Chapter 37
Pomegranate (*Punica granatum*) Seed Oil

Sarfaraz Ahmed Mahesar, Abdul Hameed Kori, Syed Tufail Hussain Sherazi, Aftab Ahmed Kandhro, and Zahid Husain Laghari

Abstract Pomegranate is an earliest and holy fruit affectionately known as the "jewel of winter" belongs to the Punicaceae family. Throughout the world, ~500 known pomegranate varieties available which reveal different quality characteristics of fruit such as size, shape, color, flavor and taste and seed hardness. The pomegranate seeds contain approximately 3% of total fruit weight, which contains typically oil in the range of 12–20%. Conjugated fatty acids are present in many plant oils with varying concentrations including pomegranate seed oil. Conjugated fatty acids are the geometric and positional isomers of polyunsaturated fatty acids with alternate double bonds. These fatty acids received remarkable interest due to valuable physiological effects on various diseases. The pomegranate seed oil contains higher concentration (>70%) of conjugated fatty acids in the form of punicic acid (9*cis*, 11*trans*, 13*cis*-conjugated linolenic acid). In the present chapter, chemistry and functionality of pomegranate fruit and seed oil especially conjugated fatty acids are reviewed.

Keywords Conjugated fatty acids · Ellagic acid · Tocols · Seed oil · Conjugated fatty acid · Punicic acid

Abbreviations

CLA	Conjugated linoleic acid
CLNA	Conjugated linolenic acid
E. coli	*Escherichia coli*
EA	Ellagic acid
ED	Erectile dysfunction

S. A. Mahesar (✉) · A. H. Kori · S. T. H. Sherazi · Z. H. Laghari
National Centre of Excellence in Analytical Chemistry, University of Sindh, Jamshoro, Pakistan

A. A. Kandhro
Dr. M.A. Kazi Institute of Chemistry, University of Sindh, Jamshoro, Pakistan

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ETs	Ellagitannins
LDL	Low density lipid
NO	Nitric oxide
PA	Punicic acid
PFLE	Pomegranate flower leaf extract
PJ	Pomegranate juice
PPAR	Peroxisome proliferator-activated receptor
UV	Ultraviolet
α-EA	Ellagic acid

1 Introduction

Human beings use fruits as the main source of food. Researchers have reported that dry and fresh fruits can be used for the medical purpose as well as food (Marwat et al. 2009). Such studies arouse great enthusiasm among researchers and food companies to produce new varietal products and extract bioactive compounds from natural fruits that can have positive effects on human life (Viuda-Martos et al. 2010). Consumers use unprocessed or raw food and fruit juices to obtain rapid energy supply as well as maintain minerals quantity in the body.

Pomegranate (*Punica granatum* L.) is the oldest holy fruit and considered as "jewel of winter", belongs to the Punicaceae family. It follows the Latin name of the fruit Malum granatum, which means "grainy apple (Fig. 37.1). Pomegranate is native to India, Iran and its cultivation stretching all the way to the entire Mediterranean and Southwest American regions since ancient times (Celik et al. 2009; Lansky and Newman 2007). Current world production is estimated around 3.5 million ton per annum (Sinha et al. 2016). The leading producers of pomegranate are India, Iran, China and USA (Holland et al. 2008). In Pakistan pomegranate is harvested in the month of August to October in geographical locations of Gilgit

Fig. 37.1 Pomegranate plant, flower, fruit and oil

Table 37.1 Proximate composition of pomegranate seed

Constituent	Value	Reference
Ash (%)	0.47–1.887	Al-Maiman and Ahmad (2002) and Dadashi et al. (2013)
Oil (%)	13.5–19.3	Dadashi et al. (2013), Fadavi et al. (2006), Habibnia et al. (2012), Melgarejo and Artes (2000), Parashar (2010), Soetjipto et al. (2010), and Laghari et al. (2018)
Moisture (%)	77.72	Al-Maiman and Ahmad (2002)
Protein (%)	4.45–18.34	Al-Maiman and Ahmad (2002), Dadashi et al. (2013), and Laghari et al. (2018)
Crude fiber (%)	13.78–42.4	Dadashi et al. (2013) and Laghari et al. (2018)
Carbohydrates (%)	24.09–35.44	Dadashi et al. (2013) and Laghari et al. (2018)
Energy (Kcal/100 g)	355.52–460.7	Dadashi et al. (2013) and Laghari et al. (2018)

Baltistan, Waziristan, Kurram agency, Dir, Chitral, Hazara, west of Baluchistan and Azad Kashmir. Table 37.1 shows the composition of pomegranate seed.

The pomegranate plant is widely considering as large shrub or small tree (~5 m), mostly grown in hot and dry and in humidity and dry season to get produce high-quality fruit with good yield. The fruit of the pomegranate is considered as a large berry and can be divided into three parts (seed, juice and peel). The pomegranate fruit contains multi-ovule chambers (8–12) which are separated by fleshy mesocarp and membranous walls. The chambers are packed with numerous seeds (arils) and enveloped by a transparent juicy layer. Depending on the variety, the size of arils, the hardness of seed and color of the juicy layer can differ from deep red to white (Holland et al. 2009).

Approximately 3% of the fruit weight contains seed, 30% juice and rest is the peel, including interior membranes (Lansky and Newman 2007). Over hundreds of years, pomegranate has accompanied mankind as a symbol of longevity, life, morality, health, knowledge, and spirituality (Mackler et al. 2013). Table 37.2 shows the main components present in different parts of the pomegranate tree and fruit.

2 Types and Varieties of Pomegranates

Several varieties of pomegranates (~500) with different size, varying shapes, taste and color are cultivated throughout the world. Fruits are round, obvate in shape and vary in diameter from 8 to 12 cm. The rind may be thick or thin and the color ranges from pale yellow to crimson. The pulp in superior types is thick, fleshy and very juicy, while in inferior types it is thin (Fig. 37.1).

The seed coat varies in hardness, some of the softer seeded types known as seedless. There is a number of seedling verities of pomegranate available. Selecting a variety with known qualities is always the better choice. Most horticulturists divide

Table 37.2 Major components of pomegranate tree and fruit

Pomegranate part	Component	References
Juice	Anthocyanins, glucose, organic acid such as ascorbic acid, ellagic acid (EA), ellagitannins (ETs), gallic acid, caffeic acid, catechin, quercetin, rutin, minerals such as iron, sodium, potassium and amono acids	Heber et al. (2007), Ignarro et al. (2006), Jaiswal et al. (2010), Lansky and Newman (2007), Mousavinejad et al. (2009), and Poyrazoğlu et al. (2002)
Seed	Majorly conjugated fatty acids such as punicic acid, eleostearic acid, catalpic acid and other fatty acids linoleic acid, oleic acid, stearic acid, EA, and sterols	El-Nemr et al. (1990), Fadavi et al. (2006), Özgül-Yücel (2005), and Sassano et al. (2009)
Peel and rind	Phenolic punicalagins; gallic acid and other fatty acids; catechin, quercetin, rutin, and other flavonols, flavones, flavonones; anthocyanidins, Luteolin, Kaempferol, EA, punicalagin, punicalin, pedunculagin	Amakura et al. (2000), Seeram et al. (2006), and Van Elswijk et al. (2004)
Flower and leaf extract	Gallic acid, ursolic acid, triterpenoids, others maslinic Asiatic acid, tannins (punicalin and punicafolin) and flavone glycosides, luteolin and apigenin, EA, polyphenols and, punicalagin, punicalin	Aviram et al. (2008), Ercisli et al. (2007), Kaur et al. (2006), and Lan et al. (2009)
Roots and barks	ETs, including punicalin and punicalagin, many piperidine alkaloids	Gil et al. (2000) and Neuhofer et al. (1993)

pomegranate verities into three categories sweet, sweet-tart and sour. Hiwale (2009) divided pomegranate into six groups based on the hardiness of the seed.

1. Soft seeded sweet
2. Soft seeded tart
3. Early variety (mostly sweet)
4. Normal (harder) seeded sweet tart
5. Normal (harder) seeded sweet
6. Sour (nearly always normal seeded)

3 Chemical Composition of Pomegranates

The constituents present in pomegranate fruits vary due to climate, region, cultivation, maturity and environment of storage (Barzegar et al. 2004; Fadavi et al. 2005; Poyrazoğlu et al. 2002). Different researchers have reported variations in fatty and organic acids, sugar, phenolic compounds, minerals, and water-soluble vitamins in pomegranate (Aviram et al. 2000; Çam et al. 2009; Davidson et al. 2009; Mirdehghan and Rahemi 2007; Tezcan et al. 2009). Around 50% weight of pomegranate fruit consist of the peel. It has many significant bioactive compounds including phenolics, ellagitannins (ETs), flavonoids and anthocyanidin (Li et al. 2006), minerals

such as nitrogen, phosphorus, calcium, sodium, magnesium and potassium (Mirdehghan and Rahemi 2007) as well as complex polysaccharide (Jahfar et al. 2003). It has been reported that edible parts of fruit mainly consist of 10% seeds and 40% arils. Water is the main part in aril ~85%, total sugars 10% (consists of glucose and fructose), pectin 1.5%, other organic and bioactive compounds like citric acid, ascorbic acids, malic acid, as well as flavonoids and phenols majorly anthocyanins (Aviram et al. 2000; Tezcan et al. 2009).

Pomegranate has strong antioxidant activity due to different compounds of polyphenols mainly ETs, gallotannins, EA acid, and flavonoids such as anthocyanins, quercetin, kaempferol and luteolin glycosides (Tabaraki et al. 2012). Punicalagin, an ETs, is the most abundant polyphenolic compound in pomegranate peel and responsible for biological properties (Bopitiya and Madhujith 2012; Mena et al. 2013). In contrast to pomegranate peels, the seeds are mainly composed by fatty acids and in a lesser extent by antioxidants such as gallic acid, methyl ellagic acid, hydroxycinnamic acids and tocopherols (Lansky and Newman 2007).

The seeds comprise around 3% of total fruit weight with varying chemical compositions (Table 37.3). As far as oil content in seeds is concerned, it has been reported that quantity and quality of oil depends upon maturity and geographical location of cultivated pomegranate fruits.

The pomegranate seed oil consists of >90% polyunsaturated fatty acids (PUFA) such as linoleic, and linolenic acids (Tables 37.4a and 37.4b), as well as other fatty acids such as stearic, oleic, and palmitic acids (Fadavi et al. 2006; Özgül-Yücel 2005). Generally, seed oil of pomegranate contains high proportions of PUFA, especially conjugated fatty acids (Kaufman and Wiesman 2007). The seed also contains fibers, protein, minerals, vitamins, sugars, pectin, polyphenols, the sex steroid, estrone, isoflavones (mainly genistein) and the phytoestrogen coumestrol (El-Nemr et al. 1990; Syed et al. 2007). Tables 37.5a and 37.5b show the tocol and sterol contents of pomegranate seed oil. It is widely accepted that the beneficial health effects of fruits and vegetables in the prevention of disease are due to the bioactive

Table 37.3 Physico-chemical properties of pomegranate seed oil

Parameters	Value	Reference
Specific gravity at 28 °C (g/cm^3)	0.9300	Laghari et al. (2018)
Viscosity at 25 °C (*m* Pas.s)	0.037	Laghari et al. (2018)
Free fatty acid (%)	0.96–8.36	Amri et al. (2017a), Dadashi et al. (2013), and Laghari et al. (2018)
Saponification value (mg/KOH)	156–182.5	Dadashi et al. (2013) and Laghari et al. (2018)
Peroxide value (meq O_2/kg)	0.39–3.42	Amri et al. (2017a), Dadashi et al. (2013), and Laghari et al. (2018)
Iodine value (g I_2/100 g)	212–220.34	Dadashi et al. (2013) and Laghari et al. (2018)
Conjugated dienes	4.15	Amri et al. (2017a)
Conjugated trienes	3.95	Amri et al. (2017a)

Table 37.4a Individual fatty acid composition of pomegranate seed varieties available in the world

	Brazil		India			Indonesia	Iran		Italy	Japan	Pakistan	Spain	Tunisia		Turkey		USA
Fatty acid	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q
C12:0 lauric acid				0.02–0.37				0.01				0.50	0.51	0.02–0.14			
C14:0 myristic acid				0.03–0.04	0.7			0.03–0.04	0.02–0.03				0.36	0.04–0.08			0.35
C14:1 cis-myristoleic acid													0.14	0.04–0.07			
C16:0 palmitic acid	4.04	2.77	2.87	18.16–22.63	5.7	0–9	2.95–3.57	4.04–4.46	2.68–4.28	3.1	2.88	2.58–14.91	22.08	3.77–7.81	2.0	2.45	4.0
C16:1 n7 (trans) trans-9-palmitoleic acid								0.06–0.09					0.40	0.07–0.08			
C16:1 n7 (cis) cis-9-palmitoleic acid				0.22–2.70					0.02–0.04			0.93–2.30	0.27	0.09–0.22			
C 16:1 n9 cis													1.88				
C 17:0 margaric								0.01	0.05–0.08				0.54				
C17:1 w8 cis-9-heptadecyl enic acid/ margaroleic								0.01–0.02					0.83	0.10			
C18:0 stearic acid	2.30	2.42	2.26	8.10–10.42	2.1	9–11	1.99–2.54	2.81–3.0	1.44–1.92	2.0	3.57	1.16–8.98	8.94	2.13–2.26	1.6	1.52	2.92
C18:1 n9 (trans) trans-elaidic acid								0.06–0.07					0.04	3.52–11.10			
C18:1 n9 (cis) cis-oleic acid	5.29	5.74	6.82	24.76–31.26	9.0	19–21	5.71–7.48	8.31–9.77	3.63–7.12	4.5	3.85	3.67–20.25	10.47	0.02–0.82	3.7	4.19	5.68

C18:1 n7 (cis) cis-11-octadecanoic acid													2.12	0.05–22.15			
C18:1 7 trans vaccenic			0.34						0.36–0.67 cis								
C18:2 (t9,c12) trans-9, cis-12-Octadecadienoic acid													0.01	0.04–0.85			
C18:2 (c9,t12) cis-9,trans-12-octadecadienoic acid													0.03	0.34–0.51			
C18:2 w6 (c9, c12) cis-cis-linoleic acid	6.05	7.29	6.46	31.49–38.61	10.8	20–21	5.22–7.08	8.11–9.03	4.11–11.32	5.1	2.67	5.19–16.50	28.86	0.11–6.13	3.3	4.49	4.08
C18:3 w6 cis-linolenic acid gamma				0.61–9.94									2.82	0.05–43.13			
C18:3 w3 (cis) cis-linolenic acid alpha		0.39						0.04–0.10	0.05–0.38				1.02	0.06–3.45	0.1		
C18:2(t9,t11) trans-trans octadecadienoic acid/linoelaidic								0.30–0.35	0.02–0.05				0.10	0.16–1.35			

(continued)

Table 37.4a (continued)

	Brazil		India			Indonesia	Iran		Italy	Japan	Pakistan	Spain	Tunisia		Turkey		USA
Fatty acid	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q
C18:2 (c11,t13) cis-11, trans-13-octadecadienoic acid													0.10	0.04–0.06			
C18:2 (t10,c12) trans-10, cis-12-octadecadienoic acid													0.16	0.35–0.40			
C20:0 arachidic acid	0.50	0.39	0.49	1.06–2.76				0.60–0.64	0.37–0.55		1.22	0.66–2.76	0.91	0.83–1.53	3.0	0.39	0.53
C2O:1 w9 eicosenoic acid	0.61	0.39	0.64					0.90–1.08	0.41–1.07				0.43	0.22–1.11	0.1	0.61	
C2O:2 eicosadienoic acid								1.08	0.47–0.73				0.08	0.18–0.43			
C2O:3 w6 dihomo-linolenic acid													0.14	0.04–1.31			
C2O:3 w3 eicosatrienoic acid													0.11	0.45–0.49			
C2O:5 w3 eicosapentaenoic acid									0.47–0.73								
C21:0 heneicosylic acid		2.91															
C22:0 behenic acid				0.23–0.85	0.1				0.1–0.25				1.25	0.19–1.63		0.18	

C22:1 erucic acid									0.71–1.54								
C22:2 docosadienoic acid									0.14–0.49								
C18:3 (c9,t11,c13) punicic acid–trichosanic osanic acid	58.14	54.90	71.76		71.5	9–16	78.25–82.4	72.07–73.31	72.42–84.11	71.7	84.68	43.43–88.22	5.12	2.23–40.10	57.3	74.11	81.22
C18:3 (c8,t10,c12) calendic acid													1.41	0.17–0.89			
C18:3 (c9,t11,t13) alpha-eleostearic acid/catalpic		16.07	4.6							2.8	1.13		2.97	0.21–13.79		6.41	
C18:3 (t9,t11,c13) trans-9,trans-11,cis-13-octadecatrienoic/catalpic acid		6.71	2.64							5.1			3.04	0.31–5.40	7.6	3.48	
C18:3 (t9,t11,t13) trans-beta eta eleostearic acid			0.49							1.6			0.45	0.06–14.57	21.1	1.03	
C24:0 lignoceric acid			0.05	0.14–0.77					0.04–0.10				0.58	0.05–1.08			1.0
C24:1 nervonic acid			0.24										0.15	0.16–0.36			

a: Melo et al. (2014), b: Melo et al. (2016), c: Sassano et al. (2009), d: Parashar et al. (2009), e: Parashar (2010), f: Soetjipto et al. (2010), g: Habibnia et al. (2012), h: Dadashi et al. (2013), i: Verardo et al. (2014), j: Suzuki et al. (2001), k: Laghari et al. (2018), l: Melgarejo et al. (2000), m: Amri et al. (2017b), n: Amri et al. (2017a), o: Ozgul-Yucel. (2005), p: Ozgen et al. (2008), q: Pande (2009)

Table 37.4b Fatty acid composition of phospholipids and glycolipids in pomegranate seed oil

	Glycolipids		Phospholipids		
	Tunisia	Indonesia	Tunisia	Indonesia	Italy
Fatty acid	Amri et al. (2017a)	Soetjipto et al. (2010)	Amri et al. (2017a)	Soetjipto et al. (2010)	Verardo et al. (2014)
C12:0 lauric acid	1.19		0.97		
C14:0 myristic acid	0.42		0.25		
C14:1 cis-myristoleic acid	0.32		0.05		
C16:0 palmitic acid	38.25	0–6	43.00	0–25	9.96–31.33
C16:1 n7 (trans) trans-9-palmitoleic acid	0.37		0.31		1.07–8.19
C16:1 n7 (cis) cis-9-palmitoleic acid	0.45		0.30		
C 16:1 n9 cis	0.30		0.25		
C 17:0 margaric	0.96		0.69		
C17:1 w8 cis-9-heptadecyl enic acid/margaroleic	0.28		0.53		
C18:0 stearic acid	22.40	0–10	24.24	10–12	5.92–21.37
C18:1 n9 (trans) trans-elaidic acid	0.13		0.03		
C18:1 n11 (trans) vccenic acid					
C18:1 n9 (cis) oleic acid	7.74	7–14	8.88	14–34	8.65–32.07
C18:1 n7 (cis) cis-11-octadecanoic acid	1.13		1.36		
C18:2 (t9,c12) trans-9, cis-12-octadecadienoic acid	0.14		0.01		
C18:2 (c9,t12) cis-9,trans-12-octadecadienoic acid	0.13		0.01		
C18:2 w6 (c9, c12) cis-cis-linoleic acid	9.60	6–30	9.98	6–16	6.91–18.80
C18:2(t9,t11)trans-trans octadecadienoic acid/ linoelaidic	0.15		0.21		
C18:2 (c11,t13) cis-11, trans-13-octadecadienoic acid	0.05		0.02		
C18:2 (t10,c12) trans-10, cis-12-octadecadienoic acid	0.12		0.01		
C18:3 w6 cis-linolenic acid	3.64		3.76		
C18:3 w3 (cis) cis-linolenic acid	0.46		0.35		
C18:3 (c9,t11,c13) punicic acid–trichosanic acid	1.42	0–42	0.68	0–22	16.81–62.40

(continued)

Table 37.4b (continued)

	Glycolipids		Phospholipids		
	Tunisia	Indonesia	Tunisia	Indonesia	Italy
Fatty acid	Amri et al. (2017a)	Soetjipto et al. (2010)	Amri et al. (2017a)	Soetjipto et al. (2010)	Verardo et al. (2014)
C18:3 (c8,t10,c12) calendic acid	0.91		0.03		
C18:3 (c9,t11,t13) alpha-eleostearic acid	0.43		0.03		
C18:3 (t9,t11,c13) trans-9,trans-11,cis-13-octadecatrienoic/catalpic acid	0.43		1.20		
C18:3 (t9,t11,t13) trans-beta eleostearic acid	0.25		0.05		
C20:0 arachidic acid	1.28		1.41		
C2O:1 w9 gadoleic acid/ eicosenoic	0.06		0.22		
C2O:2 eicosadienoic acid	0.08		0.01		
C2O:3 w6 dihomo-linolenic acid	0.05		0.01		
C2O:3 w3 eicosatrienoic acid	0.13		0.01		
C21:0					
C22:0 behenic acid	1.35		0.90		
C22:1 erucic acid/docosenoic acid					0.49–3.33
C22:2 erucic acid/ docosadienoic acid					1.59–16.44
C24:0 lignoceric acid	0.25		0.51		
C24:1 nervonic acid	0.14		0.03		

compounds they contain (Galaverna et al. 2008). Almaiman and Ahmed (2002) reported phenols and ascorbic acid 1.90 and 0.18 mg/100 g, respectively in pomegranate seed. In Tunisian pomegranates, Amri et al. (2017a) has noted following compounds in seed oil like phenols 93.4 mg/kg, flavonoid 59.4 mg/kg, *O*-diphenols 30.1 mg/kg, and pigments (chlorophyll 3.17 mg/kg, and β-carotene 3.17 mg/kg).

4 Pomegranate Seed Oil

Fatty acids are carboxylic acids with a long chain of aliphatic hydrocarbons either saturated or unsaturated. Fatty acids are found in open chain and derived from triglycerides or phospholipids. There are three types of hydrocarbons chain in fatty acids such as small, medium and long chain depends upon a number of carbon atoms present in the chain. The small chain consists of 4–6 carbon atoms, while

Table 37.5a Tocols content in extracted pomegranate seed oil

Country	α-Tocopherol	γ-Tocopherol	β-Tocopherol	δ-Tocopherol	α-Tocotrienol	β-Tocotrienol	Reference
Iran (mg/1000 g)	543.6–1134.6	1856.6–7106	–	–	–	–	Habibnia et al. (2012)
Brazil (mg/100 g)	3.81	153.21	1.03	17.04	–	–	Melo et al. (2016)
Tunisia (mg/100 g)	165.77	107.38	–	27.29	–	–	Elfalleh et al. (2011)
Italy (mg/100 g)	2.54–16.9	61.65–240.08	–	0.78–3.56	0.73–2.76	1.25–5.21	Verardo et al. (2014)

Table 37.5b Content of phytosterols in pomegranate seed oils

	Country			
	Iran (g/100 g)	Brazil (mg/100 g)	Tunisia (g/100 g)	Italy (mg/g)
Components	Habibnia et al. (2012)	Melo et al. (2016)	Amri et al. (2017a)	Verardo et al. (2014)
Cholesterol	0.37–0.40		0–23	
Campesterol	7.56–8.83	49	6–35	0.50–1.23
Stigmasterol	3.14–5.93	12	3–21	0.20–0.57
Beta-sitosterol	85.49–87.7	374	77–94	5.13–11.42
24-Methylene-cholesterol			0–1	
Campestanol			0–8	
Δ5,^{23}Stigmastadienol			0–5	
Clerosterol			1–23	
Sitostanol			0–44	
Avenasterol			7–45	
Δ5,^{24}-Stigmastadienol			0–93	
Δ7-Stigmastenol			0–27	
Δ5-Avenasterol				0.93–2.42
Δ7-Avenasterol			0–76	
Erythrodiol			0–34	
Uvaol			0.77	
Others		104		
Citrostadienol				0.26–0.82

the medium chain has 8–18 carbons and long chain contains above 18 carbons. Most of the plant seed oils usually contain unsaturated fatty acids in unconjugated form except a few seed oils, which contain conjugated double, triple or tetraenes bonds. Examples of conjugated double and triple bonds are conjugated linoleic acids (CLA) and conjugated linolenic acids (CLNA). Presence of conjugated fatty acids in oil have been an object of studies. Basically, CLNA is a mixture of octadecatrienoic fatty acid isomers. These isomers include geometrical (cis and/or *trans*) and positional forms of linolenic acid (11,13,15–18:3, 10,12,14–18:3; 9,11,13–18:3; 8,10,12–18:3). A number of plant seeds contain very high concentration (30–70% of lipids) of CLNA isomers as shown in Table 37.6. Among them pomegranate seed oil contains a higher amount of CLNA. The important CLNA present in pomegranate seed oil is PA (Fig. 37.2) (9-*trans*, 11-*cis*, 13-*trans*) which consists of approximately 70–90% of total fatty acids (Abbasi et al. 2008; Tanaka et al. 2011).

Table 37.6 Conjugated linolenic acids contents in some oils (Tanaka et al. 2011)

Seed oil	Type of CLN	Isomers	CLNA (%)
Bitter gourd	α-eleostearic	9c,11t,13t-18:3	>50
	β-eleostearic acid	9t,11t,13t-18:3	
Pot marigold	α -calendic	8t,10t,12c-18:3	>30
	β-calendic	8t,10t,12t-18:3	
Catalpa	Catalpic acid	9t,11t,13c-18:3	>40
Calendula	Calendic acid	8t,10t,12c-18:3	>55
Jacaranda	Jacaric acid	8c,10t,12c-18:3	>35
Pomegranate	Punicic acid	9c,11t,13c-18:3	>70

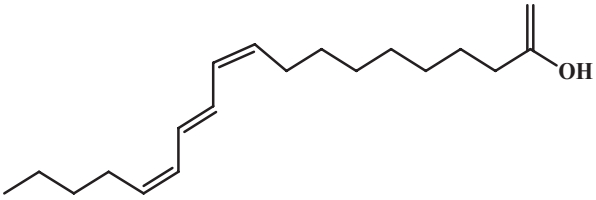

Fig. 37.2 Molecular structure of punicic acid (PA)

4.1 Punic Acid (PA)

It has been reported that PA showed a strong eicosanoid enzyme inhibition properties (Eikani et al. 2012). PA reduced fasting glucose in diabetics II, diet-induced obesity and insulin resistance, inflammation of colon, bladder, breast and prostate cancer, nephrotoxic activity, formation of hydroperoxide and improve bone mineral density (Banihani et al. 2013; Bouroshaki et al. 2010; Boussetta et al. 2009; Grossmann et al. 2010; Kohno et al. 2004; Lansky et al. 2005; Mukherjee and Bhattacharyya 2006; Spilmont et al. 2013; Wang and Martins-Green 2014). PA and α-EA also reduce the activity of sodium arsenite that is responsible for oxidative stress and deoxy (DNA) damage (Saha and Ghosh 2009).

4.2 FT-IR Spectrum of Pomegranate Seed Oil

The infrared spectrum of pomegranate seed oil is shown in Fig. 37.3. The characteristics functional groups present in pomegranate seed oil are resembled with other vegetable oils, except in the region of 1050–730 cm^{-1} due to the presence of CLNA. Prashantha et al. (2009) reported that isomers of eleostearic acid show a strong spectral band at 993 cm^{-1} corresponding to β-eleostearic acid (*trans*: *trans*: *trans*) and a doublet with a strong band at 991 cm^{-1} and a weaker band at 963 cm^{-1}

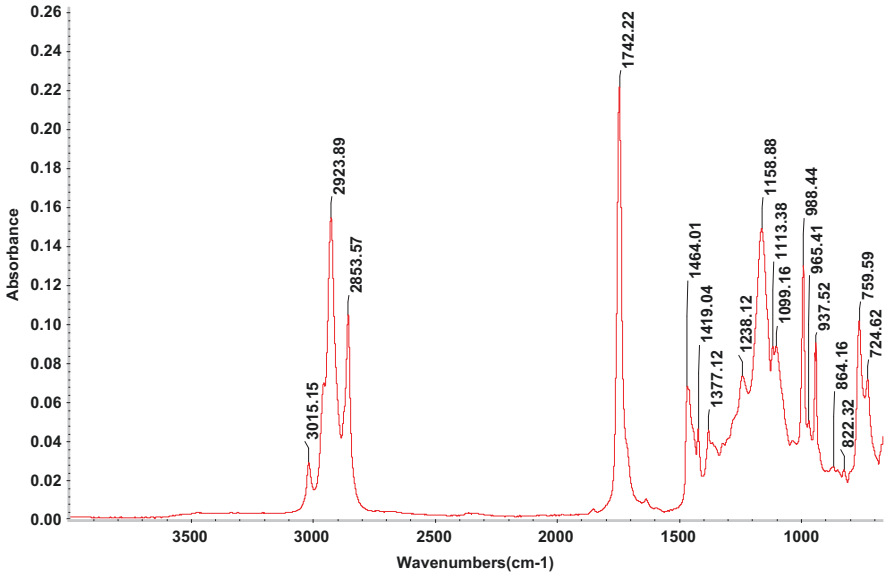

Fig. 37.3 FT-IR spectrum of pomegranate seed oil

corresponding to the α-eleostearic acid (*cis: trans*: *trans*). The corresponding doublet at 988 and 937 cm^{-1} in Fig. 37.3, confirmed the presence of CLNA in the pomegranate oil, in general these doublet bands are absent in vegetable oils.

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