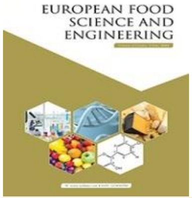

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Apricot juice processing byproducts as sources of value-added compounds for food industry

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ABSTRACT

It is well known that a big proportion of food processing wastes is formed by food processing industry. Apricot (*Prunus armeniaca* L.), which is included in the genus Prunus, is one of the most commercialized fruits produced in Turkey, the biggest apricot producer in the world with 811 thousand tons of production. As a result of processing of apricot into several products including apricot juice, significant amounts of byproducts including stone (kernel) and pomace are liberated, which are mainly discarded as landfill. In order to minimizing the environmental problems caused by discarded apricot byproducts, utilization routes from them for food and pharmaceutical industry have been investigated. Several biological activities such as anticarcinogenic, antimicrobial, and antioxidant of various fractions of apricot kernel have been demonstrated while apricot pomace has been proven as rich sources of valuable compounds such as polyphenols, dietary fibers and carotenoids. In this study, recent works devoted the utilization from different byproducts of apricot processing industry have been summarized by referring their potentially value-added constituents. Incorporation of these products into several food systems has been also discussed in this work.

1. Introduction

Food and agricultural industry produce a considerable amount of byproducts and waste. It is estimated that approximately 38% of food is formed as waste during food processing (Buzby and Hyman, 2012). According to the European Commission report, around 90 million tons of food waste are generated in European Union (EU) countries each year (European Commission, 2010). Food industry wastes include a variety of products such as skin, bone, curd, peels, cold-press byproducts, pomace and seeds, arising from animal-, dairy- and plant- based food processing (Karaman et al., 2015; Helkar et al., 2016). The major agricultural waste also can be listed as paddy, wheat, and corn residues (Ravindran and Jaiswal, 2016). Food waste and byproducts have been considered as a global environmental and economic issue in recent years (Galanakis, 2012). Disposal of food waste into environment causes both soil and water pollution due to their high accumulation rate leading to bacterial growth (Pfaltzgraff et al., 2013). Processing industries are also facing with many problems from the aspects economical costs of disposal and strict legal regulations in the countries (Banerjee et al., 2017).

Fruit industry constitutes a big proportion of food processing waste sources. Fruit pomace can be defined as the pulp residue remaining after the crushing of fruit to obtain its juice (Nawirska and Kwaśniewska, 2005). As a major global fruit manufacturer, Turkey has an important place for the fruit juice industry. Annual fruit production of Turkey is about 17.1 million tons, which constitutes about 2.5% of the world production. Turkey is one of the major manufacturers of a number of fruits including apricot, apple, cherries and peach, which are main fruits used in fruit juice production (TÜİK, 2015). Apricot (*Prunus armeniaca* L.) is included in the genus Prunus of the subfamily *Prunoideae* in the family *Rosaceae* (Kayran and Doymaz, 2017). It is a climatic and seasonal fruit and has a very short storage time, high respiratory rate and fast ripening process. To extend the shelf life of fresh fruit, several preservation methods such as drying, canning and packaging methods have been used (García-Martinez et al., 2013; İncedayi et al., 2016). Apricot is one of the most commercialized fruits produced both in Turkey and in the world. It is mainly consumed as fresh or after dried, also it is processed to a variety of products such as marmalade, jam or jelly and also canned as slices or processed as fruit juice (Ercisli, 2009). Apricots are among the most promising foods with the physiologically important constituents (dietary fiber, sorbitol, potassium, copper, and phenolic compounds) which play important roles in many aspects of human health (Seker et al., 2009).

Especially during apricot juice production, significant amounts of byproducts including stone and pomace are remained from the fruit (Sun et al., 2007). Unfortunately, these byproducts are mainly discarded as landfill and need to be utilized in different ways since they are rich sources of valuable compounds such as lignocellulose, flavonoids, carotenoids, polyphenols, tannins and enzymes (Adıbelli and Serdaroğlu, 2017). When checking the literature, it is seen that a limited number of studies has been focused to utilize from apricot pomace and stone for obtaining value-added compounds. Therefore, this study was aimed to the apricot waste valorization as biocomponents in the food industry.

2. Composition and Physicochemical Properties of Apricot Fruit and its Byproducts

Turkey is the biggest apricot producer in the world with production of 811 thousand tons of crops, which constitutes about one-fifth of the World's production, followed by Iran, Uzbekistan, Algeria and Italy (FAO, 2015). Majority of the crop is used for dried apricot production while the remaining is mostly processed to fruit nectar (juice) or freshly consumed (ZMO, 2015). Composition and physicochemical properties of flesh fruit and its byproducts (Figure 1) have been investigated by different researches. The results were summarized in Table 1.

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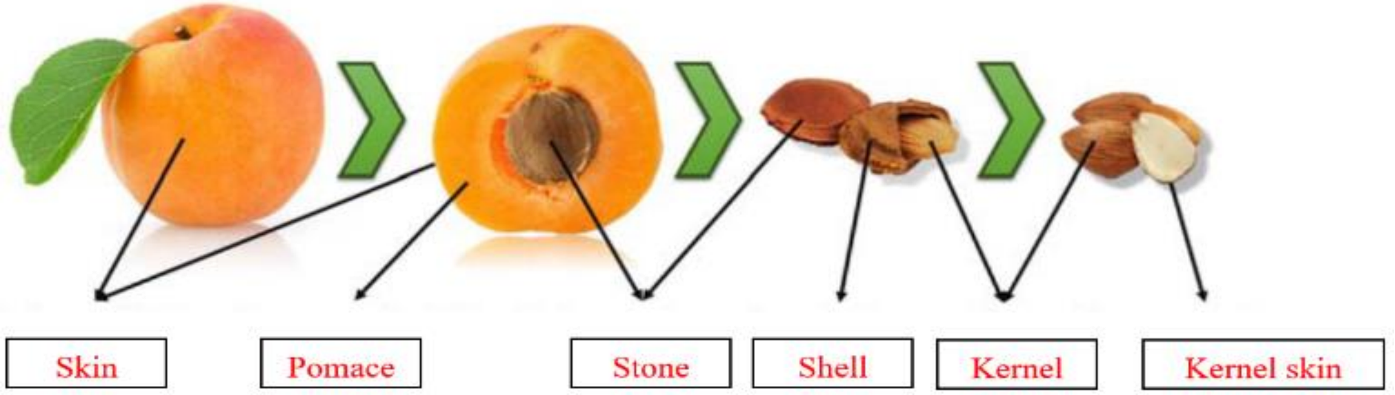

Figure 1. Apricot byproducts (Galanakis, 2015).

Apricot pomace, the byproduct of apricot nectar processing, contains all water-insoluble compounds, carbohydrates, proteins, vitamins and minerals as well as a huge amount of water and also water-soluble components. The reported crude oil, crude protein and ash contents of apricot pomace ranged between 0.2-3.12%, 1.06-4.87% and 0.60-5.34 respectively (Kang et al., 1999; Doymaz et al., 2017; Haciseferogullari et al., 2007; Ucuncu et al., 2013; Eksi and Artik, 1982) while citric, ascorbic and malic acid values of apricot pomaces also varied in a wide range (0.10-1.94%, 2.23-6.38 mg/100g, 0.17-0.79%, respectively) (Chauhan et al., 2001; Akin et al., 2008; Kang et al., 1999; Haciseferogullari et al., 2007). pH values of apricot pomaces were reported to be between 2.56 and 5.63 (Doymaz et al., 2017; Haciseferogullari et al., 2007; Chauhan et al., 2001; Akin et al., 2008). The reported total sugar of apricot pomace ranged from 6.30-9.36% (Chauhan et al., 2001; Karadeniz and Islam 1995). Pectin rate in pomace is range from 0.32 to 0.64% (Kang et al., 1999; Chauhan et al., 2001). It was reported that total dietary fiber content ranged between 6.76-7.82% (Kang et al., 1999; Chauhan et al., 2001).

The reported protein content of apricot kernel ranged from 14.1 to 45.3% (Joshi et al., 1986; Özcan 2000; Kapoor et al., 1987; Gezer et al., 2003; Vursavuş and Özgüven, 2004). The oil content of the kernels varies from 27.7 to 56% (Kapoor et al., 1987; Gezer et al., 2003; Vursavuş and Özgüven, 2004). Ash content of apricot kernel varies between 1.7-2.9 % (Joshi et al., 1986; Kapoor et al., 1987; Gezer et al., 2003; Vursavuş and Özgüven, 2004). Moisture rate of apricot kernel is approximately 4.0-4.3 % (Kumar and Bhan 2010). It was reported that the total sugar content ranged between 2.86 and 8.1 (Hussain et al., 2012; Pala 1996). The amount of ascorbic acid in the apricot kernel was determined as 1.05 and 2.14 mg/100g (Alpaslan and Hayta, 2006). The oil recovery rate from the apricot kernel varied between 45.6-57.97 with the solvent extraction method (Sharma et al., 2006; Sharma et al., 2014; Gupta et al., 2009).

The reported total dietary fiber, soluble dietary fiber, total pectin, crude ash rates of apricot flesh were 4.01, 1.07, 0.64, 0.58% respectively (Kang et al., 1999). The amount of crude protein in the apricot flesh was determined as 0.92 and 1.0% (Hussain et al., 2012; Kang et al., 1999). Crude oil content of apricot flesh varied between 0.2 and 2.28% (Hussain et al., 2012; Kang et al., 1999).

3. Valorization of Apricot Byproducts

Apricot byproducts are well-known that fruits is rich sources of valuable and nutritional compounds, therefore they should be valorized by different ways. It should be noted that Turkey represents the world's leading apricot producer and it causes a large amount of apricot by-product to accumulate (Han et al., 2013). Apricot kernel and apricot pomace are the most widely considered apricot processing byproducts for production of functional food and feed additives. Apricot kernel and apricot pomace, which are known as a non-traditional source of bioactive compounds (such as polyphenols and fatty acids), are byproducts of apricot fruit.

3.1. Apricot stone (kernel)

The hard, shell part of the pits, taken separately, represents about 35,000 metric tons annually, and the kernels within the pits, constitute 7,000 metric tons annually (FAO, 1998). The average length, width and thickness dimensions of apricot kernels were reported as 14.0–19.17 mm, 9.99–10.20 mm and 3.3–6.27 mm, respectively. The 100-kernel weight range was 28.7–65.1 g (Vursavuş and Özgüven, 2004; Gezer et al., 2003). The percentage of kernel by weight located in the apricot pit varied from 18.8 to 38.0% (Kapoor et al., 1987).

Three types of apricot kernel, namely sweet, bitter and bitter sweet are available. The apricot kernel can be consumed directly after drying while they are also added in sweet dishes like custard. The kernels of Khostar or Bongti are bitter-sweet. Different ways of apricot kernels are available. They are mainly dried and consumed as well as added in sweet dishes like custard. Sweet kernels are used as almond substitute while bitter kernels are used for oil extraction and for making some special dishes like tapu (Hussain et al., 2012). Alternatively, they are also used as a fuel (Alpaslan and Hayta, 2006).

Several biological activities such as anticarcinogenic, antimicrobial, and antioxidant of various fractions of apricot kernel have been demonstrated (Mandalari et al., 2010; Yiğit et al., 2009), which enables it to be utilized in different areas including food, cosmetics, medicines, and scent industry. Industrial application of apricot kernel for human consumption is limited due to presence of amygdalin (D-mandelonitrile-β-D-gentiobioside) (Senica et al., 2017), which produces toxic hydrocyanic acid (HCN) upon coming into contact with endogenous enzyme β-glucosidase as a result of crushing, chewing, maceration or soaking of the kernel (Gupta et al., 2009). This toxic component can lead to symptoms such as headache, nausea, vomiting, abdominal cramps, dizziness, weakness, mental confusion, convulsions, cardiac arrest, circulatory and respiratory failure, coma and in extreme cases death (Tisserand and Young, 2014). It has been reported that apricot kernels had much higher antioxidant activity and phenolic content than the flesh fruit (Soong and Barlow, 2004). Apricot kernel skin contains several glucosides such as apigenin 7-O-glucoside, (cyanidin 3-(4″-acetylrutinoside), 3-(6″-acetylglucoside)-5-glucoside and salicylic acid (Qin et al., 2019).

Effect of apricot kernel flour addition into dried salted noodles on their physicochemical (color, moisture, oil, protein and ash), cooking (optimum cooking time, loss of weight, weight and volume increase) and sensory properties were examined. The results of the study showed that noodle samples containing apricot kernel flour had higher levels of protein, lipids and ash. However, the control noodle had the highest sensory score. According to the results obtained from this study, that addition of apricot kernel flour into wheat flour on the basis of 15% weight enabled acceptable noodles in terms of physicochemical and sensory properties (Eyidemir and Hayta, 2009).

Table 1. The composition and physicochemical properties of the apricots and its byproducts.

Apricot Pomace	**Values**	**References**
Crude Oil (%)	0.2-3.12	Kang et al. (1999); Doymaz et al. (2017); Haciseferogullari et al. (2007); Ucuncu et al. (2013); Eksi and Artik (1982)
Crude Protein (%)	1.06-4.87	Kang et al. (1999); Doymaz et al. (2017); Haciseferogullari et al. (2007); Ucuncu et al. (2013); Eksi and Artik (1982)
Ash (%)	0.60-5.34	Kang et al. (1999); Doymaz et al. (2017); Haciseferogullari et al. (2007); Ucuncu et al. (2013); Eksi and Artik (1982)
Ash Insoluble in HCI (%)	0.17-0.44	Eksi and Artik (1982); Doymaz et al. (2017)
Total sugar (%)	6.30-9.36	Chauhan et al. (2001); Karadeniz and Islam (1995)
Total Dietary Fiber (%)	6.76-7.82	Kang et al. (1999); Chauhan et al. (2001)
Citric Acid (%)	0.10-1.94	Chauhan et al. (2001); Akin et al. (2008)
Ascorbic Acid (mg/100g)	2.23-6.38	Chauhan et al. (2001); Kang et al. (1999)
Malic Acid (%)	0.17-0.79	Haciseferogullari et al. (2007)
pH	2.56-5.63	Doymaz et al. (2017); Haciseferogullari et al. (2007); Chauhan et al. (2001); Akin et al. (2008)
Pectin (%)	0.32-0.64	Kang et al. (1999); Chauhan et al. (20019
Apricot Kernel		
Oil (%)	27.7-56.0	Kapoor et al. (1987); Gezer et al. (2003); Vursavuş and Özgüven (2004)
Crude protein (%)	14.1-45.30	Joshi et al. (1986); Özcan (2000); Kapoor et al. (1987); Gezer et al. (2003); Vursavuş and Özgüven (2004)
Ash (%)	1.7-2.9	Joshi et al. (1986); Kapoor et al. (1987); Gezer et al. (2003); Vursavuş and Özgüven (2004)
Moisture (%)	4.0-4.3	Kumar and Bhan (2010)
The total sugar (%)	2.86-8.1	Hussain et al. (2012); Pala (19969
Ascorbic acid (mg/100 g)	1.05-2.14	Alpaslan and Hayta (2006)
Oil recovery (%)	45.6–57.97	Sharma et al. (2014); Gupta et al. (2009)
Apricot Flesh		
Total dietary fiber (%)	4.01	Kang et al. (1999)
Soluble dietary fiber (%)	1.07	Kang et al. (1999)
Total pectin (%)	0.64	Kang et al. (1999)
Crude protein (%)	0.92-1.0	Hussain et al. (2012); Kang et al. (1999)
Crude oil (%)	0.2-2.28	Hussain et al. (2012); Kang et al. (1999)
Crude ash (%)	0.58	Kang et al. (1999)

Apricot kernel contains about 40-50% of unsaturated fatty acids which are mainly composed of oleic (60-70%) and linoleic acid (25-30%) (Özkal, 2004). The kernel oil has been used in some soap and perfume types (Ogawa et al., 1995). It is also been utilized for preparation of various value added some products such as facial cream, lip balm (Sharma et al., 2014). Ullah et al. (2009) has also highlighted the potential of wild apricot kernel oil for biodiesel production with fuel properties comparable to those of mineral diesel. Some authors showed good improvement in quality of apricot kernel oils by packing with colorful glass bottles during storage up to six months (Sharma et al., 2004; Sharma et al., 2006; Gupta et al., 2009). Apricot kernel contains dietary fiber at varying levels from 6.03 to 22.24 % (Dwivedi and Ram, 2006). Thus, high-fiber foods are important objectives in today’s food product development. As a by-product, apricot kernel offers an exciting new potential as a food ingredient especially in cereal products (Seker et al., 2009).

3.2. Apricot pomace

Apricot pomace, which is mainly constituted by skin and pulp, is the major byproduct of apricot juice processing. It is estimated that approximately 1390–3720 tons of apricot pomace are produced in Turkey annually (Eksi and Sert, 2003).

3.2.1. Incorporation of apricot pomace into food systems

Apricot pulp and pomace could be considered as useful for the food industry as a source of functional ingredient due to its nutritious compounds such as fibers and phenolic compounds. Apricot pulp was incorporated as a nutritionally enriching agent into different kinds of food systems such as ice cream, processed cheese and sausage (Purma, 2006; Mohamed and Shalaby, 2016; Ayar et al., 2018).

In a study conducted by Purma (2006), apricot pulp was added to sausage. The functional properties of the apricot pulp, the chemical composition, technological quality, texture parameters and sensory properties of the sausages were examined. Apricot pulp addition (15%) to the formulation significantly increased the amount of gel and oil separated from the emulsion. Processing efficiency of the samples with 10% and 15% apricot pulp was significantly increased. By increasing the amount of pulp added to sausage samples, a decrease in elasticity, stiffness and sting resistance values was observed. In sensory evaluations, it was determined that the addition of apricot pulp up to 5% into sausage was considered as acceptable (Purma, 2006).

In another study, the effects of dried apricot pomace on the technological, nutritional and sensory quality of frankfurters were investigated. The results indicated that apricot pomace could be an effective functional ingredient in emulsion type meat products. It was observed that the protein and fat content decreased with the increasing apricot pomace concentration to above 5%. The addition of apricot pomace resulted in lower pH and energy values while 5% addition of apricot pomace resulted in acceptable sensory properties. Moreover, the sausage incorporated with the apricot pomace had better cooking and processing efficiency (Adıbelli and Serdaroğlu, 2017).

Analogue processed cheeses were made with the addition of apricot pulps which sweetened with different proportions of sugar and chemical, textural and sensory properties were investigated during storage at different temperatures The results showed that addition of apricot pulp and sugar resulted in analogue processed cheeses with higher total solids, carbohydrates, fiber, vitamin A and potassium contents, as compared with the control samples. However, the control sample had the highest rate of protein, ash, soluble nitrogen, fat in dry matter, pH values as compared with the pulp-enriched other samples. Moreover, texture profile analysis showed that pulp addition caused lower stickiness, stiffness, cohesiveness and elasticity values than the control cheese. On the other hand, sensory evaluation scores were found to be acceptable for all cheeses (Mohamed and Shalaby, 2016).

Ayar et al. (2018) investigated the effects of incorporation of several dietary fiber-rich by-products such as grape, apricot and apple pomace and grains (rice, corn, sun-flower, barley) into the probiotic ice creams on survival of the probiotics. Fruit pomace addition into ice cream formulation enabled advanced survival of the probiotic strains without any adverse effects on the microbiological, physicochemical and sensory properties of the ice creams.

3.2.2. Apricot pomace as source of phenolics

There is an increased evidence for the free radicals cause of various diseases like cancer, diabetes, cardiovascular diseases, autoimmune disorders, neurodegenerative diseases, aging and etc. (Ajila et al., 2012). Antioxidants are functional compounds which inhibit the effect of free radicals by different routes (Lee et al., 2004). Majority of antioxidant compounds such as polyphenols, tocopherols, carotenoids, ascorbic acid, flavonoids and tannins originate from plants. Therefore, plant derived wastes and byproducts are considered as economical sources of these antioxidants (Paganga et al., 1997).

In recent years, there has been an increased attention about extraction of phenolics from fruits, vegetables or their processing byproducts (Borges et al., 2016). Pomaces from apple, apricot, pomegranate cherry, citrus, they have been extensively studied to obtain antioxidants. Several studies have been focused on purification of phenolic compounds from apricot pomace using different solvents and techniques. Especially apricot pomace contains rutin, catechin, and epicatechin while caffeic and gallic acids are major polyphenols of apricot kernels (Cheaib et al., 2018).

A large production size of apricot byproducts is generated by apricot processing, which are sources of immense quantities of carotenoids and sugars, and then secondarily, phenolics (rutin, catechin, epicatechin, and chlorogenic acid) and amino acids. Apricot pulp contain carotenes (α-, β-, and γ- carotene, etc.) rather than xanthophylls (zeaxanthin, lutein, β-cryptoxanthin, etc. (Campbell et al., 2013).

In one study, ultrasound assisted extraction conditions of polyphenols from apricot pomace at 35 °C for 60 min using ethanol/water (70:30 v:v) as solvent was optimized by (Tabaraki et al., 2016) using central composite design and response surface methodology in terms of the highest total phenolic content. Cheaib et al. (2018), who tested the effect of ultrasound, microwave and infrared assisted extraction techniques on bioactive properties and extraction yield of apricot pomace, found that infrared was the most effective method with the highest polyphenol (10 mg gallic acid equivalent/g dry matter), flavonoid (6 mg catechin equivalent/g dry matter), and tannin (3.6 mg/L) yields. Dulf et al. (2017) reported that the levels of total phenolics increased by over 70% for solid state fermentation of apricot pomace with *Rhizopus oligosporus* and by more than 30% by fermentation with *Aspergillus niger*. Fungal fermentation also provided higher flavonoid contents and radical scavenging activities.

3.2.3. Apricot pomace as source of dietary fibers

Dietary fiber is defined as carbohydrate-based polymers consisting of 10 or more monomeric units, which cannot be hydrolyzed by the enzymes present in the human small intestinal tract (Viebke et al., 2014). Dietary fibers are categorized into two classes, namely soluble and insoluble dietary fiber, based on their solubility in water. Pectin, gums, inulin-type fructans, and several types of hemicelluloses are included in soluble dietary fibers while insoluble ones include lignin, cellulose and several hemiceluloses (Quiles et al., 2018). Apricot pomace was reported as a fiber-rich by-product (72.3%) (Galanakis, 2015). Dietary fibers have numerous health benefits including reduction of risks of several diseases such as diabetes, hypertension and coronary heart disease, improvement of blood glucose levels, and regulation of immune function (Anderson et al., 2009). Therefore, consumption of high-fiber foods such as fruits and vegetables are highly recommended by international and national health agencies. On the other hand, many attempts have been undertaken in order to enrich foods with dietary fibers or fiber-rich materials.

Cellulose is the main constituent of the cell wall in all plants, and is a linear polymer of poly-(1→4)-D-glucose units with a syndiotactic configuration (Dufresne et al., 1997). Cellulose chains are organized into crystalline microfibrils surrounded by a non-cellulosic phase in the plant cell wall (Frey-Wyssling, 1954).

The most abundant organic compound is cellulose and it is replenished. It represents 40–60% of municipal solid wastes (Naik et al., 2010). From the agricultural companies and orchards, the cellulosic residues obtained in the form of stalks, straws, stems, leaves, cobs, chaffs, bunches, stumps, and stubbles, damaged grains, fruits, vegetables, etc. Especially the major cellulosic wastes from food industries include damaged vegetables, fruit and grains, and fruit-vegetables juice post-processing residues, like skins, peels, seeds, leaves, husks, bunches, bagasse, vinasse, pomace, etc. The average cellulose contents of several plant sources are shown in Table 2.

Table 2. Cellulose contents (g/100 g of dry matter) of several plant sources.

Cellulosic wastes	g/100 g of dry matter	References
Agricultural residues		
Barley straw	44	Marsden (1986)
Oat Straw	41	Marsden (1986)
Rice straw	33	Marsden (1986)
Entire bagasse	46	Srinivasan and Han (1969)
Pith bagasse	55.4	Srinivasan and Han (1969)
Pomaces		
Apples	2.9	Southgate (1976)
Cherry	13.13	Nawirska and Kwaśniewska (2005)
Cucumber	16.13	Nawirska and Kwaśniewska, (2005)
Apricot	2.96	Kayran and Doymaz (2017)
Tomato	8.60	Nawirska and Kwaśniewska (2005)
Carrot	10.0	Nawirska and Kwaśniewska (2005)
Grains		
Barley	5.3	Zaborsky (1981)
Corn	2.4	Zaborsky (1981)
Wheat	2.1	Zaborsky (1981)

As seen in Table 2, different kinds of plant-derived materials have been analyzed as sources of cellulose. In the case of pomaces, cellulose content of apricot pomace was lower than those of carrot, tomato, cherry and cucumber while apple and apricot pomaces had similar cellulose contents. As compared the cellulose contents of grains and apricot pomace, it could be seen that the cellulose abundance of apricot pomace was moderate.

Pectin, an anionic plant cell wall polysaccharide based on a-(1–4) linked D galacturonic acid, is an important byproduct that can be obtained from these fruits and vegetable wastes (Begum et al., 2014). Pectin is widely used as technological adjuvant in the food industry (Babbar et al., 2016). It is commercially obtained from sugar beet pulp, apple rice and citrus peels (Renard et al. 1995). Besides, industrial byproducts of several fruits such as apple, citrus, sugar beet, pea and cauliflower have been investigated in order to obtain pectin reported that a considerable amount (16.72–17.63%) of pectin could be extracted from jackfruit peels by microwave assisted extraction, which was remarkable higher than conventional extraction at 90 °C for 1 h (Latner et al., 2000; Koh et al., 2014). Pectin was also obtained from the durian peel (Wai et al., 2010) as well as mangosten peels and seeds (Gan and Latiff, 2011; Ajayi et al., 2007) for food applications.

As can be understood from the limited number of studies that apricot pomace was not a cost-effective source of pectin. Chauhan et al. (2001) reported that the average level of pectin in apricot pomace was 0.32% while it was found as 0.64 % by Kang et al. (1999).

3.2.4. Apricot pomace as source of carotenoids

Carotenoids are compounds widely used as colorants that are directly added into foods. Naturally occurring carotenoids are tetraterpenoids consisting of highly unsaturated isoprene derivatives.

Carotenoid pigments are the most widely class of pigments in nature, displaying yellow, orange, and red color.

β-carotene and astaxanthin are industrially carotenoid pigments using as food coloring agents, in soft drinks, and baked goods; using as precursors of Vitamin (pro-Vitamin A) in food and animal feed; using as additives to cosmetics, multivitamin preparations; and in the last decade as antioxidants to reduce cellular or tissue damage (Bauernfein, 1981; Mantzouridou et al., 2002).

Fruits and fruit byproducts are considered as foods which are rich in carotenoids. Hernández-Santos et al., (2014) reported that β-carotene level of passion fruit peel was 4.85 mg/100 g. Pineapple peel and core had β-carotene contents ranging from 2537 to 3225 mg/100 g and from 960 and 994 mg/100 g, respectively (Freitas et al., 2015).

Apricot pomace has been reported as a good source of β-carotene. Şanal et al., (2005), who optimized the supercritical carbon dioxide extraction conditions for β-carotene extraction from apricot pomace using Response Surface Methodology, showed that the optimum amount of β-carotene was extracted at temperature of 342 K, pressure of 31.1 MPa and ethanol percentage of 27.4% with the extraction yield of 100.4 µg/g dry pomace.

4. Conclusion

Huge amounts of wastes and byproducts such as peels, pomace and seeds (kernel) are formed worldwide by processing of fruits and vegetables in the food industry, which constitute an important environmental concern. Apricot, one of the most commercialized fruits produced in Turkey, is processed to several foods such as dried fruit, fruit juice, jam and jelly. Especially during apricot juice production, significant amounts of byproducts are formed. Since these byproducts are mainly discarded as landfill, they have been utilized to obtain valuable compounds such as essential oils, polyphenols, dietary fibers and carotenoids to be used in different areas including food and cosmetic industry. Besides, apricot seeds and pomaces have been incorporated into several food systems in order to improve their nutritional and functional properties. Finally, it was concluded that different extraction and processing techniques should be applied to under-utilized apricot byproducts to obtain functional constituents with higher yield and lower cost.

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