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Research article

Kale (*Brassica oleracea* L. var. *acephala*) as a source of dietary fibre

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Abstract: *The aim of the work was to determine dietary fibre content (total, soluble and insoluble) in kale. Packages of the vegetable were bought in local stores in Lodz. Dietary fibre content determined during the research was compared with the information given by producers. Conducted research proved that kale is rich in dietary fibre (from 4.36 to 5.05 g per 100 g of product in fresh weight, mostly in form of insoluble dietary fibre). The results of determinations carried out in the laboratory coincide with the data declared by the producers.*

Keywords: *kale; dietary fibre; TDF; insoluble dietary fibre; soluble dietary fibre; dry matter.*

Introduction

Brassica group is one of the most abundant families of vegetables with even more than 3,500 species included [1]. Among them we can distinguish not only cruciferous vegetables such as broccoli, cauliflower, kale, collard or cabbage, but also other plants like turnip, rapeseed or horseradish.

Kale is known from ancient times, but in Poland, its growth is dated from the XIVth century, even though the plant was not very popular and was mostly treated as decorative because of its ornamental leaves. However, the growing requirements of kale's leaves are benevolent for the majority time of the year in polish weather conditions. The only one demand for its development is providing the plant with a sufficient amount of water. Although presently, kale is consumed more often, it still remains underrated [2].

Brassicaceae have a low caloric value because of their small content of fat and protein in leaves. Also the content of macro- and micronutrients such as minerals (potassium, calcium, magnesium or phosphorous), vitamins (A, C, E, K), polyphenols, glucosinolates and carotenoids (β-carotene, lutein and zeaxanthin) is notable [1-4]. Serving of fresh kale (100 g) can give us the daily intake of micronutrients (potassium – even around 880 mg, calcium – around 300 mg, magnesium – 100 mg) [5]. The same serving of kale can contribute to even

around 7 g of prebiotic carbohydrates such as sugar alcohols, simple sugars or hemicellulose. Moreover, per 100 g of kale, there is ~7 mg of β-carotene, ~62 mg of a vitamin C, and ~2 g of ash [2]. In the case of dietary fiber, literature data vary from 3.8 g/100 g [4] to 8 g/100 g [2]. Raw and cooked leaves of kale are an excellent source of amino acids such as glutamic acid, proline and aspartic acid. [6] Kale is also an excellent source of dietary fibre. Many studies confirm that kale's components are very valuable for human health. Diet rich in fruits and vegetables that are abundant in dietary fibre reduces the risk of cancer and cardiovascular disease. Kale has the potential to reduce micro- and macronutrient deficiencies but also diseases like obesity [3].

According to the newest definition, we can distinguish three types of dietary fibre: naturally occurring in food, obtained from raw food or synthetic carbohydrate polymers. All above-mentioned categories are characterized by their beneficial effect on human health. What is more, those carbohydrate polymers are built from even ten or more monomeric units and are not hydrolyzed by enzymes in the small intestine [7]. We can distinguish two fractions of dietary fibre – soluble and insoluble. To the soluble dietary fibre belong pectins, gums, hemicelluloses, resistant starch and resistant oligosaccharides. In insoluble dietary fibre we can find celluloses, lignins, synthetic polysaccharides and as in SDF – hemicelluloses. Soluble dietary fibre is known from its property of increasing viscosity of digested food material in the intestines. SDF elongates nutrient assimilation including glucose. On the other hand, insoluble dietary fibre is related to the softening of digesta and promotes bowel peristalsis. However, in the food, there are elements of both forms of dietary fibre– SDF and IDF [8].

The daily intake of dietary fibre recommended by World Health Organization/ Food and Agriculture Organization (WHO/FAO) and European Food Safety Authority (EFSA) is 25 g per day [7]. However, in the majority of western countries, the dietary fibre intake is notably lower than the recommendation. The best sources of dietary fibre are fruits, vegetables and products composed of whole grains.

The studies show that dietary fibre has an enormous impact on our health. Diet with a very high amount of dietary fibre may reduce the incidence of evolving colorectal cancer and breast cancer [9]. Research suggests that diet rich in dietary fibre can also effectively diminish the risk of incidence from cardiovascular disease. This action on human health might be related to dietary fibre's impact on the reduction of total serum and low-density lipoprotein cholesterol [10]. Dietary fibre may be also related to a reduction of the development of type 2 diabetes. It is also responsible for decreasing action in fasting blood glucose concentration and a diminished percentage of glycated proteins [11]. Consumption of dietary fibre has an impact on weight loss and prevents obesity [12].

The aim of the study was to determine dietary fibre in kale's packages available in stores in Lodz (a city located in the central part of Poland).

Experimental

Materials

Kale producers (*Brassica oleracea* L. var. *acephala*) have been assigned numbers from 1 to 5, respectively, 3 packages were analyzed for each manufacturer. Plants were bought from local stores in Lodz. In order to obtain a representative average sample, from each package, both leaves and stems were taken. The greens were cut into smaller pieces and ground with a blender. The first part of the samples was taken for dry matter analysis. The second half of the samples were lyophilized with a Christ Alpha 1-2 LD plus lyophilizer (Martin Christ Gefriertrocknungsanlagen GmbH, Germany) for 2 days. Lyophilized leaves were ground with a coffee grinder to 0.3-0.5 mm particles, stored in an air-tight bag in the fridge.

All chemicals were an analytical grade. Thermostable α-amylase, purified protease and purified amyloglucosidase enzymes were from Megazyme assay kit.

Methods

Determination of dry matter

Dry matter was analysed using the gravimetric method. Samples of fresh (2 g), cut into smaller pieces kale were placed in the laboratory drier (Memmert, Germany) at 70°C under vacuum (60 mb) for 16 h. After drying, vessels were weighted and dry matter content calculated.

Determination of dietary fibre

The procedure to determine TDF (total dietary fibre) and IDF (insoluble dietary fibre) was based on the methods (AOAC 985.29 and AOAC 991.42). [13, 14] (see Figure 1), Megazyme Total Dietary Fibre Kit were applied. Protein and ash within the TDF determination were conducted according Kjeldahl method (protein content – AOAC 920.152) and at 525°C (AOAC 940.26), respectively. All determinations were conducted in duplicate and the results were reproducible. The soluble dietary fibre (SDF) was calculated as a difference between TDF and IDF.

Statistical analysis

The changes in dry matter composition and total, soluble and insoluble dietary fibre content were estimated using the one-way analysis of variance ANOVA. The significance of differences was analyzed with the Duncan test at $p \leq 0.05$ with Statistica 10 program by StatSoft, Kraków.

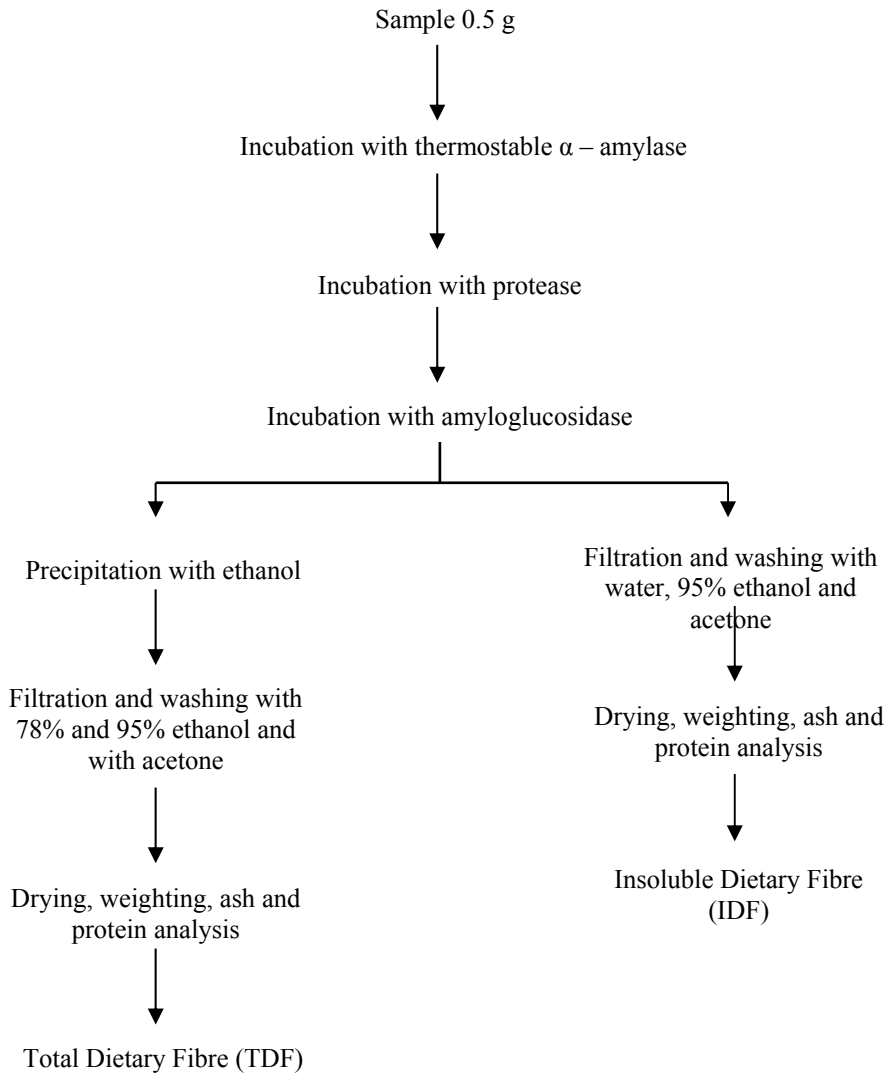

Figure 1. Scheme for the total and insoluble dietary fibre determination procedure

Results and Discussion

The dry matter content is shown in Table 1. The results ranged from 13.22 to 17.17%. The dry matter values of kale from companies 1 and 2 are statistically similar. Also, kale from companies 3 and 5 are comparable with companies 1 and 2, however values related to companies 3 and 5 are statistically distinct from each other. The obtained result of a sample of kale from company 4 is significantly different from the rest. According to research, average dry matter content in raw kale's leaves was 16.42% [15]. The other experiments show range from 15.6 to

21.1% depending on different time of storage [16] or that value of dry matter content can be around 10.4% [17]. The reason why there are such differences in dry matter content values can be related to the large availability of different biological material for this species. During this experiment, samples were examined as an average content from a package and they contained not only leaves but also parts of stems. Research shows that harvesting time of kale has also an impact on dry matter content. Late harvest of kale resulted in higher dry matter composition in comparison with kale harvested earlier [2].

Table 1. Dry matter composition in kale

Kale from company	Dry matter composition [%]
1	13.50±0.21bc
2	13.56±0.00bc
3	13.86±0.18b
4	17.17±0.19a
5	13.22±0.03c

The results of dry matter composition are expressed as mean values. Letters a, b, c indicate that mean values of dry matter content are statistically different at $p \leq 0.05$.

The TDF, IDF, and SDF of kale were also determined (Table 2) TDF content of kale's samples ranged between 4.36 to 5.05 g/100 g in fresh weight and was not statistically different. SDF ranged from 0.12 to 0.74 g/100 g and similarly to TDF, values were not distinct. Only IDF results were statistically different. Its values fluctuated between 3.62 and 4.44 g/100 g. The result of company 5 kale distinguished itself against the rest of the companies. The SDF values are generally lower than IDF and TDF results. According to Sikora and Bodziarczyk dietary fibre values were around 8.39 g/100 g [2]. In Kunachowicz the content of dietary fibre in fresh kale is 3.8 g/100 g and the value is higher than in a cabbage (2.5 g/100 g) or broccoli (2.5 g/100 g) but lower than in green peas (6.0 g/100 g) [4].

Table 2. Total, insoluble and soluble dietary fibre content, g/100 g fresh weight

Kale from company	TDF [g/ 100 g]	IDF [g/100 g]	SDF [g/100 g]
1	4.43 ± 0.03	4.31 ± 0.17a	0.12 ± 0.20
2	4.79 ± 0.16	4.44 ± 0.27a	0.35 ± 0.11
3	4.75 ± 0.02	4.24 ± 0.10a	0.51 ± 0.08
4	5.05 ± 0.54	4.43 ± 0.02a	0.62 ± 0.57
5	4.36 ± 0.02	3.62 ± 0.24b	0.74 ± 0.26

The results of TDF, IDF and SDF are presented as mean values with included standard deviation. Values are calculated as g per 100 g fresh mass of raw kale. Letters a and b indicate that values are statistically different at $p \leq 0.05$.

According to Table 3, values of total dietary fibre that were obtained in a laboratory are moderately similar to those which were taken from the information on the back of the package. Food label from company 1 did not contain any information about energy value or content of fat, protein, mineral

elements or dietary fibre at all. On the other hand, a label from company 3 contained data such as energy value, fat, protein, salt and polysaccharides content. However, it did not show any information about minerals composition. Dietary fibre was also excluded. Also, the division into an SDF and IDF is not mentioned. For consumers it can be a beneficial data thus SDF and IDF have distinct properties for human health.

Table 3. Comparison of total dietary fibre content obtained in a laboratory with information given by a manufacturer

Kale from company	TDF – information from a package [g/100 g]	TDF – result from laboratory [g/100 g]
1	–	4.43 ± 0.03
2	4.00	4.79 ± 0.16
3	–	4.75 ± 0.02
4	5.60	5.05 ± 0.54
5	4.30	4.36 ± 0.02

Values are calculated as g per 100 g of product. Results of TDF obtained from a laboratory are shown as mean values with standard deviation.

Conclusion

The study showed that kale is an excellent source of dietary fibre and its content of TDF ranges from 4.36 to 5.05 g per 100 g of product in fresh weight, mostly in form of insoluble dietary fibre. Packages of a vegetable were bought in stores in Lodz, the values of dietary fibre content from food labels are similar to those obtained by us in the laboratory. The research proved that kale is a valuable source of dietary fibre it is worth including it in a balanced diet.

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