendations 25 g/day (AI) [13] and also assessed how many slices/portions of tested bakery products should adults eat to provide the recommended amount of TDF. It was assumed that one standard slice/portion of wholemeal rye bread is 30 g, wheat-rye bread or wheat-rye bread with grains weighs 35 g, toast bread - 26 g, crispbread – 10 g and rolls - 50 g.

Estimation of index of nutritional quality (INQ)

Index of nutritional quality (INQ) determines to what extent a food product covers the daily energy needs and supplies a specific nutrient.

INQ=(A x B)/(C x D), where: A - component content in 100 g; B - standard energy needs (for men and women with medium physical activity, age 19-30 years, weight 60 and 70 kg, respectively) [13]; C - energy value per 100 g of product [16]; D - standard consumption of the component (25 g) [13]. We estimated the INQ taking into account the determined dietary fibre content in the tested bakery products. INQ value ≥1 indicates that the product can be considered as a good source of dietary fibre.

Total dietary fibre determination

The tested products were cut into small pieces and placed in an oven at 105 °C until a constant weight was attained, i.e. when there was no change in a mass after one hour in an oven at 105 °C. Dry products were then ground to a size that would pass through a 0.3 - 0.5 mm mesh. An efficient grinding procedure increases the surface area of the sample and improves the accuracy of results obtained.

TDF in bread was determined by enzymatic-gravimetric method using FOSS Fibertec E system [2]. The protein examination was carried out by the classical Kjeldahl method using Digester K-424 and Distillation Unit K-350 (Buchi, Flawil, Switzerland).

The method of TDF determination was verified using certified reference material ERM-BD518 (IRMM, Belgium). Results of the quality control analyses were consistently categorized as being in good agreement with reference values. The accuracy was 0.39% and coefficient of variance was 1.58%

Statistical analysis

Statistical analyses were performed by Statistica software version 10.0 PL for Windows (StatSoft, Cracov, Poland). Normality was determined using *Shapiro-Wilk* test and by visual inspection of normal probability plots and histograms. *Student's* t-test was used to detect any differences in TDF content for various bakery products. Differences between fibre intake from various bakery products was investigated using U *Mann-Whitney* test. A *p*-value of less than 0.05 was considered statistically significant.

RESULTS AND DISCUSSION

Two hundred and eighteen students (97.3%) declared that they have meals at home. The BMI of young adults varied between 15.9-29.1 kg/m^2 (mean 21.0±2.5 kg/m^2) and was higher ($p<0.05$) in men (23.1±2 kg/m^2) than women (20.7±3 kg/m^2) (Table 1). Categorisation of BMI values showed normal weight in most individuals (79%), underweight in 13% and overweight – 8%.

Analysis of responses concerning frequency of bakery products eating among our university students showed that 46% and 34% respondents ate these products every day and 4-6 times per week, respectively. 14% of students ate 2-3 times per week and 2% - once per week, while 4% - occasionally (Figure 1).

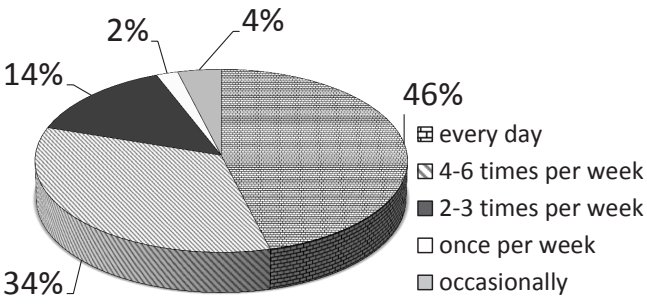

Figure 1. Frequency of bakery products consumption by young adults

The frequency of bakery consumption in this study are similar to those reported by *Bagordo* et al. [3], in which was shown that Italian university students, living at or away from home, consumed bread/cereals 6.2 servings per week. The main sources of DF in a daily diet are cereal products, vegetables, fruit, legume seeds and nuts [19]. Analysis of consumption of DF in Poland in the last decade showed that an important source of the total supply of DF derived from cereal products is bread (84%), including wheat-rye bread (82%), wheat bread (14%) and rye bread (4%) [9]. In accordance with research by *Glodek* et al. [7] also in the students diet the main source of DF was white and dark bread.

Among the cereal products, whole grains and bran are the richest sources of DF [16]. The DF content in bread depends on the type of flour used, but also on the applied technological processes. Using refined flour decreases the DF content and the amount of associated bioactive compounds in bread. Therefore, bread enriched with other sources of fibre such as wholemeal flour, bran, resistant starch, fructan/fructo-oligosaccharides or fibre was used. However, since adding these ingredients affects the properties of dough and bread, it is necessary to modify the bread-making process to achieve desirable effects [22]. Determining DF content in products can be carried out by various methods, which could be also a source of the differences in the results.

Table 1. Consumption frequency of bakery products and young women and men Body Mass Index - BMI (kg/m^2)

Consumption frequency	Female (F)		Male (M)	
	percentage of respondents	BMI (kg/m^2) mean±SD	percentage of respondents	BMI (kg/m^2) mean±SD
every day	47	20.6 ± 2	45	23.0 ± 3
4-6 times per week	34	20.4 ± 2	26	22.9 ± 3
≤ 3 times per week	19	21.7 ± 3[a]	29	23.5 ± 3
Total	100	20.7 ± 3[b]	100	23.1 ± 2

[a]$p_{3/1,2}$; [b]$p_{F/M}$ <0.05

Table 2. Total dietary fibre (TDF) intake with consumed bakery products among young adults

Bakery product	n	Consumption of bakery product per person (g/day) mean±SD (range)	[a] Content of TDF (g/100 g) mean±SD (range)	[b] Fibre intake from bakery product (g/day) mean±SD (range)	[c] Norm realisation (%)
Wholemeal rye bread	12	25.5±37.3 (0.0-200.0)	11.80±0.71 (8.97-14.79) $p_{1/2,4,6}$ <0.05	3.01±4.40 (0.00-23.60) $p_{1/2,3,4,5,6}$ <0.05	12.0
Wheat-rye bread	12	29.9±41.9 (0.0-200.0)	7.06±0.94 (5.62-8.58) $p_{2/3,4,5,6}$ <0.05	2.11±2.96 (0.00-14.12) $p_{2/3,4,5,6}$ <0.05	8.4
Wheat-rye bread with grains	12	3.2±12.0 (0.0-83.3)	10.59±0.91 (6.79-14.55) $p_{3/4,6}$ <0.05	0.34±1.27 (0.00-8.83) $p_{3/5,6}$ <0.05	1.4
Toast bread	12	3.7±13.1 (0.0-84.0)	4.94±0.30 (3.88-5.93) $p_{4/5,6}$ <0.05	0.18±0.65 (0.00-4.15) $p_{4/5,6}$ <0.05	0.7
Crispbread	12	0.6±2.7 (0.0-20.0)	11.44±2.07 (8.80-15.00) $p_{5/6}$ <0.05	0.06±0.30 (0.00-2.27) $p_{5/6}$ <0.05	0.2
Rolls	12	50.8±62.9 (0.0-325.3)	2.19±1.52 (1.00-6.70)	1.11±1.38 (0.00-7.12)	4.4

[a]Values are statistically significantly different according to *Student's* t-test ($p<0.05$)
[b]Values are statistically significantly different according to *U Mann-Whitney's* test ($p<0.05$)
[c]Norm as fibre adequate intake (AI) value for women and men 19 years or older is 25 g/day.
n - number of samples
SD - standard deviation

In this study TDF content in the tested bakery products samples (Table 2) varied between 2.19±1.52 g/100 g and 11.80±0.71 g/100 g. Among all the analysed samples the statistically ($p<0.05$) lowest average content of fibre was found in the rolls and the highest in the wholemeal rye bread. In the studies by *Kasprzak & Rzedzicki* [14] and *Rzedzicki & Kasprzak* [21], the authors examined different types of bread using the same method as in this study and showed similar results for wheat-rye bread, while the wholemeal rye bread and wheat-rye bread with grains show slightly higher values of TDF in comparison to our results.

The average consumption of bakery products per person was presented in Table 2. The obtained data showed that respondents consumed rolls in the largest amount (50.8±62.9 g/day). It provided

1.11±1.38 g/day of TDF, which was significantly less compared to other tested products ($p<0.05$). Whereas, wheat-rye bread and wholemeal rye bread provided significantly more TDF (2.11±2.96 and 3.01±4.40 g/day) than others ($p<0.05$) and were consumed in amounts 29.9±41.9 g/day and 25.5±37.3 g/day, respectively. It was interesting to note that even though the consumption of rolls was the largest, it realised norm (AI) only in 4.4%, while wheat-rye bread - 8.4% and wholemeal rye bread – 12.0%. It is worrying, that the daily consumption of rolls is about 2 times higher than bread's. In accordance with statistical data [10, 11], in the period between 1981 and 2012 in Poland, the consumption of bread per capita decreased by about 49% - from 104 kg to 53 kg. Countries with bread consumption higher than in Poland include Germany, the Czech Republic and Bulgaria. On the contrary, in Great Britain, Norway and Sweden people consume about 20 kg less bread than in Poland. The highest annual bread consumption in the world has been observed in North America and amounted to about 200 kg per capita [8].

Taking into account determined TDF content in bakery products (Table 2) we have found that the products totally supply 6.81 g/day of TDF. Additionally, we estimated that 23, 22 and 19 slices/portions of rolls, crispbread and toast bread should be consumed to cover the daily AI. In case of the wheat-rye bread the same would be achieved by consuming 10 slices of bread, and in case of wheat-rye bread with grains and wholemeal rye bread – 7 slices.

Table 3. Evaluation of different types of bakery products as a source of dietary fibre in young adults diet on the base of Index of Nutritional Quality (INQ)

Type of bread	INQ±SD	
	Female	Male
Wholemeal rye bread	5.3±0.9	6.8±1.2
Wheat-rye bread	2.7±0.4	3.4±0.5
Wheat-rye bread with grains	4.2±0.9	5.4±1.2
Toast bread	1.6±0.2	2.0±0.3
Crisp bread	3.1±0.6	4.0±0.7
Rolls	0.8±0.5	1.0±0.7

SD - standard deviation

Furthermore, we calculated that BMI for all students did not correlate (r=0.08; p=0.25) with daily consumption of bakery products. Moreover, among female students (also did not correlate r=-0.08; p=0.30) who frequently consumed bread BMI was lower than among those who rarely ate it (Table 1).

Additionally, in this study we evaluated the INQ and found that it was higher than 1 in most of the analysed bakery products, beside rolls (Table 3). Based on these results we concluded that the tested bread is a good source of TDF in university students diets.

CONCLUSIONS

In conclusion, this study provides interesting insights into the field of TDF content in bakery products. Our data indicate that wholemeal rye and wheat-rye with grains breads are a rich source of TDF in young adults diets and it should be encouraged in order to achieve the recommended TDF values. The results of our study can help young people improve their diets through a selection of the best source of dietary fibre among bakery products.

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Conflict of interest

The authors declare no conflict of interest.

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