The behavior of apricot kernel oil body and proteins during *in vitro* gastric and intestinal digestion

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PAPER

Abstract

In this study, an apricot kernel milk suspension was prepared, for which Hacıhaliloğlu-type raw and roasted apricot kernels were used. Protein, total lipid, and ash contents of apricot kernels and apricot kernel milk were determined. Palmitic acid, oleic acid, and linoleic acid were considered as major fatty acids according to gas chromatography. During *in vitro* gastrointestinal digestion, the proteins of raw and roasted apricot kernel milk were hydrolyzed and pepsin-resistant proteins were determined. No difference was recorded between the pancreatic lipase penetration in the oil–water interface of oil bodies of both milk types.

Keywords: fatty acids; oil body; protein hydrolysis; vegetable milk; vegetable protein; waste by-products

Introduction

Currently, owing to the increasing global population and rising environmental concerns, demand for the sustainability of food and agriculture systems has been intensifying. The global consumption of meat and dairy products is projected to increase by ~173% and 158%, respectively, from 2010 to 2050 (Food and Agriculture Organization of the United Nations [FAO], 2011). In particular, considerable concerns for the production and consumption of animal protein in terms of environmental effects, such as increasing greenhouse emissions and water consumption, have caused increased interest in producing alternate sources of proteins, such as vegetable proteins, which are already present in the human diet (Fasolin *et al.*, 2019). Moreover, the current intention of consumers to include additional plant-based proteins in their daily diet requires greater knowledge about using alternative protein sources and their impact on the human health. The by-products of alternative protein sources and food wastes have considerable potential

to be included in the human diet, especially those rich in protein, vitamins, minerals, fibers, oils, and bioactive compounds (Coman *et al.*, 2019; Morais *et al.*, 2015).

Apricot (*Prunus armeniaca* L.) kernels, a valuable by-product obtained from the processing of apricot plants, can have the potential to be used as a functional food ingredient to increase product differentiation and accomplishment of consumer requirements. The total production of apricots in the world is 4.3 million tons per year, and Turkey itself produces ~985,000 tons (Turkey Ministry of Agricultural and Forestry, 2020). Turkey produces 10–12% of fresh apricot and 60–65% of dried apricot in the world; moreover, ~10–20% of fresh apricot and 80–85% of dried apricot are exported throughout the world (Sığırcı *et al.,* 2015). Moreover, the apricot kernel is rich in phytochemicals, vitamins, minerals, unsaturated fatty acids (oleic acid and linoleic acid), α-, γ-, δ-tocopherols, and fibers (Al Juhaimi *et al.*, 2018; Fratianni *et al.*, 2018). Lipids found in apricot kernel are in the form of oil body, in which triglyceride particles are

coated with a stabilizing layer of phospholipids and proteins (Gallier *et al.*, 2017). The oil body is a lipid-storage compartment in plant seeds and its structure is similar to that of emulsions. In most oil seeds, oil bodies have a diameter of 0.6–2 μm, while it could be 10–20 μm in some fruits (Dave *et al.*, 2019). Owing to easy extraction, high recovery yield, and safe use in food products, plant-derived oil bodies have received considerable attention (Abdullah and Zhang, 2020). Several studies related to oil bodies from different sources have focused on their physicochemical characteristics such as droplet size, zeta (ζ) potential, emulsifying properties, and their microstructures (Dave *et al.*, 2019; Ishii *et al.*, 2017; Yan *et al.*, 2016). However, few studies have investigated the behavior of oil bodies from different sources, including almond oil bodies, bovine milk fat globules, and sunflower oilseed bodies during *in vitro* digestion (Gallier *et al.*, 2012, 2013; Mandalari *et al.*, 2008; Wang *et al.*, 2020; White *et al.*, 2008). Certain studies have focused on the occurrence, structure, and allergenicity of oil bodies (Barre *et al.*, 2018), the possibility of oil bodies derived from a plant source with unique facilities that could be used as an alternative to milk fat globules (Mantzouridou *et al.*, 2019), the extraction, isolation, and characterization of oil bodies (Zderic *et al.*, 2016), and the effects of food processing, such as roasting, sterilization, and high-pressure homogenization, on oil bodies (Yan *et al.*, 2016; Zaaboul *et al.*, 2019).

Protein contents determined in various types of apricot kernels are reported as 15.1–24.2% (Gezer *et al.*, 2011). Moreover, proteins determined in apricot kernels contain high levels of tyrosine, cysteine, methionine, aspartic acid, glutamic acid, serine, proline, and alanine (Elkot *et al.*, 2017). Owing to this valuable composition, especially protein and fat contents, the apricot kernel could be considered as a functional food or functional food ingredient. However, for the food industry, only a small amount of apricot kernel is consumed as nuts and a large amount is a waste by-product. Therefore, in spite of having a considerable industrial potential, lack of systematic collection and utilization has led to the lack of exploitation of this valuable product. The primary concern is amygdalin, a cyanogenic glycoside, contained in the kernels and seeds of apples, apricots, almonds, cherries, plums, and peaches (Mirzaei and Razei, 2019). Karsavuran *et al.* (2015) reported that the amount of amygdalin in sweet Hacıhaliloğlu-type apricot seeds was 0.25 mg/g and the predicted amount of hydrogen cyanide was 0.014 mg/g. With this amygdalin level, approximately 800-g seed would have to be ingested to cause poisoning of a child weighing 20 kg. However, this amount that causes poisoning in a child weighing 20 kg was very low for bitter apricot seeds (i.e., for Paviot-type, 4.48-g seeds; for Alyanak-type, 6.29-g seeds; and for Ninfa-type apricot, 12.87-g seeds).

In recent years, rather than dairy products, plant-based food alternatives, such as vegetable milk extracted from soy, almond, rice, and oats, have increased. The beverage obtained from apricot kernel could be a good alternative. Generally, studies related to apricot kernel as a functional food ingredient were based on foods added with apricot kernel. Elkot *et al.* (2017) produced stirred yogurt supplemented with apricot kernel powder and reported an increase in the protein content of yogurt. Eyidemir and Hayta (2009) incorporated apricot kernel flour into the noodle and indicated the increased contents of protein, lipid, and ash in the noodle.

To our knowledge, the possibility of extracting vegetable milk from apricot kernel has not been studied to date. In addition, the physicochemical characteristics of oil bodies and proteins of apricot kernel and their behavior during *in vitro* gastrointestinal digestion have not been explored. As most apricot kernels are waste by-products, converting them into value-added products would be beneficial in terms of both waste utilization and human health. Therefore, in order to explore certain physicochemical properties of oil bodies and proteins, protein profile and protein hydrolysis during *in vitro* gastrointestinal digestion are substantial.

The objectives of this study are to: characterize certain physicochemical properties of oil bodies and proteins of apricot kernel milk, understand their behavior during *in vitro* gastrointestinal digestion, evaluate the effect of microstructure on the physicochemical properties of oil bodies, evaluate it as an alternative vegetable protein source, and, finally, investigate the effect of roasting on all these properties.

Materials and Methods

Samples and reagents

Apricot kernels (Hacıhaliloğlu-type) were supplied by Apricot Research and Application Centre, Inonu University, Malatya, Turkey.

Following chemicals were purchased from Sigma Aldrich Corporation (St. Louis, MO, USA): Bradford reactive (B6916), bile acid (B8631), pepsin (P7000), pancreatin (P7545), glycine (G8898), bromphenol blue (B0126), Coomassie brilliant blue R (27816), sodium dodecyl sulfate (L4390), marker for sodium dodecyl sulfate–polyacrylamide gel electrophoresis (SDS-PAGE; S8445), and fatty acids methyl esters standard (47885-U). Mini-PROTEAN TGX precast gels (12%) were purchased from Bio-Rad (New York, USA). All the chemicals were of analytical grade.

Preparation of apricot kernel milk

For preparing apricot kernel milk, 250 g of apricot kernel was soaked overnight in 1-L ultrapure water at room temperature. The mixture was subjected to agitation with a blender, and filtered using a cheesecloth. The supernatants were stored at -20°C until analyzed. The amount of kernel in the final product was 20 g/100 mL.

Roasting

Apricot kernels were roasted in an oven for 10 min at 170°C, and the roasting process was selected as it was generally applied to nuts.

Chemical composition

The protein contents of apricot kernel and both kinds of milk were determined by Dumas method using LECO-FP 528 analyzer. The protein contents of digested samples were determined using the Bradford (1976) method, and bovine serum albumin (BSA) was used as a standard. The total lipid contents of apricot kernel and apricot kernel milk were detected using the methods proposed by Folch *et al.* (1957) and Bligh and Dyer (1959), respectively.

In vitro gastrointestinal digestion

The samples were subjected to *in vitro* gastrointestinal digestion (Minekus *et al.*, 2014). Accordingly, simulated salivary fluid (SSF), simulated gastric fluid (SGF), and simulated intestinal fluid (SIF) were prepared daily from stock solutions. In this method, the activities of enzymes were determined as per the protocol described by Brodkorb *et al.* (2019). Pepsin and pancreatin were used in gastric digestion and intestinal digestion, respectively. Pefabloc was used to stop enzymatic activity.

Protein profile

The protein profiles of milk from roasted and unroasted apricot kernels and aliquots obtained from *in vitro* gastric and gastrointestinal digestions were determined using SDS-PAGE. Then the samples were diluted to a protein concentration of 1 mg/mL and mixed with sample buffer solution in a 1:1 ratio. The samples were maintained at 95°C for 10 min and then loaded on gels (12% Mini-PROTEAN® TGX™ precast gels) as 40 μL for gastric samples and 20 μL for intestinal samples. Moreover, electrophoretic separations were conducted at 150 V using a running buffer, and gels were stained with Coomassie brilliant blue R-250 solution (50% ethanol and 10% glacial acetic acid).

Analysis of fatty acid

The major fatty acids of apricot kernel were quantified using 7820A GC gas chromatography system (Agilent Technologies, Santa Clara, CA, USA) with a flame ionization detector (FID) and conventional injector. A fused silica capillary column was used (J&W DB-23, 30-m × 0.25-mm inner diameter, 0.25-μm film thickness; Agilent Technologies).

Methyl esters were prepared using the official method Ce 2-66 of American Oil Chemists' Society (AOCS). The procedure described by Wu *et al.* (2011) was applied with slight modifications, and the injection volume was 1 μL. The temperature in both injector and detector was 250°C. The temperature program was started at 45°C, held for 4 min, increased to 175°C at a rate of 15°C/min, held for 15 min, then increased to 215°C at a rate of 4ºC/5 min and held for 10 min. Supelco 37 component fatty acid methyl esters (FAME) mixture was used for identifying fatty acids.

Total titratable acid release

The rate of free fatty acid release was monitored using a pH-stat titration unit (Automatic Potentiometric Titrator AT-510; KEM, Kyoto, Japan). NaOH solution, 0.1 M, was used to maintain pH at 7.0 for 2 h at 37°C. Samples obtained from gastric digestion were subjected to pH-stat titration to determine release of free fatty acid. An excessive amount of pancreatic lipase was added to sample at the end of gastric phase to obtain the lipase activity of 2,000 U/mL as recommended by Mat *et al.* (2016).

Measurement of zeta potential

The zeta potentials of apricot kernel milk, roasted apricot kernel milk, and digested samples were measured using Malvern Zeta Sizer Nano ZS. The apricot kernel milk was diluted 100-fold with purified water, gastric digested samples were diluted with citrate buffer (pH = 2.5), and intestinal digested samples were diluted to 100-fold with phosphate buffer (pH = 7.2) according to the procedure proposed by Gallier and Singh (2012).

Optical microscopy

The images of the microstructures of oil bodies of milk and digested samples were taken with motorized light microscope PSARON Floptik (HPTS 150, AIV Labs, Ankara, Turkey) equipped with a controlled vehicular access (CVA) camera using a digital image. A drop of the

sample was placed on a microscope slide, covered with a cover glass, and detected with a 10× objective lens.

Statistical analysis

Parallel proximate analysis was conducted in triplicate. Data were analyzed using ANOVA (SPSS for Windows version 18.0) and comparisons between mean values were performed using a *t*-test. Differences between mean values were considered significant at $p < 0.05$.

Results and Discussion

Chemical composition of apricot kernel and apricot kernel milk

Table 1 lists protein, total lipid, and ash contents of apricot kernel and apricot kernel milk. Protein, total lipid, and ash contents of apricot kernel were higher than that of apricot kernel milk ($p < 0.05$). Different results were reported for protein (15.1%–24.2%) and total lipid contents (27.7–66.7%) (Alpaslan and Hayta, 2006; Gezer *et al.*, 2011). Differences in the chemical compositions of apricot kernels were due to their physical characteristics such as kernel weight and length (Femenia *et al.*, 1995).

Proteins hydrolyze during *in vitro* gastrointestinal digestion

There were 10 protein bands in the SDS-PAGE profile of samples; their molecular weight (MW) was between 97 kDa and 6.5 kDa (Figure 1A). In the unroasted form, three protein bands whose molecular weight was 97, 66, and 66–55 kDa might correspond to storage proteins, specifically nutrient reservoir protein (96 kDa), Prunin 1 (63 kDa), and Prunin 2 (53 kDa) as reported by Ghorab *et al.* (2018). Moreover, the authors indicated that the protein bands with molecular weight of 45, 36, and 29 kDa could be hexosyltransferase (43 kDa), hydroxyisourate hydrolyze activity (37 kDa), and ribosomal protein S18 (31 kDa), respectively. In the roasted form, the disappearance of two protein bands with molecular weight of 97 and

14.2 kDa might be attributed to the breakdown of these proteins during roasting. The SDS-PAGE patterns of *in vitro* gastric digestion of apricot kernel milk (Figure 1B) demonstrated that there were no differences in the protein bands of the samples obtained from gastric chyme at different time intervals. This result indicated that pepsin was not able to hydrolyze proteins with molecular weight of 97 and 66 kDa. Protein band with MW = 20 kDa in the SDS-PAGE profile of gastric digested apricot kernel milk but not in the undigested apricot kernel milk might be a sign of the breakdown of proteins with MW > 20 kDa. A similar SDS-PAGE profile was obtained for *in vitro* gastric digestion of roasted samples (Figure 1C).

Intestinal enzyme pancreatin contains proteases with a molecular weight of 23.8–64 kDa, amylase with a molecular weight of 51–55.4 kDa, lipase with a molecular weight of 45–50 kDa, chymotrypsin with a molecular weight of 25 kDa, trypsin with a molecular weight of 24 kDa, and ribonuclease with a molecular weight of 13.7–14.7 kDa. Protein bands with molecular weight of 45, 24, and ~13 kDa were present in the enzymes of intestinal digestive system (Figures 1D and E). Four protein bands (with MW = 45, 29, 20, and 6.5 kDa) were observed in apricot kernel milk whereas seven protein bands (with MW = 45, 36-37, 29, 24, ~22, 6.5, and <6.5 kDa) were observed in roasted apricot kernel milk during intestinal digestion (Figure 1E). The fact that protein bands with MW > 45 kDa present in the SDS-PAGE profile of the gastric digestion system did not appear in the first 15 min of intestinal digestion indicated that these proteins were hydrolyzed in the first 15 min of intestinal digestion. As reported by Beisson *et al.* (2001), for almond oleosins, the 6.5-kDa protein fraction that was not hydrolyzed during intestinal digestion as a function of time might be the central hydrophobic domain of apricot kernel oleosins. Proteins with MW > 45 kDa were completely hydrolyzed at the end of intestinal digestion.

The disappearance of bands with MW > 45 kDa present in the SDS-PAGE profile of gastric digestion established the hydrolysis of proteins with a higher molecular weight during intestinal digestion. The observation of fractions with molecular weight of 45–6.5 kDa could be attributed to the hydrolysis of proteins with a higher molecular weight.

Table 1. The proximate composition of apricot kernel and apricot kernel milk.

	Apricot kernel	Roasted apricot kernel	Apricot kernel milk	Roasted apricot kernel milk
Protein (%)	21.65 ± 0.08[a]	22.98 ± 0.98[a]	3.78 ± 0.72[b]	3.97 ± 0.81[b]
Total lipid (%)	26.22 ± 1.40[c]	25.87 ± 5.67[c]	7.74 ± 3.79[d]	6.53 ± 2.45[d]
Ash (%)	2.55 ± 0.20[e]	2.36 ± 0.51[e]	0.15 ± 0.07[f]	0.11 ± 0.1[f]

Values are mean ± standard deviation.
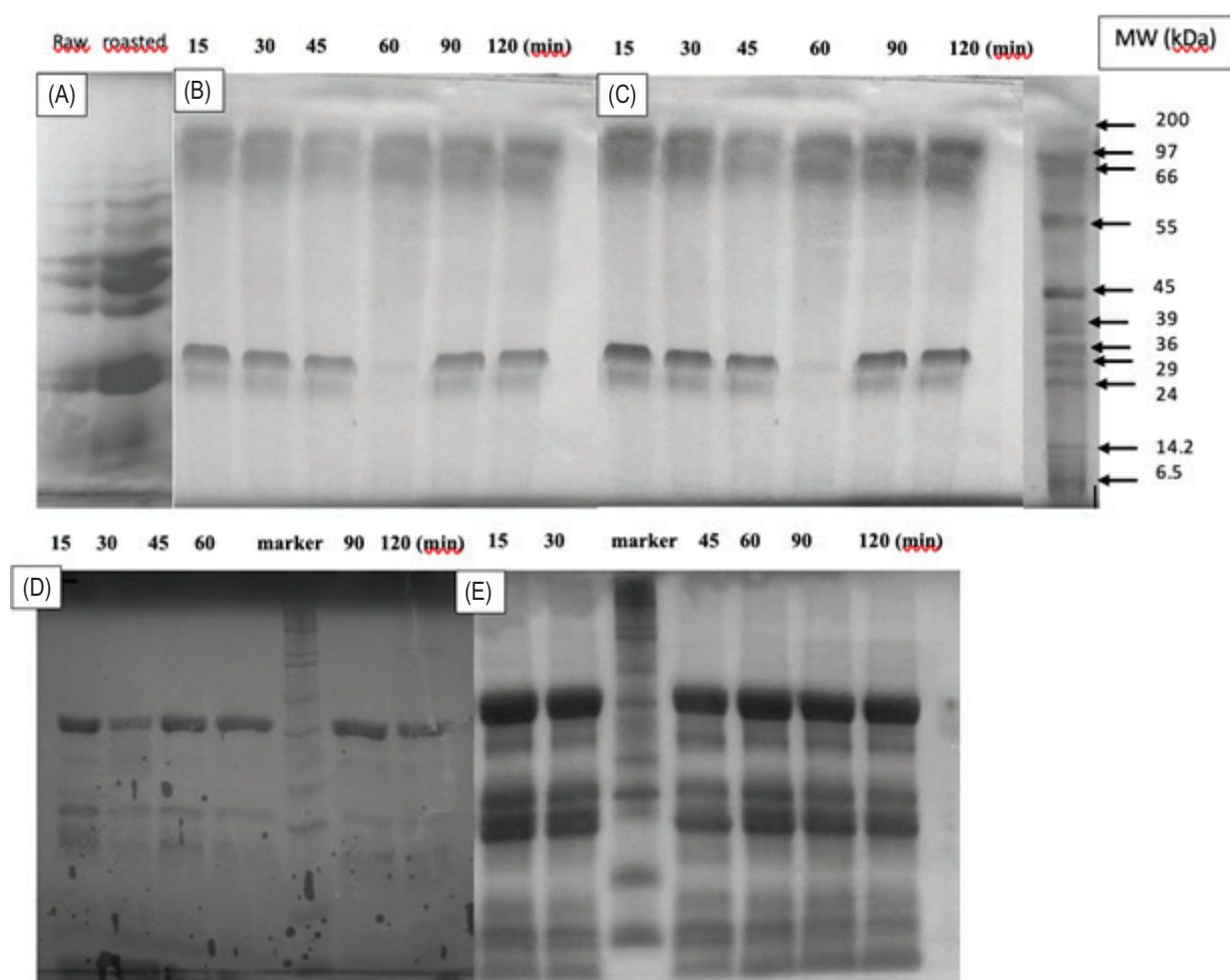Different letters in the same row indicate statistical significance at $p < 0.05$.

Figure 1. **SDS-Page patterns. (A) Apricot kernel milk; (B)** *in vitro* **gastric digests of apricot kernel milk; (C)** *in vitro* **gastric digests of roasted apricot kernel milk; (D)** *in vitro* **intestinal digests of apricot kernel milk; and (E)** *in vitro* **intestinal digests of roasted apricot kernel milk.**

In a study conducted by Gallier and Singh (2012), three primary almond protein bands (20-42 kDa) determined in tricine SDS-PAGE were hydrolyzed in the first 15 min of gastric digestion. The acidic polypeptides were hydrolyzed into smaller peptides in the first 2 min of intestinal digestion and the hydrolysis of all peptides was completed after 5 min of intestinal digestion. Different results obtained in these two studies could be related to pH = 1.5 of gastric chyme used in the study conducted by Gallier and Singh (2012) and difference between the sources of proteins (almond kernel versus apricot kernel) used in both studies.

Composition of fatty acid

The oil and milk extracted from apricot kernels were primarily composed of fatty acids such as palmitic acid, oleic acid, and linoleic acid (Figure 2). Fatty acid profiles of both kernels were identical (Figures 2A and B). Similarly,

high amounts of oleic acid and linoleic acid and a low amount of palmitic acid were determined in the apricot kernel oil (Fratianni *et al.*, 2018; Mattheus *et al.*, 2016).

Total titratable acid release

No lag phase was observed during release of total titratable acid from *in vitro* gastric digested apricot kernel milk oil bodies (Figure 3). This indicated that pancreatic lipase easily penetrated the oil-water interface. An early and rapid release of fatty acids from oil bodies was identified in the first 10 min of lipolysis. After 10 min, there was a reduction in the lipolysis rate, although acid release continued slowly to reach a value of 76.5 μM for apricot kernel milk and 85.5 μM for roasted apricot kernel milk at the end of 2-h digestion. During the first 30 min, the rate of free fatty acid release increased rapidly as the oil–water interface was easily accessible by pancreatic lipase. The rate of release of free fatty acid slowed down
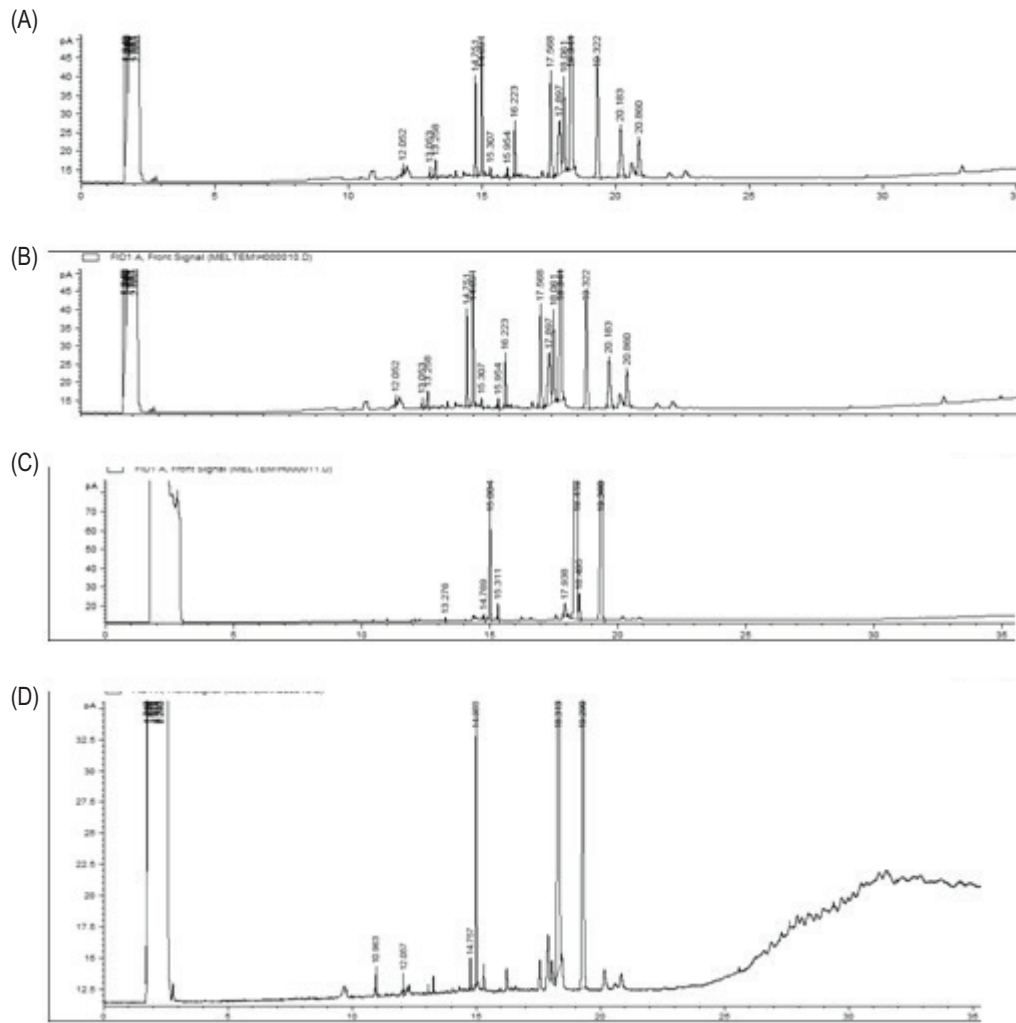
(A)

(B)

(C)

(D)

Figure 2. Gas chromatograms of apricot kernels. (A) Raw apricot kernel; (B) roasted apricot kernel; (C) apricot kernel milk; (D) roasted apricot kernel milk.
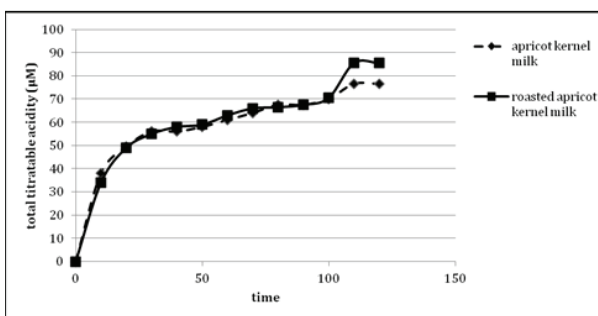

Figure 3. Total titratable acid release from gastric digested apricot kernel milk oil bodies during 120 min of intestinal digestion.

because the interfacial saturation of lipolytic products slowly solubilized into micelles. Unlike our result, Gallier and Singh (2012) observed a lag phase of 2 min, indicating the prevention of lipolysis by the membranes of oil bodies of almond, and the release of 133-μmol/mL free

fatty acids of almond oil bodies after *in vitro* intestinal digestion. Moreover, rapid increase in the release rate of fatty acid in the first 25 min of intestinal digestion was also identified.

Measurement of zeta potential

It is important to measure the zeta potential and surface charge of emulsified particles on the stability of emulsions. The power of electrostatic impulsion has a significant contribution to prevent flocculation and coalescence (Çelebi, 2009). Change in the net surface charge on the surface of native apricot kernel bodies was ~0 mV. The zeta potential of oil bodies is governed by the active component oleosins present on the surface.

The zeta potentials of apricot kernel milk and roasted apricot kernel milk were monitored during 2 h of gastric digestion and 2 h of intestinal digestion (Figure 4). The
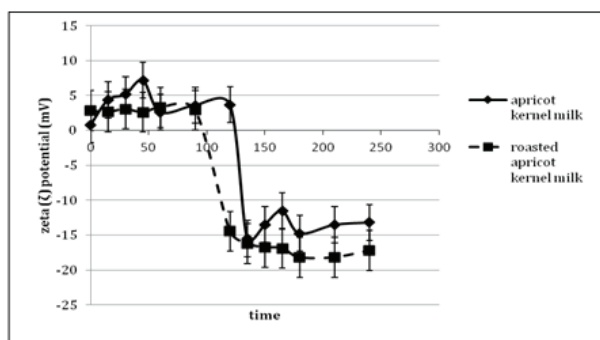
Figure 4.   The zeta-potentials of *in vitro* **gastric and intestinal digested samples.**

zeta potential of apricot kernel milk was ~0 mV at the beginning of *in vitro* gastric digestion; moreover, it was increased to +7.17 mV in the 45th min of gastric digestion. At the end of gastric digestion, the zeta potential of apricot kernel milk was +3.68 mV. The positive value of zeta potential indicated that electrostatic repulsion in protein-stabilized oil droplets decreased and caused flocculation because of the low pH value of gastric environment. During *in vitro* gastric digestion, the zeta potential of roasted apricot kernel milk was different from that of apricot kernel milk. The zeta potential of roasted sample did not change during 0–90 min of *in vitro* gastric digestion and was approximately +3.0 mV (Figure 6). Moreover, zeta potential was −14.47 mV in 120 min of *in vitro* gastric digestion. Low zeta potential (0–±5) indicated that the solution or dispersion might have rapidly coagulated or flocculated. Therefore, the flocculation continued during 90 min of gastric digestion of roasted apricot kernel milk, but solubilization occurred after this point. However, the low positively charged zeta potential of apricot kernel milk did not change during 120 min of gastric digestion. Similarly, Makkhun *et al.* (2015) reported that the emulsion droplets located on the oil bodies of sunflower remained positively charged for 2 h of *in vitro* gastric digestion. The zeta potential of apricot kernel milk became negative at the very beginning (0–15 min) of intestinal digestion. Moreover, the zeta potential of apricot kernel milk was -14.45 mV during the 15 min of intestinal digestion and increased slowly and reached −13.2 mV at the end of intestinal digestion. During intestinal digestion, the zeta potential of roasted apricot kernel milk remained practically the same ranging from −16.23 to −18.2 mV. Although there was an insignificant difference between the zeta potentials of apricot kernel milk and roasted apricot kernel milk, a slightly higher zeta potential of roasted samples could be related to the more extensive association of bile salts with the surface of oil bodies in roasted apricot kernel milk than that in apricot kernel milk, as reported by Makkhun *et al.* (2015) for emulsion droplets located on the oil bodies of sunflower.

Although no research has been conducted on the zeta potential of apricot kernel milk, few studies are determined on the oil bodies of almond, pumpkin seed, soybean, and coconut milk. Gallier and Singh (2012) reported that the charge of native almond oil body was highly negative (-30 mV). At the start of *in vitro* gastric digestion, the zeta potential of almond oil body was highly positive and continued to remain positive during 60 min of gastric digestion. Along with the *in vitro* intestinal digestion of almond milk, the zeta potentials of samples were negatively charged. Dave *et al.* (2019) reported that the zeta potential of oil bodies of coconut milk measured at pH 6.1 was −13 ± 1 mV. At pH 7.5, the zeta potential of oil bodies in washed cream and that of purified oil bodies were −32.6 and -33.8 mV, respectively. The zeta potentials of oil bodies of pumpkin seeds were different at different pH values and salt concentrations. An increase in the concentration of salt up to 10 mM at pH 3 increased the positive charge of zeta potential, which decreased with change in the concentration of salt. However, at pH 7.4, increase in salt concentration from 10 to 100 mM induced negative potentials. Ishii *et al.* (2017) studied the interfacial and emulsifying properties of two types of oil bodies extracted from soybean seeds at different pH values. The zeta potentials of purified oil bodies (OB) and crude oil bodies (OBC), including storage and other minor proteins, were −14.2 and −39.0 mV, respectively. This indicated that there was a strong electrostatic repulsion between crude oil bodies than between purified oil bodies.

Optical microscopy

Spherical and variable size of oil bodies were observed for apricot kernel milk and roasted apricot kernel milk (Figures 5A and B). The size of oil bodies of apricot kernel milk was greater than that of roasted apricot kernel milk. Unlike oil bodies of apricot kernel milk, roasting caused aggregation of oil bodies (Figure 5B, 0 min). Zaaboul *et al.* (2019) reported that roasted peanut oil bodies were larger compared to raw peanut oil bodies. The flocculation started within the 15 min of gastric digestion of both samples (Figures 5A and B). Large aggregates were still present after 90 min of gastric digestion of apricot kernel milk, but disruption in aggregates commenced in roasted apricot kernel milk at 90 min of gastric digestion. This result is supported by the increased zeta potential of roasted apricot kernel milk after 90 min of gastric digestion. The flocculation probably occurred due to the destabilization of oil bodies during hydrolysis of interfacial proteins by pepsin. A similar result indicated that the oil bodies of almond flocculated under low pH conditions (pH 1.5) during gastric digestion (Gallier and Singh, 2012). Moreover, a liquid crystalline phase observed
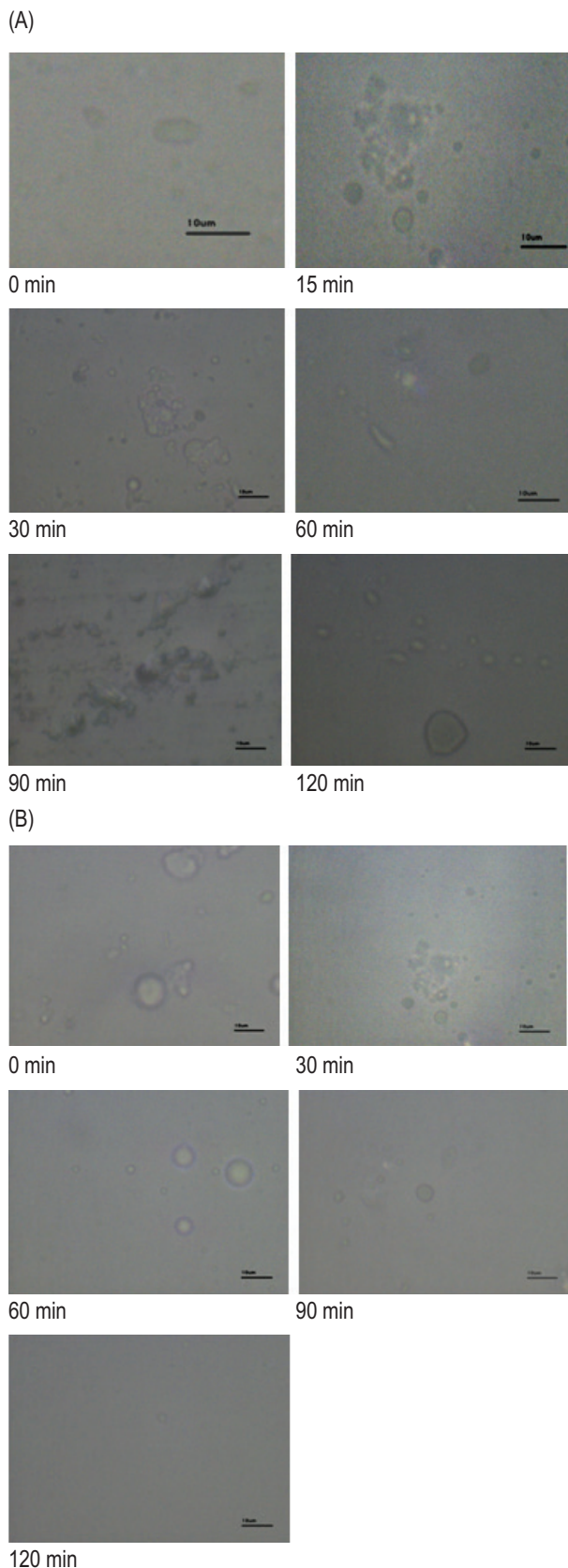
(A)

0 min   15 min

30 min   60 min

90 min   120 min

(B)

0 min   30 min

60 min   90 min

120 min

Figure 5. **(A) Optical microscopic images of apricot kernel milk and (B) roasted apricot kernel milk digests obtained at different time intervals of** *in vitro* **gastric digestion.**

surrounding lipid droplets at 90 min of *in vitro* gastric digestion (Figure 5B) could be attributed to the presence of insoluble calcium long-chain fatty acid soaps precipitated around oil bodies as reported by Gallier and Singh (2012) in the case of almond oil bodies at 30 min of intestinal digestion.

In the 30th min of intestinal digestion, although large aggregates were still present, marginally disaggregated oil bodies were observed. This disaggregation was probably due to adding bile salts, and pancreatic lipase that they caused to the solubilization of lipolytic products into the mixed micelles formed of bile salts. This solubilization-induced disaggregation of oil bodies after 60 min of intestinal digestion is shown in Figure 6. Gallier and Singh (2012) reported similar behavior of almond oil bodies, revealing the disruption of aggregates after 30 min of intestinal digestion.

Few oil bodies of different sizes were still present at the end of intestinal digestion of apricot kernel milk. However, disaggregation did not occur during 120 min of intestinal digestion of roasted apricot kernel milk (Figure 6B).
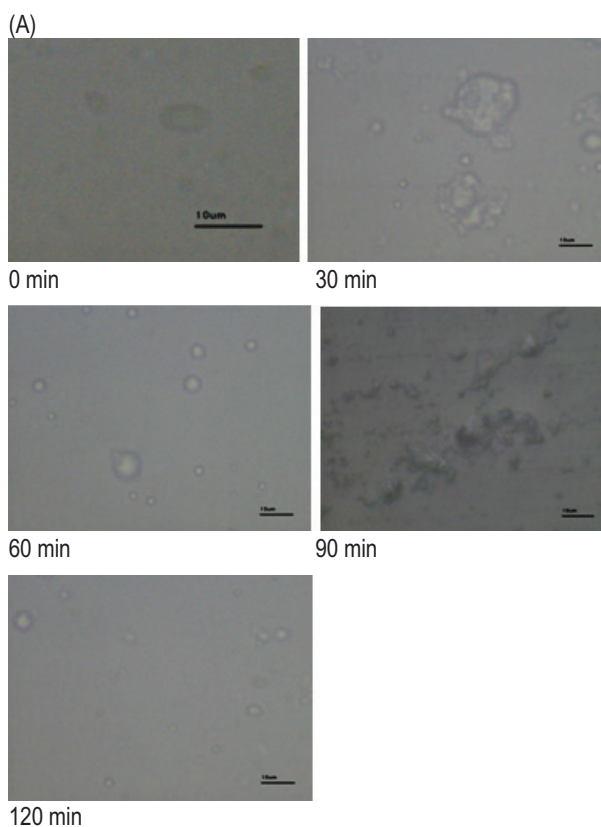
(A)

0 min   30 min

60 min   90 min

120 min

Figure 6. **(A) Optical microscopic images of apricot kernel milk and (B) roasted apricot kernel milk digests obtained at different time intervals of** *in vitro* **intestinal digestion.**
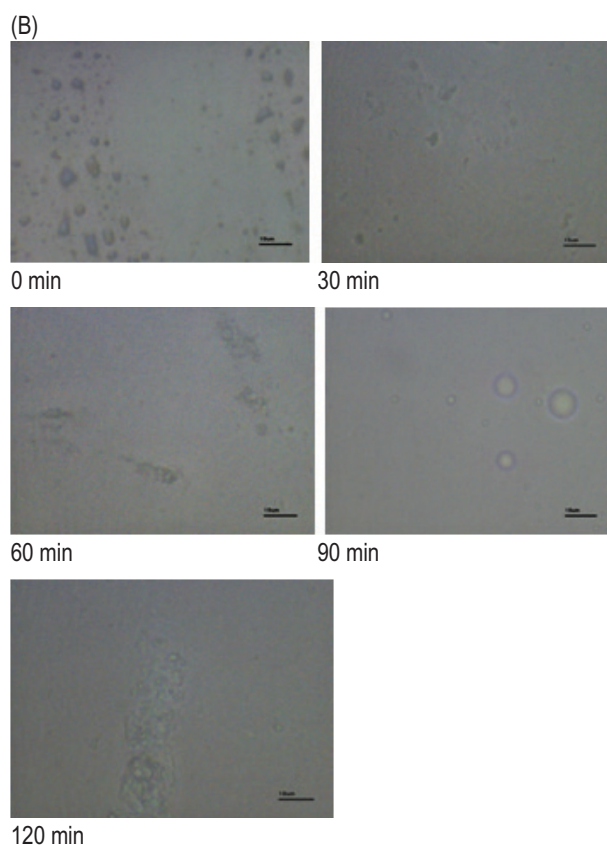
(B)

0 min   30 min

60 min   90 min

120 min

Figure 6.   (Continued).

Conclusion

Roasting seems to cause aggregation of oil bodies compared to unroasted apricot kernel milk oil bodies. The proteins of apricot kernel milk and roasted apricot kernel milk were hydrolyzed to a greater or lesser extent during *in vitro* gastrointestinal digestion. However, pepsin-resistant proteins were determined in both samples and the flocculation of oil bodies was observed. No difference was recorded between the pancreatic lipase penetration in the oil-water interface of oil bodies of both milk types. Moreover, a few oil bodies of different sizes were still present at the end of intestinal digestion of apricot kernel milk. However, disaggregation did not occur during 120 min of intestinal digestion of roasted apricot kernel milk. In addition, 250 mL of apricot kernel milk contains 50-g kernel corresponding to 12.5-mg amygdalin, which is considerably lower than the amount (200 mg) that causes poisoning in a child weighing 20 kg, as reported by Karsavuran *et al.* (2015).

In conclusion, the results of the study demonstrated that apricot kernel milk and roasted apricot kernel milk are a good source of alternative vegetable protein. It could be utilized as a value-added product such as a functional food ingredient and/or a novel functional product. The future research must be conducted on the sensory properties of apricot kernel milk.

Disclosure Statement

The authors declare no conflicts of interest.

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