НАУЧНИ ТРУДОВЕ НА
УНИВЕРСИТЕТ ПО ХРАНИТЕЛНИ
ТЕХНОЛОГИИ - ПЛОВДИВ
2016 г.
ТОМ 63, КНИЖКА 1

SCIENTIFIC WORKS OF
UNIVERSITY OF FOOD
TECHNOLOGIES
2016
VOLUME 63 ISSUE 1

Adsorption of Lead (II) Ions from Aqueous Solution by Pectin-Containing Powder of Dietary Fibre from Apple Pomace

Zoya Vasilenko[1], Vlada Redko-Bodmer[1*]

[1] *Department of Technology of Catering Products and Meat Products, Mogilev State University of Food Technology, Mogilev, Republic of Belarus*

***Corresponding author**: Vlada Redko-Bodmer, PhD; Department of Technology of Catering Products and Meat Products, Chemical-Technological Faculty, Mogilev State University of Food Technology, 3 Schmidt Avenue, 212027 Mogilev, Republic of Belarus, tel.: ++375 222 48 84 65; fax: ++375 222 48 00 11; E-mail: vco@tut.by*

Running title: **Adsorption of Lead (II) Ions By Powder of Dietary Fibre from Apple Pomace**

Abstract
It was studied the adsorption of Lead (II) ions from aqueous solution by pectin-containing powder of dietary fibre from apple pomace. In order to optimize the conditions to be utilized the adsorption-influencing factors such as pH, temperature, and contact time were investigated. The result revealed that the lead-binding capacity of pectin-containing powder of dietary fibre from apple pomace is 12,14 mg of Lead (II) ions per 1,0 gram of dry matter on pH 2,0 (simulating pH value of stomach environment) and 41,5 mg of Lead (II) ions per 1,0 gram of dry matter on pH= 7,6 (simulating pH value of large intestine environment). The largest amount of Lead (II) ions (increased from baseline in 1,7 times) were bound by pectin-containing powder of dietary fibre from apple pomace with temperature 343 K, concentration of Sodium cations 336,9 mmol/kg of pectin, contact time 120 minutes. These results obtained through the study suggest that pectin-containing powder of dietary fibre from apple pomace is favorable adsorbent.

Practical applications
The total quantity of Lead (II) ions which binds by 1 gram of dry matter of pectin-containing powder of dietary fibre from apple pomace on pH=2,0 and pH = 7,6 (simulating pH values of stomach and large intestine environment respectively) is 53,64 mg that several times exceeds the size of a toxic dose of the metal causing chronic poisoning of an organism.

Key words: Dietary fibre, apple pomace, adsorption capacity, Lead (II) ions

Introduction

According to sanitary and epidemiological services reports food are carriers more than 70% of potentially harmful chemicals entering the human body in the course of life. Particular danger and cause early chronic serious illness are heavy metals (including Lead). Lead is a cumulative toxicant that affects multiple body systems and is particularly harmful to young children. Lead exposure is estimated to account for 143 000 deaths per year with the highest burden in developing regions. Young children are particularly vulnerable to the toxic effects of lead and can suffer profound and permanent adverse health effects, particularly affecting the development of the brain and nervous system. Lead also causes long-term harm in adults, including increased risk of high blood pressure, reduction in hemoglobin formation, mental retardation and kidney damage. Exposure of pregnant women to high levels of Lead can cause miscarriage, stillbirth, premature birth and low birth weight, as well as minor malformations (Fact Sheet №379, 2014). There is no known level of Lead exposure that is considered safe. Lead is excreted harmlessly and much more efficiently when pectin is included in to a diet (Regulation (EU) №432, 2012; World Cancer Report, 2003; Boyle et al., 2005).

As the literature reports, the daily intake of pectin from fruit and vegetables can be estimated to be around 5 g (where the consumption of approximately 500 g fruit and vegetable per day is estimated).

In human digestion, pectin goes through the small intestine more or less intact but is acted upon by microbial growth of large intestine. Pectin thus acts as a soluble dietary fibre. In the large intestine and colon, microorganisms degrade pectin and liberate short chain fatty acids that have favorable influence on health (also known as prebiotic effect). Commercially, pectin is extracted by treating the raw material with hot dilute mineral acid at pH about two. At present, commercial pectins are almost exclusively derived from citrus peel or apple pomace, both of which are by-products from juice manufacturing units (Sharma, P. C., et al, 2014; Francielo, V. et al., 2008; Redko, V., 2003). The hot pectin extract is separated from the solid residue as efficiently as possible. This is not easy since the solids are by now soft and the liquid phase are viscous. The viscosity increases with pectin concentration and molecular weight. There is a compromise between efficient extraction and solids separation and operating cost. The pectin extract may be further clarified by filtration through a filter aid. The clarified extract is then concentrated under vacuum. Powdered pectin can be produced by mixing the concentrated liquid from either apple or citrus with an alcohol (usually isopropanol). The pectin is separated as a stringy gelatinous mass, which is pressed and washed to remove the mother liquor, dried and grounded (Srivastava, P., Malviya, R., 2011).

In view of the multi-stage and resource intensity of the classical method of producing pectin it was considered appropriate to examine the possibility of applying for the prevention of Lead poisoning of the human body pectin-containing product from apple pomace obtained by the simplified flow sheet without extracting pectin from the raw material. Pectin-containing powder of dietary fibre from apple pomace was investigated as an object.

Materials and Methods

Pectin-containing powder of dietary fibre from apple pomace

Fresh apple pomace left after extraction of juice from processable grade fruits were treated with sulphur dioxide, heat treated at 353 K, mashed and dried to air-dry powdery state in a vibrofluidized bed of inert material. Pectin-containing powder of dietary fibre from apple pomace was packed to avoid absorption of moisture.

Analysis

Carbohydrate composition of pectin-containing powder of dietary fibre from apple pomace

The carbohydrate composition of pectin-containing powder of dietary fibre from apple pomace was determined by the standard methods (Pleshkov, 1976). The content of total sugars was determined by Bertrand method (GOST 8756.13, 1987). The content of cellulose, hemicellulose, sugars was determined after extraction of the scheme proposed by Kiesel R.A. (Pleshkov, 1976). Content of pectin was determined by carbazole method (Arasimovich et al., 1970; Sapozhnikova, 1971; Demchenko et al., 1981).

Adsorption of Lead (II) ions from aqueous solution

Adsorption of Lead (II) ions from aqueous solution by pectin-containing powder of dietary fibre from apple pomace was investigated by methods of Complexometric titration and Emission spectrum analysis (Kaysheva et al., 1992; MN 254, 2003).

Determination of Lead (II) ions concentration was made with the use of the calibration schedules constructed on standard samples with known concentration of Lead (II) ions. In a measured flask with a capacity of 250 cm^3 brought 100 cm^3 of mix of the pectin-containing powder of dietary fibre from apple pomace and water at the rate of contents of pectin in mixes of 0,5%, added 50 cm^3 of standard solution of Lead (II) ions (0,035 N) and buffer solution before creation of pH 2,0 (pH 7,6) that approximately corresponds to pH value of stomach (large intestine) environment. Contents of a flask were brought to a tag water and maintained at a temperature of 309,75 K within 3 hours, then mix was filtered twice via the glass porous filter and in the received filtrate were determined the content of Lead (II) ions by method of the Emission spectrum analysis (Programmatically Hardware Complex of the Institute of Applied Optics, Republic of Belarus) by the existing technique. The amount of Lead (II) ions adsorbed by the pectin-containing powder of dietary fibre from apple pomace was determined by a difference between its initial contents in 50 cm^3 0,035 N of solution and the residual contents in a filtrate.

Results

The main substances of the pectin-containing powder of dietary fibre from apple pomace are dietary fibre (73...75%), including pectin substances (15...16%), cellulose (44...45%), hemicellulose (13...14%). Pectin of pectin-containing powder of dietary fibre from apple pomace (Table 1) is characterized by a high degree of methoxylation. Pectin substances of the pectin-containing powder of dietary fibre from apple pomace are generally in a water-soluble form that provides to product good functional and technological properties (jelly forming, water absorbing abilities) and possibility of development with its use of the wide range of food. It is known that pectins are involved in the formation of chemical bonds with heavy metal ions, thereby forming insoluble complexes which are then excreted. The adsorption capacity of pectin with heavy metal ions depends on degree of esterification of polymer and molecular weight. However, the existing methods of reducing the degree of esterification (acid, alkali, enzyme, using ion exchange resins and others) often lead to the simultaneous reduction and molecular weight of pectins that, as a consequence, reduces their adsorption capacity. In this regard, studies are under way to improve the adsorption capacity of high esterificated pectin with ions of heavy metals in the presence of monovalent cations, with gentle processing conditions created by certain values of pH and temperature. In order to find an effect of pH value the concentration of Sodium cations ranged from 33,5 to 2193 mmol/kg of pectin. From Table 2 obtained results that on pH 2,0 (simulating pH value of stomach environment) adsorption capacity tend to increase. The concentration of Sodium cations 336,9 mmol/kg of pectin is the optimum condition in which the adsorption capacity reaches a maximum value (44,23 mg Lead (II) ions per 1,0 gram of dry matter of pectin-containing powder of dietary fibre from apple pomace). The adsorption capacity decreases sharply when the concentration of Sodium cations is 2193 mmol/kg of pectin. The degree of acidity or pH of the solution is one important factor that determines the performance of an adsorbent in the adsorption process. Adsorption capacity of pectin-containing powder of dietary fibre from apple pomace is different because of different pre-treatment conditions and further pH values 2,0 and 7,6 (simulating pH value of stomach and large intestine environment respectively). From Table 2 obtained results that on pH 7,6 adsorption capacity tend to decrease. It is caused of the condition that higher pH, the solution have more - OH ions in solution. The existence of these ions causes Lead (II) ions are hydrolyzed and forms $Pb(OH)_3$. The adsorption capacity decreases sharply when the Sodium cations concentration of pre-treatment is at its maximum. Contact time is one important parameter to determine the optimum condition for adsorption process. Optimum contact time allows better mechanism the diffusion process and binding of adsorbate molecules. The binding process grows up and reaches the maximum during 120 minutes of pre-treatment (Table 2). The adsorption capacity reaches 44,23 mg Lead (II) ions per 1,0 gram of dry matter of pectin-containing powder of dietary fibre from apple pomace on pH 2,0 and 49,61 mg Lead (II) ions per 1,0 gram of dry matter of pectin-containing powder of dietary fibre from apple pomace on pH 7,6. In order to find an effect of temperature the temperature of pre-treatment ranged from 283K to 343 K. The temperature of pre-treatment had no effect on the intensification of sorption process on pH 7,6 (simulating pH value of large intestine environment). The adsorption capacity decreases sharply when the temperature and Sodium cations concentration of pre-treatment is at its maximum because of saturation of an adsorbent by the Leads (II) ions.

Discussion

In the model system of this study, simulating pH value of stomach environment (pH=2,0) and pH value of large intestine (pH=7,6) was established that pectin-containing powder of dietary fibre from apple pomace binds to 12,14 mg of Lead (II) ions per 1,0 gram of dry matter on pH=2,0 and 41,5 mg of Lead(II) ions per 1,0 gram of dry matter on pH=7,6. The total quantity of Lead (II) ions which is bound by 1 gram of dry matter of pectin-containing powder of dietary fibre from apple pomace on pH=2,0 and on pH = 7,6 is 53,64 mg that several times exceeds the size of a toxic dose of the metal causing chronic poisoning of an organism (Kaysheva, N. Sh., et al., 1992). The degree of acidity or pH and temperature of pre-treatment are important factors which determine the performance of an adsorbent and adsorption process were investigated. In order to increase the adsorption capacity on pH value simulating the stomach and the large intestine environment of the pectin-containing powder of dietary fibre from apple pomace is to be treated at the temperature 343 K, concentration of Sodium cations 336,9 mmol/kg of pectin within 120 minutes. In this case, the adsorption capacity increases from baseline in 1,7 times.

Conclusions

The present study was aimed to evaluate the pectin-containing powder of dietary fibre from apple pomace for the Lead (II) ions adsorption from aqueous solution. The result revealed that the total quantity of Lead (II) ions which is bound by 1 gram of dry matter of pectin-containing powder of dietary fibre from apple pomace on pH=2,0 and pH = 7,6 (simulating pH values of stomach and large intestine environment respectively) is 53,64 mg that several times exceeds the size of a toxic dose of the metal causing chronic poisoning of an organism. The result revealed that the pectin-containing powder of dietary fibre from apple pomace may be considered as perspective for adsorption of Lead (II) ions and as the reasonable element of daily food intake of the modern human being to protect the body from harmful the impact of Lead (II) ions in ecological unfavorable regions.

Acknowledgements

The authors have declared no conflict to interest.

References

Lead poisoning and health. Fact sheet **№379** Reviewed October (2014). Available at: http://www.who.int/mediacentre/factsheets/fs379/en/ Date: 18.07.2016

World Cancer Report, J.A.R.C. Press, Lyon (2003). Available at: http://www.iarc.fr/en/publications/pdfs-online/wcr/2003/ Date: 18.07.2016.

Boyle, P., Ferlay, J. Cancer incidence and mortality in Europe, J. Ann. Oncol. Vol. **16** (2005) 481 â 488. Available at: http://annonc.oxfordjournals.org/content/ 16/3/481.full.pdf Date: 18.06.2016/

COMMISSION REGULATION (EU) № 432/2012 of 16 May 2012 establishing a list of permitted health claims made on foods, other than those referring to the reduction of disease risk and to children's development and health //http://www.uvzsr.sk/docs/info/hv/reg_432_2012_EN.pdf Date: 18.07.2016/

Sharma, P. C., Gupta, A. and Kaushal, P., Optimization of method for extraction of pectin from apple pomace, Indian J. Nat. Prod. Resour, 2014, 5(2),184 – 189.

Francielo, V., Patrcia, M. A., Fernanda, S., Elisa, E. and Jorge, L. N. Apple pomace: a versatile substrate for biotechnological applications, Crit Rev Biotechnol, 2008, 28 (1), 1 – 12.

Redko, V., Candidate′s Dissertation in Technical sciences, Mogilev State University of Food Technologies, Mogilev (2003).

Srivastava, P., Malviya, R. Sources of pectin, extraction and its applications in pharmaceutical industry − An overview. Indian Journal of Natural Products and Resources. Vol. 2(1), March 2011, 10 – 18.

Pleshkov, B.P. Workshop on biochemistry of plants: Manual, second ed., Kolos, Moscow (1976).

GOST 8756.13-87 Products of processing of fruits and vegetables. Methods of definition of sugars (Instead of GOST 8756.13-70).– It is entered 01.01.1989. – Moscow: Standards Publishing House (1988) – 15 pages.

Arasimovich, V.V., Baltaga, C.B., Ponomareva, N.P. Methods of analysis of pectin, hemicellulose and pectolytic enzymes in the fruit, Academy of Sciences of the Moldavian SSR, Chisinau (1970).

Sapozhnikova, E.V. Pectin and pectolytic enzymes, Results of science. Series: Biological Chemistry (Tom **5**), All-Union Institute of Scientific and Technical Information, Moscow (1971).

Demchenko, E.I., Los, T.I., Vasilenko, Z.V., Baranov, V.S. Methods of research of carbohydrates: Methodical instructions for graduate students of specialty 05.18.16, Publishing department of the Moscow institute of a national economy of G. V. Plekhanov, Moscow (1981).

Kaysheva, N. Sh., Kompantsev, V.A., Shcherbak, S. N., Krikova, N. I. Structures of soluble complexes with pectins, J. Food Industry. 1 (1992) 28 â 29.

Technique of performance of measurements. MN 254 (2003). Raw materials and foodstuff. Determination of mass concentration of heavy metals and toxic elements in milk and dairy products by a nuclear and issue method. Technique of performance of measurements. – Instead of the Technique of performance of measurements 254 – 95. – Mogilev, Institute of applied optics, National academy of Sciences, Republic of Belarus. – 29 pages. Available at: http://www.belgim.by/ uploaded/file/MVI% 20inf %20perech%201-01-2010.pdf Date: 18.07.2016 http://www.belgim. by/uploaded/file/temat_01_07_2011.pdf

Table 1. Physical and chemical indicators of pectin, extracted from pectin-containing powder of dietary fibre from apple pomace

Physical and chemical indicators	Pectin, extracted by	
	0,013 N HCl	1 % $(NH_4)_2C_2O_4$
Humidity,%	11,40±0,06	10,99±0,04
Content of groups,%		
- free carboxyl	3,30±0,03	2,79±0,02
- methoxylated	11,19± 0,12	8,56±0,07
- acetyl	0,14±0,01	0,08±0,01
Degree of methoxylation,%	77,20±0,23	76,54±0,28

Table 2. Adsorption capacity of pectin-containing powder of dietary fibre from apple pomace

Concentration of Sodium cations, mmol/ kg of pectin	Temperature processing of samples, K			
	283	293	318	343
	Adsorption capacity, mg Lead ions per 1,0 gram of dry matter of pectin-containing powder of dietary fibre from apple pomace			
	pH=2,0 (simulating pH value of stomach environment)			
0	12,14	12,14	12,14	12,14
33,5	22,89	25,35	31,32	31,48
336,9	26,95	29,51	36,69	44,23
2193	26,98	25,28	21,35	18,34
	pH=7,6 (simulating pH value of large intestine environment)			
0	41,50	41,50	41,50	41,50
33,5	47,46	49,61	47,89	43,81
336,9	47,63	47,21	46,70	46,49
2193	48,50	46,79	40,63	30,22