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USING PECTIN AS HEAVY METALS DETOXIFICATION AGENT TO REDUCE ENVIRONMENTAL CONTAMINATION AND HEALTH RISKS*

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Abstract

Global environmental contamination is a vital ecological issue in today's society. Pollutants are entering the environment from different sources and based on their physicochemical properties. They are transported and take part in biochemical cycles in the varied components of the environment, especially in the air, aquatic environment, soil and in rocks or segments. They enter the food chain through which they enter the human body, where they are transformed into either harmless metabolites that are easily excluded or else harmful, reactive products are formed. Indeed, Environmental pollutants are one of the leading causes of obesity. Humans' exposure to heavy metals leads to serious chronic diseases. Chemical chelators have side effects, thus cannot be used for long period treatment, especially for children treatment. Chemical chelators recommended at a high level of heavy metals in the blood. So, they cannot be used as a preventive and safe treatment method. Pectin known for its functional properties and health benefits is already used as a natural chelating agent. Using of Pectin with heavy metals binding capacity, functional and technological properties in dairy industry may lead to the production of new dietary therapeutic dairy beverages which will be efficient, gentle and safe treatment strategy against heavy metals toxicity, moreover against different chronic human diseases. In fact, Pectin reduces environmental pollutant-induced obesity. The detoxification process can be fortified by beneficial and nutritive properties of dairy products. Such products can be easily added to the daily diet, as milk products are an important food group in human nutrition worldwide. We tried to summarize the available literature on the potential use of Pectin is a natural chelating agent in milk products composition.

Keywords: dairy products, detoxification, environmental pollution, environmental pollutants, heavy metals, pectin

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1. Introduction

Heavy metals are basically entered into the environment from natural and anthropogenic activities. Given the fact that they persist in the environment, they are able to inflict detrimental health and environmental impacts. The increasing release of heavy metals is one of the important environmental pollution factors in worldwide (Feng and Guo, 2012). The influence of environmental pollution on human health reaches up to 30%. According to the World Health Organization (WHO) about 23% of human deaths directly related to environmental risks (WHO, 2016).

Growing industrialization and various usage of heavy metals led to a widespread distribution in nature (Wang et al., 2019). The situation with air, soil, water pollution more serious in developing countries (Konuspayeva et al., 2009). Pollutants as heavy metals could be concentrated in the food chain and can be enriched in the organism, causing health and environmental problems (Akhmetsadykova et al., 2013). Jamshidi-Naeini et al. (2019) proposed the ferritin concentration effects on blood pressure and food safety discussed.

To decrease the toxic effects of heavy metals on various organs of the body, different chelating agents are used. A traditional pharmaceutical chelating agent such as EDTA (ethylenediaminetetraacetic acid), DMSA (meso-2,3- dimercaptosuccinic acid) and DMPS (sodium 2,3- dimercaptopropane-1-sulfonate) are effective in high intoxication cases, but they have different side effects on human health, even death and increase excretion of essential minerals. Therefore, such chelating agents not suitable for ongoing use (Eliaz et al, 2007; Lara-Espinoza et al., 2018; Mehrandish et al., 2019; Zhao et al., 2008).

Several natural polymers are reported to be the potential absorbent of heavy metals, like Pectin and algal polysaccharides alginate (Mehrandish et al., 2019). Pectin, a cell walls anionic heteropolysaccharide, an important member of dietary fibre which presents in fruits, vegetables, and legumes. Pectins are already used as cheap and abundant bio sorbents to bind heavy metals and radionuclides from wastewater (Lessa et al., 2020; Schiewer and Iqbal, 2010; Wang et al., 2019). Pectin is grabbing increased attention due to its multiple functionalities in jellies, milk products production and health and environmental benefits (An et al. 2019; Celus et al., 2018). Several scientific studies demonstrate that Pectin could be an alternative to the conventional chelators by binding heavy metals such as lead, cadmium, mercury and their excretion from the human body (Lara-Espinoza et al., 2018, Naqash et al., 2017). Metal cations binding capacity of pectins related to its degree of methyl- esterification, degree of polymerization and its glycosyl residue composition (Le Gall et al., 2006). For the treatment against heavy metal toxicity most effective was a low degree of esterification and low molecular weight pectin, according to the literature data. The presence of rhamnogalacturonan II rich in free carboxyl groups in Pectin contribute to the chelation of metals (Lara-Espinoza et al., 2018).

According to the World Health Organization, the daily intake of Pectin for lowering blood cholesterol level, in case of poisoning by heavy metals, pesticides, high blood sugar level, infectious diseases, and oncological diseases is about 15 grams. Different Pectin based supplements are available. But, to make pectins intake more accessible and admissible, modified Pectin could be added into popular products as milk products which consumed in important quantity worldwide. According to the available statistical data, in Central Asia countries milk products consumption about 200 kg/habitant/year, in European Union countries, in the USA and Australia is more than 250 kg/habitant/year (Ritchie and Roser, 2019). World milk production was increasing each year and expected to increase by 177 million tons by 2025. Pectins are already used for stabilization and gelling properties in milk products production, but there are no literature data about using Pectin with a low degree of esterification in milk products against heavy metals toxicity. Developing and production such type of novel functional bioactive products with detoxifying properties potential improvement of the population health status could be obtained and can be used on an ongoing basis.

The potential of low esterified Pectin to be used as a health-promoting and environmentally-friendly additive to dairy products is not well researched scientifically up to now. The aim of this review article is to try to describe the potential use of the low-esterified Pectin containing dairy products as biosorbents for removal of toxic metals from the human body thus, it represents innovativeness.

2. Toxicity of heavy metals for human health

Toxic metals are ubiquitous in our environment due to their widespread usage in industrial and electricity-generating activities, chemicals production, lead pipes production, paint production, nanomaterials production, they are also by-products of mining activities, gasoline etc. (Sears, 2013). Heavy metals pollution of the environment has become an increasingly serious problem, which affects the human health and environment, through passing up the food chain, inhalation and dermal contact they could be concentrated and accumulated in living tissues (Liang et al., 2020; Mata et al., 2009).

Heavy metals cannot be metabolized by the body; they could exert toxic effect several times by migrating back to the bloodstream and to tissues because they are not completely immobilized. Heavy metals contribute to slowly developing and non-communicable chronic diseases such as, cardiovascular diseases, neurological and neurobehavioral abnormalities, diabetes, blood abnormalities, various types of cancer and interfere with functions of essential cations (Koriem et al., 2013). The most common heavy metals that cause adverse effects even at low doses are arsenic, mercury, lead and cadmium due to their high degree of toxicity (Eliaz et al, 2007; Lara-Espinoza et al., 2018). Heavy metals can damage DNA leading to apoptosis and carcinogenesis (Mehrandish et al., 2019; Zhao et al., 2008). Cadmium classified as a known carcinogen, inorganic lead a probable carcinogen, and methylmercury a possible carcinogen according to the International Agency for Research on Cancer (IARC) (Sears, 2013). However, the toxic effect of heavy metals depends from temperature mechanism of absorption, dose, contact pattern, chemical species, age, sex, genetics and nutritional status (Mehrandish et al., 2019).

Toxicity of heavy metals is very dangerous for very young, as the young organism cannot confront against toxicants leading to affecting development, with lifelong physical, intellectual, and behavioural impairments (Zhao et al., 2008). Therefore, biological mobility, tissue concentrations, and excretion of metals depends on oxidation state, solubility, a complex set of equilibria between complexing sites, active transport through membranes. Metals with a charge of +2 or more are bound in tissues by ionic or coordination bonds (Sears, 2013). Furthermore, the human body has proper toxins chelation and removal systems based metal-binding proteins, such as metallothioneins and glutathione, which allow the body to self-repair via formation of complexes and their excretion (Sears, 2013). However, in the current situation of environmental pollution and a large quantity of heavy metals exposure sources in humans' daily life, natural chelating agents may be helpful for organism against pollutants toxicity.

3. Chelating agents of heavy metals

The Greek word "chelos" for claw, means capturing of an ion or cation into a complex involving sulphur, oxygen, and/or nitrogen atoms by small organic molecule (Sears, 2013).

The possibility to bind and strength of the chemical bonds between the chelating agent and metal ions depends from several factors, as the identity of element, presence and quantity of other competitive elements, accessibility of the chelators to the tissues, level of immobilization of metal ions (Sears, 2013).

Chemical chelators

Administration of chemical chelators is the most popular method for heavy metals toxicity treatment (Mehrandish et al., 2019). The main pharmaceutical intravenous chelators against heavy metals poisoning are EDTA (ethylenediaminetetraacetic acid), DMSA (meso-2,3- dimercaptosuccinic acid) and DMPS (sodium 2,3- dimercaptopropane-1-sulfonate), metals after binding in the bloodstream by such chelators, are excreted via the urine and feces (Eliaz et al, 2007). But, such method of treatments has several disadvantages and side effects. According to available literature data, treatment by chemical chelators can lead to redistributing metals to the brain or bone, to reduce critical minerals, to the problems with gastrointestinal tract and skin, hypertension, cardiac arrhythmias, etc. (Eliaz et al, 2007; Lara-Espinoza et al., 2018). One of the serious side effects is the excretion of essential minerals, it was shown that the quantity of Zn in urine after 24 h of EDTA chelation was 15 times higher the normal amount. Cases of cardiac arrest due to the hypocalcemia with fatal outcome was reported (Eliaz et al, 2007; Zhao et al., 2008).

Chelation by traditional pharmaceutical chelators is recommended at the blood lead level above 45 kg/dL, but the US Centers for Disease Control recommends to treat child's environmental exposure at 5 kg/dL (Sears, 2013). Thus, chemical chelating agents not safe for use in children, do not suitable for ongoing use and prevention (Eliaz et al, 2007; Zhao et al., 2008). In addition, the chemical chelation methods are expensive, need multiple treatments, and requires medical monitoring in specialized clinics (Eliaz et al, 2007).

Natural chelators

Natural chelating compounds, administered orally, could be a gentle, safe and less expensive alternative for chemical chelating agents. Based on published articles, different foods, herbal products, supplements, plants, natural polymers, vitamins, dietary fibres have proved their capacities to bind heavy metals and to reduce their concentration in the blood, bone and internal organs (Sears, 2013; Zhai et al., 2015). Sulphur-containing foods were effective against cadmium-induced kidney damage due to the high tendency of toxic elements to bind to sulphur containing peptides. Sulphur-containing amino acids (taurine and methionine) and glutathione can decrease the oxidative damage caused by heavy metals (Mehrandish et al., 2019; Sears, 2013).

Chelating agents of medical plants could reduce the bioavailability, and gastrointestinal absorption of heavy metals, also by affecting the gastrointestinal movements can speed up the process of excretion of heavy metals by feces (Mehrandish et al., 2019). Natural polymers such as algal polysaccharides alginate are also showed a high potential to bind heavy metals. Several studies on rats, showed the effectiveness of calcium pectate and calcium alginate in decreasing of lead accumulation in kidneys and bones (Khotimchenko et al., 2006).

Dietary fibres, including pectins, alginates, chitin and chitosan, carrageenans, lignin, are becoming more interesting for heavy metals chelation due to their binding capacities and beneficial influence on organism (Khotimchenko et al., 2006; Wang et al., 2019). Mostly insoluble dietary fibres are used as an effective chelating agent, but not soluble ones which may increase intestinal absorption of toxicants (Sears, 2013). Pectin is one of the dietary fibres with proved efficiency against heavy metals and radionuclides toxicity. Pectin can reduce absorption and accumulation toxicants by binding in the digestive tract and in the bloodstream (Kartel et al., 1999).

Absorption performance of pectins suggests their applicability as a food additive or remedies for efficient removal of heavy metals from different biological systems, including human and animals' organisms (Kartel et al., 1999; Pacheco et al. 2019).

4. Pectin as chelating agent against heavy metals toxicity

Pectin is a natural and non-toxic complex polysaccharide present plant, fruit and vegetable cell walls (Wang et al., 2019). Fruit peels of banana, papaya, grapefruit, orange and pomace of apple, kiwifruit, sugar beet are potential sources of Pectin. Most popular industrial sources of Pectin are apple pomace, citrus peels, and sugar beet pulp due to the availability, low cost and high pectin content, 15-20% in dried apple pulp, 30-35% in dried citrus peel, up to 23% in sugar beet, accordingly (Lara-Espinoza et al., 2018, Lessa et al. 2020; Naqash et al., 2017). Therefore, approximately 50% of the global sugar beet produced in European Union countries; as a result, 111.6 million tons of waste per year is thrown away (Pacheco et al. 2019). The worldwide volume of industrial citrus waste is about 15 ^ 10^6 tons per year (Nasseri et al., 2008). Thus, utilization of fruit and vegetable waste can solve the problem with waste accumulation.

The pectin structure plays a major role which determines its functionality and possibility of potential application in food or pharmaceutical industries (Naqash et al., 2017). Pectin is mainly composed of D-galacturonic acid units (homogalacturonan (HG), rhamnogalacturonan-I (RG-I) and rhamnogalacturonan-II (RG-II)) linked together by a-(1—+4) glycosidic bonds (Kyomugasho et al., 2017; Wang et al., 2019). 'Smooth' and 'hairy' regions alternate of along the entire length of the molecule, smooth regions are represented by homogalacturonanas (HG's), and hairy regions represented by rhamnogalacturonans (Naqash et al., 2017).

Depending of the percentage of carboxylic groups esterified by a molecule of methanol pectin can have a different degree of esterification (DE) - high methoxyl pectin (DE is greater than 50); low methoxyl pectin (DE is below 50); pectic acid (DE is below 10). The molecular weight of Pectin can vary from 50 to 1 50 kilodaltons (Wang et al., 2019). Many years, pectins are used for thickening, stabilization and gelling in the food industry. Nowadays, they are widely used for colon-specific drug delivery, microorganisms' delivery, gene delivery, tissue engineering, production of edible films and coatings in food packaging. Pectins possess different beneficial properties important for human health maintaining such as immuno-modulation effect, anti-ulcer, prebiotic potential, anti-cancer properties, cholesterol-lowering, serum glucose-lowering, heavy metal and radionuclides detoxification ability (Dominiak, 2014; Eliaz et al, 2007; Koriem et al., 2013; Naqash et al., 2017). Several studies demonstrated that pectins could be used as an efficient biosorbents for the binding metals in wastewater (Mata et al., 2010). But, there are some limits due to the problems with pectin separation from aqueous solution, lack of stability. Using pectate-based hydrogels and chemically modified pectins could be a good solution from the practical point of view (Zhang et al., 2020).

The pectin-derived oligosaccharides, derived from the intestinal fermentation of Pectin, play a key role in immune protection, prevention and treatment intestinal disorders and cancer (Leclere et al., 2013; Maxwell et al., 2012). Pectins with low degrees of esterification reported to inhibit tumour growth, induce apoptosis, suppress metastasis, and modulate immunological responses (Zhang et al., 2015). Classified as an emerging prebiotic, Pectin can positively affect gut microbiota by promoting the growth of probiotics such as *Bifidobacterium longum* and *Lactobacillus acidophilus,* and inhibiting the growth of *Clostridium perfringens,* pathogenic *E. coli* and *Helicobacter pylori* (Gottesmann et al., 2020). Pectins enhance gut barrier function leading to liver and kidney protection from translocation of pro-inflammatory bacteria and its products (Kieffer et al., 2016). Scientific studies on animals and humans were carried out and proved pectins capacity to decrease the level of toxicants in the body (Zhao et al., 2008).

Heavy metals binding mechanisms by Pectin

Ability to bind divalent cations is one of the significant functionalities of Pectin, which is very actual in the current environmental situation. Sorption process based on binding of the metal ions with binding sites such as non-esterified carboxyl groups. The intensity of sorption processes and binding capacity depend from the number of the free carboxyl groups in pectin structure. It means the formation of the junction zones between free carboxyl groups of Pectin and heavy metals according to the "egg-box" model, which means forming pockets, by fibre chains stacked together, where metals can complex with fibres (Koksharov et al., 2019). This process related to the degree of esterification. Formation of the ionic bonds between metal and non-esterified carboxyl groups and the hydrogen bonds between metal and oxygen atoms is the basis of binding mechanism (Khotimchenko et al., 2007).

Pectin is not degradable in the upper gastrointestinal tract, passes through the stomach and the small intestine, and at the colon level is extensively fermented (Leclere et al., 2013). In comparison with high ester pectins, low ester pectins are degraded faster (Dominiak, 2014). Owing to this property, pectins are used to deliver drugs until colon with minimal degradation (Koriem et al., 2013). After being absorbed pectin fragments are transported, modified, bounded with toxicants and by forming insoluble pectinates in organism, excreted by urine and feces. According to Maxwell et al. (2012) the passive absorption or active cell capture processes involved in pectin fragments absorption mechanism (Maxwell et al., 2012), also uptake by gastrointestinal associated lymphoid tissue is possible (Eliaz et al., 2006). The molecular charge of Pectin fragments one of the important factors as well as the degree of esterification, for passive absorption. It was reported that acidic fragments of Pectin with positive charges could not pass across Caco-2 cell monolayers. Thus only neutral fragments of Pectin do (Zhang et al., 2015).

Pectin with the lower molecular weight (5 to 12 kDa) can be easily absorbed into the bloodstream during digestion. Unmodified Pectin has a high molecular weight (Mw), and a non-digestible polysaccharide in long polymers of cross-linked chains, by modification, which involves enzymatic and pH modification, low molecular weight and shorter chain molecules could be obtained. According to several authors, the absorption of modified citrus pectin (MCP) with lower molecular weight which was broken down into shorter chain molecules and reduced side-chain structure into the bloodstream was very fast.

Pectin absorption performance determined by pectin source, extraction methods, cation type, structural difference, degree of esterification, pH, molecular weight (Celus et al., 2018). Pectin binding capacity to its targets increases with the reducing of the degree of esterification (Celus et al., 2018). Research studies showed that pectins with a low degree of esterification penetrate deeper into colonic epithelial crypts than highly esterified ones. Low degree of esterification and 10% rhamnogalacturonan II increased capacity to bind heavy metals ions, and not essential minerals (Khotimchenko et al., 2007). Celus et al. (2019) obtained the same results when the degree of methylation was reduced, leading to a higher amount of bound and stronger interactions between cation and Pectin (Celus et al., 2018). Liang et al. (2020) found that ethylenediamine-modified pectins with a high degree of amidation have great removal efficiency of Pb^{2+} ($\geq$94 %) via the ion exchange of carboxylic groups and chelation with acylamino and amino groups (Liang et al., 2020).

Most part of available literature suggests that pectins do not release essential minerals from the human body. On the contrary, the results of certain studies suggest that depending from the type of administrated Pectin and its degree of esterification, pectins can disturb mineral balance leading to reduction of bioavailability of essential elements due to cation-pectin interactions in the small intestine. Some studies reported a negative effect of low esterified apple pectin on the bioavailability of the calcic minerals (Jourdain et al., 2005). But, more branched and highly acetylated sugar beet pectin can promote minerals bioaccessibility (Kyomugasho et al., 2017).

However, bounded minerals could be released during pectin fermentation by colon microflora, leading to increasing of the minerals absorption rate. But, as the main site for nutrients absorption is the small intestine which suggested that free minerals may not be absorbed in the colon. Moreover, minerals may be utilized by colon microflora; as a result, becoming not available for human organism (Celus et al., 2018) des of the coin, binding of essential minerals and reducing their bioaccessibility in the small intestine and fixation of toxicants leading to their excretion from the human body, by using pectins as sugar beet pectin and controlling of the structure of Pectin containing product, this dilemma could be solved positively.

One of the important factors that affect the sorption process is pH value. Depending on pectin type and structure, different pH values are suitable. Pectins precipitate at pH values lower than 2 leading to decreasing of sorption capacity. At pH values higher than 8 pectins become unstable (Khotimchenko et al., 2008). Thus, the heavy metals removal rate by unmodified Pectin at pH 2.3 was 60 % and at pH 4.0 increased up to 90 % (Liang et al., 2020). The optimal pH values for lead binding by low-esterified Pectin was at the pH range from 4 to 8. The pH value in the gastrointestinal tract varies from highly acid in the stomach (1.5-3.5) to 6 in the duodenum and small intestine, increase up to 7.4 in the terminal ileum, decrease again in the caecum (5.7), and in the rectum reaches pH 6.7. A normal pH of the blood range between 7.35 to 7.45 (Helmenstine, 2020). Which means, binding of heavy metals by pectins is possible in the gastrointestinal tract and in the blood conditions, it is confirmed by multiple scientific studies on animals and humans.

Pectin heavy metals binding affinity also depends on the cation. Important parameters are the level of electronegativity and ionic size of the cation. Pectins have the highest affinity to divalent cation types, especially Cu^{2+} and Pb^{2+} (Celus et al., 2018). According to the batch experiment in aqueous solution for heavy metals fixation by orange peel modified with sodium hydroxide and calcium chloride, the order of the selectivity was as follows: $Pb^{2+} > Cu^{2+} > Zn^{2+}$. Kartel et al. (1999) determined the same selectivity in simulant aqueous solution, $Pb^{2+} > Cu^{2+} > Co^{2+} > Zn^{2+} > Ni^{2+} > Cd^{2+}$, sugar beet pectin exhibited high affinity for Pb and Cu binding, apple pectin for Co, citrus Pectin for Ni, respectively (Kartel et al., 1999). These results show a high affinity of modified pectins to bind lead. The authors mentioned that the sorption process is very rapid within the first 10 min (Feng ang Guo, 2012). According to Khotimchenko et al. (2007) metal uptake time was 20 min (Khotimchenko et al., 2007).

In vivo study with modified citrus pectin (PectaSol), it's reduced molecular weight pectin, with a 3.8% degree of esterification and approximately 10% rhamnogalacturonan II based on the presence of 2-keto-3-deoxy-octatonic acid, was effective for the children treated with a high level of lead in the blood, after 24 h pectin consumption (15 g/daily) lead level decreased (161 % average change) in the blood and increased in the urine (132% average change), without essential minerals releasing (Zhao et al., 2008). Another study was carried out with the same pectin supplement PectaSol to determine the pectin effect on the urinary excretion of toxicants in healthy individuals. After 24 h of pectin administration (15 g/daily) arsenic level significantly increased in the urine (130%, $p < 0.05$). Cadmium level in the urinary excretion increased significantly (150%, $p < 0.05$) on a sixth day and lead level importantly increased in excretion (560%, $p < 0.08$). Such results could be due to the presence of rhamnogalacturonan II, which possess metals chelating properties (Eliaz et al., 2006). These results explained by direct chelation process by the low molecular weight pectin containing rhamnogalacturonan II in the blood, and elimination of the medium-pectin complex by urine (Koriem et al., 2013).

Some clinical experiments suggest that 4 g per day was sufficient to achieve significant results in heavy metals treatment seen in 3-6 months (Eliaz et al, 2007). Thus, mentioned quantities of Pectin could be easily consumed by consumption of Pectin containing dairy product, because of different dairy products present in the human diet in an important amount per day. Therefore, Pectin can be used as an effective and safe chelating agent, especially for the vulnerable as children, consumed directly as a supplement or in the composition of food products like dairy products. Consumption of such Pectin containing products could be easily consumed and be an innovative preventive measure against heavy metals toxicity for ongoing use.

5. Pectin containing dairy products

Nowadays, the conception of new innovative Pectin containing dairy products with detoxification effect is actual because human exposure to heavy metals is increasing each day, attractive for dairy producer due its huge potential on dairy products worldwide market. Pectin considered as a safe and acceptable daily intake for Pectin has not been determined by the FAO/WHO joint Expert Committee on Food Additives. According to the International Numbering System for identifying food additives, Pectin's number is 440 as a food additive (Nasseri et al., 2008). Pectins mostly used in the food industry as a gelling agent in jams and jellies, as a stabilization agent fruit juices and acidified milk drinks, as a protein source in high protein drinks, as an anti-oxidant (ability to bind $Fe2+$) and prebiotic agent in functional foods, as a fat replacer in spreads, ice creams, and emulsified meat products (Nasseri et al., 2008).

All of the above-mentioned beneficial properties leading to increasing of the worldwide pectin consumption (29). Nowadays, pectins more and more used for healthcare applications, the market volume is about $ 890 million (Nasseri et al., 2008). Dairy products are an important and consumable food group in the human diet in different countries. According to the FAO (2017), world milk production will increase up to 177 million tons per year by 2025. Moreover, annual sales of different milk products are increasing year-over-year (Nasseri et al., 2008). Dairy products are consumed in large amount, for example, in Central Asia countries it is about 200 kg/year/habitant, in European countries more than 250 kg/year/habitant (https://ourworldindata.org/meat-production). Such perspective and consumable food group containing pectins with toxic elements binding capacity may become an effective method for safe and pleasant heavy metals toxicity treatment.

Pectin technological properties depend to the source and ways of extraction, in addition, chemical and physical properties of Pectin depend from the degree of esterification, patterns of acylation, nature and placing of the neutral sugars, the difference in polymer size distributions (Maxwell et al., 2012). The most interesting pectin property for the food industry is the capacity to form gels correlated with the degree of esterification (Lara-Espinoza et al., 2018). To obtain desired texture gelation of polysaccharides plays a main role. The gel formation process and gel properties depend from extrinsic factors (ionic strength, pH, co-solute concentrations and temperature) and intrinsic factors (degree of methylation, molar mass, the sequence of sugars along the chain, distribution of the methyl groups along the chain) (Dominiak, 2014). The presence of homogalacturonan (HG) is very important for the gel formation ability of pectins (Maxwell et al., 2012). Thus, the commercial pectins procedures optimize extraction conditions to increase the content of HG regions.

Sugar beet pectin has poor gelling ability compared to other Pectin's due to the high amount of acetyl groups, high content of neutral sugars, protein moiety and lower molecular weight. Thus, acetylated Pectin of sugar beet demonstrates poor gelling properties, but possess excellent emulsion-stabilizing properties (Lara-Espinoza et al., 2018). The emulsifying properties depend from the degree of methylation, highly methyl esterified Pectin, possesses hydrophobic properties which able to reduce the interfacial tension between oil and water phase. The emulsifying properties of sugar beet give the possibility to use it in acidic environments, for production fruit drinks and acidified milk products (Naqash et al., 2017). Nowadays, acidified dairy drinks and yogurts are very popular. Influence of combination carboxymethylcellulose and Pectin on the stability of acidified milk drinks (Yuliarti et al., 2019). The absence of stabilizers in such products leads to protein flocculation and whey separation. Pectins can be used as a protecting colloid (Nasseri et al., 2008). Generally, high methoxyl (HM) pectin (range of esterification 68-72%) is used as a stabilization agent because low methoxyl (LM) pectin exhibits lower stabilization properties. At pH values 3.6-4.5 due to the electrostatic interactions between the negatively and positively charged particles, HM pectin adsorbs onto the casein molecule surface. It was reported that about 90% of added Pectin does not interact directly with casein in dairy product, but this Pectin will be useful during homogenization (Dominiak, 2014). For high viscosity acidified milk drinks HM-apple pectin and for low viscosity product HM-citrus pectin are suitable for stabilization (Nasseri et al., 2008).

Effect of LM-pectin on the camel milk was studied. Impact on the average size of the casein micelles, maximal size at pH 4 was reported, leading to improvement of acid gelation properties. Moreover, important impact on rheological proprieties and a viscosity (Zidi et al., 2019). The dietetic products with low-fat content becoming more and more popular; thus low methoxyl pectin may be used to improve the texture of such products. Positive results were obtained for low-fat cheese, LM pectin increased moisture content and improved product texture due to the calcium pectate gels formation (Ibáñez et al., 2016).

Accumulation and concentration of heavy metals in the human body are directly related to the nutritional status; malnourished people are at greater risks for toxicity. Its explained by the transportation of heavy metals cations by proteins for essential elements. Thus supplementation and sufficient quantity of nutrients can blunt absorption of toxicants. For example, calcium supplementation decrease lead mobilization from maternal bones leading to newborn protection from toxicity (Sears, 2013). Thus, using dairy pectin containing products can solve several problems at once. Milk and milk products are rich in minerals and vitamins and can enhance mineral balance; as a result excretion of heavy metals by pectins will be more effective.

6. Conclusion

Pectin has a good effect on reducing obesity resulted from environmental pollutants through regulating gut microbiota and provided a potential strategy for the treatment of environmental pollutant-caused health problems. According to reviewed scientific publications concerning pectin binding capacity suggest that it is one of the effective natural and safe chelators. The structure of Pectin has effects on its performance as a potential nutraceutical or a bioactive food polysaccharide. The low degree of esterification homogalacturonan and rhamnogalacturonan II structure of Pectin, amount of free carboxyl groups is essential for the chelation of heavy metals. Therefore, sugar beet pectin according to its properties, especially with high affinity to bind lead, could be used in dairy acid products to ameliorate technological product properties, but also like a gentle and pleasant chelating agent for ongoing use.

Choosing dairy products as a matrix for Pectin due to its increasing consumption quantity worldwide. Such products may have a positive effect on health and ecosystem due to the huge variety of beneficial pectin properties and milk products composition, which rich in minerals and vitamins. Using Pectin which does not disturb the mineral balance of the organism, effective for heavy metals excretion and has suitable technological properties for dairy production open up board perspectives for creation fundamentally new safe food products with pronounced functional properties. Such products would also serve in preventing or even full elimination of other serious human diseases due to the large variety of health benefit pectin properties.

Studies mentioned above do not provide sufficient information about the potential of pectin usage in dairy products as a chelating agent with human body detoxification from heavy metals. This review article is the beginning of the scientific project where the technology of dairy products containing Pectin with binding capacity will be worked out. Moreover, effectiveness will be studied *in vivo* experiments on the rats. Thus, further research studies are required.

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