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Amino acid profile, physico-chemical properties and fatty acids composition of some fruit seed kernels after detoxification

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Abstract

Background The use of food processing wastes and by-products, as well as the under-utilization of agricultural products, have recently received increased attention. Mango, apricot and peach are the three most significant fruits grown and processed in Egypt.

Results This work aimed to evaluate the amino acid composition, physio-chemical properties and fatty acids content of mango, apricot, and peach seed kernels after removal antinutritional components. According to the results, mango kernel flour contained all the essential amino acids with levels higher than those of the FAO/WHO reference protein. In addition, total essential amino acids were 28.88, 26.78 and 36.46 g/100 g protein for apricot, peach and mango kernel flours, respectively. The highest essential amino acids value was leucine, while the highest non-essential amino acids value was glutamic in all kernel protein. All kernel oils showed adequate values for acid and peroxide value. The main unsaturated fatty acids in all kernel oils were oleic and linoleic acids. Oleic acid contents ranged between 41.76% and 59.87%. On the other hand, linoleic acid contents varied between 5.25% and 26.61%.

Conclusions Mango, apricot, and peach kernels are by-products that present a novel potential source of excellent protein and oil that might be used for food and other industrial applications after reduction of antinutritional matter. As a result, detoxified kernel flour might be used to enhance high-value food products with economical, high-quality sources of protein and oil.

Keywords Fruits, Seeds, Kernels, Amino Acids, Fatty Acids, Biological Value, Acid Value, Peroxide Value

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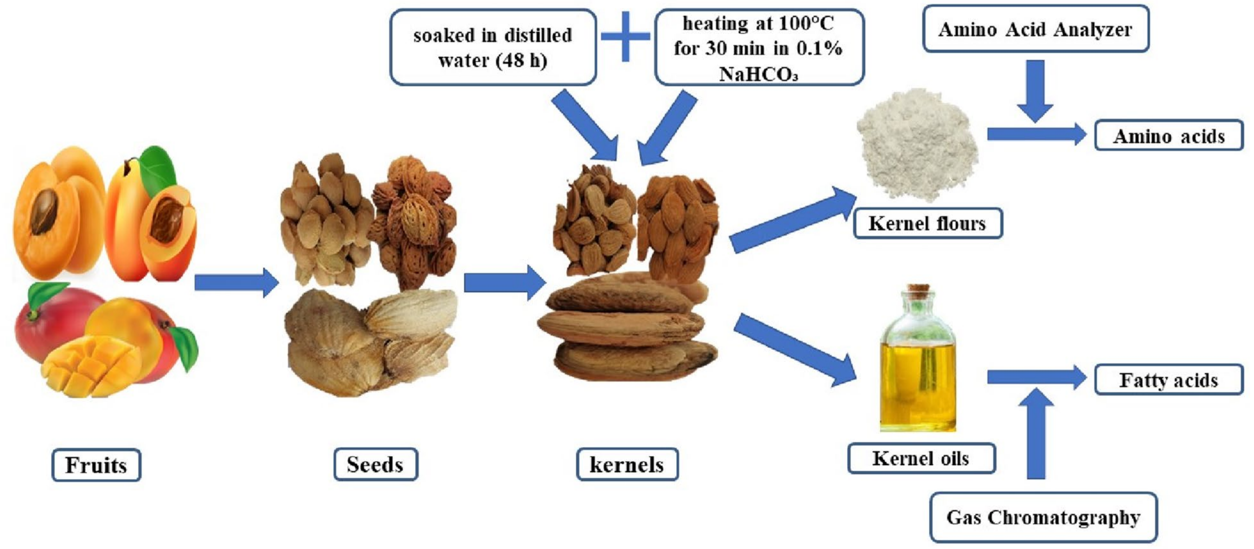
Graphical Abstract



Background

Nowadays, most food byproducts are disposed of in landfills or burned. Both strategies result in the discharge of additional pollutants and the release of greenhouse gases (furans, dioxins, particles, etc.). However, a lot of these byproducts might be put to good use. For instance, food waste with a high protein content is used to make biomass and animal feed [1, 2]. However, using some byproducts to create inexpensive products could mean they contain valuable materials; therefore, doing so does not necessarily mean that these resources are being used effectively. Fruit stones are one example of a byproduct that includes a lot of protein [3]. In the early phases of plant growth, proteins, lipids, and carbohydrates make up the plant food reserves. They are stored in these tissues. Most research on the utilization of fruit seed proteins concentrated on seeds from tropical and subtropical fruits grown in underdeveloped nations, like jack fruit or akee apple [4]. Some fruit seed proteins are valued for their physicochemical features, potential in alternative medicine, and nutritional benefits [5, 6]. Other researchers have assessed the fruit seed's capacity to produce bioactive peptides [7].

Prunus armeniaca L., also known as the apricot, is a significant temperate fruit that benefits humanity in all its parts. Different regions of the world commercially farm apricots. Due to their perishable nature, apricot fruits are utilized fresh and produce various value-added goods. The residual stone and kernel are thrown away after processing, which pollutes the environment [8].

Apricot kernel eating has been linked to a lower risk of chronic diseases because apricot seeds contain a wide range of bioactive components [9]. Apricot kernel flour contains 5.52% moisture, 2.76% ash, 45.37% fat, 26.39% protein, and 19.96% carbohydrates [10]. The proteins of apricot are rich in aspartic, arginine, glutamic acids and essential amino acids [8, 11], with good thermal, physico-chemical and emulsifying attributes. They are advantageous to human health and help in lowering the risk of diabetes, hypertension, and high cholesterol [12–14]. The digestibility of the protein was quite low when trypsin or pepsin used while, in the pepsin-pancreatin system was high. The ability of flour and protein isolates to absorb water and fat and to emulsify them was quite similar to that of soybean. It appears that detoxified apricot kernel flour is a useful source of protein for food products [15].

Nevertheless, the apricot kernel that is extracted from these stones is a good source of oil (45–50%) that contains a high amount of unsaturated and polyunsaturated fatty acids, such as linolenic and linoleic acids, in addition to oleic acid, which is monounsaturated and is described to be beneficial for all skin kinds including irritated or dry skins and aged skin as well as with pharmaceutical importance and good nutritional [9]. Apricot kernel oil is edible and can be used for salad and frying oil compared to the oil yield of some commercial seed oils such as soybean (15–20%), cottonseed (30–36%) and sunflower (36–55%) [16].

After apple and pear, the peach (*Prunus persica* L) is the world's third most significant deciduous tree fruit. Processing of a substantial portion of the harvested peaches results in a large amount of waste stones. Nearly 50% by weight of peach kernels are oils [17]. Pelentir et al. [18] reported that the chemical composition of peach kernel flour under drying at 65°C was moisture 7.75%, ash 5.50%, ether extracts 24.30%, protein 21.33%, and 8.92% fiber. According to Pelentir et al. [18], peach kernels have a large amount of protein. Albumins made up the majority of the protein fractions (60%) followed by non-protein nitrogen (17%), globulins and glutelins made up 9.5% and 8.2% of the total protein fractions, respectively, while prolamines made up just 6.0%. The protein is rich in leucine, lysine, valine, isoleucine, threonine, basic and acidic amino acids but poor in methionine. Due to its unsaturated fatty acid and antioxidant contents, peach kernel oil has the potential to produce high-quality products from the biowaste in the peach industry [19]. One of the nine plant elements in the cardiovascular protection mix (CVPM) cocktail used to treat cardiovascular disease is the peach kernel [20]. Such importance is probably associated with its unsaturated fatty acid composition, oleic and linoleic acids, around 55% and 25% in unsaturated fatty acid, respectively [21]. Oleic acid is essential in the human diet and helps reduce total cholesterol, triglycerides, (LDL)-cholesterol, and glycemic index. In addition, since it lowers total and LDL cholesterol levels, linoleic acid is crucial for the growth and maintenance of the neurological system and physiological processes in humans [22].

Due to its excellent nutritional value and sensory quality, the mango (*Mangifera indica* L.), which had a global production of 50.65 million tons in 2017, is one of the most significant tropical fruits in the world [23]. The main byproduct of mango processing is mango seed, which, depending on the varieties, makes from 30 to 45% of total fruit weight [24]. Mango seed kernel contains 11% fat, 6.0% protein, 77% carbohydrate, 2.0%, and ash 2.0% fiber on a dry weight basis. The protein value of mango seed kernel is good. The amino acids profile of different mango kernel varieties protein contains the most essential amino acids, with the highest leucine, lysine, and valine [25]. The composition of the essential amino acids leucine (6.9), isoleucine (4.4), phenylalanine (3.4), methionine (1.2), threonine (3.4), lysine (4.3), tyrosine (2.7), and valine (5.8) (g amino acid /100 g protein) indicates that the protein is of good quality [25]. About 38% stearic acid and 45% oleic acid make up most of the fatty acids in mango kernel oil [26]. Stearic acid is a saturated fatty acid reported to plasticize and bind composites, α-helical sites in bio-molecules, and albumin serum in humans [27].

Because of their toxic, cyanogenic glycoside amygdalin content, the use of some fruit seeds for human nutrition is limited. It is important to remember that while amygdalin itself is nontoxic, depending on the amount, its breakdown products, such as hydrogen cyanide (HCN), may be poisonous. When consumed orally, 0.1–0.2 g of amygdalin is considered an acute toxic or deadly dose for humans and animals. Due to the potential toxicity of cyanide, the kernels must undergo detoxification before consumption. Several techniques/methods have recently been reported for debittering the seeds, including fermentation, soaking, ultrasound, vacuum, and microwave methods [28, 29]. The main objective of this work is to evaluate the composition and nutritional value of amino acids, the fatty acids composition and the physicochemical properties of Egyptian apricot, peach and mango kernels after the reduction of antinutritional matter.

Materials and Methods

Materials

Materials and chemicals

During the summer season of 2019, about 150 kg of each fruit: peach (*Prunus persica* L.), namely Shamy, apricot (*Prunus armeniaca* L.), namely Amar and mango (*Mangifera indica* L.), namely Zebda were collected from the local fruit market in Assiut city, Egypt. All chemicals used in analytical methods were produced by Sigma Chemical Co. (St. Louis, MO, U.S.A) and purchased from Al-Gomhouria Trading Chemicals and Drugs Company. Assiut, Egypt.

Methods

Preparation of fruit seed kernels

Seeds were removed from the fruits, and the seed's outer shell was washed with tap water to remove the remaining fruit pulp and sun-dried for about 3 weeks; the outer shell of the seeds was cracked manually and then collected the kernels (Fig. 1).

Detoxification of apricot, peach and mango seed kernels

The kernels were collected and soaked in distilled water for 48 hour with occasional decantation and replacement with an equivalent amount of water until the water remained colourless, then heated at 100 °C for 30 min in 0.1% $NaHCO_3$ [30], then dried at (50 °C) in an electric oven for (24 h) and ground into a fine flour. Then kept in air-tight polythene bags and stored at (4 °C) until utilization and analysis according to the method described by Lakshmi et al. [31] with some modifications (Fig. 2).

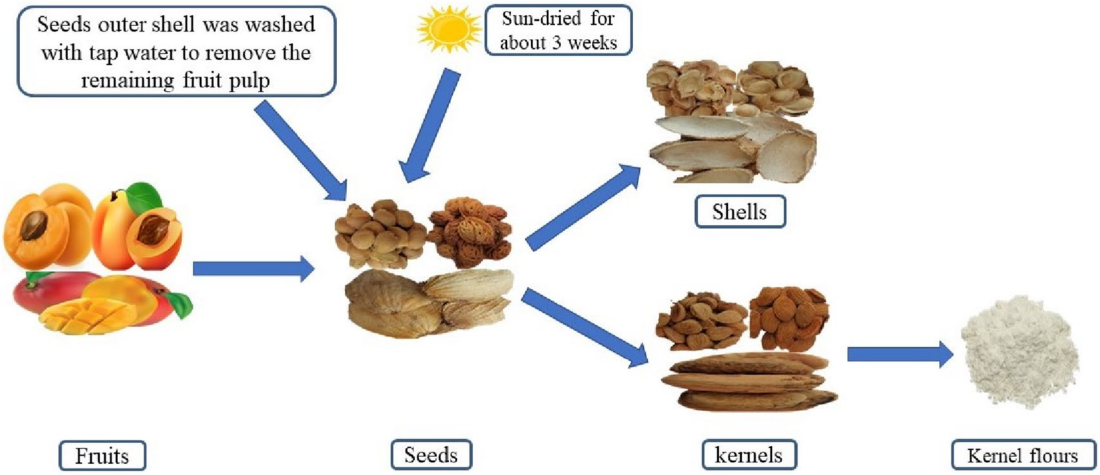


Fig.1 Preparation of fruit seed kernel flours

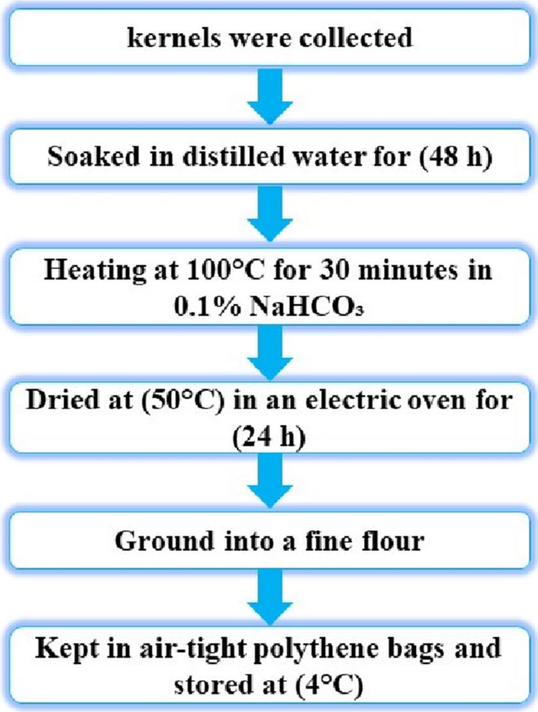


Fig.2 Detoxification of fruit seed kernels

Extraction of oil

Hexane was used for extraction of oil from the kernels by immersing in an extractor in order to get rid of the existed oil. The solvent was removed by a rotary evaporator Shabeer et al. [32].

Determination of amino acids composition

Amino acids were determined according to the method reported by Pellett & Young, [33] with some modifications, which could be summarized as follows: 0.2 g of sample was hydrolyzed with 5 ml of 6 N HCL, in a long neck tube sealed at (110 °C, 24 h), then the hydrolysate was filtered. The residues were washed with distilled water, and the filtrate was evaporated in water both at 50 °C. The residue was dissolved in 5 ml/loading buffer (sodium citrate buffer of pH 2.2). The analysis was performed in the Central Service unit, National Research Center, Egypt using Beckmen Amino Acid Analyzer model 119 CL.

Determination of tryptophan Tryptophan was determined using the spectrophotometric method described by Sastry and Tummuru, [34]. 100 mg of sample were mixed with 10 ml of 5 M NaOH and hydrolyzed at 110 °C for 18 h in a scaled tube. The hydrolysate was neutralized with 5 M HCL and diluted to 100 ml with distilled water. Aqueous solution of sucrose 10% and thioglycolic acid 2.5% each at 0.1 ml level were successively added to test tube containing 4 ml of 66% H_2SO_4 and kept for 5 min in water at 45–50 °C and cooled. About 0.5 ml sample solution was then add and mixed. The volume was made to 5 ml by adding 0.1 N HCL and was allowed to stand for 5 min at room temperature for the development of full color. The absorbance was measured at 550 nm using a spectrophotometer (6505 UV/Vis, Jenway LTD., Felsted, Dunmow, UK). A calibration curve of tryptophan (10 µg/ml) was prepared and tested under similar conditions. All values were expressed as mean ± SD for 3 replications.

Computation of chemical score The chemical score (Cs) was defined according to Bhanu et al. [35] as follows:

$$Cs = \frac{\text{mg of essential amino acid in 1 gm test protein}}{\text{mg of essential amino acid in 1 gm reference protein}} \times 100$$

Protein efficiency ratio (PER) The PER was the first method adopted for routine assessment of the protein quality of food. PER measures body weight gain per unit of protein consumed. The PER based on the amino acids content of sample was calculated using the equation reported by Alsmeyer et al. [36] as follows:

$$\text{PER} = -0.468 + 0.454\ (\text{Leucine}) - 0.105$$

Biological Value (BV) BV measures protein quality by calculating the nitrogen used for tissue formation divided by the nitrogen absorbed from food. Computed BV was calculated using the equation suggested by Mitchell & Block, [37] as follow:

$$\text{B.V} = 49.9 + 10.53\ (\text{PER})$$

Computation of A/E ratio The relationship between content of an individual essential amino acid in the food protein (A) and the total essential amino acids content (E) was calculated according to FAO, [38] as follows:

$$\text{A/E ratio} = \frac{\text{mg of the individual essential amino acid}}{\text{gm of total essential amino acids}}$$

Determination of physico-chemical properties of oil

Specific gravity, iodine value, acid value, peroxide value, and saponification value of the oil were determined according to the method described in AOAC Standard [39].

Determination of fatty acids

About 100 mg of oil was dissolved in 2 ml hexane, and then 0.4 ml potassium hydroxide (KOH) in anhydrous methanol was added, as reported by Mapiye et al. [40]. Fatty acid methyl esters, as converted from the corresponding fatty acids in the seed kernel oil according to the [41] IUPAC method, were analyzed by Philips Pye-Unicam PU 4500 (Philips Electronics UK Ltd, Guildford, Surrey, UK) gas chromatography equipped with a flame ionization detector. The amount of each fatty acid was given as a percentage of the total fatty acid content. The analysis was performed in the Central Service unit, National Research Center, Giza city, Egypt.

Statistical analysis

One-way analysis of variance (ANOVA) was performed for data analysis using IBM SPSS Statistics software version 25. Duncan test was used to compare significant differences ($P \leq 0.05$) among the means. Data are expressed as the mean ± standard deviation (SD) of at 3 replications.

Results and discussion

Amino acids composition of apricot, peach and mango kernel flours:

Food quality is evaluated based on the amount and types of essential amino acids present and the amount of protein present. The amino acid content of apricot, peach and mango kernel flours is presented in Table 1. Results clearly show that all essential amino acids occurred at higher levels in the defatted mango kernel flour than in the FAO/WHO reference protein [42]. Mahmoud [43] reported that mango kernel protein contained the most essential amino acids in higher concentration than in the FAO reference. The amino acid content of mango kernel protein contains the all-essential amino acids and

Table 1 Amino acids composition of apricot, peach and mango kernel flours (g/100 g protein)

Amino acids (g.A.A/100 g. Protein)	Samples			FAO/WHO
	Apricot	Peach	Mango	2007
Essential amino acids (E.A.A)				
Isoleucine	3.47 ± 0.03^{B}	3.22 ± 0.02^{C}	4.33 ± 0.04^{A}	3.0
Leucine	6.66 ± 0.02^{B}	6.15 ± 0.07^{C}	8.16 ± 0.01^{A}	5.9
Lysine	3.09 ± 0.03^{B}	2.58 ± 0.03^{C}	4.50 ± 0.02^{A}	4.5
Methionine	0.87 ± 0.02^{B}	0.80 ± 0.03^{B}	2.00 ± 0.01^{A}	1.6
Phenylalanine	5.63 ± 0.03^{A}	4.96 ± 0.01^{B}	5.33 ± 0.04^{C}	3.0
Threonine	3.03 ± 0.02^{B}	3.05 ± 0.02^{B}	4.33 ± 0.04^{A}	2.3
Tryptophan	1.31 ± 0.03^{C}	1.53 ± 0.03^{B}	1.65 ± 0.03^{A}	0.6
Valine	4.82 ± 0.02^{C}	4.49 ± 0.02^{B}	6.16 ± 0.03^{A}	3.9
Total E.A. A	28.88 ± 0.06^{B}	26.78 ± 0.07^{C}	36.46 ± 0.10^{A}	–
Non-essential amino acids (Non-E.A. A)				
Aspartic	11.30 ± 0.10^{B}	16.27 ± 0.02^{A}	10.50 ± 0.20^{C}	
Glutamic	23.52 ± 0.02^{A}	23.25 ± 0.00^{B}	20.33 ± 0.04^{C}	
Histidine	2.42 ± 0.02^{A}	2.20 ± 0.03^{C}	2.33 ± 0.03^{B}	1.5
Arginine	9.43 ± 0.02^{A}	8.91 ± 0.04^{B}	7.14 ± 0.00^{C}	
Proline	4.23 ± 0.02^{B}	3.98 ± 0.01^{C}	4.50 ± 0.10^{A}	
Cystine	1.63 ± 0.01^{B}	1.48 ± 0.05^{C}	2.16 ± 0.04^{A}	0.6
Serine	4.11 ± 0.01^{B}	4.24 ± 0.07^{A}	4.27 ± 0.02^{A}	
Glycine	5.34 ± 0.01^{A}	5.05 ± 0.04^{B}	4.16 ± 0.02^{C}	
Tyrosine	3.53 ± 0.02^{A}	2.80 ± 0.10^{B}	3.51 ± 0.03^{A}	
Alanine	4.99 ± 0.00^{A}	4.32 ± 0.20^{B}	4.33 ± 0.03^{B}	
Total Non. E.A. A	70.50 ± 0.23^{B}	72.50 ± 0.56^{A}	63.23 ± 0.35^{C}	

Values are the mean of triplicate determinations with standard division

The different letters at the row means significant differences at ($p \leq 0.05$) and the same letters means no significant differences occurred at higher levels than those of the FAO/WHO reference, except for threonine and methionine [25]. While in the defatted apricot and peach kernel flours all, the essential amino acids occurred at higher levels than those of the FAO/WHO reference protein except for lysine and methionine. Zayan et al. [44] reported that the essential amino acid contents of apricot kernel meal were higher than those of the FAO reference, except leucine, lysine and threonine. Abd El-Rahman et al. [45] found that the essential amino acids present in a more significant amount in apricot kernel meal protein were lysine, leucine, isoleucine, phenylalanine, threonine and tryptophan compared with the FAO reference, except valine and methionine. According to many studies, the amino acid composition of fruit seed kernels varies depending on the variety [25]. In addition, data showed that leucine recorded the highest amino acid value among the essential amino acids in all kernel flours, followed by phenylalanine. In contrast, methionine and tryptophan recorded the lowest values. The highest value of leucine was recorded in mango kernel flour (8.16 g/100 g protein), followed by apricot kernel flour (6.66 g/100 g protein) and peach kernel flour (6.15 g/100 g protein), while the highest value of phenylalanine recorded in apricot kernel flour (5.63 g/100 g protein), followed by mango kernel flour (5.33 g/100 g protein) and peach kernel flour (4.96 g/100 g protein). Because the essential amino acid index was high, the protein in the apricot, peach, and mango kernel flours was high quality [46]. Zein et al. [47] found that isoleucine and leucine recorded the highest amino acid value in mango seed kernel flour. On the other hand, leucine and valine are the predominant essential amino acids [43]. Lysine recorded (4.50%) was higher when compared with wheat flour (2.41%) or triticale flour (3.74%) [48]. In apricot kernel protein, phenylalanine and leucine were the predominant essential amino acids, while leucine and lysine were the predominant essential amino acids in peach kernel protein [45]. The apparent differences between the results were likely due to environmental conditions, genotypic types, and the time of sample taking.

Data revealed that total essential amino acids were 28.88, 26.78 and 36.46 g/100 g protein for apricot, peach and mango kernel flours, respectively. Similar observations were reported by Mahmoud, 2009 [43] he found that the total essential amino acids were 39.34 g/100 g protein in mango kernel flour. El-Safy et al. [49] found that the total essential amino acids in apricot kernel flour was 31.44 g/100 g protein. On the other hand, glutamic and aspartic acids revealed the highest values of all non-essential amino acids in all kernel flour content. Meanwhile, cysteine and histidine contents gave the lowest values. The highest value of glutamic was recorded in apricot kernel flour (23.52 g/100 g protein), followed by peach kernel flour (23.25 g/100 g protein) and mango kernel flour (20.33 g/100 g protein). In contrast, the highest value of aspartic was recorded in apricot kernel flour (16.27 g/100 g protein), followed by peach kernel flour (11.30 g/100 g protein) and mango kernel flour (10.50 g/100 g protein). Zayan et al. [44] found that defatted apricot kernel powder contained 12.82, 20.75, 2.53, 4.73, 1.27, 5.38, 11.86, 5.93, 7.52, and 72.79 g/100 g protein for aspartic, glutamic, histidine, arginine, cysteine, serine, glycine, tyrosine, alanine and total non-essential amino acids, respectively.

Data showed total non-essential amino acids were 70.50, 72.50 and 63.23 g/100 g protein for apricot, peach and mango kernel flours, respectively. These results agreed with Zein et al. [47] studied the amino acid composition in mango kernel flour; they found that the total non-essential amino acids were 56.69 g/100 g protein. Meanwhile, glutamic acid recorded the highest value of all non-essential amino acids, 23.23 g/100 g protein.

Chemical score, limiting amino acids, protein efficiency ratio and biological value of apricot, peach and mango kernel flours:

The results in Table 2 demonstrated the chemical score, limiting amino acids, protein efficiency ratio and biological value of apricot, peach and mango kernel flours. Data revealed that lysine (37.39, 44.78 and 65.21) was the first limiting amino acid in peach, apricot and mango kernel flours; respectively. Meanwhile, the second limiting amino acid was isoleucine (58.54, 63.09 and 78.72) in peach, apricot and mango kernel flours, respectively. The first limiting amino acid in mango kernel protein was methionine, followed by threonine [47]. While, Fowomola [50] found that lysine was the first limiting amino acid, followed by threonine. El-Safy et al. [49] reported that threonine and lysine were the first and second limiting amino acids in apricot kernel protein, respectively. Methionine and cysteine recorded the first limiting amino acid in apricot and peach kernels protein [45].

On the other hand, the highest protein efficiency ratio (2.86) and biological value (80.01) were recorded for mango kernel flour. In contrast, the lowest value of protein efficiency ratio (2.03) and biological value (71.27) were recorded for peach kernel flour. Similar results were reported by Dakare et al. [51], who found that protein efficiency ratio and biological value were 2.06 and 71.59, respectively for mango kernel protein. Abd El-Rahman et al. [45] reported that the protein efficiency ratio and

Table 2 Chemical score, limiting amino acids, protein efficiency ratio and biological value of apricot, peach and mango kernel flours

Essential amino acids	Chemical score			Human Milk^{a}
	Apricot	Peach	Mango	
Isoleucine	63.09 ± 0.55^{B}	58.54 ± 0.36^{C}	78.72 ± 0.85^{A}	55
Leucine	69.37 ± 0.27^{B}	64.06 ± 0.75^{C}	85.00 ± 0.12^{A}	96
Lysine	44.78 ± 0.46^{B}	37.39 ± 0.52^{C}	65.21 ± 0.16^{A}	69
Methionine + Cysteine	75.75 ± 0.30^{B}	69.09 ± 0.30^{C}	126.06 ± 0.60^{A}	33
Phenylalanine + Tyrosine	97.44 ± 0.28^{A}	82.55 ± 0.12^{C}	94.04 ± 0.16^{B}	94
Threonine	68.86 ± 0.45^{B}	69.31 ± 0.55^{B}	98.40 ± 0.70^{A}	44
Tryptophan	77.05 ± 0.58^{C}	90.00 ± 0.50^{B}	97.05 ± 0.53^{A}	17
Valine	87.63 ± 0.36^{B}	81.63 ± 0.31^{C}	112.0 ± 0.55^{A}	55
First limiting A. A	Lysine	Lysine	Lysine	
Second limiting A. A	Isoleucine	Isoleucine	Isoleucine	
PER^{b}	2.18 ± 0.01^{B}	2.03 ± 0.02^{C}	2.86 ± 0.01^{A}	
BV^{c}	72.85 ± 0.10^{B}	71.27 ± 0.21^{C}	80.01 ± 0.06^{A}	

[a] Human Milk = mg Essential amino acid/g protein FAO/WHO (2007)

[b] Protein efficiency ratio

[c] Biological value

Values are the mean of triplicate determinations with standard division

The different letters at the row means significant differences at ($p \leq 0.05$) and the same letters means no significant differences

Table 3 Computation of A/E ratio of apricot, peach and mango kernel flours compared with FAO (1985)

Essential amino acids	A/E ratio			FAO (1985)	
	Apricot	Peach	Mango	School child	Adult
Isoleucine	120.15 ± 0.91^{A}	120.23 ± 1.28^{A}	118.76 ± 0.78^{A}	126	117
Leucine	230.60 ± 0.77^{A}	229.64 ± 2.03^{A}	223.80 ± 0.79^{B}	198	171
Lysine	106.99 ± 0.57^{B}	96.34 ± 0.69^{B}	123.42 ± 1.06^{A}	198	144
Methionine	30.12 ± 0.74^{B}	29.87 ± 0.89^{B}	54.85 ± 1.71^{A}	99	153
Phenylalanine	194.94 ± 0.80^{A}	185.21 ± 0.21^{B}	146.18 ± 0.99^{C}	99	171
Threonine	104.91 ± 0.53^{C}	113.89 ± 0.92^{B}	118.76 ± 1.45^{A}	126	81
Tryptophan	45.36 ± 0.90^{B}	57.13 ± 0.85^{A}	45.25 ± 1.20^{B}	40	45
Valine	166.89 ± 0.48^{B}	167.66 ± 0.00^{AB}	168.95 ± 1.17^{A}	112	117

Values are the mean of triplicate determinations with standard division

The different letters at the row means significant differences at ($p \leq 0.05$) and the same letters means no significant differences

biological value were (1.83), (1.99) and (69.16), (70.85) for apricot and peach kernels protein, respectively.

Computation of A/E ratio

The data given in Table 3 represented the A/E ratio between individual essential amino acid content (mg) and total essential amino acid content (g) of apricot, peach and mango kernel flours as compared with FAO recommendations for school children and adults. The data revealed that levels of leucine, valine, phenylalanine and tryptophan were higher than that recommended by FAO for school children and adults. At the same time, lysine and methionine were lower than FAO recommendations for school children and adults in apricot and peach kernel flours. In contrast, the content of isoleucine and threonine was lower than the recommended by FAO for a school child.

On the other hand, the content of leucine, valine and tryptophan were higher than that recommended by FAO for school children and adults. At the same time, lysine and methionine were lower than FAO recommendations for school children and adults in mango kernel flours. While, the levels of isoleucine and threonine were, lower than the recommended by FAO for a school child.

Physico-chemical properties of apricot, peach and mango seed kernel oils:

Fats and edible oils have a variety of physical and chemical properties that are important for determining their palatability, quality assurance and consumer acceptability. These properties are also linked to the safe, healthy standards for these oils and the foods that are prepared or processed. Thereupon, these quality assurances of apricot, peach and mango kernel oils to assess the possible use of it as edible oils were determined.

The results for some physicochemical properties of the extracted oils from the different seed kernels are presented in Table 4. The investigated seed kernel oils exhibited a significant ($p \leq 0.05$) variation for most

Table 4 Physicochemical properties of Apricot, peach and mango seed kernel oils

Physiochemical properties	Apricot seed oil	Peach seed oil	Mango seed oil
Specific gravity	0.9136 ± 0.00^{A}	0.9153 ± 0.00^{A}	0.8969 ± 0.00^{B}
Acid value	1.35 ± 0.06^{B}	0.97 ± 0.03^{C}	1.59 ± 0.06^{A}
Peroxide value (meq O_2/kg oil)	1.06 ± 0.11^{B}	0.73 ± 0.10^{C}	1.93 ± 0.12^{A}
Saponification number (mg of KOH/g of oil)	192.60 ± 0.93^{B}	188.24 ± 1.94^{C}	199.77 ± 2.85^{A}

Values are the mean of triplicate determinations with standard division

The different letters at the row means significant differences at ($p \leq 0.05$) and the same letters means no significant differences

physicochemical properties such as specific gravity, acid value, peroxide value and saponification number.

Vegetable oil handling and storage are influenced by its specific gravity, which is also connected to the amount of fatty acids present in the oil and the number of carbon atoms or average molecular weight of the fatty acids. The specific gravity of the studied samples of the oils were as follows: 0.9136 for apricot, 0.9153 for peach and 0.8969 for mango oil. These results are in agreement with those reported by Ebrahim & El Gaali, [52], who found that the specific gravity of the extracted oils were 0.840, 0.772, 0.820, 0.750 and 0.940 for Abu-samaka, Baladia, D. Night, Elphons and Sennaria mango cultivars, respectively.

One of the most critical chemical constants for ensuring the quality of edible fats and vegetable oils is the free fatty acid content, also known as acid value (% as oleic acid). It serves as a reliable indicator of the degree of hydrolysis that occurs in oils both before and during extraction procedures. Data presented in Table 4 showed that free fatty acid (FFA) contents of apricot, peach and mango kernel oils were 1.35, 0.97 and 1.59%, respectively. The low acidity obtained for peach kernel oil is an indication that the triacylglycerols present have not been hydrolyzed. These results agreed with that obtained by previous studies [20, 53, 54]. Whereas the (FFA) content of seed kernel oils in the present investigation were much lower than those (7.80, 1.3 and 3.97%) reported by [15, 55, 56] for apricot, peach and mango seed kernel oils, respectively. The lack of hydrolytic rancidity brought on by lipases and the low free fatty acid content in seed kernel oils allowed for the direct use of such oils in industries without further neutralization, as described by Kittiphoom & Sutasinee, [57].

On the other hand, seed kernel oils had a high quality due to the low level of peroxide value. One of the most crucial tests for determining oxidative rancidity in oils is the peroxide value, which measures the concentrations of peroxides and hydroperoxides produced during the early stages of lipid oxidation. The peroxide value of peach seed kernel oil in the present study was 0.73 meq O_2/kg oil, which was lower than 1.06 and 1.93 meq O_2/kg oil for apricot and mango seed kernel oil, respectively. The lowest peroxide values obtained with the peach seed oil could be attributed to high level of phenolic compounds or antioxidants, preventing the peroxidation in polyunsaturated fatty acid of the oil. This value agreed with that reported by other studies [20, 55, 58].

A low saponification number occurs because fat contains some impurities that cannot be saponified, which is why the saponification value is crucial for determining the quality of fats. The obtained results in Table 4 showed that the saponification number of apricot, peach and mango seed kernel oils were 192.60, 188.24 and 199.77 mg KOH/g oil, respectively, which was in close approximately agreement with the value obtained by previous studies [52, 55, 59]. While this result was lower than those were (207.5 and 199.4 mg KOH/g oil) reported by [26, 60] for mango and apricot seed kernel oils; respectively. Peach seed oil had the lower saponification number may be due to related with fatty acids composition; high saponification value is an indication of the presence of fatty acids with higher number of carbon atoms. It provides information on the average molecular weight and hence, chain length of a lipid [61].

Fatty acid composition of apricot, peach and mango seed kernel oils:

It is commonly recognized that understanding a novel vegetable oil's fatty acid makeup can help predict its potential uses for edible or industrial products, and relate potential oxidation to particular unsaturated fatty acids. Additionally, the oxidative state, stability, and safe, healthy quality of these lipids are all significantly connected with the fatty acid content of dietary oils and fats [62]. Therefore, the fatty acids composition of apricot, peach and mango kernel oils was carried out by gas chromatography analysis; the obtained data are recorded in Table 5.

The obtained results showed that the total saturated fatty acids content in apricot, peach and mango seed oils were 10.63, 10.77 and 51.86%, respectively, while the total unsaturated fatty acids contents were 89.16, 89.00 and 48.03%; thus, the ratio between total saturated and total unsaturated (TSFA/TUSFA) were recorded as 0.11, 0.12

Table 5 Fatty acids composition of apricot, peach and mango seed kernel oils

Fatty acids	Carbon chain	Samples		
		Apricot	Peach	Mango
Saturated				
Caprylic	$C_{8:0}$	ND^{a}	ND^{a}	0.20 ± 0.01
Capric	$C_{10:0}$	ND^{a}	ND^{a}	0.16 ± 0.03
Lauric	$C_{12:0}$	1.42 ± 0.03^{B}	0.90 ± 0.10^{C}	1.88 ± 0.03^{A}
Myristic	$C_{14:0}$	0.39 ± 0.02^{B}	0.16 ± 0.01^{C}	0.62 ± 0.02^{A}
Palmitic	$C_{16:0}$	7.11 ± 0.01^{C}	7.64 ± 0.04^{B}	10.77 ± 0.02^{A}
Heptadecanoic	$C_{17:0}$	ND^{a}	ND^{a}	0.15 ± 0.02
Stearic	$C_{18:0}$	1.54 ± 0.02^{C}	1.91 ± 0.02^{B}	35.56 ± 0.02^{A}
Arachidic	$C_{20:0}$	0.17 ± 0.01^{B}	0.16 ± 0.01^{B}	2.09 ± 0.01^{A}
Behenic	$C_{22:0}$	ND^{a}	ND^{a}	0.43 ± 0.02
Unsaturated				
Palmitoleic	$C_{16:1}$	0.67 ± 0.02^{A}	0.36 ± 0.03^{B}	ND^{a}
Oleic	$C_{18:1}$	59.87 ± 0.06^{A}	54.94 ± 0.05^{B}	41.76 ± 0.03^{C}
Vaccenic	$C_{18:1}$	1.50 ± 0.11^{A}	0.98 ± 0.01^{B}	0.36 ± 0.01^{C}
Linoleic	$C_{18:2}$	26.61 ± 0.01^{B}	32.42 ± 0.08^{A}	5.25 ± 0.03^{C}
Linolenic	$C_{18:3}$	0.39 ± 0.01^{B}	0.20 ± 0.03^{C}	0.47 ± 0.02^{A}
Gadoleic	$C_{20:1}$	0.12 ± 0.01^{B}	0.10 ± 0.01^{B}	0.19 ± 0.01^{A}
Total saturated fatty acids (TSFA)		10.63 ± 0.05^{B}	10.77 ± 0.16^{B}	51.86 ± 0.01^{A}
Total unsaturated fatty acids (TUSFA)		89.16 ± 0.17^{A}	89.00 ± 0.10^{A}	48.03 ± 0.02^{B}
Essential fatty acids		27.00 ± 0.04^{B}	32.62 ± 0.07^{A}	5.72 ± 0.01^{C}
TSFA / TUSFA		0.11 ± 0.01^{C}	0.12 ± 0.01^{B}	1.07 ± 0.01^{A}

[a] ND = not detected

Values are the mean of triplicate determinations with standard division

The different letters at the row means significant differences at ($p \leq 0.05$) and the same letters means no significant differences

and 1.07 for apricot, peach and mango seed kernel oils, respectively. These results confirmed those of Mohamoud, [63] who found the total saturated and unsaturated fatty acids content in mango kernel oil were 51.86 and 47.86%. The peach seed oil contained about 8.71% total saturated fatty acids and 91.27% total unsaturated fatty acids [20], while apricot seed oil was 5.56% total saturated fatty acids and 94.44% total unsaturated fatty acids [55].

Among the unsaturated fatty acids, oleic and linoleic were the predominant acids in all seed kernel oils. The highest values of oleic and linoleic acids were obtained in apricot oil at 59.87 and 26.61%, respectively, followed by peach oil 54.94 and 32.42%, respectively. The lowest values 41.76 and 5.25% of oleic and linoleic were observed in mango oils, respectively. The presence of high amounts of the essential oleic suggests that the apricot, peach and mango kernel oils could be used in some as nutrient-rich food [27]. These results agreed with Song et al. [64], who found that apricot kernel oil contained 50.66% oleic acid, 32.65% linoleic acid. Özcan et al. [55] evaluated the fatty acid composition extracts of peach kernel oil, and reported that oleic and linoleic acids were 57.46 and 25.44%, respectively. Oleic and linoleic acids contents of almond ranged from 71.98% to 78.68% and 12.02 to 17.65% depending on harvest time, respectively [65]. While in mango kernel oil, oleic and linoleic acids were 43.77 and 6.78% respectively [66].

High oleic acid (omega-6) concentrations help lower blood cholesterol levels and reduce the incidence of cardiac issues [67]. Oleic acid is currently the subject of a new study due to the recent revelation that it protects against breast cancer. A cancer-causing oncogene termed HER-2/neu, which is present in around 30% of breast cancer patients, is inhibited by oleic acid [68]. Similarly, it has been conclusively demonstrated that linoleic acids suppress carcinogenesis and lower the incidence of cancers in a number of experimental animal models [69].

On the other hand, Data in Table 5 showed that the major saturated fatty acids in mango seed kernel oil were stearic and palmitic acids which recorded 35.56 and 10.77%, respectively. While apricot and peach seed kernel oils presented relatively low contents of stearic (1.54 and 1.91) and palmitic (7.11 and 7.64%), respectively. These results agree with those obtained by other studies [20, 70]. On the other hand, Banjanin et al. [71] determined 4.24–5.83% palmitic, 1.13–2.18% stearic, 61.39–77.15% oleic and 16.02–30.06%

linoleic acids in 12 Serbia regional and commercial almond (*Prunus dulcis*) cultivars.

Conclusions

It is necessary to look for answers to get through this challenging moment in the next years at a time when the globe is experiencing many changes, including global climate change, resource depletion, rational and sustainable agriculture production and overpopulation. Fruit kernels are a nutritionally interesting source of vegetable protein and oils which make up their weight's second-most abundant component. From the results, it may be inferred that the apricot, peach, and mango seed kernel provenances had high amino acid levels and quality protein. Oils' physicochemical qualities and fatty acid profiles indicate that the kernels can be a viable resource for producing high-quality essential oil products. The high quality and nutritional value of kernel oils has potential application in human foods.

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Author contributions

All authors of this research contributed to the conception of the study; MAM, conceptualization, validation, methodology, data acquisition, statistical analysis, interpretation, and writing of the original draft; MAS, AEM, SMH supervision, validation and writing-review and editing. All the authors have read and approved the final manuscript.

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Availability of data and materials

The data sets used or analyzed during this study are available to readers as in the manuscript.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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