METHODOLOGY OF DIETARY FIBRE DETERMINATION IN GRAIN PRODUCTS

Vija Ozoliņa[1], Ilze Grāmatiņa[2], Daiga Kunkulberga[3]

Latvia University of Agriculture

e- mail: *vro@apollo.lv[1]; IlzeGramatina@inbox.lv.lv[2]; Daiga.Kunkulberga@llu.lv[3]*

Abstract

The dietary fibre is edible parts of plants' carbohydrates that are resistant to digestion in human small intestine. Diets naturally rich in dietary fibre support to prevent constipation, improve gastrointestinal health, glucose tolerance and the insulin response, and reduce the risk of colon cancer, hyperlipidemia, hypertension and other coronary heart disease risk factors. About 45% of the dietary fibre intake comes from grains and grain mixtures. In Latvia, there are neither data, nor investigations of the dietary fibre content in grain products during processing and in the end products in which manufacturers and consumers are interested. The aim of this paper was an approval of dietary fibre determination methodology by using analytical equipment the Full option science system (FOSS) Analytical Fibertec E 1023. The dietary fibre determination experiments were carried out in the Research Laboratory of the Department of Food Technology at the Latvia University of Agriculture in 2009. The Total Dietary Fibre (TDF) content was analyzed in the samples of rye whole grain flour, rye whole grain bread, and wheat biscuit. Experiments showed that the fibre content in rye whole grain flour is 13.8 g 100 g^{-1}, in rye whole grain bread –11.6 g 100 g^{-1}, and in the wheat biscuit –1.9 g 100 g^{-1}. Reached data are comparable with results of other researchers` data.

Key words: dietary fibre, grain products.

Introduction

It is generally believed that E.H. Hipsley in 1953 was the first to use 'dietary fiber' as a term for the nondigestible constituents that make up the plant cell wall. These constituents were known to include cellulose, hemicellulose, and lignin (DeVries et al., 1999).

By 1976, the dietary fibre definition had been broadened to include all indigestible polysaccharides such as gums, modified celluloses, mucilages, oligosaccharides, and pectins (Trowell et al., 1976). It remained primarily a physiological definition, identifying dietary fibre on the basis of edibility and resistance to digestion. The definition was broadened to reflect chemical research findings obtained in the interim years. In alter years scientists began to seek consensus on a dietary fibre definition with the aim to quantify it in foods for nutrition improvement and labeling purposes. By the 1981 workshop of the Association of Official Analytical Chemists (AOAC) in Canada, general consensus had been achieved on methodology that would quantify dietary fibre, as defined by H. C. Trowell in 1976, and adopted in collaborative study by 43 laboratories in 29 countries (Prosky, 1990). The method was adopted by AOAC as the first Official Enzymatic-Gravimetric Method of Analysis for total dietary fibre, in foods-AOAC Official Method 985.29 (Andrews, 1998). After that American Association of Cereal Chemists (AACC) adopted the method as AACC Approved Method 32-05. Also adopted as official methods were: AOAC 992.16, Total Dietary Fiber, Enzymatic Method and AOAC 994.13, Total Dietary Fiber (Determined as Neutral Sugar Residues, Uronic Acid Residues, and Klason Lignin)–Gas Chromatographic–Colometric–Gravimetric Method (Uppsala Method), (Andrews, 1998).

At the end of 90th last century before scientists had realized the International survey of 147 scientists for dietary fibre methodology (DeVries et al., 1999), 65% of the scientists supported the physiological definition; while an additional 5% favored using it in combination with the chemical definition. Fifty nine per cents supported the inclusion of digestion-resistant oligosaccharides in that definition. Workshop participants acknowledged that AOAC 985.29/AACC 32-05 did not quantify non-digestible oligosaccharides. After that, methods were developed to specifically measure oligosaccharides – methods 997.08, 999.03, 2001.02, 2000.11, 2001.03, 2002.02, and (IFST, 2007). Codex Committee on Nutrition and Foods for Special Dietary Uses (CCNFSDU) and International Life Sciences Institute (ILSI) took part in dietary fibre methodology development (ILSI, 2007). The Issue of a definition for dietary fibre has been discussed and debated in the scientific community for many years (ILSI, 2007). A consensus has been developed basing on clear scientific evidence that the definition of dietary fibre should be based on the physiological properties of food constituents, not merely on their physiochemical characteristics. This consensus is reflected in the

original definition developed in CCNFSDU, AACC and numerous other definitions, including US National Academy of Institute of Medicine and Health Council of the Netherlands. Each of these definitions is based on the physiological property of non-digestion and non-absorption in the small intestine, with one or more desirable health effects (ILSI, 2007).

Dietary fibre definition adopted at the 28th Session of CCNFSDU in November 2006 is as follows: 'Dietary fibre means carbohydrate polymers with a degree of polymerization (DP) not lower than 3, which are neither digested nor absorbed in the small intestine. A degree of polymerization not lower than 3 is intended to exclude mono- and disaccharides. It is not intended to reflect the average DP of a mixture. Dietary fibre consists of one or more:

- edible carbohydrate polymers naturally occurring in the food as consumed;
- carbohydrate polymers, which have been obtained from food raw material by physical, enzymatic or chemical means;
- synthetic carbohydrate polymers' (AACC, 2007).

Grain foods provide complex carbohydrates important not only as a source of energy, but also a source of fibre in human diet and therefore a benefit to human health (Poutanen, 2006). Consumers are interested in higher content of dietary fibre in grain products, which improves health because dietary fibres are an extremely beneficial component. There is strong and expanding epidemiological evidence linking high intake of cereal fibre to reduced risk of chronic and cardiovascular disease (Poutanen, 2006). A diet naturally high in fibre helps prevent constipation, reduce the risk of colon cancer, improves gastrointestinal health, effect of satiety, and impacts weight loss by reducing food intake at meals (Leeds, 1982). Such dietary fibre component as β-glucan lowers cholesterol level in blood and effected diabetes disease (Shinnick et al., 1991), but the World Health Organization has recommended that total fibre intake be 25 g day^{-1} (Viscione, 2007).

The aim of this study is to approve the total dietary fibre determination methodology in grain products produced in Latvia according to AOAC standard No. 985.29 using FOSS Analytical Fibertec E 1023 system. At present this method is the most commonly accepted choices for nutrition labeling of fibre content.

Materials and Methods

The experiments were carried out in the Research Laboratory of the Department of Food Technology, Latvia University of Agriculture in 2009. The samples used in experiments were obtained from:

- rye whole grain flour (stock company 'Jelgavas Dzirnavas', Type 1740);
- rye whole grain bread (baked from whole meal grain flour with scalding and sourdough at the Department of Food Technology);
- wheat biscuit (baked from wheat flour Type 405 at the Department of Food Technology).

The total dietary fibre in these samples was determined according to the AOAC approved method No. 985.29 by FOSS Analytical Fibertec E 1023 system (Fig. 1).

Figure 1. FOSS Analytical Fibertec E 1023 System.

The samples of every type were used in duplicates. The samples were defatted and dried with a particle size less than 0.5 mm. After weighing, each sample was enzymatically digested with α amylase and incubated at 100 °C, and then the samples were digested with protease and amyloglucosidase and were incubated at 60 °C. The determination procedure of TDF is shown in Figure 2. After digestion, the total fibre content was precipitated by adding 95% ethanol. Then the solution was filtered and fibre was collected, dried and weighed. The protein and ash content were determined to correct any of these substances which might remain in the fibre. For calculations, basic equation was applied: Content of fibre=residue weight–weight of (protein+ash) (Prosky, 1990).

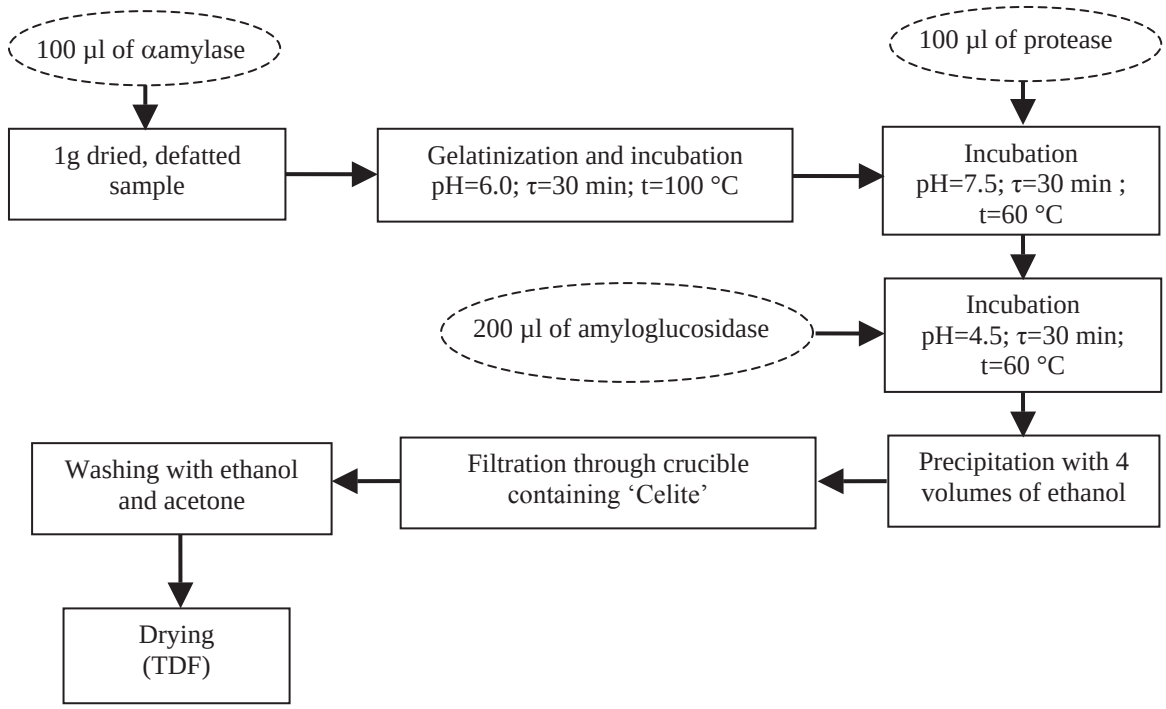

Figure 2. TDF determination procedure.

The experiments were carried out by using enzymatic processing with incubation in a thermostatic shaking water bath. The TDF residues were filtrated by using the Filtration Module. The protein content was determined by using Kjeldahl (AACC, 1995) nitrogen equipment. Each determination process took 2 days.

Results and Discussion

The authors evaluated practice and experience of investigations and found out that factors most impacting determination of dietary fibre are weighing, sample preparing, and residue transfer and practice (Figure 3).

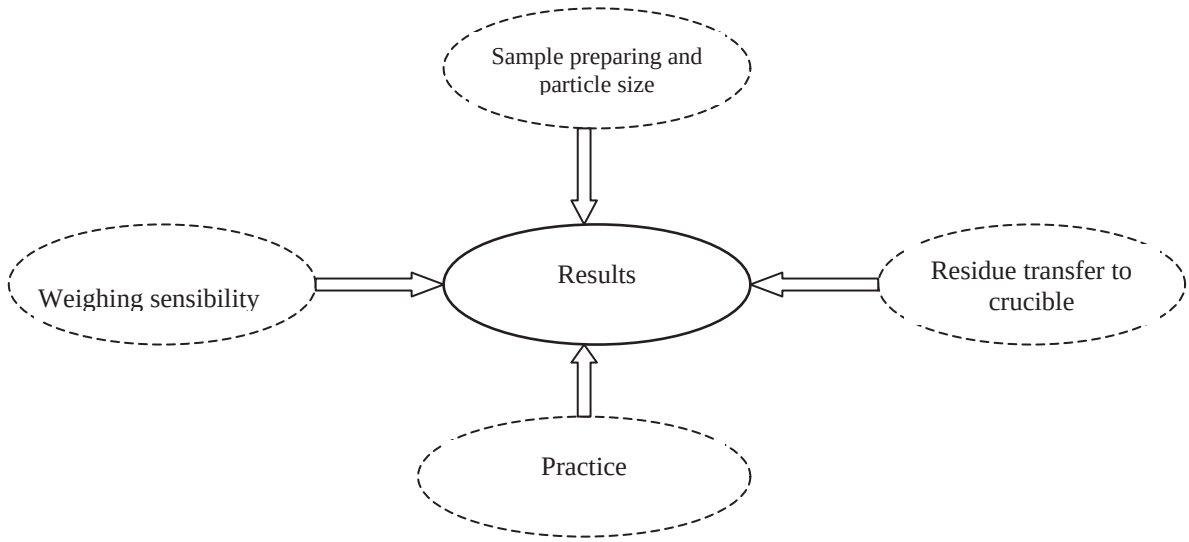

Figure 3. Factors impacting results of dietary fibre content.

In the determination procedure more attention should be devoted to sample preparation and particles transferring degree from precipitate sample to crucible. From our experience, the most attention should be addressed to weighing procedure if gravimetrical methods are applied. To reach comparable analytical results, quality of reagents and enzymes is important, as well as practical arrangements like qualification of involved personnel and major analytical equipment at the same location. It is envisaged to continue the studies of grain and other food products total dietary fiber content determination.

The content of total dietary fibre was determined in rye whole grain flour, rye whole grain bread, and wheat biscuit. The results of total dietary fibre were obtained in three independent repetitions by using FOSS Analytical Fibertec E 1023 system (see Table 1).

Table 1

Results of experiments compared to the literature data

Sample	Experimental data of TDF, g 100 g^{-1}	Literature data of TDF, g 100 g^{-1}		
		Kujala, 1999	Lindhauer, 2005	Fineli, 2008
Rye whole grain flour	13.8±0.7	13.6	–	13.9
Rye whole grain bread	11.6±0.6	9.9	9.0	11.0
Wheat biscuit	1.9±0.1	–	–	1.3

Fibre content in grain depends on corn sort and climatic, growing and harvesting conditions. In the milling process, the kernel can be ground and fractionated into different types of flour. Whole grain rye flour contains all parts of the grain. In the literature it was found that the average dietary fibre content usually is between 12% and 15% of dry matter (Kujala, 1999). This research showed that the amount of total dietary fibre in whole grain rye flour is 13.8±0.7 g 100 g^{-1}.

The fibre content in rye bread is about three times higher (about 8.5 –10 g 100 g^{-1}) than in wheat bread. The latest research data demonstrate that in the rye whole grain bread total dietary fibre content is 11.6±0.6 g 100 g^{-1}. This amount is higher than that in the literature and should be taken into account corn sort, and that bread was baked from whole grain flour.

Wheat biscuit baked from wheat flour 550. Type contains very limited amount of fibre-according Fineli Food Composition Database – 1.3 g 100 g^{-1}. New experimental data 1.9±0.1 g 100 g^{-1} (Table 1) and the literature data demonstrate high comparability.

Conclusions

1. The experiments of total dietary fibre determination show that using Full option science system Analytical Fibertec E 1023 is acceptable and workable to analyze grain products according to standard method AOAC 985.29 for investigations in future.
2. Experimental data demonstrate that fibre content in rye whole grain flour is 13.8±0.7 g 100 g^{-1}, in rye whole grain bread –11.6±0.6 g 100 g^{-1}, and in wheat biscuit –1.9±0.1 g 100 g^{-1}.
3. Reached data are comparable with results of other researchers` data.

References

1. AACC Method 46-12 (1995) Crude Protein–Kjeldahl Method Boric Acid Modification *Approved Methods of the American Association of cereal Chemists*.–9th ed. Vol.I.–St.Paul, Minnesota: AACC Inc. pp. 487-520.
2. AACC (2007) Alinorm 06/29/26. Available at: http://www.aaccnet.org/definitions/labeling.asp, 18.12.2008.
3. Andrews K. (1998) Dietary fiber in National Nutrient Databank: Data and Methods. Available at: http://www.nal.usda.gov/fnic/foodcomp/conf/, 06.01.2009.
4. DeVries J.W., Prosky B., Li B. and Cho S. (1999) A historical perspective on defining dietary fiber. *Cereal Foods World,* 44, pp. 367-369.
5. Fineli (2008) Finnish Food Composition Database, Release 9. Available at: http://www.fineli.fi/foodlist.php?name=B%&lang=en, 16.02.2009.
6. Hipsley E.H. (1953) Dietary 'fibre' and pregnancy toxaemia. *British Medicine Journal*, 2, pp. 420-422.
7. IFST (2007) Dietary fibre. Available at: http://www.ifst.org/uploadedfiles/cms/store/ATTACHMENTS/dietaryfibre.pdf, 10.02.2009.
8. ILSI (2007) ILSI comments on CL 2007/3-NFSDU. Available at: http://www.ilsi.org/NR/rdonlyres/DD84805B-CE7A-4DBD-83E2-2C8C7AF69614/0/CCNFSDUfiberltrSHarris.pdf, 06.01.2009.
9. Kujala T. (1999) Rye: *Nutrition, health and functionality*. Nordic project 'Rye and health', Helsinki, 36 p.
10. Leeds A.R. (1982) Modification of intestinal absorption by dietary fiber and components. In: Vahouny G.V., Kritchevsky D.N.Y (eds) *Dietary Fiber in Health and Disease*. Plenum Press, New York, pp. 57-71.
11. Lindhauer M.G. (2005) Ernährungsphysiologische Bedeutung von Getreide. *Getreidetechnologie, Bochum: BackMedia*, 59/3. pp. 168-172.
12. Poutanen K. (2006) Grain fibre: How to deliver the health benefits. In: Kristiina Ahlgren(ed) *Dietary fibre*, Markprint, Yliopistopaino, Finland, 80 p.
13. Prosky L. (1990) Collaborative study of a method for soluble and insoluble dietary fiber. *Advances in Experimental Medicine and B iology*, 270, pp. 193-203.
14. Shinnick F.L., Mathews R. and Ink S. (1991) Serum cholesterol reduction by oats and other fiber sources. *Cereal Foods World*, 36 (9), pp. 815-821.
15. Trowell H.C., Southgate D.A.T., Wolever T.M.S., Leeds A.R., Gassull M.A. and Jenkins D.J.A. (1976) Dietary fiber redefined. Available at: http://www.aaccnet.org/news/pdfs/DFHistory.pdf, 04.01.2009.
16. Viscione L. (2007) Wellness Foods Europe Dietary Fibre. Available at: http://www.harnisch.com/well/files/pdf/107/dietary_fibre.pdf, 10.02.2009.