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FORMULATION AND QUALITATIVE ANALYSIS OF POTATO PEEL INCORPORATED ICE CREAM

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INTRODUCTION

Potato (Solanum tuberosum L.) is the fourth most important crop in the world after wheat, maize and rice with 314.1 million tones annual production on 18.1 million hectares (Anonymous, 2010a). Potato production areas and production quantities in Turkey were recorded as 142.684 ha and 4.397.711 tones in 2009, respectively (Anonymous, 2010b).

The mean potato yield (30 t/ha) in Turkey is much beyond the world's average and also most European countries' averages. Turkey has a very favorable geographical condition for potato production; therefore, potato is grown almost in all provinces in the country. The middle, north and northeast parts of the country have temperate climate, and as such, potato is grown as a main crop during summer months (Caliskan et al, 2010). Potato is among the basic food products in the Black Sea region (north of Turkey) along with corn and bean. It is one of the basic ingredients used as local food and without any alternative in the regional cuisine of the Black Sea region (Aytac et al, 2002).

Potato had initially come to Turkey in the 1870's from north, Russia and Causcasia, and it had been grown in high uplands in Eastern Anatolia and the Black Sea region. There have been many migrations from Causcasia to Anatolia at the end of the 18th century and early in the 19th century. It is highly probable that these immigrants have brought potato to the region. As potato is still called with a Russian word "kartol" in Eastern Anatolia and Black Sea region, local genotypes in some areas are still grown. These potato genotypes are widely accepted by the farmers for various reasons such as cooking quality and taste of tubers. Among genotypes, there are significant types in terms of maturity period, disease resistance (Ilisulu, 1957).

Potato (Solanum tuberosum L.) is ranked among one of the chief crops producing worldwide. As per the statistics of the Food and Agriculture Organization (FAO), the annual production of potato was over 300 million tons in 2016 (FAO, 2016).

Besides, food processing industry is one of the most important businesses worldwide produces a large number of byproducts as organic waste that need to be handled and managed inappropriate way not only to avoid environmental pollution but also extend further apart by contributing towards economic boost from byproduct utilization (Grigorakis et al, 2016).

Potato peel as a byproduct of food processing industry poses to be totally inexpensive, valuable and affordable starting material for the production of economically important substances, value addition, product extraction including dietary fibre, biopolymers, natural antioxidants, and natural food additives (Chiellini et al, 2004).

Industrial processing generates between 70 to 140 thousand tons of peels worldwide annually (Chang, 2019). Traditionally potato peel waste is used for producing low-value animal feed (Nelson, 2010). Fertilizer or being the raw material of biogas, which causes

waste of abundant nutritive materials within it having the properties of antioxidant, antibacterial, apoptotic, chemo preventive and anti-inflammatory (Coats et al, 2014). The central dogma of the present study is the proper waste management with the economic feasibility of the processing development (Sharma et al, 2008).

In food processing industries, environmentally friendly solution for food by-products is yet to found and is under investigation (Israilides et al, 2010). On a global basis, potato is the fourth most important food crop following rice, wheat, and corn (Krause et al, 1994).

Potato popularly known as "the king of vegetables" because it grows in more than 100 countries (Bhajantri, 2008). In developing countries, potato production has increased at an average rate of five percent per year. Currently the total share of developing countries to global potato production rose from 20% to 52%. This is a remarkable achievement, considering the past two decades (FAO, 2008). Due to increasing urban populations and rising incomes of people living in developing country, the demand for processed food is dramatically increased (Maria and Freire, 2010).

Potato Chips are the most common food processed potato products which produce a large amount of potato peel as by-product (Stearns et al, 1994). Potato peel is a zero value by-product, which occurs in huge amounts after processing. Depending on the peeling method used, it ranges from 15 to 40% of the first product mass (Sepelev and Galoburda, 2015).

In food processing industries, the most common cause of environmental pollution is associated with organic wastes decomposition. The decomposition occurs when bacterial and other biological forms use the compounds as a source of food (Pailthorp, Filbert and Richter, 1987). To avoid such problem, use of potato waste as an antioxidant in food systems due to its high phenol content is mandatory (Sepelev and Galoburda, 2015). Phenolic compounds of potato peel synthesized by potato plant for protection from bacteria, fungi, viruses, and insects (Akyol et al, 2016).

The residues of fruit and vegetable industrial processing have been widely used for animal feed or as a source of energy, but it is believed that still too few residues are used in other applications e.g., in the food industry. The high nutritional and health-promoting value and presence of active compounds such as antioxidants should favour this area of re-use or recovery (Kowalska et al, 2017).

Potatoes are one of the most commonly consumed crops in the world, which is connected with their impact on residue generation. The disposal of this waste poses a challenge. Potato peels constitute a major waste of potato processing that ranges from15 to 40% of the initial product's mass; therefore, their valorization should be of interest to the food industry (Akyol et al, 2016, Gebrechristos and Chen, 2018). The periderm (skin) of the potato provides a protective layer for the potato tuber against phyto pathogens and therefore contains numerous secondary metabolites, including phenolic compounds (Ezekiel et al, 2013 and Huang et al, 2017). Phenolic antioxidants such as hydroxycinnamic and hydroxybenzoic acid derivatives and flavonoids have been found in the extracts of potato peel (Al-Weshahy and Rao 2009; Dauber et al, 2012).

In accordance with the growing antipathy of consumers towards synthetic food additives, potato peels seem to constitute a potential source of natural antioxidants that can be used in the food industry (Carocho et al, 2018). Natural antioxidants have been the focus of scientists and food business operators' for many years. These compounds show similar or even higher potential than their synthetic counterparts, which makes them an attractive alternative to artificial agents (Sielicka and Malecka, 2016; Ozkan and Ozcan, 2017).

The ubiquity of their occurrence in plants, as well as the great number of active compounds, creates the potential for extending the list of antioxidants feasible to use in food. Although the method of obtaining a given chemical does not prejudge its toxicity, synthetic compounds are disliked by consumers. In contrast to synthetic food additives,

which are regarded as 'unhealthy' and provoke controversy, natural compounds are better perceived by consumers. Producers who are aware of consumers' attitudes avoid using them in food, replacing synthetic antioxidants with widely accepted compounds of natural origin (Carocho et al, 2018)

The recovery of natural antioxidants from plant material residues such as pomaces, kernels, skins and peels in order to extend the shelf life of lipid-containing foods is in line with sustainable management policy and consumers' expectations. The properties of potato peel extracts have been tested in in vitro antioxidant assays, but the data remain scarce and concern only selected cultivars out of over 300 described so far (AHDP Potatoes 2018). Moreover, still too few studies have been conducted on the potato peel's effectiveness in lipid matrices in the context of selective effect of antioxidants indifferent media and differentiated activity towards primary and secondary oxidation products (Frankel, 2007). Hence the present study entitled "FORMULATION AND QUALITATIVE ANALYSIS OF POTATO PEEL INCORPORATED ICE CREAM" is undertaken with the following objectives.

OBJECTIVES

- To develop potato peel ice cream
- To analyze the nutritive value of potato peel ice cream
- To carry out organoleptic evaluation of potato peel ice cream
- To analyze acceptability of potato ice cream

REVIEW OF LITERATURE

The literatures pertaining to the **"Formulation and qualitative analysis of potato peel incorporated ice cream"** were reviewed under the following headings:

A. HISTORY AND ORIGIN OF POTATO
B. HEALTH BENEFITS OF POTATO PEEL
C. UTILIZATION OF POTATO PEEL
D. NUTRITIONAL COMPOSITION OF POTATO PEEL

A. HISTORY AND ORIGIN OF POTATO

Amado et al (2014) stated that potatoes (Solanum tuberosum L.) are one of the most widely consumed vegetables worldwide. (FAO STAT, 2017) reported that the world production of potatoes in 2017 was 4325478 tons.

According to Mohdaly et al (2010) most of the liquid and solid wastes from potato arise from peeling, trimming, slicing, cleaning, and rinsing operations which creates a pollution problem. This has resulted in environmental problems associated with waste generated by such manufacturing processes. Potato peel waste is the major waste from the potato processing industry and a potential source of functional and bioactive compounds, including not only antioxidants but also pigments, dietary fibre, vitamins and minerals.

Al-Weshahy and Rao (2012) stated that potato peel also has acquired attention as a natural antioxidant in food system due to its high content of poly phenols, which was reported to be 10 times higher than their levels in the flesh accounting for approximately 50 % of all polyphenols in potato tuber. Therefore, the effective utilization of potato peel as an antioxidant in food has been investigated extensively.

Akyol et al (2016) stated that phenolic compounds in potatoes and by-products also exhibit beneficial antioxidative, antibacterial and health-promoting properties. Mohdali (2010) reported that methanolic extract of potato peels exhibited the highest extraction ability for phenolic compound and also showed the strongest antioxidant capacity.

Khalifa et al (2016) stated that generally, polar organic solvents are the most effective in bioactive substances solubilizing from plant tissues. Therefore, the objectives of the present study were to evaluate the potato peel extracts as a source of antioxidant and antimicrobial substances.

According to Woolfe (1987) the cultivated potato (Solanum tuberosum) originated in South America where it has been used for food for over 10,000years (CDC, 1999) and domesticated during pre-Columbian times over 8,000 years ago (CIP, 2008). Pre-Columbian food preparation involved the production of chuno˜, which was used in soups and stews, much as it is still produced in the Andes today.

Buckenhuskes (2005) stated that harvested potato tubers are piled on the ground and repeatedly frozen over several nights. Skin removal (through trampling) is followed by soaking or leaching in running river water. This serves to remove the bitter flavors caused by glycoalkaloids. The final step involves sun-drying which pre-serves the chuno˜ for up to several years. Another product, papaseca, is produced by boiling, peeling, slicing, then sun-drying and grinding and is also used in stews and soups. Potatoes were first spread to European countries, including Spain and England, in the late 1500s (CDC, 1999). The potato may have been instrumental in preventing scurvy among early consumers, including sailors, due to its relatively high vitamin C content.

Hils and Pieterse (2007) stated that Potatoes became so widely distributed and important, especially in certain parts of Europe, that they are often referred to as “European” or “Irish” potatoes.

Agriculture and Agri-Food Canada (2007) reported that Potatoes are now grown in 160 countries with over 4,000cultivars. Potatoes are eaten fresh or following storage; prepared in a multiplicity of different way sat home or commercially processed into many different food.

B. HEALTHBENEFITS OF POTATO PEEL

1. Good for heart health

According to Sabeena et al (2010) the peel of potato has potent radical scavenging or antioxidant activity due to the presence of two dominant phenolic compounds chlorogenic and gallic acids. These compounds may help maintain good heart health by reducing damage to the heart due to free radicals. Potato peels also contain a significant amount of potassium, which is a good element in regulating the blood pressure in the body.

2. Has antibacterial and antifungal properties

Nostro et al (2000) stated that Potato peel has strong antimicrobial compounds against a range of bacterial and fungal infections. This is due to the presence of terpenes and flavonoid organic compounds in the peel. Upon consumption, it may help prevent infections and keep a person healthy. Also, the bacteriostatic nature of the potato peel is considered safe to be used in food processing industries as they naturally help protect against food borne pathogens and help in food preservatives.

3. Helps heal wounds

Haftom (2018) stated that potato peel acts as a natural wound healer and may help heal wounds and prevent bacterial overgrowth in the affected skin area. It has the ability to induce cutaneous healing by promoting cell growth and providing tensile strength to the wounded skin. Also, potato peel dressing is cheap, always available, less painful and easy to apply remedy, and better than gauze alone dressing especially during the healing phase.

4. Has antiviral properties

According to Norma Patrica et al (2017) potato peel not only has antibacterial and antifungal qualities, but also antiviral properties against enteric viruses, those human viruses which are mainly transmitted by the faecal-oral route, vomit, from person-to-person direct contact or by consumption of contaminated food or water. Chlorogenic and caffeic acid in the peel is the major phenolic compounds that are responsible for its antiviral activity.

5. Prevents anemia

According to USDA (2018) baked (1.08 mg) and micro waved (1.24 mg) potato along with its skin provide the maximum amount of iron to the body. Another study says that potato peel contains 55 per cent of iron of the total tuber iron content. Philip et al (2011)

reported that as we know that iron is an important component in maintaining the production and supply of red blood cells in the body, consumption of potato peel can help prevent or reduce eth risk of related diseases like anemia.

6. Helps lose weight

According to Camire et al (2009), potato peel is a staple food that is low in fat, high in energy and packed with an abundance of nutrients like vitamin B, vitamin C, potassium and dietary fibre. These nutrients in potato peel add it to the list of diet which is best known for weight management. Consuming potato peel dishes help you stay energised and full for longer, and also keep your calories under control.

7. Has Anthocyanins

Hellman et al (2012) stated that anthocyanins are flavonoids that give fruit or vegetables their natural color. Tubers like potatoes, especially red, yellow and purple have an abundance of this vital flavonoid linked to several health benefits. Potato peel has maximum anthocyanins than its flesh, and from preventing inflammatory diseases to chronic diseases, it has various roles in the body of people of all age groups.

8. Helps reduce glucose levels

According to Singh et al (2005) a study talks about the anti-diabetic and ant hyperglycemic effects of potato peel. It says that dietary fibre and polyphenols in potato peel powder can help reduce glucose levels when added to the diet for four weeks. Additionally, potato peel also helps reduce damage to the liver and kidney due to free radicals and improve their functions in people with diabetes. Potato peel also helps prevent damage to eye nerves due to high glucose.

9. Has chemo preventive or cancer-fighting properties

Friedman et al (2005) stated that Potato naturally contains glycoalkaloids to protect itself from insects and herbivores. When exposed to light, the concentration of this chemical increases which can be harmful to the body when consumed in excess amount. However, in a small amount, it can have many positive benefits. A study has shown that pure isolated glycoalkaloids possess anticarcinogenic properties that may help prevent a range of cancer types such as cervical, liver, stomach and lymphoma.

10. Helps in the management of necrotising fasciitis

Manjunath et al (2015) reported that necrotising fasciitis (NF) is a rare, fatal and aggressive form of skin condition. As aforementioned, potato peel works wonderfully for wounded skin, but it can also be effective for many chronic, rapidly spreading and polymicrobial skin wounds like NF. A study has shown that when applied to necrosis-based wounds, potato peel can help treat it with various modalities, especially due to the glycoalkaloids present in potatoes such as alpha chaconine and alpha solanine which act as a toxic compound for microorganisms present in wounds.

C.UTILIZATION OF POTATO PEEL

Food preservation

According to Tiwari et al (2009), synthetic food preservatives could be used alone or in combination with natural preservatives both synthetic and natural antioxidants been used in food industry; however, application of synthetics preservatives has potential carcinogenic effects but use of natural preservatives alone has a better advantage for human health with low side effect. As a result, attention has being given to vegetable waste with rich source phenols.

Pezeshk et al **(**2015) stated that food processing industries generate phenolic-rich vegetable by-products, and this has been an area of research investigations as sources of antioxidants and antimicrobial for food preservation. According to Sonia et al (2016), the entire tissue of fruits and vegetables is rich in bioactive compounds or phenols but the by-products have higher contents of antioxidant.

Antioxidant

According to Throat et al (2013), antioxidants inhibit oxidation of lipids in foods and consumption of high concentration synthetic antioxidant has carcinogenic effect unlike the natural antioxidants. Jacobsen, (2010) stated that the antioxidant activity of potato peel extracts has strong radical scavenging ability and prevents oxidation reaction in oily foods. Arun et al (2015) reported that, the ability on minimizing oxidation on vegetable oil, potato peel extracts has equal performance with synthetic antioxidants such as butylhydroxyanisole (BHA) and butylhydroxytoluene (BHT). In comparison with mature potato, young potato peel has excellent source of bioactive phytochemicals nature with antioxidant potential. However, as compared to the application of synthetic antioxidants, potato peel extracts need to apply in higher amount but still looking the advantage of natural antioxidants than the synthetic, it is a promising source of natural antioxidant that could be used as eco-friendly product on food industries.

Antimicrobial

According to Chabuck et al (2013) more than three-quarter of the world's population has used medicinal plants for treatment of different disease. Herbal plants are important on prevention against highly pathogenic micro-organisms, and they are safer means of food preservation. Nostro et al (2000) stated that potato peel extracts have antimicrobial compounds against bacterial and fungal organisms. The antimicrobial nature could be due to the presence of flavonoids and terpenes organic compounds.

According to Amanpour et al (2015), potato peel has bacteriostatic nature with non mutagenic behavior and safe to use in food processing industries. Therefore, potato peel extract is the future and natural against food borne pathogenic microbial and the broad spectrum nature of the plant help to discover new chemical classes of antibiotic substances that could serve as food preservative in food processing industries.

Pharmaceutical Ingredient

WHO (2011) reported that pharmaceutical ingredient is a substance used in a finished pharmaceutical product, intended to give pharmacological activity to cure, mitigation, treatment, or prevention of disease .

Garget et al (2014) stated that peels of various fruits and vegetables are generally considered as waste product and are normally thrown away. But they have important elements, which could be used for pharmaceutical purpose.

Chem (2009) stated that when we look the highest amounts of glycoalkaloids are found in potato peel than the flesh part of potato. According to Dudek et al (2013), in addition to this, potato powder has a potential of wound healing activity as antiulcerogenic agent Therefore, use of potato peel as pharmaceutical ingredient is natural, nontoxic, and environmentally friendly. So this could be one of the solutions on prevention of the current threat of drug resistance, emerging disease effective treatment and lower the health damaging side effect of synthetic drugs.

Wound management

According to Lalande et al (2004), Wound is a result of disruption of normal structure of skin. To ensure proper healing process, wound tissue need free of revitalized tissue, clear of infection, and moist. Wound dressings should cut dead tissue, exudate, prevent bacterial overgrowth. Various natural topical agents are available which help wound healing process. Patil et al (2011) stated that potato peel is one of the natural wound healer herbal plants that has ability to produce high tensile strength of wounded skin.

Dudek et al (2013) reported that about 2.5% in ointment form of potato could trigger cutaneous wound healing through improve cells migration and gastric ulceration through protecting gastric mucosa wrinkles.

According to Aertgeerts et al (2011) sterile potato peel dressings are better than gauze alone dressing particularly during the healing phase so potato peel dressings could be an alternative for wound dressing in developing countries.

Glycoalkaloids

According to McCue et al (2009) glycoalkaloids are naturally found in vegetable crops. Potato glycoalkaloids are known for their toxic nature but the glycoalkaloids found in potato leaves offer natural protection to the plant against pests.

Chem (2009) stated that potato peel has 43% of phenolic acids and 10% of the glycoalkaloids. The highest amounts of glycoalkaloids found in potato peel unlike of the potato flesh.

Maldonado (2014) reported that separation of toxic glycoalkaloids from potato peel prior applying in food processing is important to use for further pharmaceutics products. This can be performed using food grade water/ethanol solvents extraction.

According to Handling et al (1996), as a general trend, there is reduction in alkaloids due to its volatile nature. For instance, during potato processing, partial degradation of caffeic acid and glycoalkaloids occurred. However, y dried potato samples have higher steroidal alkaloids such as α-solanine and α-chaconine than fresh samples. The air-drying techniques had the highest steroidal alkaloid contents than freeze and vacuum oven-drying.

D. NUTRITIONAL COMPOSITION OF POTATO PEEL

According to the USDA, 100 g of raw potato peel contains 83.3 g of water and gives 243 kJ of energy. Nutritional composition of potato peel are presented in below Table-I

TABLE-I

Nutritional composition of potato peel

Name	Amount
Protein	2.57 g
Dietary fibre	2.5 g
Calcium	30 mg
Iron	3.24 mg
Magnesium	23 mg
Phosphorus	38 mg
Potassium	413 mg
Sodium	10 mg
Zinc	0.35 mg
Copper	0.42 mg
Manganese	0.6 mg
Selenium	0.3 mcg

Vitamin C	11.4 mg
Vitamin B3	1.03 mg
Folate	17 mcg

According to McDonald et al (2014) potato peel also contains starch (25%), non-starch polysaccharide (30%), protein (18%), acid-soluble and acid-insoluble lignin (20%), lipids (1%) and ash (6%) on dry basis.

Liang et al (2014) stated that, the lipid fraction includes long-chain fatty acids, alcohols, triglycerides and sterol esters. In addition, lignin units have been found in the cell wall of potatoes.

According to Arapoglou et al (2010) potato peel is rich in starch (52% dry weight), but the content of fermentable reducing sugar is limited (0.6% dry weight). For this purpose, fermentation of potato peel is not practically possible, thus initial hydrolysis (enzymatic or acidic) of carbohydrates is required to increase the content of fermentable reducing sugar.

Liang et al (2015) reported that elemental analysis of potato peel shows that it contains (in % dry basis): C (43.78 ± 0.15), H (5.96 ± 0.12), N (4.06 ± 0.01) and O (46.21 ± 0.28). The C/N ratio of potato peel is 10.7.

Liang et al (2014) stated that the calorific value of potato peel is 17.37 ± 0.38 (MJ/kg).