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CHANGES OF THE DOUGH RHEOLOGICAL PROPERTIES INFLUENCED BY ADDITION OF POTATO FIBRE

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ABSTRACT

Fibre is an important component of diet and nutrition and is one of the groups of biologically important substances consumed in insufficient quantity. One possibility to increase its intake is to enrich with fibre the food consumed in significant quantities, such as bread and pastries. The aim of this experimental work was to verify the influence of the addition of commercially produced potato fibre Potex to wheat flour and to evaluate the changes in physical properties of subsequently prepared doughs. The addition of 1%, 3%, 5% and 7% of Potex has been chosen and rheological properties were evaluated by the means of E-Farinograph (consistency, water absorption, dough development time, stability and degree of softening), Extensograph-E (resistance to extension, maximal resistance to extension, extensibility, extensibility maximum and energy dough), and Amylograph-E (beginning of gelatinization, viscosity, maximum of gelatinization). The addition of Potex depending on the amount changed the physical dough properties: above 3% of addition significantly increased the beginning of gelatinization and with increasing addition the maximum of gelatinization has increased. Based on the evaluation of farinograph curves it can be concluded that the addition of Potex increased water absorption of composite flours, prolonged dough development time and dough stability. Extensograph measurements showed, with increasing addition of Potex the decrease in dough extension. All doughs were easy to process and with the suitable amount of addition their satisfactory parameters could be maintained. From a technological point of view, the addition of fibre (Potex) up to 3% was fully acceptable and did not significantly alter the rheological properties of processed doughs.

Keywords: bread; potato fibre; kneading; dough rheology

INTRODUCTION

Bread and pastries are basic foods consumption of which in Slovakia, despite the downturn in recent years still reaches high numbers, around 67 kg per person per year (Figure 1). However, considering the technology of milling of cereals, where the milling process changes the appearance and nutrition value of cereal grains by separating the bran and germ from the endposperm and reducing the particle size **(Barbosa and Yan, 2003)**, it is appropriate to consider the enrichment of bread with nutritionally important ingredients that would increase its nutritional benefits for consumers **(Paturi et al., 2012)**. One of the groups of biologically important substances consumed in insufficient quantities is fibre, which is often deficient in the diet. Generally speaking, dietary fibre is the edible parts of plants, or similar carbohydrates, that are resistant to digestion and absorption in the small intestine **(Lattimer and Haub, 2010)**. There are many beneficial effects of increased dietary fibre consumption on human health and body function.

Codex alimentarius Commission **(FAO/WHO 2009)** defines dietary fibre as carbohydrate polymers with ten (or three) or more monomeric units, which are not hydrolysed by the endogenous enzymes in the small intestine of humans and belong to the following categories:

Edible carbohydrate polymers naturally occurring in the food as consumed; carbohydrate polymers, which have been obtained from food raw material by physical, enzymatic or chemical means and which have been shown to have a physiological effect of benefit to health as demonstrated by generally accepted scientific evidence to competent authorities; and synthetic carbohydrate polymers which have been shown to have a physiological effect of benefit to health as demonstrated by generally accepted scientific evidence to competent authorities.

Many studies have confirmed the beneficial effect of fibre on human health, especially on the physiology of digestion **(Fardet, 2010; Yikyung et al., 2011; Gong and Yang, 2012)**. In addition to the favourable preventive effect on development and progression of gastrointestinal diseases, such as colon and rectum cancer, chronic inflammation of the colon, gallbladder diseases, fibre is important in the prevention of so-called lifestyle diseases - type 2 diabetes mellitus, obesity, cardio-vascular diseases, etc. **(Champ et al., 2003; Marcil et al., 2003; Mohamed, 2014)**.

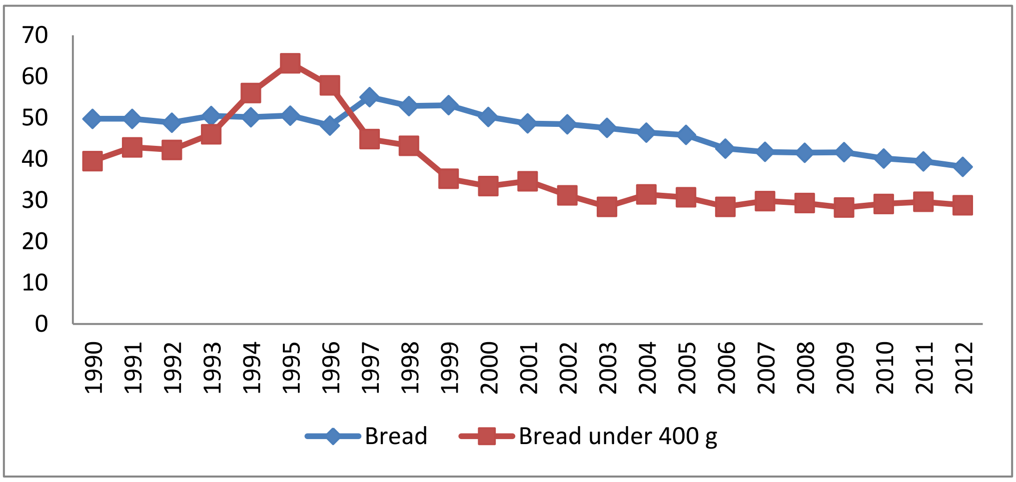

Figure 1 Consumption of bread and bread under 400g per person per year in Slovakia **(URL 1)**

Based on the recommendations (recommended dietary intakes) the daily fibre intake should range from 1 g (children up to 6 months) to 30 g per day depending on age, gender and physical demands of the work. One possibility for securing that intake is consumption of fibre-enriched bread; however, the possibility of its production is affected by the processability of dough. In the frame of our research work the potato fibre Potex has been added to wheat flour what caused the changes in the monitored and evaluated rheological properties of kneaded dough.

MATERIAL AND METHODOLOGY

For the production of dough the wheat flour T650 was used, to which 1%, 3%, 5% and 7% of potato fibre (POTEX, source: LYCKEBY CULINAR, Horaždovice, Czech Republic) was added with the following composition (g per 100 g of product): fibre 65 g, carbohydrates 17 g, 5 g protein, 0.3 g fat, dry matter min 90%)

Composite flour was analysed in order to determine the rheological properties by the means of following devices: Farinograph-E, Brabender OhG, Duisburg, Germany (ICC Standard 115/1, 1992, AACC Method 54-21, 1995). The mixing curve is characterised by an ascending part that indicated the changes during the dough development process, while the subsequent decline in the resistance is taken as a sign of a steady breakdown of the dough structure upon mixing beyond the point of optimum development. Optimum development from the standpoint of bread quality may occur slightly past "mixing peak". The effects of the Potex addition on consistency, water absorption, dough development time, stability and degree of softening were established (FU = farinograph units - unit commonly used for evaluation of rheologic consistency in bakery practice. It was defined by Brabender company. The physical equation is Nm - 100 FU = 0.1 Nm).

Extensograph-E, Brabender OhG, Duisburg, Germany (ICC-Standard 114/1, AACC Method 54-10) measures dough extensibility and dough relaxation behaviours. The effects of the Potex addition on resistance to extension, maximal resistance to extension, extensibility, extensibility maximum and energy dough were established.

Amylograph-E, Brabender OhG, Duisburg, Germany (ICC-Standard 126/1, AACC Method 22-10). The effects of the Potex addition on beginning of gelatinization, viscosity (enzyme activity), maximum of gelatinization were established (AU = amylograph units - unit commonly used for evaluation of rheologic consistency in bakery practice. It was defined by Brabender company. The physical equation is Nm - 100 AU = 0.1 Nm).

Control dough without Potex was also analysed.

RESULTS AND DISCUSSION

The potato pulp and potato peel are formed as a result of industrial processing of potatoes. Potato peel can be used after modification as an addition in wheat bread **(Kaack et al., 2006)**. The major components of commercially produced potato fibre Potex are non-starch polysaccharides. Potex constitutes a potato fibre, preparation widely used as an ingredient to meat and bakery products which with thermal treatment results in creation of new compounds **(Perez-Jimenez et al., 2014)**. Melanoidins are high molecular weight brown end products of Maillard reaction (formed in the process of bread baking), and few data presenting tumour cell growth inhibiting activity of melanoidins have been reported. The results suggest potential application of Potex preparation as a functional food ingredient and chemopreventive agent **(Langner et al., 2011)**.

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.

Regarding the rheological properties of prepared doughs with the addition of Potex, based on the amylografic evaluation the significant (double) increase in the beginning of gelatinization was recorded (AU = amylograph units) with the addition of 3% Potex and more (Figure 2). With the increasing amount of addition maximum of gelatinization was increased, for all samples the values were higher than the optimum. (**Bojňanská et al., 2013**). It can be assumed that this

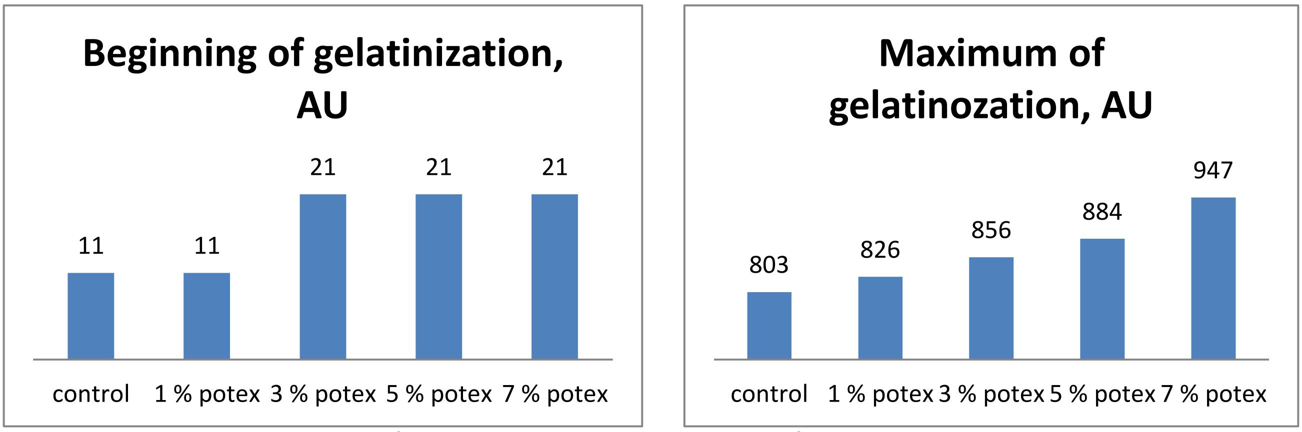

Figure 2 Amylographic properties of prepared doughs with the addition of Potex (AU = amylograph units)

phenomenon could be caused by the increased content of non-starch polysaccharides that form viscous solutions and are part of Potex **(Mohammed et al., 2012; Almeida et al., 2013)**. Obtained values suggest deterioration of properties of breadcrumb, surface and other bread properties.

Changes of **farinograph characteristics** of dough with the addition of Potex are shown in Figure 3a to 3e. With an increasing proportion of Potex slower hydration of the dough components and prolongation of the period of dough development were observed. With the increasing addition of Potex the dough stability increased and dough flexibility slightly decreased compared to control samples. **Almeida et al. (2010)** verified that the fibres studied altered the main farinographic parameter drastically, suggesting that the incorporation of these fibres in bread making processes leads to various consequences to the dough forming stage (mixing), which must be considered for the adjustment of process parameters.

The addition of Potex significantly increased the water absorption of composite flours, which was caused by the presence of fibre components. As mentioned in **Camire et al. (1997)** high water absorption of potato fibre is mainly due to the high proportion of cellulose, hemicellulose and lignin. With increasing addition, the dough development time increased, with 5% and 7% of Potex to unacceptable 15 to 20 minutes. With regard to the development time, the incorporation of fibre increased the time to reach the maximum consistency of dough, as has already been observed by **Sanz Penella et al. (2008)**.

It can be assumed that due to the higher content of fibre components there was a change in the structure and hence delayed hydration and later the creation of compact homogeneous dough mass. This effect could be attributed to a fibre-gluten interaction, which prevents protein hydration **(Gomez et al., 2003; Rosell et al., 2006)**.

Stability of dough was significantly prolonged. Under certain processing conditions this can be interesting, but such dough is harder to process with higher demands for energy.

When analysing the dough **extensografic characteristics** extensografic curves were obtained (Figure 4).

Based on the obtained results it can be pointed out that the changed of dough character with the addition of Potex were in favour of elastic properties. To create an optimal dough structure desirable viscoelastic properties are needed, not just its elasticity or viscosity. Very elongated doughs (low and wide curves of extensograf) are characterized by spreadability (fluidity), which is undesirable because of the low volume of bread, which is caused by leakage of CO2 through the weakened dough structure. On the other hand, very firm doughs (high and narrow curves of extensograf), do not allow the increase of the products volume due to the very solid dough structure. The formed CO2 does not have sufficient overpressure to increase product volume.

With increasing proportion of Potex significant decrease in dough elongation was observed (as reflected in narrowing the curve). **Gomez et al. (2003)** investigated the effect of the addition of different types of fibre on the rheological properties of wheat dough. Their findings show a decrease in elongation rheology of doughs with the addition of fibre compared to the wheat dough, which is consistent with the results obtained by us. The bigger the dough elongation the looser the dough, but too low values are not desirable to produce bread with demanded parameters **(Dodok and Szemes, 1998)**. Fibre incorporation into bread dough systems greatly interferes with protein association and behaviour during heating and cooling, for example, the incorporation of sugar beet fibre into the dough matrix induces the disruption of the viscoelastic system yielding weaker doughs, and it greatly competes for water with starch affecting pasting and gelling. Conversely, inulin in the range tested seems to integrate into the dough increasing its stability **(Rosell et al., 2010)**.

It can be stated that the addition of Potex did not change significantly the extensografic energy, but importantly affected the dough properties in a way that the values of elongation decreased and the extensografic maximum increased. It shows that although the extensografic energy was about the same for all douh samples, its properties were different.

Almeida et al. (2013) verified that, depending on the type and quantity of the dietary fibre source used, different responses can be obtained for process parameters and final quality characteristics of bread. Fibres can be used by the food technologist in bread formulations.

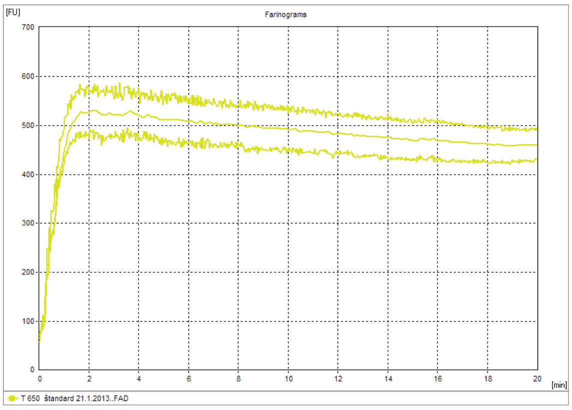

Figure 3a (control)

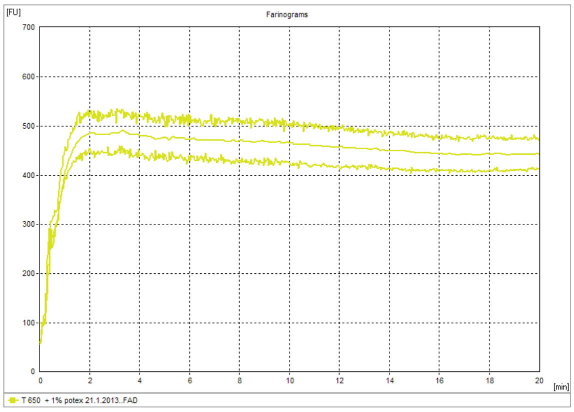

Figure 3b (1 % Potex)

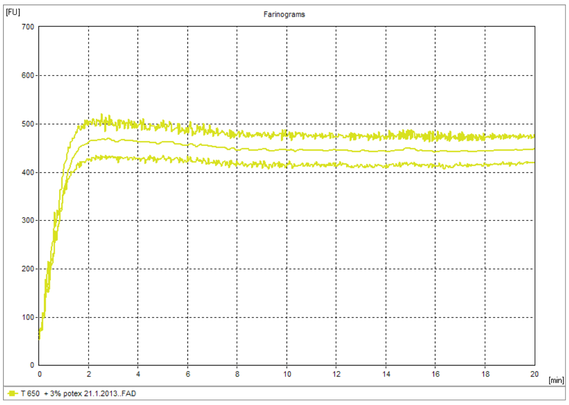

Figure 3c (3 % Potex)

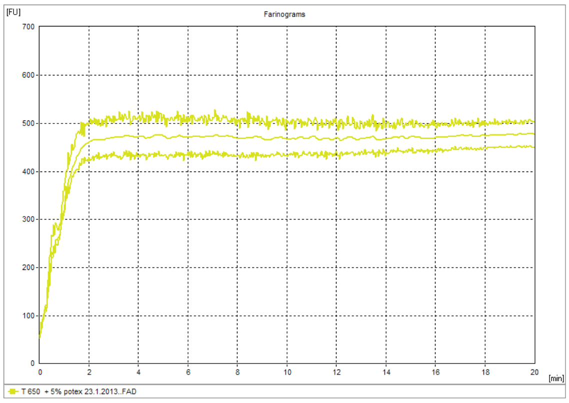

Figure 3d (5 % Potex)

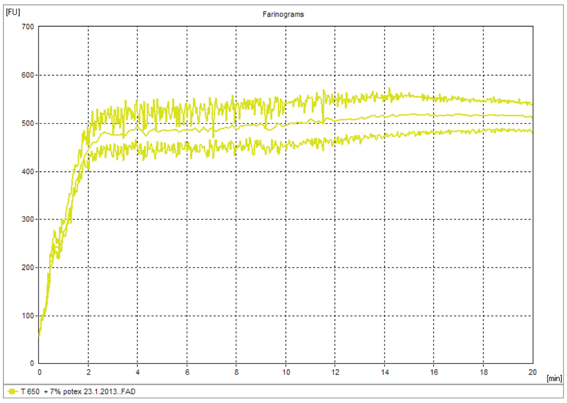

Figure 3e (7 % Potex)

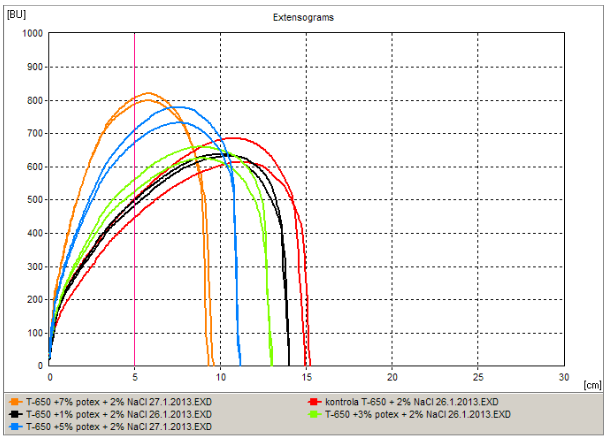

Figure 4 Extensographic parameters

Potato fibre combines the positive properties of insoluble fibre with its innate starch in a perfect way. One key technological property of fibre containing cellulose is the construction of a three-dimensional fibre network in the end product greatly improving the texture and stability of the food. In addition the moisture binding and retention of the cellulose from the potato which are independent of external factors such as temperature, pH value or storage time, are synergistically complemented by the temperature-induced water-binding ability of the starch. That is why potato fibre is distinguished by an extremely high water-binding capacity **(Meyer et al., 2009)**.

It has been found that the addition of fibre to the bread dough improves its nutritional value **(Fardet, 2010; Mohamed, 2014)**, and can also positively influence the rheological properties of the dough. Furthermore, the addition of fibre extends product shelf life and ultimately improves qualitative and sensory properties of bread **(Gómez et al., 2003)**. The addition of fibre in the products is particularly important in terms of the required increase of its daily intake and reducing the calorific value of the bakery products. With a suitably chosen amount of addition satisfactory technological parameters of dough can be maintained.

CONCLUSION

Based on the results of evaluation of the physical characteristics of doughs prepared from composite flours with addition of 1%, 3%, 5% and 7% of potato fibre Potex it can be stated that the addition of fibre affects the rheological behaviour of dough during processing.

From a technological point of view, the addition of 3% of potato fibre (Potex) was fully acceptable and did not alter the rheological properties of the processed dough. Higher amounts significantly increased the beginning of gelatinization and with increasing addition the maximum of gelatinization was increased. Based on the evaluation of farinograph curves it can be concluded that the addition of Potex increased water absorption of composite flours, prolonged dough development time and dough stability. Extensograph-E measurements highlighted the decrease in elongation of dough with increasing addition of Potex. All prepared doughs were easy to process and their satisfactory parameters can be maintained with the addition of a suitably chosen amount. From a technological point of view, the addition of 3% of potato fibre (Potex) was fully acceptable and did not alter the rheological properties of the processed dough. Whether the product from such dough is accepted by consumers is at the end decided based on its sensory quality.

REFERENCES

Almeida, E. L., Chang, Y. K., Steel, C. J. 2010. Effect of adding different dietary fiber sources on farinographic parameters of wheat flour. *Cereal Chemistry*, vol. 87, p. 566-573. http://dx.doi.org/10.1094/CCHEM-05-10-0063

Almeida, E. L., Chang, Y. K., Steel, J. C. 2013. Dietary fibre sources in bread: Influence on technological quality. *LWT - Food Science and Technology*, vol. 50, p. 545-553. http://dx.doi.org/10.1016/j.lwt.2012.08.012

Barbosa-Canovas, G. V., Yan, H. 2003. Powder characteristics of pre-processed cereal flour. *Characterization of Cereals and Flour. Properties, Analysis and Applications*. Marcel Dekker, Inc., New York, Basel, pp. 523. ISBN 0-8247-0734-6

Bojňanská, T., Muchová, Z., Frančáková, H., Urminská, D., Mendelová, A., Mareček, J., Solgajová, M., Vietoris, V., Czako, P. *Hodnotenie surovín a potravín rastlinného pôvodu*. 1 vyd. Nitra: Slovenská poľnohospodárska univerzita (Nitra, Slovakia) 2013. 335 s. ISBN 978-80-552-1086-5.

Camire, M. E., Violette, D., Dougherty M. P., McLaughlin, M. A. 1997. Potato peel dietary fiber composition: effects of peeling and extrusion cooking processes. *Journal of Agriculture and Food Chemistry*, vol. 45, no. 4, p. 1404-1408. http://dx.doi.org/10.1021/jf9604293

Champ, M., Langkilde, A. M., Brouns, F., Kelitz, B., ColletT, Y. I. B. 2003. Advances in dietary fibre characterisation. 1. Definition of dietary fibre, physiological relevance, health benefits and analytical aspects. *Nutrition Research Reviews*, vol. 16, no. 1, p. 71-82. http://dx.doi.org/10.1079/NRR200254 PMid: 19079938

Dodok, L., Szemes, V. 1998. *Laboratórne kontrolné metódy pre pekárenskú a cukrársku prax.* CPaC, Pezinok, 80 p.

FAO/WHO 2009 Codex Alimentarius Commission. Report of the 30th session of the Codex Committee on Nutrition and Foods for Special Dietary Uses, ALINORM 09/32/26.

Fardet, A. 2010. New hypotheses for the health-protective mechanisms of whole-grain cereals: what is beyond fibre? *Nutrition Research Reviews*, vol. 23, no. 1, p. 65-134. http://dx.doi.org/10.1017/S0954422410000041 PMid: 20565994

Gómez, M., Ronda, F., Blanco, C. A., Caballero, P. A., Apesteguia, A. 2003. Effect of dietary fibre on dough rheology and bread quality. *European Food Research and Technology*, vol. 216, p. 51-56.

Gong, J., Yang, C. 2012. Advances in the methods for studying gut microbiota and their relevance to the research of dietary fiber functions. *Food Research International*, vol. 48, p. 916-929. http://dx.doi.org/10.1016/j.foodres.2011.12.027

Kaack, K., Pedersen, L., Laerke, H. N., Meyer, A. 2006. New potato fibre for improvement of texture and colour of wheat bread. *European Food Research and Technology*, vol. 224, p. 199-207. http://dx.doi.org/10.1007/s00217-006-0301-5

Langner, E., Nunes, F. M., Pozarowski, P., Szerszen, M. K., Pierzynovski, S. G., Rzeski, W. 2011. Antiproliferative Activity of Melanoidins Isolated from Heated Potato Fiber (Potex) in Glioma Cell Culture Model. *Journal of Agricultural and Food Chemistry*, vol. 59, no. 6, p. 2708-2716. http://dx.doi.org/10.1021/jf1047223 PMid: 21341669

Lattimer, J. M., Haub, M. D. 2010. Effect of dietary fiber and its components on metabolic health. *Nutrients*, vol. 2, p. 1266-1289. http://dx.doi.org/10.3390/nu2121266 PMid: 22254008

Marcil, V., Delvin, E., Garofalo, C., Levy, E. 2003. Butyrate impairs lipid transport by inhibiting microsomal triglyceride transfer protein in caco-2 cells. *Journal of Nutrition*, vol. 133, no. 7, p. 2180-2183. PMid: 12840175

Meyer, A. S., Dam, B. P., Learke, H. N. 2009. Enzymatic solubilization of a pectinaceous dietery fiber fraction from potato pulp: Optimalization of the extraction process. *Biochemical Engineering Journal*, vol. 43, no. 1, p. 106-112. http://dx.doi.org/10.1016/j.bej.2008.09.006

Mohamed, S. 2014. Functional food against metabolic syndrome (obesity, diabetes, hypertension and dislipidemia) and cardiovascular diseases. *Trends in Food Science and Technology*, vol. 35, p. 114-128. http://dx.doi.org/10.1016/j.tifs.2013.11.001

Mohammed, I., Abdelrahman R. A., Senge, B. 2012. Dough rheology and bread quality of wheat-chickpea flour blends. *Industrial Crops and Products*, vol. 36, p. 196-202. http://dx.doi.org/10.1016/j.indcrop.2011.09.006

Paturi, G., Nyanhanda, T, Butts, C. A., Herath, T, D., Monro, J. A., Ansell, J. 2012. Effects of Potato Fiber and Potato-Resistant Starch on Biomarkers of Colonic Health in Rats Fed Diets Containing Red Meat. *Journal of Food Science*, vol. 77, no. 10, p. H216-H223. http://dx.doi.org/10.1111/j.1750-3841.2012.02911.x PMid: 22950602

Perez-Jimenez, J., Diaz-Rubio, M. E., Mesias, M., Morales, F. J., Saura-Calixto, F. 2014. Evidence for formation of maillardized insoluble dietary fiber in bread: A specific kind of dietary fiber in thermally processed food. *Food Research International*, vol. 55, p. 391-396. http://dx.doi.org/10.1016/j.foodres.2013.11.031

Rosell, C. M., Santos, E., Collar, C. 2006. Mixing properties of fibre enriched wheat bread doughs: a response surface methodology study. *European Food Research and Technology*, vol. 223, p. 333-340. http://dx.doi.org/10.1007/s00217-005-0208-6

Rosell, C. M., Santos, E., Collar, C. 2010. Physical characterization of fiber-enriched bread doughs by dual mixing and temperature constraint using the Mixolab. *European Food Research and Technology*, vol. 231, p. 535-544. http://dx.doi.org/10.1007/s00217-010-1310-y

Sanz Penella, J. M., Collar, C., Haros, M. 2008. Effect of wheat bran and enzyme addition on dough functional performance and phytic acid level in bread. *Journal of Cereal Science*, vol. 48, p. 715-721. http://dx.doi.org/10.1016/j.jcs.2008.03.006

Yikyung, P., Subar, A. F., Hollenbeck, A., Schatzkin, A. 2011. Dietary fiber intake and mortality in the NIH-AARP diet and health study FREE. *Archives of International Medicine*, vol. 171, no. 12, p. 1061-1068.

URL1: [cit. 2013-10-31] Retrieved from the web: http://www.statistics.sk/pls/elisw/vbd

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