Acta Sci. Pol., Technol. Aliment. 11(4) 2012, 347-354
pISSN 1644-0730 eISSN 1889-9594 www.food.actapol.net/

THE EFFECT OF THERMAL PROCESSING OF CRUCIFEROUS VEGETABLES ON THEIR CONTENT OF DIETARY FIBER AND ITS FRACTIONS

Patrycja Komolka, Danuta Górecka, Krzysztof Dziedzic

Department of Food Service and Catering, Poznań University of Life Sciences
Wojska Polskiego 31, 60-624 Poznań, **Poland**

ABSTRACT

Background. Dietary fiber is composed of many compounds exhibiting various properties. Individual fractions are characterised by a diverse action in the human organism, thus it is crucial to know the fraction composition of dietary fiber. The aim of this study was to determine the effect of thermal processing of cruciferous vegetables on the content of dietary fiber and its fractions.
Material and methods. The experimental material comprised common cabbage cv. *Cilion*, red cabbage cv. *Lektro* and savoy cabbage cv. *Fiona*. Tested various parts of raw material – the whole head of cabbage, leaves and stumps. Cabbages were boiled for 17 min, and steamed for 13 min. Contents of neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to the Van Soest method, while contents of hemicelluloses and cellulose were calculated from the difference between NDF and ADF.
Results. Cabbages were characterised by varied NDF contents. The highest content of dietary fiber was found in red cabbage (15.48 g/100 g d.m.), while it was lowest in common cabbage (12.66 g/100 g d.m.). Moreover, high variation was observed in contents of individual fractions of dietary fiber. The highest content of hemicelluloses was recorded in red cabbage (4.46 g/100 g d.m.), cellulose – in savoy cabbage (10.76 g/100 g d.m.), while lignin – in common cabbage (1.70 g/100 g d.m.). Boiled vegetables were characterised by a significantly higher content of dietary fiber than steamed cabbage.
Conclusions. Thermal processing of cruciferous vegetables had a significant effect on changes in contents of dietary fiber and its fractions. Boiled vegetables were characterised by the highest contents of dietary fiber. Different contents of dietary fiber were also found in individual anatomical parts of cruciferous vegetables.

Key words: cruciferous vegetables, dietary fiber, thermal processing, cellulose, hemicelluloses, lignin

INTRODUCTION

Cruciferous vegetables belong to the family Brassicae [Fahey et al. 2001, Higdon et al. 2007, Mithen et al. 2000, Sosińska and Obiedziński 2007], and their representatives include e.g. common and red headed cabbage, savoy cabbage, Chinese cabbage, Brussels sprouts, broccoli, cauliflower, etc. Cabbage, such as e.g. common cabbage, plays a particular role in human nutrition due to its high content of vitamin C,

*Financial supported by the UE Project no POiG 01.01.02.00-061/09.

✉pkomolka@up.poznan.pl

potassium, organic acids, glucosynolates and dietary fiber [Bartoszek et al. 2002, Gajewski and Radzanowska 2004, Jarczyk and Berdowski 1997].

Dietary fiber is a complex of heterogeneous substances of cell walls, indigestible in the human alimentary tract. According to the definition developed by the American Association of Cereal Chemist (AACC) the term dietary fiber refers to "edible parts of plants, as well as derivatives of carbohydrates, indigestible and absorbed in the human small intestine as well as partly or completely fermented in the large intestine" [AACC... 2001]. It includes among other things cellulose, hemicelluloses, lignin, inulin, β-glucanes, pectins, gums and mucilage [Bach Knudsen 2001, DeVries 2001, Hasik et al. 1997, Jones 2000, Viuda-Martos et al. 2010]. It is a component of products with a reduced calorie content, due to the sensation of satiety appearing after its consumption as a result of water absorption and swelling in the stomach [Davidson and McDonald 1998, Gertig and Gawęcki 2001, Kristensen and Jensen 2010, Prosky 1999, Winiarska-Mieczan and Sołtys 2009]. The consumption of dietary fiber is recommended in the prevention of alimentary disorders, since it stimulates the alimentary tract and prevents constipation. Moreover, dietary fiber, by limiting the digestibility of nutrients and reducing their absorption, reduces blood glucose and cholesterol levels, as well as removes toxins and heavy metals from the organism and reduces the risk of colon cancer [Bartnikowska 1994, 1997, Ferguson and Harris 2003, Galisteo et al. 2008, Jenkins et al. 2004, Marlett et al. 1997, Nowak et al. 2003, Viuda-Martos et al. 2010, Gambuś et al. 2011].

The effect of dietary fiber on the human organism is dependent not only on the amount of dietary fiber in the diet, but also on its fraction composition, which may change depending on the plant species, the degree of ripeness, anatomical parts of the material and the applied technological process [Górecka 2008, Hamułka and Wawrzyniak 2011, Mc Dougall et al. 1996, Wołoch and Pisulewski 2002, Górecka et al. 2009, 2010 a, b]. Insoluble cellulose binds water and increases the amount of removed substances harmful for human health, limits body weight gain, eliminates constipation and stabilizes blood glucose level. Partially soluble hemicelluloses also eliminate constipation, reduce body weigh gain and prevent colon cancer, while insoluble lignin eliminates constipation, excess bile acids and food cholesterol, prevents the formation of gall stones and cancers in the final sections of the alimentary system.

In the course of the applied technological processes in cruciferous vegetables changes occur in their contents of dietary fiber and its functional properties [Chang and Moris 1999, Górecka 2004, Nawirska et al. 2008]. Thus the aim of this study was to determine the effect of thermal processing on the content of dietary fiber and its fractions in cruciferous vegetables.

MATERIAL AND METHODS

Material for analyses comprised vegetables from the family Brassicae: common cabbage cv. *Cilion*, red cabbage cv. *Lektro* and savoy cabbage cv. *Fiona*. Cabbages were subjected to pretreatment, in the course of which outer leaves were removed, heads were washed and shredded. In the analyses whole cabbage heads and their anatomical parts, i.e. leaves and cabbage stumps, were used. Two methods of thermal processing were applied, i.e. boiling and steaming. Thermal processing in water was run at 100°C for 17 min, i.e. until fully soft. The recommended ratio of the product to water of 2:1 (v/v) was applied, when cabbage remained fully immersed in water and thermal processing was started from boiling water. Steaming was conducted in a Rational Combi-Steamer CCC convection oven, in a stream of steam at 100°C for 13 min, also until completely soft. Next the product was frozen, dried in an Alpha 1-4 LSC lyophilizer and comminuted in a Grindomix GM 200 knife mill.

In the obtained material the content of neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) was determined based on the method developed by Van Soest as modified by Mc Queen [McQueen and Nicholson 1979, Van Soest 1963, 1967], while the contents of hemicelluloses and cellulose were calculated from the difference between NDF and ADF. This method consists in hot extraction of samples using detergent solutions, appropriate for the determined fraction of dietary fiber, and next drying and combustion of samples, as well as weighing the residue.

Results concerning contents of dietary fiber were converted to dry matter (d.m.) and expressed in g/100 g d.m.

Recorded results constituted the arithmetic mean from three replications. To ensure objectivity of inference they were subjected to one-way analysis of variance using the Scheffe test. Dependencies were considered statistically significant at the significance level $p < 0.05$. Significant differences between groups are denoted in Tables with different letter superscripts.

RESULTS AND DISCUSSION

Under conditions applied in the experiments the content of dietary fiber was influenced both by the type of product (Table 1), as well as applied thermal processing (Table 2). The highest contents of neutral detergent dietary fiber (NDF) were found in red cabbage

Table 1. Influence of the type of raw cabbage on the content of dietary fiber, g/100 g d.m.

Cabbage	NDF ($\bar{x}$ ±SD)	ADF ($\bar{x}$ ±SD)	Hemicellulose ($\bar{x}$ ±SD)	Cellulose ($\bar{x}$ ±SD)	Lignin ($\bar{x}$ ±SD)
Common	12.66 ±0.33^{a}	9.56 ±0.18^{a}	3.09 ±0.50^{b}	7.87 ±0.43^{a}	1.70 ±0.29^{b}
Red	15.48 ±0.09^{c}	11.02 ±0.37^{b}	4.46 ±0.27^{c}	9.98 ±0.45^{b}	1.03 ±0.08^{a}
Savoy	14.24 ±0.31^{b}	12.28 ±0.09^{c}	1.96 ±0.24^{a}	10.76 ±0.05^{b}	1.52 ±0.14^{a,b}

$\bar{x}$ – mean value of tree measurements, SD – standard deviation; a, b, c – mean values in the same columns, denoted by different letters, vary statistically significantly among one another at $p < 0.05$.

Table 2. Influence of heat treatment on dietary fiber content in cabbage: common, red and savoy, g/100 g d.m.

Cabbage	NDF ($\bar{x}$ ±SD)	ADF ($\bar{x}$ ±SD)	Hemicellulose ($\bar{x}$ ±SD)	Cellulose ($\bar{x}$ ±SD)	Lignin ($\bar{x}$ ±SD)
Common					
raw	12.66 ±0.33^{a}	9.56 ±0.18^{a}	3.09 ±0.50^{a}	7.87 ±0.43^{b}	1.70 ±0.29^{a}
boiled	23.98 ±0.43^{b}	18.25 ±0.36^{b}	5.72 ±0.78^{b}	14.83 ±0.48^{c}	3.42 ±0.12^{b}
steamed	12.26 ±0.11^{a}	8.99 ±0.25^{a}	3.26 ±0.14^{a}	5.19 ±0.09^{a}	3.81 ±0.20^{b}
Red					
raw	15.48 ±0.09^{a}	11.02 ±0.37^{a}	4.46 ±0.27^{a}	9.98 ±0.45^{a}	1.03 ±0.08^{a}
boiled	28.52 ±0.46^{b}	23.39 ±0.22^{c}	5.12 ±0.65^{a}	20.08 ±0.24^{b}	3.31 ±0.14^{b}
steamed	16.18 ±0.03^{a}	11.96 ±0.07^{b}	4.22 ±0.05^{a}	10.48 ±0.32^{a}	1.48 ±0.25^{a}
Savoy					
raw	14.24 ±0.31^{a}	12.28 ±0.09^{b}	1.96 ±0.24^{b}	10.76 ±0.05^{b}	1.52 ±0.14^{a}
boiled	22.66 ±0.45^{b}	21.87 ±0.12^{c}	0.79 ±0.56^{a}	19.56 ±0.17^{c}	2.31 ±0.05^{b}
steamed	14.19 ±0.07^{a}	11.33 ±0.04^{a}	2.86 ±0.03^{b}	9.56 ±0.05^{a}	1.77 ±0.09^{a}

$\bar{x}$ – mean value of tree measurements; SD – standard deviation; a, b, c – mean values in the same columns in each category, denoted by different letters, vary statistically significantly among one another at $p < 0.05$.

(15.48 g/100 g d.m.), followed by savoy cabbage (14.24 g/100 g d.m.), while the lowest in common cabbage (12.66 g/100 g d.m.). Content of acid detergent fiber (ADF) ranged from 9.56 g/100 g d.m. in common cabbage to 12.28 g/100 g d.m. in savoy cabbage. In the analyzed materials the fraction of cellulose predominated, which content ranged from 7.87% (common cabbage) to 10.76% (savoy cabbage). Significantly more hemicellulose fractions were recorded in red cabbage (4.46 g/100 g d.m.), while for the lignin fraction it was in common cabbage (1.70 g/100 g d.m.).

Boiled vegetables were characterised by significantly higher contents of dietary fiber than steamed vegetables (Table 2). Content of neutral detergent dietary fiber after thermal processing in water, irrespective of the type of vegetable, increased significantly by approx. 59-89%, in comparison to the fresh raw material, while content of acid detergent dietary fiber increased by 78-112%. Thermal processing in steam contributed to a significant reduction of NDF and ADF contents, except for red cabbage, in which an increase was observed for contents of these fractions of dietary fiber. Thermal processing of vegetables in water and in steam also caused changes in contents of individual fractions. After thermal processing in water the content of hemicellulose increased from approx. 14% in red cabbage, to 85% in common cabbage, that of cellulose from 82% in savoy cabbage to 101% in red cabbage, while that of lignin from 52% in savoy cabbage to 221% in red cabbage, in comparison to the fresh material. Only in case of savoy cabbage the content of hemicellulose was reduced by 56%. In turn, thermal processing in steam caused an increase in the contents of hemicellulose from 5% in common cabbage to 46% in savoy cabbage, and that of lignin from 16% in savoy cabbage to 124% in common cabbage, while a reduction of cellulose content ranged from 11% in savoy cabbage to 34% in common cabbage.

Recorded results indicate high variation in terms of the percentage proportion of individual fractions in dietary fiber of raw vegetables, as well as boiled and steamed vegetables. Conducted studies confirmed that during thermal processes quantitative and qualitative changes occur in individual fractions of dietary fiber in analysed raw materials. In other studies [Górecka 2004] it was also found that thermal processing has a significant effect on the content of dietary fiber, with the direction of these changes being consistent with those recorded in this study in case of boiling, while in case of steaming it was different. Rodríguez et al. [2006] indicated that it is difficult to determine which components of dietary fiber undergo the greatest changes during heating, although there are assumptions that hemicelluloses and pectin substances are most sensitive. Moreover, an increment in the contents of dietary fiber may be explained by leaching of soluble components to the solution, which resulted in changes in percentage contents of these components in the analysed raw materials. According to those authors an apparent increase in the contents of dietary fiber is a consequence of the formation of complexes between polysaccharides and other components, such as proteins and phenolic compounds, which are assayed as dietary fiber. Mathee and Appledorf [1978] also observed an increment in fractions of dietary fiber in cabbage subjected to cooking. They claimed that it is connected with cellulose content increasing with heating time. In turn, Elleuch et al. [2011] in their studies observed a decrease in contents of hemicelluloses and cellulose during pressure cooking, which is caused by the degradation of polysaccharides to simple sugars. In this study a similar decrease in the contents of hemicelluloses is observed in red cabbage, while that of cellulose – in common and savoy cabbage subjected to steaming.

Contents of dietary fiber and its fractions, depending on the anatomical parts of plants, are presented in Table 3. Significant differences in the contents of neutral detergent fiber in individual anatomical parts of plants were only stated in case of red cabbage. In both cabbages, i.e. common and red cabbage, statistically significant differences were recorded in the contents of acid detergent fiber and varied contents of individual fractions were found, as it was also indicated by other authors [Englyst et al. 1988, McDougall et al. 1996]. Leaves of common cabbage contained significantly more cellulose. The stump of boiled common cabbage contained statistically significantly more NDF, hemicelluloses and lignin, while in that of steamed cabbage there was only more lignin. In turn, leaves of red cabbage, both raw and boiled, contained significantly more NDF. Raw leaves of this cabbage contained significantly more hemicelluloses and cellulose, at less lignin in comparison to the cabbage stump. Leaves

Table 3. The content of dietary fiber in common and red cabbage dependend on plant anatomy and kind of thermal processing, g/100 g d.m.

Cabbage	NDF ($\bar{x}$ ±SD)	ADF ($\bar{x}$ ±SD)	Hemicellulose ($\bar{x}$ ±SD)	Cellulose ($\bar{x}$ ±SD)	Lignin ($\bar{x}$ ±SD)
Raw common					
leafs	11.56 ±0.40[a]	9.67 ±0.15[b]	1.88 ±0.55[a]	8.69 ±0.30[b]	0.98 ±0.15[a]
stump	11.57 ±0.41[a]	8.55 ±0.26[a]	3.02 ±0.67[a]	6.95 ±0.61[a]	1.60 ±0.36[a]
Common boiled					
leafs	24.30 ±0.41[a]	19.63 ±0.24[b]	4.67 ±0.29[a]	18.80 ±0.25[b]	0.83 ±0.06[a]
stump	27.72 ±0.07[b]	18.29 ±0.14[a]	9.42 ±0.07[b]	17.11 ±0.22[a]	1.18 ±0.15[b]
Common steamed					
leafs	11.92 ±0.64[a]	9.74 ±0.02[b]	2.18 ±0.64[a]	8.90 ±0.10[b]	0.84 ±0.09[a]
stump	11.49 ±0.29[a]	9.33 ±0.23[a]	2.16 ±0.10[a]	5.64 ±0.24[a]	3.70 ±0.47[b]
Raw red					
leafs	16.02 ±0.44[b]	11.86 ±0.13[b]	4.16 ±0.56[b]	11.03 ±0.04[b]	0.83 ±0.08[a]
stump	13.72 ±0.16[a]	10.94 ±0.23[a]	2.78 ±0.39[a]	8.22 ±0.27[a]	2.71 ±0.25[b]
Red boiled					
leafs	29.89 ±0.24[b]	28.41 ±0.27[b]	1.47 ±0.49[a]	24.88 ±0.31[b]	3.54 ±0.44[b]
stump	26.88 ±0.39[a]	23.61 ±0.11[a]	3.27 ±0.28[b]	21.08 ±0.13[a]	2.53 ±0.23[a]
Red steamed					
leafs	15.49 ±0.37[a]	14.09 ±0.10[b]	1.39 ±0.47[a]	10.86 ±0.09[a]	3.23 ±0.08[b]
stump	16.16 ±0.17[b]	12.07 ±0.73[a]	4.09 ±0.66[b]	10.51 ±0.76[a]	1.56 ±0.09[a]

$\bar{x}$ – mean value of tree measurements; SD – standard deviation; a, b – mean values in the same columns in each category, denoted by different letters, vary statistically significantly among one another at $p < 0.05$.

of boiled cabbage were characterised by significantly higher contents of cellulose and lignin, at a lower content of hemicellulose, whereas steamed leaves had more lignin and less hemicellulose in comparison to the cabbage stump.

CONCLUSIONS

1. Cruciferous vegetables selected for analyses were characterised by great variation in terms of contents of dietary fiber and its individual fractions, with red cabbage being the richest source of NDF. Common cabbage contained the highest amount of lignin, savoy cabbage – cellulose, while red cabbage contained most cellulose and hemicellulose.

2. Thermal processing of cruciferous vegetables had a significant effect on changes in contents of dietary fiber. The direction of these changes was dependent on the type of applied thermal processing. Boiled vegetables were characterised by significantly higher contents of dietary fiber and its fractions in comparison to steamed vegetables. An increased proportion of the cellulose and lignin fractions was found in cabbages after thermal processing in water.

3. Significant differences in contents of dietary fiber in individual anatomical parts were observed first

of all in case of red cabbage. Leaves of red cabbage were characterised by a higher content of dietary fiber in comparison with cabbage stumps.

REFERENCES

AACC Report, 2001. The definition of dietary fiber. Cereal Food World 46 (3), 112-129.

Anderson N.E., Clydesdale F.M., 1980. Effect of processing on the dietary fiber content of wheat bran, pureed green beans, and carrots. J. Food Sci. 45, 1533.

Bach Knudsen K.E., 2001. The nutritional significance of "dietary fibre" analysis. Anim. Feed Sci. Techn. 90, 3-20.

Bartnikowska E., 1994. Wpływ włókna pokarmowego na metabolizm lipidów [Effects of dietary fiber on lipid metabolism]. Żyw. Człow. Metab. 21 (3), 269-285 [in Polish].

Bartnikowska E., 1997. Włókno pokarmowe w żywieniu człowieka. Cz. 2 [Dietary fiber in human nutrition. Part 2]. Przem. Spoż. 6, 14-17 [in Polish].

Bartoszek A., Forc A., Grześkowiak J., 2002. Antioxidative properties of some vegetable products traditional for diets in Central Europe. Pol. J. Food Nutr. Sci. 11/52, 67-70.

Chang M., Moris M., 1999. Effect of heat treatment on chemical analysis of dietary fiber. J. Food. Sci. 55, 1647-1675.

Davidson M.H., McDonald A., 1998. Fibre: Forms and functions. Nutr. Res. 18, 617-624.

DeVries J.W., 2001. The definition of dietary fiber. Cereal Food World 46 (3), 112-129.

Elleuch M., Bedigian D., Roiseux O., Besbes S., Blecker C., Attia H., 2011. Dietary fibre and fibre-rich by-products of food processing: Characterisation, technological functionality and commercial applications: A review. Food Chem. 124, 411-421.

Englyst H.N., Bingham S.A., Runswick S.A., Collinsom E., Cummings J.H., 1988. Dietary fibre (non-starch polysaccharides) in fruit, vegetables and nuts. J. Hum. Nutr. Diet. 1 (4), 247-286.

Fahey J.W., Zalcmann A.T., Talalay P., 2001. The chemical diversity and distribution of glucosinolates and isothiocyanates among plants. Phyt. Chem. 56, 5-51.

Ferguson L.R., Harris P.J., 2003. The dietary fibre debate: more food for thought. Lancet 361, 1487-1488.

Gajewski M., Radzanowska J., 2004. Skład chemiczny i jakość sensoryczna kapusty głowiastej w zależności od jej odmiany i dawki azotu stosowanej w nawożeniu mineralnym [Chemical composition and sensory quality of common cabbage depending on the cabbage cultivar and nitrogen dose as applied in mineral fertilization]. Żyw. Nauka. Techn. Jakość 2 (39), 108-120 [in Polish].

Galisteo M., Duarte J., Zarzuelo A., 2008. Effects of dietary fibers on disturbances clustered in the metabolic syndrome. J. Nutr. Biochem. 19, 71-84.

Gambuś H., Gibiński M., Pastuszka D., Mickowska N., Ziobro R., Witkowicz R., 2011. The application of residual oats flour in bread production in order to improve its quality and biological value of protein. Acta Sci. Pol., Technol. Aliment. 10 (3), 313-325.

Gertig H., Gawęcki J., 2001. Słownik terminów żywieniowych [Dictionary of nutrition]. Wyd. PWN Warszawa [in Polish].

Górecka D., 2004. Zabiegi technologiczne jako czynniki determinujące właściwości funkcjonalne włókna pokarmowego [Technological processing as determinant factors on functional properties of dietary fibre]. Rocz. AR Pozn. Rozpr. Nauk. 344 [in Polish].

Górecka D., 2008. Wpływ sposobu obróbki termicznej warzyw i owoców na właściwości funkcjonalne błonnika pokarmowego [Influence of thermal processing of vegetables and fruits on the functional properties of dietary fiber]. Bromat. Chem. Toksykol. 41 (3), 575-584 [in Polish].

Górecka D., Hęś M., Szymandera-Buszka K., Dziedzic K., 2009. Contents of selected bioactive components in buckwheat groats. Acta Sci. Pol., Technol. Aliment. 8 (2), 75-83.

Górecka D., Dziedzic K., Sell S., 2010 a. Wpływ zabiegów technologicznych stosowanych podczas produkcji kaszy gryczanej na zawartość błonnika pokarmowego [The influence of the technological processes applied to production of buckwheat groats on the dietary fiber content]. Nauka Przyr. Technol. 4, 2, #16 [in Polish].

Górecka D., Pachołek B., Dziedzic B., Górecka M., 2010 b. Raspberry pomace as a potential fiber source for cookies enrichment. Acta Sci. Pol., Technol. Aliment. 9 (4), 451-461.

Hamułka J., Wawrzyniak A., 2011. Analiza spożycia głównych źródeł włókna pokarmowego ogółem oraz jego frakcji w wybranej grupie młodych kobiet [Evaluation of intake of main sources of dietary fibre and its fractions in selected young women]. Probl. Hig. Epidem. 92 (4), 813-815 [in Polish].

Hasik J., Dobrzańska A., Bartnikowska E., 1997. Rola włókna roślinnego w żywieniu człowieka [The role of plant fiber in human nutrition]. Wyd. SGGW Warszawa [in Polish].

Higdon J.V., Delage B., Williams D.E., Dashwood R.H., 2007. Cruciferous vegetables and human cancer risk: epidemiologic evidence and mechanistic basis. Pharm. Res. 55, 224-236.

Jarczyk A., Berdowski J.B., 1997. Przetwórstwo owoców i warzyw. Cz. 1 [Fruit and vegetable processing. Part 1]. WSiP Warszawa [in Polish].

Jenkins D.J.A., Marchie A., Augustin L.S.A., Ros E., Kendall C.W.C., 2004. Viscous dietary fibre and metabolic effects. Clin. Nutr. Suppl. 1, 39-49.

Jones J., 2000. Update on defining dietary fiber. Cereal Food World 45 (5), 219-220.

Kristensen M., Jensen M. G., 2010. Dietary fibres in the regulation of appetite and food intake. Importance of viscosity. Appetite 56, 65-70.

Marlett J.A., McBurney M.I., Slavin J.L., 1997. Position of the American Dietetic Association: Health implications of dietary fiber. J. Am. Diet. Assoc. 97, 1157.

Mathee Y., Appledorf A., 1978. Effect of cooking on vegetable fiber. J. Food Sci. 43, 1344.

McDougall G.J., Morrison I.M., Stewart D., Hillman J.R., 1996. Plant cell walls as dietary fibre: range, structure, processing and function. J. Sci. Food Agric. 70, 133-150.

McQueen R.E., Nicholson J.W.G., 1979. Modification of the neutral detergent fiber procedure for cereal and vegetables by using α-amylase. J. Assoc. Off. Anal. Chem. 62, 676-680.

Mithen R.F., Dekker M., Verkerk R., Rabot S., Johnson I.T., 2000. The nutritional significance, biosynthesis and bioavailability of glucosinolates in human foods. J. Sci. Food Agric. 80, 967-984.

Nawirska A., Sokół-Łętowska A., Kucharska A.Z., Biesiada A., Bednarek M., 2008. Porównanie zawartości frakcji włókna pokarmowego w odmianach dyni z gatunku cucurbita maxima i cucurbita pepo [Comparing the contents of dietary fibre fractions in varieties of cucurbita maxima and cucurbita pepo]. Żyw. Nauka Techn. Jakość 1 (56), 65-73 [in Polish].

Nowak W., Kruczyńska H., Grochowska S., 2003. The effect of fibrolytic enzymes on dry matter, ADF and NDF ruminal disappearance and intestinal digestibility. Czech. J. Anim. Sci. 48, 191-196.

Prosky L., 1999. What is fibre? Current controversies. Trends Food Sci. Techn. 10, 271-275.

Rodríguez R., Jiménez A., Fernández-Bolaños J., Guillén R., Heredia A., 2006. Dietary fibre from vegetable products as source of functional ingredients. Trends Food Sci. Tech. 17, 3-15.

Sosińska E., Obiedziński M.W., 2007. Badania nad bioaktywnymi glukozynolanami w wybranych odmianach warzyw krzyżowych techniką HPLC [Investigation on bioactive glucosinolates in chosen cruciferous vegetables varieties by HPLC]. Żyw. Nauka Techn. Jakość 5 (54), 129-136 [in Polish].

Van Soest P.J., 1963. Use of detergents in the analysis fibrous feeds. I. Preparation of fiber residues of low nitrogen content. J. Assoc. Off. Anal. Chem. 46, 825-835.

Van Soest P.J., 1967. Use of detergents in the analysis fibrous feeds. IV. Determination of plant cell wall constituents. J. Assoc. Off. Anal. Chem. 50, 50-55.

Viuda-Martos M., López-Marcos M.C., Fernández-López J., Sendra E., López-Vargas J.H., Pérez-Álvarez J.A., 2010. Role of fiber in cardiovascular diseases: A review. Compr. Rev. Food Sci. Food Safety 9, 240-258.

Winiarska-Mieczan A., Sołtys R., 2009. Ocena zawartości włókna surowego i jego frakcji w wybranych produktach zbożowych [Evaluation of the content of crude fibre and its fractions in cereal products]. Bromat. Chem. Toksykol. 42, 4, 1083-1088 [in Polish].

Wołoch R., Pisulewski P.M., 2002. Wpływ procesów technologicznych na zmiany zawartości włókna pokarmowego i frakcji b-glukanów w ziarnie nieoplewionych i oplewionych form jęczmienia i owsa [Influence of technological processes for changing the contents of dietary fiber and b-glucan fraction in the grain of naked and covered barley and oats]. Żyw. Nauka Techn. Jakość 3 (32S), 207-212 [in Polish].

WPŁYW OBRÓBKI TERMICZNEJ WARZYW KAPUSTNYCH NA ZAWARTOŚĆ BŁONNIKA POKARMOWEGO I JEGO FRAKCJI

STRESZCZENIE

Wstęp. Błonnik pokarmowy składa się z wielu związków o różnych właściwościach. Poszczególne frakcje charakteryzują się zróżnicowanym działaniem w organizmie człowieka, dlatego też bardzo ważna jest znajomość składu frakcyjnego błonnika pokarmowego. Celem pracy było określenie wpływu obróbki cieplnej warzyw kapustnych na zawartość błonnika pokarmowego i jego frakcji.

Materiał i metody. Materiałem badanym były: kapusta biała odmiany 'Cilion', kapusta czerwona odmiany 'Lektro' i kapusta włoska odmiany 'Fiona'. Badano różne partie surowca – całą główkę, liście oraz głąby kapuściane. Warzywa kapustne gotowano w wodzie przez 17 min, a na parze – 13 min. Zawartość neutralnego detergentowego błonnika pokarmowego (NDF), kwaśnego detergentowego błonnika (ADF) i kwaśnej detergentowej ligniny (ADL) oznaczono metodą Van Soesta, a zawartość hemiceluloz i celulozy obliczono z różnicy między NDF i ADF.
Wyniki. Kapusty charakteryzowały się zróżnicowaną zawartością NDF-u. Najwięcej błonnika zawierała kapusta czerwona (15,48 g/100 g s.s.), najmniej kapusta biała (12,66 g/100 g s.s.). Stwierdzono również duże zróżnicowanie w zawartości poszczególnych frakcji błonnika pokarmowego. Największą zawartością hemiceluloz charakteryzowała się kapusta czerwona (4,46 g/100 g s.s.), celulozy – kapusta włoska (10,76 g/100 g s.s.), a ligniny – kapusta biała (1,70 g/100 g s.s.). Warzywa gotowane w wodzie cechowały się istotnie większą zawartością błonnika niż gotowane na parze.
Wnioski. Obróbka cieplna warzyw kapustnych wpłynęła w istotny sposób na zmianę zawartości błonnika pokarmowego i jego frakcji. Warzywa gotowane w wodzie charakteryzowały się największą zawartością błonnika. Różne zawartości błonnika stwierdzono także w poszczególnych częściach anatomicznych warzyw kapustnych.

Słowa kluczowe: warzywa kapustne, błonnik pokarmowy, obróbka termiczna, celuloza, hemicelulozy, lignina

Received – Przyjęto: 21.04.2012 Accepted for print – Zaakceptowano do druku: 16.06.2012

For citation – Do cytowania

Komolka P., Górecka D., Dziedzic K., 2012. The effect of thermal processing of cruciferous vegetables on their content of dietary fiber and its fractions. Acta Sci. Pol., Technol. Aliment. 11(4), 347-354.