Acta Sci. Pol., Technol. Aliment. 11(4) 2012, 381-387
pISSN 1644-0730 eISSN 1889-9594 www.food.actapol.net/

INFLUENCE OF CARROT POMACE POWDER ON THE RHEOLOGICAL CHARACTERISTICS OF WHEAT FLOUR DOUGH AND ON WHEAT ROLLS QUALITY

Zlatica Kohajdová✉, Jolana Karovičová, Michaela Jurasová

Department of Food Science and Technology, Institute of Biotechnology and Food Science, Slovak University of Technology
Radlinského 9, SK – 812 37 Bratislava, **Slovak Republic**

ABSTRACT

Background. Vegetable by-products are considered as good sources of dietary fibre and other biologically important compounds. Moreover, they are inexpensive and are available in large quantities. The objective of this study was to determine chemical composition and hydration properties of dietary fibre rich carrot pomace powder. The impact supplementation of carrot pomace at different levels (replacing of fine wheat flour with 1, 3, 5 and 10% of carrot pomace) on farinographic properties of wheat dough and qualitative and sensory characteristics of wheat rolls were also evaluated.
Material and methods. Chemical analyses included determination of moisture, ash, fat, proteins and total dietary fibre. Hydration properties such as water holding, water retention and swelling capacity were also determined. Rheological parameters of carrot pomace powder incorporated wheat doughs were determined by farinograph. Wheat rolls were evaluated for their qualitative (volume, cambering) and sensory characteristics.
Results. Carrot pomace powder was found as good source of total dietary fibre and showed high values of hydration properties. Incorporation of this by-product to wheat dough influences farinographic characteristics (increasing of water absorption, dough development time and dough stability, decreasing of mixing tolerance index) of dough and qualitative parameters of final products (decreasing of loaf volume and cambering). From the sensory evaluation resulted that loaves incorporated with carrot pomace powder up to 3% were the most acceptable for assessors.
Conclusions. Carrot pomace powder can be considered as suitable functional ingredient for wheat rolls. Enrichment wheat flour with low concentrations of carrot pomace powder (1 and 3%) not only increases nutrition value of products but also did not have significant impact on their quality and sensory acceptability.

Key words: carrot by-product, dough, farinographic properties, wheat rolls

INTRODUCTION

Total dietary fibre (DF) is the part of plant that is resistant to intestinal digestion in human large intestine. The beneficial effects of total DF on human health and body function are well-documented, thus a high consumption of DF is associated with a reduced incidence of common disorders and diseases in developed societies [Navarro-González et al. 2011] such as chronic bowel disorders, obesity, diabetes, cardiovascular disease and cancer [Chau et al. 2004, Benítez et al. 2011].

Fibre-rich by-products may be incorporated into food products as inexpensive, non-caloric bulking

✉zlatica.kohajdova@stuba.sk

agents for partial replacement of flour, fat or sugar, as enhancers of water and oil retention and to improve emulsion or oxidative stabilities [Elleuch et al. 2011]. Bread and some other bakery products have proved to be acceptable carriers of DF from various sources [Almana and Mahmoud 1994]. Addition of DF to bakery products increases DF intake, decreases the caloric density of wheat rolls and prolongs freshness due to its capacity to retain water and thus reduces economic losses [Elleuch et al. 2011, Kohajdová et al. 2011].

Traditionally, the fibre components used as functional ingredients are obtained, mostly, from the cereal industry [Fuentes-Alventosa et al. 2009, González--Centeno et al. 2010, Górecka et al. 2009]. However by-products derived from various vegetable such as carrot [Chantaro et al. 2008, Shyamala and Jamana 2010], red beet [Shyamala and Jamana 2010], onion [Benítez et al. 2011] and tomato [Navarro-González et al. 2011] are also good sources of DF. In general, the residues derived from vegetable processing contain a higher soluble DF content, present a better insoluble/soluble DF ratio, and also have better functional properties than those obtained from cereal processing [González-Centeno et al. 2010]. Moreover, these residues are inexpensive and available in large quantities [Chantaro et al. 2008, Shyamala and Jamuna 2010], exhibit a lower caloric content, and, often, include other interesting compounds such as antioxidants [Chantaro et al. 2008, González-Centeno et al. 2010] which might provide additional health benefits [González--Centeno et al. 2010].

The objective of this study was to evaluate the effect of total DF rich carrot pomace powder on chemical, rheological, qualitative and sensory properties of wheat rolls. The chemical composition and hydration properties of carrot pomace powder were also determined.

MATERIAL AND METHODS

Carrots, fine wheat flour and other ingredients applied for wheat rolls preparation were purchased from Slovak local markets. Carrot pomace powder (CPP) was obtained by washing of carrots in tap water, removing non-edible parts and juice pressing. Subsequently, the residue (pomace) was dried at 40°C for 12 h. A grinder mill and sieves were used to obtain of CPP particle size 160-270 μm.

Chemical composition. Moisture, fat and ash contents were determined by method of Chen et al. [1988] and Sowbhagya et al. [2007]. Protein content was determined by multiplying the nitrogen content with factor 5.75 (fine wheat flour) and 6.25 (CPP) [Chau et al. 2004]. Total dietary fibre (TDF) content was measured by enzymatic-gravimetric method [Kohajdová et al. 2011]. Total carbohydrate content and energetic value of flours were calculated according to method of Mortuza and Tzen [2009].

Hydration properties. Water holding capacity (WHC), water retention capacity (WRC) and swelling capacity (SWC) were determined according to method described by Raghavendra et al. [2004].

Preparation of flour blends. Blends of 0%, 1%, 3%, 5% and 10% were prepared by substitution fine wheat flour (wet gluten content 34.74%) with CPP.

Dough characteristics. The effect of CPP on dough rheology during mixing was determined by a Farinograph (Brabender, Duisburg, Germany) [Wang et al. 2002, Bouaziz et al. 2010]. The parameters determined were: water absorption (WA) or percentage of water required to yield dough consistency of 500 BU (Brabender Units), dough development time (DDT, time to reach maximum consistency in minutes), dough stability (DS, time dough consistency remains at 500 BU), mixing tolerance index (MTI, consistency difference between height at peak and that 5 min later).

Preparation of wheat rolls. Wheat rolls were prepared using a straight dough method according to procedure described by Kohajdová and Karovičová [2007 and 2008].

Quality of wheat rolls. Evaluation of loaf quality included: loaf volume (cm^3), and cambering (loaf height/width ratio). Millet seeds were used to measure loaf volume.

Sensory evaluation (after cooling for 2 h at room temperature). Sensory evaluation was performed by method reported by Kohajdová and Karovičová [2007 and 2008]. The 11 assessors evaluated: shape of product, crust colour and thickness/hardness, crust/crumb odour and taste, crumb: elasticity, porosity, colour, resistance to the bite and adhesion to palate (on longer chewing) and overall acceptability.

Statistical analysis. All analyses were carried out using three independent determinations and expressed as mean value ±standard deviation. Data were analysed using the Statgraphic Plus, Version 3.1 (Statsoft Inc. USA) statistical software. Duncan's test was used to calculate the means and their 95% confidence intervals.

RESULTS AND DISCUSSION

Chemical composition of fine wheat flour and CPP is presented in Table 1. It was concluded that TDF content of the CPP was lower (55.70%) than those of some other agricultural by-products such as asparagus by-products (62-77%) [Elleuch et al. 2011, Fuentes-Alventosa et al. 2009] and tomato fibre (65.9%) [Claye et al. 1996]. On the other hand Chantaro et al. [2008] found lower TDF content in unblanched dried carrot peels (45.47-49.23%). These differences could be related to the characteristics of raw materials and processing steps [Chantaro et al. 2008]. In literature, there are many by-products that are valuable TDF source, with content varying between 30 and 90%. Three different groups could be established: low-TDF sources (30-50%), medium-TDF (50-70%) and high-TDF sources (70-90%) [Fuentes-Alventosa et al. 2009]. According to this classification, CPP falls into the medium-TDF content group. Moreover, it was found that CPP was characterised with low fat (2.10%) and protein content (6.73%) and low energetic value (608.23 kJ·kg^{-1}).

Table 1. Chemical composition and hydration properties of fine wheat flour and CPP

Chemical parameters	Fine wheat flour	CPP
	%, dry matter	
Moisture	10.72 ±0.05	9.13 ±0.09
Ash	0.40 ±0.02	1.39 ±0.06
Fat	1.35 ±0.03	2.10 ±0.01
Proteins	11.32 ±0.02	6.73 ±0.16
Total dietary fibre	1.54 ±0.05	55.70 ±0.11
Total carbohydrates	74.67 ±2.01	24.95 ±0.95
Energetic value, kJ·kg^{-1}	1 486 ±10.23	608.23 ±4.83
Hydration properties		
Water holding capacity, g·g^{-1}	1.14 ±0.06	14.84 ±0.03
Water retention capacity, g·g^{-1}	1.45 ±0.05	11.97 ±0.04
Swelling capacity, cm^3·g^{-1}	2.12 ±0.01	10.48 ±0.09

Hydration properties of DF refer to its ability to retain water within its matrix [Shyamala and Jamuna 2010, Navarro-González et al. 2011]. DF interacts with water through two mechanisms mainly: (1) water held in capillary structures as a result of surface tension strength and (2) water interacting with molecular components through hydrogen bonding or dipole forms [Daou and Zhang 2011]. Hydration properties of CPP are presented in Table 1. It was recorded that CPP showed higher WHC (14.84 g·g^{-1}) as was described for asparagus [Fuentes-Alventosa et al. 2009], onion by-products [Benítez et al. 2011] and cereal brans [Lebesi and Tzia 2011]. The high WHC of CPP may be due to their high TDF content [Shyamala and Jamuna 2010]. CPP was also characterized with high value of WRC (11.97 g·g^{-1}). High WRC was also previously observed for carrot peel and pulp wastes and tomato peel residue [Chantaro et al. 2008, Shyamala and Jamuna 2010, Navarro-González et al. 2011]. Grigelmo-Miguel and Martín-Belloso [1999] and Shyamala and Jamuna [2010] reported that high WRC values are related to the soluble DF fraction. SWC is related to fibre structure [Benítez et al. 2011]. The greater capacity to swell is the most desirable parameter for the physiological functionality of DF [Lebesi and Tzia 2011]. CPP examined in this study exhibited high SWC (10.48 cm^3·g^{-1}). These values were similar to those described by Kohajdová et al. [2011] for lemon DF preparation, but higher than those reported for cereal brans [Lebesi and Tzia 2011] and tomato peel fibre [Navarro-González et al. 2011]. From this study it resulted that CPP can be considered as suitable for food applications as a functional ingredient due to high values of hydration properties. These conclusions were also postulated in earlier studies of Chau et al. [2004] and Elleuch et al. [2011].

Information on the rheological properties of dough will be useful for predicting the potential application of the wheat flour and also the quality of the end products [Mohammed et al. 2012]. The effect of CPP supplementation on rheological characteristics of fine wheat flour are summarised in Table 2. It can

Table 2. Effect of CPP addition on farinographic characteristics of wheat dough

Addition of CPP	WA	DDT	DS	MTI
%	%	min	min	BU
0	60.67 ±0.35	6.17 ±0.20	6.83 ±0.13	33.32 ±0.15
1	61.23 ±0.37	7.33 ±0.29*	7.03 ±0.26	30.67 ±0.16*
3	69.40 ±0.10*	7.67 ±0.18*	9.88 ±0.19*	16. 67 ±0.58*
5	69.83 ±0.32*	7.83 ±0.11*	10.17 ±0.29*	14.00 ±0.08*
10	72.01 ±0.25*	7.91 ±0.12*	10.35 ±0.22*	13.28 ±0.13*

*Indicates a statistically significant difference at p = 0.05 level.

be noticed that WA increased with increasing level of CPP from 60.67% (control sample) to 72.01% (sample with 10% substitution of CPP). Similar effects on WA was recorded by Tańska et al. [2007] and Ashoush and Gadallah [2011] when the dried carrot pomace and mango peels were incorporated to wheat dough. The explanation of this phenomenon is based partly on the fact that the fibre structure contains a large number of hydroxyl groups, which interact with the hydrogen bonds of water [Bouaziz et al. 2010, Gómez et al. 2011]. DDT increased from 6.17 to 7.91 min with 10% incorporation of CPP. During this phase of mixing, water hydrates, the flour components and the dough are developed [Kohajdová et al. 2011, Mohammed et al. 2012]. Similar trends in DDT were observed by Borchani et al. [2011] and Ashoush and Gadallah [2011]. Increasing of DDT could be attributed to the fibre-gluten interaction, which prevents protein hydration [Gómez et al. 2011]. DS is known to be related to the quality of the protein matrix, which is easily damaged by the incorporation of other ingredients [Gómez et al. 2012]. Addition of CPP concluded in increasing of DS from 6.83 to 10.35 min. These observations were similar with those obtained by Nassar et al. [2008], Ognean et al. [2010] and Anil [2011] for orange by-products, commercial potato fibre and rice bran supplemented wheat dough. This effect could be explained by a higher interaction between DF, water and flour proteins [Borchani et al. 2011]. From the measurements it was also concluded that increasing level of CPP resulted in decrease of MTI. These results were in agreement with findings of Nassar et al. [2008] and Kohajdová et al. [2011] which substituted wheat flour by citrus by-products. Reduction of MTI can be observed due to interactions between fibre and gluten [Wang et al. 2002, Bouaziz et al. 2010].

Loaf volume is regarded as most important baked goods characteristic since it provides a qualitative measurement of baking performance [Kohajdová and Karovičová 2008]. Incorporation of CPP to wheat rolls negatively affected loaf volume of final products with reduction of loaf volume from 253.33 cm^3 (fine wheat flour) to 169.53 cm^3 (fine wheat flour incorporated with 10% of CPP; Table 3). Other researchers also observed decreasing volume of different bakery products such as bread, cookies and muffins after the addition of wheat bran [Gómez et al. 2011], date flesh fibre concentrate [Borchani et al. 2011] and spray dried apple fibre [Chen et al. 1988]. This phenomen was possibly a results of the fibre weaning or crippling dough structure and reducing CO_2 gas retention. Moreover, appreciable amounts of water could have strongly bound to the added fibre during baked goods making, so less water was available for the development of the starch-gluten network, causing an under-developed gluten network and reduced loaf volume [Sivam et al. 2010]. Cambering of CPP incorporated wheat rolls presented as height and width ratio was decreased with increasing level of CPP in products (Table 3). It was stated that cambering values under 0.50 are not sufficient [Kohajdová and Karovičová 2007]. These low cambering values were observed after incorporation of 5 and 10% of CPP to fine wheat flour.

Data regarding sensory evaluation of CPP incorporated wheat rolls are presented in Figure 1. Results showed that incorporation of CPP significantly

Table 3. Effect of CPP on loaf volume, cambering and overall acceptability of baked goods

Addition of CPP, %	Loaf volume, cm^3	Cambering	Overall acceptability, %
0	286.00 ±4.93	0.56 ±0.02	99.80 ±0.12
1	253.33 ±2.89*	0.54 ±0.01*	96.70 ±1.04
3	217.33 ±4.43*	0.50 ±0.01*	94.40 ±1.02
5	172. 67 ±2.31*	0.44 ±0.01*	87.26 ±0.94*
10	169.53 ±2.02*	0.42 ±0.01*	75.43 ±0.78*

*Indicates a statistically significant difference at p = 0.05 level.

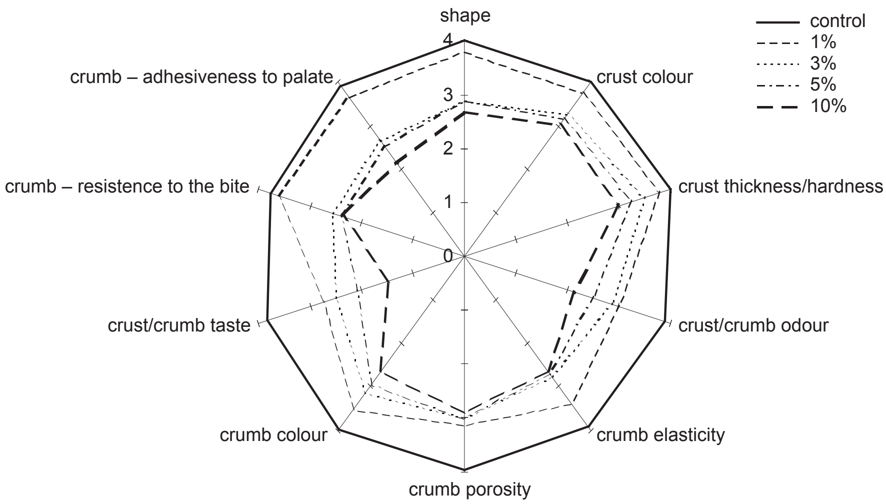

Fig. 1. Sensory characteristics of CPP incorporated baked goods

influences taste and odour of wheat rolls. It has been primarily attributed to terpenoids and sugars which are mainly responsible for carrot flavour [Jones 2009] of CPP. Wheat rolls with 5 and 10% of CPP were significantly harder than wheat rolls prepared only from fine wheat flour. The hardening effect observed after addition of DF results from the dilution of gluten content [Sivam et al. 2010] and also due to the thickening of the walls surrounding the air bubbles in the crumb [Gómez et al. 2003]. Increasing of CPP level resulted in appreciable darker crust colour of wheat rolls. Similar observations were found by Tańska et al. [2007] and Kumar and Kumar [2011] for dried carrot pomace incorporated breads and cookies. Incorporation of CPP also concluded in increasing intensity orange colour of wheat rolls crumbs come from carotenoids mainly ß-carotene that is primarily responsible for carrot colour [Jones 2009] of CPP. Evaluation of overall acceptability (Table 3) of wheat rolls showed that acceptance of products with higher content of CPP (5 and 10%) was markedly decreased because it negatively affected taste, odour, colour and hardness of final products.

CONCLUSION

Most bakery products are used as sources for incorporation of different nutritionally rich ingredients for their diversification [Sudha et al. 2007]. CPP investigated in this study can be considered as suitable ingredient for wheat rolls supplementation due to high content of TDF, low energetic value and relatively high hydration properties.

It also resulted from this study that blend flours which contained up to 3% of CPP could be incorporated in the formulation to produce wheat rolls with acceptable quality. Furthermore it was found that addition of higher levels (5 and 10%) of CPP to wheat flour CPP negatively affected rheological parameters of wheat dough, qualitative and sensory properties of wheat rolls. These findings are in agreement with Gómez et al. [2003] which described that small additions of dietary fibre from different origin to wheat flour (at the 2% level) produced in general, very similar bread (a straight dough process) to the white bread without any noticeable damage to acceptability, but the addition of 5% could imply use of some additives to correct the rheological properties of dough and bread volume reduction. On the other hand, Tańska et al. [2007] indicated that optimal amount of dried carrot pomace used in bread baking mix is 5%. This was due to higher volume and organoleptic quality of prepared breads compared to control bread (without addition of carrot pomace). These researchers also stated that breads with greater (7.50 and 10%) addition of dried carrot pomace were richer in biologically active compounds (carotenoids, fibre and mineral compounds) but were presented with worse rheological and organoleptic properties.

REFERENCES

Almana H.A., Mahmoud R.M., 1994. Palm date seeds as an alternative source of dietary fibre in Saudi bread. Ecol. Food Nutr. 32 (3-4), 261-270.

Anil R., 2011. Effects of wheat bran, corn bran, rice bran and oat bran supplementation on the properties of pide. J. Food Proc. Preserv. DOI: 10.1111/j.1745-4549. 2011.00592.x [in press].

Ashoush I., Gadallah M., 2011. Utilisation of mango peels and seed kernels powder as sources of phytochemicals in biscuit. World J. Dairy Food Sci. 6 (1), 35-41.

Benítez V., Mollá E., Marín-Cabrejas M.A., AguileraY., Lopéz-Andreéu F.J., Esteban R.M., 2011. Effect of sterilisation on dietary fibre and physicochemical properties of onion by-products. Food Chem. 127 (2), 501-507.

Borchani Ch., Masmoudi M., Besbes S., Attia H., Seroanne C., Blecker Ch., 2011. Effect of date flesh fibre concentrate addition on dough performance and bread quality. J. Text. Stud. 42 (4), 300-308.

Bouaziz M.A., Amara H.B., Attia H., Blecker Ch., Besbes S., 2010. Effect of the addition of defatted date seeds on wheat dough performance and bread quality. J. Text. Stud. 41 (4), 511-531.

Chantaro P., Devahastin S., Chiewchan N., 2008. Production of antioxidant high dietary fibre powder from carrot peels. LWT – Food Sci. Technol. 41 (10), 1987-1994.

Chau Ch.F., Chen Ch.H., Lee M.H., 2004. Comparison of the characteristics, functional properties, and in vitro hypoglycaemic effects of various carrot insoluble fibre-rich fractions. LWT – Food Sci. Technol. 37 (2), 155-160.

Chen H., Rubenthaler G.L., Leung H.K., Baranowski J.D., 1988. Chemical, physical and baking properties of apple fibre compared with wheat and oat bran. Cereal Chem. 65 (3), 244-247.

Claye S.S., Idouraine A., Weber Ch.W., 1996. Extraction and fractionation of insoluble fibre from five fibre sources. Food Chem. 37 (2), 305-310.

Daou Ch., Zhang H., 2011. Physico-chemical properties and antioxidant activities of dietary fibre derived from defatted rice bran. Advance J. Food Sci. Technol. 3 (5), 339-347.

Eim V.S., Simal S., Rossell C., Femenia A., 2008. Effects of addition of carrot dietary fibre on the ripening process of a dry fermented sausage (sobrassada). Meat Sci. 80 (2), 173-182.

Elleuch M., Bedigian D., Roiseux O., Besbes S., Blecker Ch., Attia H., 2011. Dietary fibre and fibre-rich by-products of food processing: Characterisation, technological functionality and commercial applications: A review. Food Chem. 124 (2), 411-421.

Fuentes-Alventosa J.M., Rodríguez-Gutiérrez G.R., Jaramillo-Carmona S., Espejo-Calvo J.A., Rodríguez-Arcos R., Fernández-Bolaňos J., Guillén-Bejarano R., Jiménez-Araujo A., 2009. Effect of extraction method on chemical composition and functional characteristics of high dietary fibre powders obtained from asparagus by--products. Food Chem. 113 (2), 665-671.

Gómez M., González J., Oliente B., 2012. Effect of extruded wheat germ on dough rheology and bread quality. Food Bioproc. Technol., DOI: 10.1007/s11947-011-0519-5 [in press].

Gómez M., Jiménez S., Ruiz E., Oliete B., 2011. Effect of extruded wheat bran on dough rheology and bread quality. LWT – Food Sci. Technol. 44 (10), 2231-2237.

Gómez M., Ronda F., Blanco C.A., Caballero P.A., Apesteguía A., 2003. Effect of dietary fibre on dough rheology and bread quality. Eur. Food Res. Technol. 216 (1), 51-56.

González-Centeno M.R., Rosselló C., Simal S., Garau M.C., López F., Femenia A., 2010. Physico-chemical properties of cell wall materials obtained from ten grape varietiesand their by-products: grape pomaces and stems. LWT – Food Sci. Technol. 43 (10), 1580-1586.

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.

Grigelmo-Miguel N., Martin-Belloso O., 1999. Comparison of dietary fibre from by-products of processing fruits and greens and from cereals. Lebensm.-Wiss. u.-Technol. 32 (8), 503-508.

Jones M.G., 2009. Formation of vegetable flavour. In: Fruit and vegetable flavour – Recent advances and future prospects. Ed. B. Brücker, W.S. Grant. Woodhead Publ.

Kohajdová Z., Karovičová J., 2007. Effect incorporation of spelt flour on the dough properties and wheat bread quality. Żywn. Nauka Technol. Jakość 53 (4), 36-45.

Kohajdová Z., Karovičová J., 2008. Influence of hydrocolloids on quality of baked goods. Acta Sci. Pol., Technol. Aliment. 7 (2), 43-49.

Kohajdová Z., Karovičová J., Jurasová M., Kukurová K., 2011. Application of citrus dietary fibre preparations in biscuit preparation. J. Food Sci. Nutr. Res. 50 (3), 182-190.

Kumar N., Kumar K., 2011. Development of carrot pomace and wheat flour based cookies. J. Pure Appl. Sci. Technol. 1 (1), 4-10.

Lebesi D.M., Tzia C., 2011. Use endoxylanase treates cereal brans for development of dietary fibre enriched cakes. Innov. Food Sci. Emer. Technol., DOI: 10.1016/j.ifset.2011.08.001 [in press].

Mohammed I., Ahmed A.R., Senge B., 2012. Dough rheology and bread quality of wheat-chickpea flour blends. Indust. Crops Prod. 36 (1), 2012, 196-202.

Mortuza M.G., Tzen J.T.C., 2009. Physicochemical and functional properties of ten cultivars of seem (*Lablab purpureus* L.), an underexploited bean in Bangladesh. J. Sci. Agric. 89 (8), 1277-1283.

Nassar A.G., Abdel-Hamied A.A., El-Naggar E.A., 2008. Effect of citrus by-products flour incorporation on chemical, rheological and organolepic characteristics of biscuits. World J. Agric. Sci. 4 (5), 612-616.

Navarro-González I., Garciá-Valverde V., Garciá-Alonso J., Periago M.J., 2011. Chemical profile, functional and antioxidant properties of tomato peel fibre. Food Res. Inter., DOI:10.1016/j.foodres.2011.04.005 [in press].

Ognean M., Ognean C.F., Darie N., 2010. Rheological effects of some natural fibres used in breadmaking. Acta Univ. Cib. 14 (2), 3-10.

Raghavendra S.N., Rastogi N.K., Raghavarao K.S.N., Tharanathan R.N., 2004. Dietary fiber from coconut residue: effects of different treatments and particle size on the hydration properties. Eur. Food Res. Technol. 218 (6), 563-567.

Shyamala B.N., Jamuna P., 2010. Nutritional content and antioxidant properties of pulpwastefrom *Daucus carota* and *Beta vulgaris*. Mal. J. Nutr. 16 (3), 397-408.

Sivam A.S., Sun-Waterhouse D., Quek S.Y., Perera C.O., 2010. Properties of bread dough with added fibre polysaccharides and phenolic antioxidants: A review. J. Food Sci. 75 (8), 163-174.

Sowbhagya H.B., Suma F.P., Mahadevamma S., Tharanathan R.N., 2007. Spent residue from cumin – a potential source of dietary fibre. Food Chem. 104 (3), 1220-1225.

Sudha M.L., Vetrimani R., Leelavathi K., 2007. Influence of fibre from different cereals on the rheological characteristics of wheat flour dough and on biscuit quality. Food Chem. 100 (4), 1365-1370.

Tańska M., Zadernowski R., Konopka I., 2007. The quality of wheat bread supplemented with dried carrot pomace. Pol. J. Nat. Sci. 22 (1), 126-136.

Wang J., Rossel M., De Barber C.B., 2002. Effect of the addition different fibres on wheat dough performance and bread quality. Food Chem. 79 (2), 221-226.

Received – Przyjęto: 19.04.2012 Accepted for print – Zaakceptowano do druku: 27.06.2012

For citation – Do cytowania

Kohajdová Z., Karovičová J., Jurasová M., 2012. Influence of carrot pomace powder on the rheological characteristics of wheat flour dough and on wheat rolls quality. Acta Sci. Pol., Technol. Aliment. 11(4), 381-387.