

10.1. *CARISSA* L. nom. conserv.

Proximate Composition, Carbohydrates and Lipids

The fruits of *Carissa* species are edible. Glucose and galactose, as well as the amino acids serine, glutamine, alanine, valine, phenylalanine and glycine were detected in the fruit of *Carissa carandas* (Naim *et al.*, 1986). The fruits of *Carissa carandas*, from Bangladesh, contained substantial amounts of glucose and fructose and high dietary fiber (DF). The smaller amounts of water-soluble DF were mainly composed of uronic acid, arabinose and galactose. The larger amounts of water-insoluble nonstarch polysaccharides were mainly composed of residues of glucose, uronic acid, galactose, arabinose, and xylose. Starch content of the fruits was very low (Rahman *et al.*, 1991). The fruit of *Carissa macrocarpa* is rich in monounsaturated and essential fatty acids with the linoleic acid to α -linolenic acid ratio conforming to the recommended range for cardiac health (Moodley *et al.*, 2012). Analysis of mineral elements present in fruits, seeds and leaves of *Carissa opaca* showed that the plant has good quantities of K, Mg, Fe, Zn, Cu and Cr. The nutritional value of the fruits was 333.84 cal/100 g and they are a good source of fiber, lipids, protein and carbohydrates. The fruit of *Carissa opaca* is a good source of essential nutrients including minerals, carbohydrates, proteins and lipid. It contains moisture, 15.00; ash, 4.78; fiber, 13.55; fat 13.40; protein, 6.31 and carbohydrates, 47.00% (Ahmed *et al.*, 2010b, 2011). The following fatty acids were identified from seeds of *Carissa carandas*: palmitic (66.42%), stearic (9.36%), arachidic (21.19%), oleic (2.038%), and linoleic (0.99%) acids (Shrivastava and Bokadia, 1979).

Essential Oils and Terpenes

Steam distillation of the concrete, from the flowers of *Carissa carandas* gave 4.2% essential oil, which contained 2-phenylethanol 60.0, 1-octanol 3.0, linalool 8.0, and benzyl acetate 22.0 wt. % (Chandra, 1972). The volatile oils of the flowers of *Carissa carandas* L. and *Carissa grandiflora* DC, growing in Egypt, contain myrcene, limonene, camphene, Δ^3 -carene, dipentene, farnesol, nerolidol, dihydrojasnone, α -terpineol, methyl heptanone, linalyl acetate, geraniol and piperitone. *p*-Cymene and γ -terpineol were detected only in *Carissa grandiflora* oil, while *Carissa carandas* contains citronellal, β -ionone, menthol, neryl acetate, linalool and geranyl acetate (Zaki *et al.*, 1981b). One hundred and fifty compounds were identified in the aroma concentrate of *Carissssa carandas* fruits, growing in Cuba, of which isoamyl alcohol, isobutanol and β -caryophyllene were found to be the major constituents (Table 9) (Pino *et al.*, 2004). A total of 20 compounds, accounting for 99.5% of the essential oil of *Carissa opaca* were identified. The main component was palmitic acid (82.5%). Other major compounds were benzyl salicylate (6.0%), benzyl benzoate (4.6%) and (*E,E*)- α -farnesene (3.5%) (Rai *et al.*, 2006). Thirty-five compounds, representing 98.3% of the root essential oil of *Carissa opaca* Stapf ex. Haines, were identified. 2-Hydroxyacetophenone was characterized as the main component, amounting to 89.5% of the oil (Mallavarupu *et al.*, 2009).

Table 9. Chemical composition of flavour volatiles of *Carissa carandas* fruit (Pino *et al.*, 2004)

Compound	Concentration	Compound	Concentration
Acetic acid	0.56	(<i>E,Z</i>)-3,6-Nonadienol	0.13
Isobutanol	6.06	Benzyl acetate	< 0.01
Butanethiol	0.44	Borneol	< 0.01
Methyl butyrate	< 0.01	2-Ethylphenol	0.12
Isoamyl alcohol	6.65	Ethyl benzoate	< 0.01
2-methylbutanol	2.21	Nonanol	0.21
Amyl alcohol	0.56	Allyl heptanoate	< 0.01
Butyric acid	0.22	Terpinen-4-ol	0.08
(<i>Z</i>)-2-Hexenol	0.35	Octanoic acid	0.22
2-Methylpentanol	0.25	<i>p</i> -Methylacetophenone	< 0.01
Furfural	1.02	<i>p</i> -Cymen-8-ol	0.09
Isovaleric acid	0.18	α -Terpineol	0.51
Furfuryl alcohol	0.12	Methyl salicylate	0.92
(<i>E</i>)-2-Hexenal	0.12	Ethyl octanoate	0.31
(<i>Z</i>)-3-Hexenol	0.13	Decanal	0.11
Hexanol	0.41	α -Ionene	0.10
Isoamyl acetate	1.99	(<i>E,E</i>)-2,4-nonadienal	0.10
Styrene	0.06	<i>trans</i> -carveol	< 0.01
Cyclohexanol	0.80	Benzothiazole	0.13
2-Heptanol	< 0.01	3-Phenylpropanol	0.18
γ -Butyrolactone	< 0.01	Cuminaldehyde	0.19
Methyl hexanoate	0.08	Carvone	0.04
α -Pinene	< 0.01	Methyl carvacrol	0.03
Heptanol	0.35	Ethyl phenylacetate	0.12
(<i>Z</i>)-2-Hexenyl acetate	0.07	2-Phenylethyl acetate	0.61
β -Pinene	< 0.01	(<i>E</i>)-2-Decenal	0.05

Table 9. Chemical composition of flavour volatiles of *Carissa carandas* fruit (cont.)

Compound	Concentration	Compound	Concentration
Methyl furoate	< 0.01	Ethyl salicylate	0.55
Phenol	0.20	4-ethylguaiacol	0.42
2-Octanone	< 0.01	(<i>E</i>)-Anethole	0.37
Myrcene	0.25	Bornyl acetate	0.35
Ethyl hexanoate	2.22	Safrole	0.14
(<i>Z</i>)-3-Hexenyl acetate	0.06	Indole	0.05
Hexyl acetate	0.23	Thymol	0.07
α -Terpinene	0.05	4-Vinylguaiacol	0.37
<i>p</i> -Cymene	0.45	(<i>E,Z</i>)-2,4-Decadienal	0.04
Limonene	3.20	4-Ethylveratrole	0.08
1,8-Cineole	< 0.01	Allyl phenylacetate	0.14
Benzyl alcohol	0.18	Benzyl butyrate	0.03
Cyclohexyl acetate	1.22	Eugenol	0.11
Propylbenzene	0.13	δ -Nonalactone	0.10
Ethyl furoate	< 0.01	Benzyl isothiocyanate	0.10
Isomyl butyrate	< 0.01	Neryl acetate	0.10
γ -Terpinene	0.52	Dihydroeugenol	0.06
Acetophenone	0.07	Hydrocinnamyl acetate	0.04
Octanol	0.13	Decanoic acid	0.14
<i>p</i> -Tolualdehyde	0.10	Ethyl (<i>Z</i>)-cinnamate	< 0.01
Terpinolene	0.28	(<i>E</i>)- β -Damascenone	0.35
<i>p</i> -Cymenene	0.01	β -Elemene	0.55
<i>o</i> -Guaiacol	0.40	Benzyl isovalerate	0.11
Methyl benzoate	3.03	Ethyl decanoate	0.11
2-Nonanone	0.20	(<i>Z</i>)-isoeugenol	< 0.01
Linalool	0.20	α -Cedrene	0.19
Nonanal	0.16	β -Caryophyllene	5.94
2-Phenylethanol	1.71	<i>trans</i> - α -Bergamotene	0.09
Isophorone	0.10	Benzyl valerate	0.19
Methyl octanoate	0.10	(<i>E</i>)-Isoeugenol	0.14
Benzyl cyanide	0.10	α -Humulene	0.35
4-Oxoisophorone	0.03	<i>allo</i> -Aromadendrene	0.08
<i>cis</i> - β -Terpineol	0.04	Ethyl (<i>E</i>)-cinnamate	0.18
Veratrole	< 0.01	Geranyl propionate	0.16
(<i>Z</i>)-3-nonenol	0.17	<i>ar</i> -Curcumene	0.23
(<i>E</i>)- β -Ionone	0.22	Humulene epoxide II	0.08
α -Selinene	0.29	α -Bisabolol	0.06
α -Zingiberene	0.18	Tetradecanoic acid	0.08
Germacrene A	0.16	Ethyl tetradecanoate	0.02
β -Bisabolene	0.57	Pentadecanoic acid	0.07
γ -Cadinene	0.20	Methyl hexadecanoate	0.11
α -Calacorene	0.01	Palmitoleic acid	0.28
3,4-Dihydro-8-hydroxy-3-methylisocoumarin	1.61	Hexadecanoic acid	4.36
(<i>E</i>)-Nerolidol	< 0.01	Ethyl hexadecanoate	0.57
		Methyl linoleate	0.12

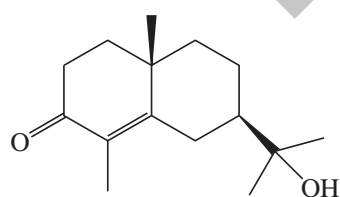
Table 9. Chemical composition of flavour volatiles of *Carissa carandas* fruit (cont.)

Compound	Concentration	Compound	Concentration
Caryophyllene alcohol	0.30	Methyl oleate	0.14
Dodecanoic acid	0.35	Oleic acid	2.20
Cayophyllene oxide	0.21	Ethyl linoleate	0.70
Viridiflorol	0.29	Ethyl oleate	1.55
Ethyl dodecanoate	0.18		

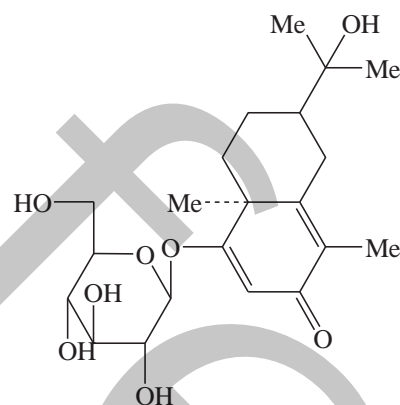
Sesquiterpenes

The following are examples of sesquiterpenes identified from some *Carissa* species:

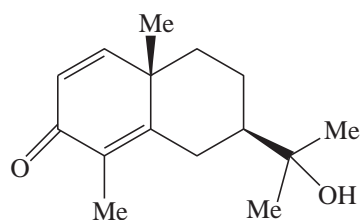
1. *Carissa carandas* L.: Carissone (**978**) (Rizk and Al-Nowaihi, 1989) and carandoside (**979**) from the stems (Wangteeraprasert and Likhitwitayawuid, 2009).
2. *Carissa congesta* Wight (syn. *Carissa carandans* Auct.): Carissone from the roots (Joshi and Boyce, 1957).
3. *Carissa grandiflora* DC. (Natal-plum): Carissone from the plant growing in Egypt (Zaki *et al.*, 1981a).
4. *Carissa lanceolata* R. Br. (conkerberry): Three eudesmanes, carissone, dehydrocarissone (**980**) and carindone (**981**) were isolated from the wood (Lindsay *et al.*, 2000). Carissone from roots (Mohr *et al.*, 1954; Hettiarachchi *et al.*, 2011).



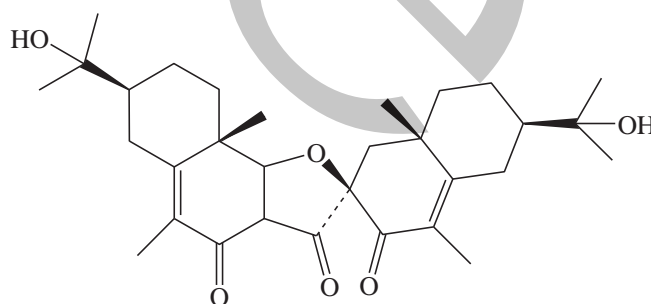
978 Carissone



979 carandoside



980 Dehydrocarissone

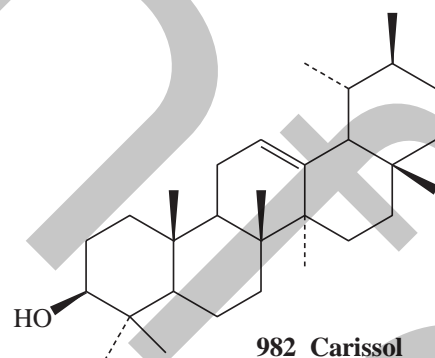


981 Carindone

Triterpenenes and Sterols

The following are examples of triterpenes and sterols identified in some *Carissa* species:

1. *Carissa bispinosa*: Ursolic acid from the leaves of the plant growing in Egypt (Motawi and Hammouda, 1962).
2. *Carissa carandas* L.: Ursolic acid, lup-12,20(29)-dien-3 β ,28-diol and urs-12-ene-3 β ,22 β -diol (Hegde *et al.*, 2009a), lupeol, 16 β -hydroxybetulinic acid and α -amyrin (Hegde and Joshi, 2010a) from the roots; lupeol from the flowers (Chandra, 1972); carissol (**982**, an epimer of α -amyrin) and carissic acid (an isomer of ursolic acid) from the fruits and leaves (Naim *et al.*, 1985, 1988); carissin (3 β -hydroxy-27-*E*-feruloyloxyurs-12-en-28-oic acid), 3- β -hydroxy-27-*p-E*-coumaroyl-oxyurs-12-en-28-oic acid, oleanolic acid and ursolic acid from the leaves (Siddiqui *et al.*, 2003b); methyl ursolate (Pakrashi *et al.*, 1968) and carindone (a C₃₁-terpenoid) (Zaki *et al.*, 1981a); β -sitosterol and β -sitosterol glucoside from the roots (Hegde and Joshi, 2010a).
3. *Carissa congesta* Wight: Carissone, carindone, lupeol, ursolic acid, and its methyl ester, stigmasterol from the roots (Ganapaty *et al.*, 2010) and β -sitosterol D-glucoside (Joshi and Boyce, 1957).
4. *Carissa grandiflora* DC. (Natal-plum): Lupeol, ursolic acid and carindone and β -sitosterol from the plant growing in Egypt (Zaki *et al.*, 1981a,b).
5. *Carissa macrocarpa*: β -Amyrin, methyl oleanolate, oleanolic acid and 3 β -hydroxyolean-11-en-28,13 β -olide from the fruits (Moodley *et al.*, 2011).



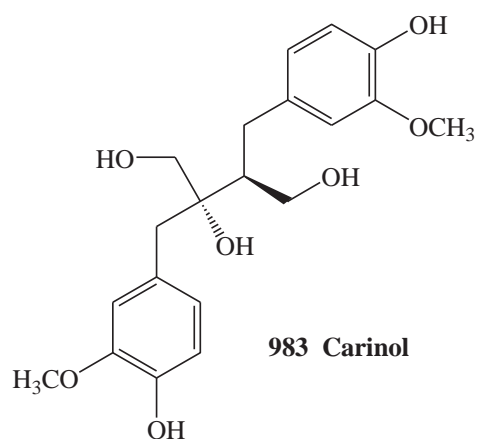
Cardiac Glycosides

The following are examples of cardiac glycosides identified from some *Carissa* species:

1. *Carissa acokanthera* (Winter sweet): Significant amounts of immunoreactive cardiac glycosides were present in the shrub (Radford *et al.*, 1986).
2. *Carissa carandas*: Odoroside, digitoxigenin, 14,15-anhydrodigitoxigenin (together with glucose and D-digitalose) were identified from the hydrolysis of the polar glycoside (Rastogi *et al.*, 1967).
3. *Carissa lanceolata* R. Br.: Odoroside H from the roots (Mohr *et al.*, 1954).
4. *Carissa ovata* (R. Br.) var. *stolonifera* F. M. Bailey: Odoroside H from the roots (Mohr *et al.*, 1954).
5. *Carissa spectabilis* (Bushman's poison): Significant amounts of immunoreactive cardiac glycosides were present in the shrub (Radford *et al.*, 1986).

Lignans

Carinol (**983**) was identified from *Carissa carandas* (Pal *et al.*, 1975). Another lignan, identified as (6*S*,7*R*,8*R*)-7- α [(β -glucopyranosyl)oxyl] lyoni-resinol, together with three other lignans were isolated from the stems of *Carissa carandas* (Wangteeraprasert and Likhitwitayawuid, 2009).



Other Constituents

1. *Carissa carandas*: Five compounds, probably aromatic amides from the roots (Malipatil *et al.*, 2009); oxalic acid in the leaves (Kaushik, 1983); caffeic acid from the plant growing in Egypt (Zaki *et al.*, 1981a); and cyanidin-3-rhamnoglucoside (Iyer and Dubash, 1993).
2. *Carissa grandiflora*: Caffeic acid (Zaki *et al.*, 1981a).
3. *Carissa lanceolata* R.Br.: 2'-Hydroxyacetophenone from the roots (Hettiarachchi *et al.*, 2011).