Potravinarstvo, vol. 10, 2016, no. 1, p. 506-511
doi:10.5219/597
Received: 1 March 2016. Accepted: 6 July 2016.
Available online: 16 October 2016 at www.potravinarstvo.com

ISSN 1337-0960 (online)

EFFECT OF HYDRATED APPLE POWDER ON DOUGH RHEOLOGY AND COOKIES QUALITY

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ABSTRACT

Dietary fiber is a group of food components, which are resistant to human enzymatic digestion. The incorporation of dietary fiber obtained from various sources of fruit and vegetable by-products into the cereal based products such as bread, rolls, cookies, muffins, crackers, cakes and pasta is of growing interest for the food industry. The replacement of wheat flour by dietary fiber from various sources can change physicochemical, textural and organoleptic characteristic of bakery products. Apple pomace is the main by-product produced in the apple fruit processing industry. It is a rich source of carbohydrate, pectin, crude fiber, and minerals. The dietary fiber content in apple pomace ranges between 33 – 35%. The influence of hydrated commercial dietary fiber on wheat dough rheology (5, 10 and 15% flour replacement) and physical and sensory properties of cookies was examined. It was found that addition of HAP significantly increased the rheological properties of dough such as water absorption (from 58.0% to 75.3%), dough stability (from 6.7 min to 11.6 min) and prolonged dough development time (from 3.5 min to 11.0 min) and reduced the mixing tolerance index (from 34.7 BU to 11.9 BU). It was also concluded that hydrated apple powder addition reduced physical properties of cookies such as volume (from 10.4 cm^3 to 8.0 cm^3), diameter (from 4.7 cm to 4.2 cm), volume index (from 1.35 cm to 1.10 cm) and porosity (from 0.32 to 0.24). Sensory properties (taste, odour, stickiness, firmness and density) of cookies were also analysed. Cookies with addition of hydrated apple powder had fruity taste and odour and showed high overall acceptance. From this study resulted that hydrated apple powder can be used as potentially source of dietary fiber in cookie formulation. Moreover, addition of apple pomace inhibits the use of any other flavouring ingredients because has a pleasant fruity flavour.

Keywords: hydrated dietary fiber; rheology; cookie; apple

INTRODUCTION

Because of the rising interest in functional food, especially bioactive substances, food producers look for new sources and carriers of those substances. Consumers search products which would allow them to maintain their physical and mental fitness. Among many bioactive substances to be found in food – such as antioxidants, plant sterols, pro- and prebiotics and vitamins – a crucial role is played by dietary fibre (DF) **(Górecka et al., 2010)**.

The benefits associated with an adequate intake of DF include the regulation of intestinal transit and prevention or treatment of diabetes, cardiovascular disease and colon cancer. DF reduces the risk of hyperlipidaemia, hypercholesterolaemia and hyperglycaemia via mechanisms that modulate food ingestion and influence the digestion, absorption and metabolism of nutrients **(Macagnan et al., 2015)**.

DF as a class of compounds includes a mixture of plant carbohydrate polymers, both oligosaccharides and polysaccharides, e.g., cellulose, hemicelluloses, pectic substances, gums, resistant starch, inulin, that may be associated with lignin and other non-carbohydrate components (e.g., polyphenols, waxes, saponins, cutin, phytates, resistant protein) **(Kohajdová et al., 2011a)**.

Many fiber sources have been identified and are being used in various baked products **(Masoodi et al., 2002)**. Traditionally, consumers have chosen foods such as whole grains, fruits and vegetables as sources of dietary fiber. Recently, food manufacturers have responded to consumer demands for foods with higher fiber content by developing products in which high-fibre ingredients are used **(Almedia et al., 2013)**. The by-products of fruits from industrial applications are potential sources of DF that can be incorporated into food products. In addition, fruit fibres have significant amounts of secondary compounds associated with them, such as polyphenols with high biological activity and other bioactive compounds **(Macagnan et al., 2015)**.

DF can also impart some functional properties to foods, e.g., increase water holding capacity, oil holding capacity, emulsification and/or gel formation. That dietary fibre incorporated into food products (bakery products, dairy, jams, meats, soups) can modify textural properties, avoid synaeresis (the separation of liquid from a gel caused by contraction), stabilise high fat food and emulsions, and improve shelf-life **(Karovičová et al., 2015)**, colour, aroma and reduce energy of the final product **(Bilgiçli et al., 2007)**.

Dietary fibre is classified as soluble dietary fibre (SDF) and insoluble dietary fibre (IDF). The SDF/IDF ratio close to 1:2 indicates fibre as suitable for use as food ingredient Fruit fibres have better quality due to higher total and soluble fibre content **(Kołodziejczyk et al., 2007)**.

Apples are good sources of fiber with a well-balanced proportion between soluble and insoluble fraction **(Figuerola et al., 20005)**. Apple pomace (AP) from straight pressing, the primary by-product of the apple juice industry, is rich in cell wall material and is an interesting source of pectins and fibres **(Massiot and Renard, 1997)** and can be considered as a raw material for direct preparation of dietary fiber. AP consists of a heterogeneous mixture of peel, seeds, calyx, stem and pulp. AP can represent about 20 – 40% of the weight of processed fruits, depending on the technology used in the extraction of juice **(Macagnan et al., 2015)**. Dried AP is considered as a potential food ingredient **(Kohajdová et al., 2009, Sudha et al., 2007)**. AP is constituted by simple sugars (glucose, fructose, and sucrose) **(Mirabella et al., 2014)** and is a rich source of carbohydrates total dietary fibre including cellulose, hemicellulose, lignin, pectin, and galacturnic acid and minerals such as calcium, magnesium, zinc, iron, and copper. AP is also a good source of phytochemicals primarily phenolic acids such as chlorogenic, protocatechuic, and caffeic acid and flavonoids, e.g. flavanols and flavonols **(Kohajdová et al., 2014)**. Addition of AP in cake making can avoid the application of other flavouring ingredients as the cakes prepared with AP had pleasant fruity flavour **(Kohajdová et al., 2011a, Sudha et al., 2007)**.

Among foods enriched in fibre, the most known and consumed are breakfast cereals and bakery products such as integral breads and cookies **(Dhingra et al., 2012)**. Cookies have been suggested as a good way to use composite flours as they are ready-to-eat, provide a good source of energy, and are consumed widely throughout the. The term cookies, or biscuits as they are called in many parts of the world, refers to a baked product generally containing the three major ingredients flour, sugar and fat. These are mixed together with other minor ingredients to form dough **(Zucco et al., 2011)**. A variety of fibers from plant sources have been used in cookies to improve the texture, color and aroma with a reduced energy of the final product **(Gupta et al., 2011)**.

In the recent years, several studies have shown potential use of AP in cereal based products such as bread, cakes, cookies, biscuits and muffins **(Chen et al., 1988; Kohajdová et al., 2011a, 2014; Masoodi et al., 2002; Sudha et al. 2007; Vitali et al., 2009; Rupasinghe et al., 2009; Kučerová et al., 2013)**.

The aim of the present study was to determine the potential use of commercial apple powder, through a systematic study of the influence of hydrated apple powder on the rheological properties of wheat dough and the final quality of cookies. The sensory evaluation of cookies was also performed.

MATERIAL AND METHODOLOGY

Material

Fine wheat flour, commercial apple DF powder (Country life, s.r.o., Beroun, Czech Republic) and other ingredients (sugar, shortening, salt and baking powder) were purchased from local market in Slovakia.

Hydrated dietary fiber

Hydrated apple powder (HAP) was prepared according to method of **Chen et al. (1988)**. Seven parts of distilled water were added to one part of commercial apple powder to hydrate for 12 h. The excess water was decanted and discarded before rheological determination of and baking.

Chemical analysis

The chemical composition of commercial apple powder and fine wheat flour was presented in previous study by **Kohajdová et al. (2011a)**. The commercial apple powder contained 46.1% of total dietary fiber, of which 20.4% was content of pectin.

Rheological characteristics

The Farinographic parameters of dough (water absorption, dough development time, dough stability, degree of softening, mixing tolerance index) were determined using Farinograph Brabender (Duisburg, Germany) according to method ISO 5530-1: 2013.

Cookie formulation

The cookies were prepared according to modified formula described by **Tyagi et al. (2007)**. The control formula included: 100 g wheat flour, 53 g sugar, 26.5 g shortening, 1.1 g sodium bicarbonate, 0.89 g sodium chloride and 12 cm^3 water. Wheat flour was replaced by hydrated apple powder at level 5, 10, and 15%. The dough was rolled out to a height of 2 mm and cut into round shape with diameter of 40 mm using cookie cutter. The cookies were baked at 180 °C in oven (Mora, Slovakia) for 8-9 min. The cookies were cooled for 30 min and packed in polyethylene bags.

Cookies physical properties

Volume index of cookies was measured according to the method of **Turabi et al. (2008)**. Cookies were cut vertically through the center and the heights of the cookies were measured at three different points (B, C, and D) along the cross-sectioned cookie using the template. According to this method volume index was determined by the following formula: Volume index = B + C + D, where C is the height of the cookie at the center point and B and D are the heights of the cookie at the points 2.5 cm away from the center towards the left and right sides of the cookie, respectively.

Methods of **Shittu et al. (2007)** were used for determination of cookies weight, volume, specific volume and porosity. The weights of samples (W_1) (accuracy 0.001) were determined after sufficient cooling and the cookie volumes were determined using rapeseed displacement method (V_1). The samples were milled and sieved to 100 mesh size and the underflow was weighed (W_2). The sample was then poured into a 20 cm^3 measuring cylinder (accuracy = 0.5 cm^3) and tapped 10 times. The volume occupied by the cookie sample was determined (V_2). The data were used to determine the crumb (ρ_c) and solid density (ρ_s) as follows: $\rho_c = W_1/V_1$ and $\rho_s = W_2/V_2$. The porosity ε_c was calculated as: $\varepsilon_c = 1 - (\rho c/\rho s)$ **(Shittu et al., 2007)**.

Thickness and diameter of cookies were measured with a calliper in each cookie at three different places.

Sensory evaluation of cookies

The sensory evaluation of cookies was assessed in eight criteria (descriptors) of quality by five point hedonic scale which ranged from 5 = most liked to 1 = most disliked. The panel was made up of staff and students of the Faculty of Chemical and Food Technology, Slovak University of Technology, Bratislava, Slovakia. The overall acceptability of cookies was determined using 100 mm graphical non-structured abscissas with the description of extreme points (minimal or maximal intensity, from 0 to 100%) according to the method described by **Kohajdová et al. (2011a)**.

Statistical analysis

All analyses were carried out in triplicate and average values were calculated. The results were expressed as mean ± standard deviation. One-way analysis of variance and Fisher's least significant differences procedure were applied to the data to establish the significance of the differences between the samples at the level of $p = 0.05$. Statgraphic Plus, Version 3.1 (Statistical Graphic Corporation, Princeton, NY, USA) was used as the statistical analysis software.

RESULTS AND DISCUSSION

The mixing process is the crucial operation in bakery industry by which the wheat flour, water, and additional ingredients are changed through the mechanical energy flow to coherent dough. It is well known that dough properties can be affected by many features with different significance, therefore the dough development and processing optimization towards best quality bakery products is quite a difficult problem **(Bojňanská et al., 2014)**. The effect of the application of HAP on farinographic parameters of dough is presented in Table 1. It was concluded that incorporation of HAP significantly increased the water absorption from 58.0% (control) to 74.5% (15% of HAP). The increase of water absorption could be explained by the important number of hydroxyl groups existing in the fiber structure, which allow more water interactions through hydrogen bonding **(Borchani et al., 2001)**. Similar increase of WA was recorded by **Kohajdová et al. (2012)** and **Ajila et al. (2008)** when the carrot pomace powder and mango peel powder was incorporated to dough.

The dough development time (DDT) is the time from water addition to the flour until the dough reaches the point of the greatest torque. During the mixing phase, water hydrates the flour components and the dough is developed **(Lei et al., 2008)**. It was observed that addition of HAP significantly prolonged DDT from 3.5 min (control) to 11 min (15% of HAP). The same effect on the DDT was reported by several authors when the hydrated apple fiber **(Chen et al., 1988)**, laboratory prepared apple fiber **(Kohajdová et al., 2014)** or commercial apple wheat, potato and bamboo fiber were added to wheat dough **(Kučerová et al., 2013)**. An increase in the DDT indicates that an increase in fiber content in the blends has slowed the rate of hydration and development of gluten **(Sudha et al., 2007)**.

The dough stability (DS) gives some indication of the tolerance of the flour to mixing **(Lei et al., 2008)**. It was found that addition of HAP significantly increased DS from 6.7 min (control) to 11.6 min (15% of HAP). Recently, **Kohajdová et al. (2011a, 2014)** also reported an increase in DS after addition of apple dietary fiber. It can be explained by higher interaction of DF, water and flour proteins **(Kohajdová et al., 2014)**.

Also it was concluded that MTI was significantly reduced by the addition of HAP. Similar effect to MTI was also observed by **Kohajdová et al. (2013)** and **Nassar et al. (2008)** after addition of grapefruit dietary fiber, orange peel and pulp to wheat flour. Reduction in MTI could be explained by the interactions between fibres and gluten **(Kohajdová et al., 2014)**.

The physical properties of cookies with HAP are shown in Table 2. It was showed that addition of HAP significantly reduced the volume of cookies (Figure 1). It can be attributed to the dilution of gluten and also to the

Table 1 Effect of the different level of HAP on rheological parameters of dough.

	Water absorption (%)	Dough development time (min)	Dough stability (min)	Mixing tolerance index (BU)
Control	58.0 ±0.7	3.5 ±0.2	6.7 ±0.3	34.7 ±1.3
5% HAP	66.1 ±1.2*	10.3 ±0.5*	10.8 ±0.6*	30.8 ±0.2*
10% HAP	72.5 ±1.2*	10.4 ±0.4*	11.0 ±0.4*	30.3 ±1.3*
15% HAP	75.3 ±0.7*	11.0 ±0.5*	11.6 ±0.5*	10.9 ±0.5*

NOTE: * denotes a statistically significant difference at $p = 0.05$ level, HAP- hydrated apple powder.

Table 2 Effect of hydrated apple powder on physical parameters of cookies.

	Diameter (cm)	Volume (cm^3)	Porosity	Volume index (cm)
control	4.7 ±0.2	10.3 ±0.5	0.32 ±0.01	1.35 ±0.01
5% HAP	4.6 ±0.1	9.5 ±0.3*	0.32 ±0.01	1.33 ±0.05
10% HAP	4.4 ±0.0*	8.6 ±0.4*	0.27 ±0.01*	1.28 ±0.04
15% HAP	4.2 ±0.1*	8.0 ±0.3*	0.24 ±0.01*	1.10 ±0.05*

NOTE: * denotes a statistically significant difference at $p = 0.05$ level, HAP- hydrated apple powder.

Table 3 Sensory evaluation HAP enriched cookies.

	grain taste	sweet taste	fruity taste	grain odour	fruity odour
control	5.0 ±0.0	4.9 ±0.1	1.0 ±0.1	5.0 ±0.0	1.0 ±0.1
5% HAP	3.7 ±0.1*	4.0 ±0.2*	2.5 ±0.1*	3.7 ±0.1*	3.0 ±0.1*
10% HAP	2.5 ±0.1*	3.4 ±0.2*	3.9 ±0.1*	3.3 ±0.1*	3.7 ±0.1*
15% HAP	2.0 ±0.1*	2.5 ±0.1*	4.5 ±0.1*	2.4 ±0.1*	4.1 ±0.1*

NOTE: * denotes a statistically significant difference at $p = 0.05$ level, HAP- hydrated apple powder.

Table 4 Overall acceptance and textural characteristics of cookies.

	firmness	stickiness	density	overall acceptance
control	4.9 ±0.1	1.1 ±0.1	4.9 ±0.1	99.9 ±0.1
5% HAP	4.6 ±0.1*	1.3 ±0.1*	4.6 ±0.1	96.3 ±0.4
10% HAP	4.5 ±0.1*	2.5 ±0.1*	4.0 ±0.1*	92.8 ±0.7*
15% HAP	4.2 ±0.1*	2.7 ±0.1*	3.5 ±0.1*	90.6 ±0.5*

NOTE: * denotes a statistically significant difference at $p = 0.05$ level, HAP- hydrated apple powder.

Figure 1 Cookies with addition HAP. NOTE: HAP- hydrated apple powder.

interaction of gluten, DF components, and water **(Kohajdová et al., 2014)**. Hydration of apple fiber before addition to wheat flour can partially alleviate the detrimental effects on bread loaf volume **(Chen et al., 1988)**.

Moreover, it was observed that volume index of cookies decreased significantly when the level of HAP reached 15%. The same effect was reported by **Masoodi et al. (2002)** after addition of apple pomace to cake formula.

From results also concluded that higher level of HAP (10 and 15% of HAP) significantly reduced diameter of cookies. This finding is in agreement with those described by **El-Sharnouby et al. (2012)**, **Larrea et al. (2005) and Chen et al. (1988)** for wheat bran and date powder, orange pulp and apple fiber incorporated cookies and biscuits.

Results also showed that cookies with higher level (10 and 15%) of HAP had significant lower porosity (0.27 and 0.24 respectively) as control sample. This decreased porosity is related to the incorporation of air as smaller bubbles during the kneading process, giving rise to a dough with greater stability that achieves greater expansion in the subsequent processes **(Martínez et al., 2014)**.

The effects of HAP on the sensory properties of cookies are presented in Table 3. Results showed that addition of HAP significantly increased fruity taste and fruity odour and reduced grain taste and odour of cookies. Similar effect of increasing fruity taste and odour was noticed after addition of raspberry pomace **(Górecka et al., 2010)**, apple dietary fiber **(Kohajdová et al., 2011a)** and grapefruit dietary fiber **(Kohajdová et al., 2013)** to cookies and biscuits. It was also observed that incorporation of HAP at level 5% had no significant effect on overall acceptability (Table 4).

Incorporation of HAP to cookies also resulted in the significant decrease of density and firmness. Moreover, the stickiness was significantly increased after increasing flour substitution by HAP. The same result was reported by **Kohajdová et al. (2011a)** in cookies with addition of commercial apple fiber.

CONCLUSION

The additions of hydrated commercial apple powder significantly affect the rheological properties of wheat dough in various ways. It was concluded that WA was increased, DS and DDT were prolonged and MTI was decreased. Physical characteristics of cookies (diameter, volume, volume index and porosity) were significantly decreased with the increasing level of HAP. Sensorical parameters were also affected significantly. Furthermore, it was observed that cookies with 5% HAF were the most acceptable for assessors.

The result of this study showed that cookies with acceptable physical, textural and sensory properties can be developed by incorporating hydrated apple powder in wheat flour at level 5%. Moreover, it was reported that the addition of apple pomace avoids the use of any other flavouring ingredients because has a pleasant fruity flavour.

REFERENCES

Ahmed, J. 2015. Effect of barley β-glucan concentrate on oscillatory and creep behavior of composite wheat flour dough. *Journal of Food Engineering*, vol. 152, p. 85-94. http://dx.doi.org/10.1016/j.jfoodeng.2014.11.018

Ajila, C. M., Leelavathi, K., Prasada Rao, U. J. S. 2008. Improvement of dietary fiber content and antioxidant properties in soft dough biscuits with the incorporation of mango peel powder. *Journal of Cereal Science*, vol. 48, no. 2, p. 319-326. http://dx.doi.org/10.1016/j.jcs.2007.10.001

Almedia, E. L., Chang, Y. K., Steel, C. J. 2013. Dietary fibre sources in bread: Influence on technological quality. *LWT - Food Science and Technology*, vol. 50, no. 2, p. 545-553. http://dx.doi.org/10.1016/j.lwt.2012.08.012

Anil. M. 2007. Using of hazelnut testa as a source of dietary fiber in breadmaking. *Journal of Food Engineering*, vol. 80, no. 1, p. 61-67. http://dx.doi.org/10.1016/j.jfoodeng.2006.05.003

Arun, K. B., Persia, F., Aswathy, P. S. P., Chandran, J., Sajeev, M. S., Jayamurthy, P., Nisha, P. 2015. Plantain peel - a potential source of antioxidant dietary fibre for developing functional cookies. *J. Food Sci. Technol.*, vol. 52, no. 10, p. 6355-6364. http://dx.doi.org/10.1007/s13197-015-1727-1 PMid:26396380

Bilgiçli, N., İbanoğlu, Ş., Herken, E. N. 2007. Effect of dietary fibre addition on the selected nutritional properties of cookies. *Journal of Food Engineering*, vol. 78, no. 1, p. 86-89. http://dx.doi.org/10.1016/j.jfoodeng.2005.09.009

Bojňanská, T., Tokár, M., Frančáková, H. Changes of the dough rheological properties influenced by addition of potato fibre. *Potravinarstvo*, vol. 8, no. 1, p. 161-166. http://dx.doi.org/10.5219/371.

Borchani, Ch., Masmoudi, M., Besbes, S., Attia, H., Deroanne, C., Blecker, Ch. 2011. Effect of date flesh fiber concentrate addition on dough performance and bread quality. *Journal of Texture Studies*, vol. 42, no. 4, p. 300-308. http://dx.doi.org/10.1111/j.1745-4603.2010.00278.x

Dhingra, D., Michael, M.,Rajput, H., Patil, R. T. 2012. Dietary fibre in foods: a rewiew. *Journal of Food Science and Technology*, vol. 49, no. 3, p. 255–266. http://dx.doi.org/10.1007/s13197-011-0365-5

El-Sharnouby, G. A., Aleid, A. M., Al-Otaibi, M. M. 2012. Nutritional Quality of Biscuit Supplemented with Wheat Bran and Date Palm Fruits (*Phoenix dactylifera* L.), *Food and Nutrition Sciences*, vol. 3, no. 3, p. 322-328. http://dx.doi.org/10.4236/fns.2012.33047

Fernández-Ginés, J. M., Fernández-López, J., Sayas-Barberá, E., Sendra, E., Pérez-Álvarez, J. A. 2004. Lemon albedo as a new source of dietary fiber: Application to bologna sausages. *Meat Science*, vol. 67, no. 1, p. 7-13. http://dx.doi.org/10.1016/j.meatsci.2003.08.017

Gómez, M., Ronda, F., Blanco, C. A., Caballero, A., Apesteguía, A. 2003. Effect of dietary fibre on dough rheology and bread quality. *European Food Research and Technology*, vol. 216, no. 1, p. 51-56. http://dx.doi.org/10.1007/s00217-002-0632-9

Gupta, M., Bawa, A. S., Abu-Ghannam, N. 2011. Effect of barley flour and freeze–thaw cycles on textural nutritional and functional properties of cookies. *Food and Bioproduct Processing*, vol. 89, no. 4, p. 520-527. http://dx.doi.org/10.1016/j.fbp.2010.07.005

Chen, H., Rubenthaler, G. L., Leung, H. K., Baranowski, J. D. 1988. Chemical, Physical, and Baking Properties of Apple Fiber Compared with Wheat and Oat Bran. *Cereal Chemistry*, vol. 65, no. 3, p. 244-247. [cit. 2016-02-06] Available at: http://www.aaccnet.org/publications/cc/backissues/1988/documents/65_244.pdf.

ISO 5530-1: 2013. *Wheat flour -- Physical characteristic of doughs -- Part 1: Determination of water absorption and rheological properties using a farinograph.*

Jurasová, M., Kohajdová, Z., Karovičová, J. Dietary fiber: Definition, sources and extraction. *Potravinarstvo*, vol. 5, no. 2, p. 22-26. http://dx.doi.org/10.5219/125

Karovičová, J., Kohajdová, Z., Minarovičová, L., Kuchtová, V. 2015. The Chemical Composition of Grape Fibre. *Potravinarstvo*, vol. 9, no. 1, p. 56-57. http://dx.doi.org/10.5219/428

Kohajdová, Z., Karovičová, J., Jurasová, M., Kukurová, K. 2011a. Effect of the addition of commercial apple fibre powder on the baking and sensory properties of cookies. *Acta Chimica Slovaca*, vol. 4, no. 2, p. 88-97. [cit. 2016-02-05] Available at: http://www.acs.chtf.stuba.sk/papers/acs_0095.pdf.

Kohajdová, Z., Karovičová, J., Šimková, S. 2009. Use of Apple fibre in bakery products. *Acta fytotechnica et zootechnica*, vol. 12, p. 286-290.

Kohajdová, Z., Karovičová, J., Jurasová, M., Kukurová, K. 2011b. Application of citrus dietary fibre preparations in biscuit production, *Journal of Food and Nutrition Research*, vol. 50, no. 3, p. 182-190. Available at: http://web.b.ebscohost.com/ehost/pdfviewer/pdfviewer?sid=cf25913f-ce38-4a6a-8de1-0cca7196cf67%40sessionmgr102&vid=2&hid=106

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 Scientiarum Polonorum, Technologia Alimentaria*, vo.11, no.4, p. 381-387. Available at: http://www.food.actapol.net/pub/7_4_2012.pdf.

Kohajdová, Z., Karovičová, J., Magala, M., Kuchtová, V. 2014. Effect of apple pomace powder addition on farinographic properties of wheat dough and biscuits quality. *Chemical papers*, vol. 68, no. 8, p. 1059-1065. http://dx.doi.org/10.2478/s11696-014-0567-1

Kołodziejczyk, K., Markowski, J., Kosmala, M., Król, B., Płocharski, W. 2007. Apple pomace as a potencial source of nutraceutical products. *Polish Journal of Food and Nutrition sciences*, vol. 57, no. 4, p. 291-295.

Kučerová, J., Šottníková, V., Nemodová, Š. 2013. Influence of Dietary Fibre Addition on the Rheological and Sensory Properties of Dough and Bakery Products. *Czech Journal of Food Science*, vol. 31, no. 4, p. 340-346. Available at: http://www.agriculturejournals.cz/publicFiles/97017.pdf.

Larrea, M. A., Chang, Y. K., Martinez-Bustos, F. 2005. Some functional properties of extruded orange pulp and its effect on the quality of cookies. *LWT - Food Science and Technology*, vol. 38, no. 3, p. 213-220. http://dx.doi.org/10.1016/j.lwt.2004.05.014

Lei, F., Ji-Chun, T., Cai-Ling, S., Chun, L. 2008. RVA and Farinograph Properties Study on Blends of Resistant Starch and Wheat Flour. *Agricultural Sciences in China*, vol. 7, no. 7, p. 812-822. http://dx.doi.org/10.1016/S1671-2927%2808%2960118-2

Macagnan, F. T., Santos, L. R., Roberto, B. S., De Moura, F. A., Bizzani, M., Da Silva, L. P. 2015. Biological properties of apple pomace, orange bagasse and passion fruit peel as alternative sources of dietary fibre. *Bioactive Carbohydrates and Dietary Fibre*, vol. 6, no. 1, p. 1-6. http://dx.doi.org/10.1016/j.bcdf.2015.04.001

Martínez, M. M., Díaz, Á. Gómez, M. 2014. Effect of different microstructural features of soluble and insoluble fibres on gluten-free dough rheology and bread-making. *Journal of Food Engineering*, vol. 142, p. 49-56. http://dx.doi.org/10.1016/j.jfoodeng.2014.06.020

Masoodi, F. A., Sharma, B., Chauhan, G. S. 2002. Use of apple pomace as a source of dietary fiber in cakes. *Plant Foods for Human Nutrition*, vol. 57, p. 121-128. http://dx.doi.org/ 10.1023/A:1015264032164

Mirabella, N., Castellani, V., Sala, S. 2014. Current options for the valorization of food manufacturing waste: a review. Journal of Cleaner Production, vol. 65, p. 28-41. http://dx.doi.org/10.1016/j.jclepro.2013.10.051

Rupasinghe, H. P. V., Wang, L. X., Pitts, N. L., Astatkie, T. 2009. Baking and sensory characteristics of muffins incorporated with apple skin powder. *Journal of Food Quality*, vol. 32, no. 6, p. 685-694. http://dx.doi.org/10.1111/j.1745-4557.2009.00275.x

Shiau, S.-Y., Wu, M.-Y., Liu, Y.-L. 2015. The effect of pineapple core fiber on dough rheology and the quality of mantou. *Journal of Food and Drug Analysis*, vol. 23, no.3, p. 493-500. http://dx.doi.org/ http://dx.doi.org/10.1016/j.jfda.2014.10.010

Shittu, T. A., Raji, A. O., Sanni, L. O. 2007. Bread from composite cassava-wheat flour: I. Effect of baking time and temperature on some physical properties of bread loaf. *Food Research International*, vol. 40, no. 2, p. 280-290. http://dx.doi.org/10.1016/j.foodres.2006.10.012

Singh, M., Liu, S. X., Vaughn, S. F. 2012. Effect of corn bran as dietary fiber addition on baking and sensory quality. *Biocatalysis and Agricultural Biotechnology*, vol. 1, no. 4, p. 348-352. http://dx.doi.org/10.1016/j.bcab.2012.02.005

Sowbhagya, H. B. Suomya, C., Indrani, D., Srinivas, P. 2015. Physico-chemical characteristics of – chilli spent residue and its effect on the rheological, microstructural and nutritional qualities of bread. *J. Food Sci. Technol.*, vol. 52, no. 11, p. 7218-7226. http://dx.doi.org/10.1007/s13197-015-1824-1

Struck, S., Gundel, L., Zahn, S., Rohm, H. 2016. Fiber enriched reduced sugar muffins made from iso-viscous batters. *LWT – Food Science and Technology*, vol. 65, p. 32-38. http://dx.doi.org/10.1016/j.lwt.2015.07.053

Sudha, M. L., Baskaran, V., Leelavathi, K. 2007. Apple pomace as a source of dietary fiber and polyphenols and its effect on the rheological characteristics and cake making. *Food Chemistry*, vol. 104, no. 2, p. 686-692. http://dx.doi.org/10.1016/j.foodchem.2006.12.016

Turabi, E., Gulum, S., Sahin, S. 2008. Rheological properties and quality of rice cakes formulated with different gums and an emulsifier blend. *Food Hydrocolloids*, vol. 22, no. 2, p. 305-312. http://dx.doi.org/10.1016/j.foodhyd.2006.11.016

Tyagi, S. K., Manikantan, M. R., Oberoi, H. S., Kaur, G. 2007. Effect of mustard flour incorporation on nutritional, textural and organoleptic characteristics of biscuits. *Journal of Food Engineering*, vol. 80, no. 4, p. 1043-105. http://dx.doi.org/10.1016/j.jfoodeng.2006.08.016

Vitali, D., Dragojević, I. V., Šebečić, B. 2009. Effects of incorporation of integral raw materials and dietary fibre on the selected nutritional and functional properties of biscuits. *Food Chemistry*, vol. 114, no. 4, p. 1462-1469. http://dx.doi.org/10.1016/j.foodchem.2008.11.032

Zucco, F., Borsuk, Y., Arntfield, S. D. 2011. Physical and nutritional evaluation of wheat cookies supplemented with pulse flours of different particle sizes. *LWT - Food Science and Technology*, vol. 44, no. 10, p. 2070-2076. http://dx.http://dx.doi.org/10.1016/j.lwt.2011.06.007

Acknowledgments:

This work was supported by courtesy of Slovak Grant Agency (VEGA Grant No. 1/0487/16 and No. 1/0453/13).

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