7. 4.11. ***Amaranthus viridis*** L., Sp. Pl., ed. 2, 1405 (1763); Boulos, Fl. Egypt 1: 135 (1999).
Syn. *Amaranthus gracilis* Poir. In Lam., Encycl. Suppl. 1: 312 (1810).

Proximate Composition, Carbohydrates and Proteins

Amaranthus viridis is a rich source of proteins (38.5 %), and the biological value (75.6) indicated that it could be used as a source of good quality protein with a digestibility of about 80 % (Kidwai *et al*., 1969). The proximate composition and amino acids of *Amaranthus viridis*, growing in Egypt are shown in Tables 38 and 39. Ezeala (1985), reported that the leaves of *Amaranthus viridis* were composed of crude protein, 32.2; fiber, 11.2; fat, 3.68; ash, 18.7 %; and a gross energy of 4.19 Kcal/g (all on dry matter basis). The leaves of

Amaranthus viridis were superior to those of *Amaranthus caudatus* in the cholorophyll and carotene contents and vitamin A potency. There were very high P concentrations in both leaves, with the value in *Amaranthus viridis* about 18 % higher than in *Amaranthus caudatus*. *Amaranthus viridis*, growing in Qatar contained 7.3% lipids and 15.10% ash. The minerals (ppm) of the same sample were Na, 0.036; Fe, 0.126; Ni, 0.006; Mn, 0.178; Al, 0.00638; Co, 0.021; Cu, 0.010, Mg, 0.95; Si, 7.89; and Cr, 0.13 (Al-Easa *et al*., 2003). The mineral content of *Amaranthus viridis*, growing in Niger, was as follows: Ca, 27,400; Cr, 9.30; Cu, 8.50; Fe, 687; K, 65,000; Mg, 14,700; Mn, 39.4; Mo, 7.50; Na, 1,160; Ni, 6.10; P, 3,910; Se, 19.3; and Zn, < 5.0 μg/g dry weight. The plant contains also significant amounts of selenium. High concentrations of P were also reported in the leaves (Ezeala, 1985; Freiberger *et al*., 1999). *Amaranthus viridis*, growing in Zaire contains 24.3 ng/g weight selenium. The leaves are rich in K, Mg, Fe, Mn and Cu (Umar *et al*., 2011). The detection of these minerals as well as others has been reported by several others (e.g. Onyamboko *et al*., 1990; Hussain *et al*., 2009; Bhadur *et al*., 2011; Singh *et al*., 2011b; Srivastava, 2011; Umar *et al*., 2011). There are several reports on the accumulation of heavy metals in the plant and its potential and practical use in phytoremediation (Yusuf and Oluwole, 2009; Lu *et al*., 2010; Malik *et al*., 2010; Aurangzeb *et al*., 2011; Sainger *et al*., 2011).

The proximate composition, amino acids and carbohydrates of *Amaranthus gracilis* are given in Tables 13, 26-28 and 51. Table 61 summarises the proximate composition of *Amaranthus viridis*. The leaves had calorific value (530.34 kcal/100g) (Umar *et al*. 2011). Also, the starch characteristics as well as the oxalate and phytic acid content of the seeds are shown in Tables 42 and 52.

Table 61. Proximate composition of *Amaranthus viridis*

Plant part	Protein %	Fat %	Crude fiber %	Ash %	Carbohydrates %
Leaves [1]	16.41	1.83	10.13	22.84	52.68
Leaves [2]	35.11	5.26	14.04	21.05	24.54
Leaves [3*]	7.85				10.29
Aerial parts [4]	31.19		15.21	18.42	40.86
Seeds [5]	12.18-14.90				

1. Hussain *et al*. (2009); 2. Umar *et al*. (2011); 3. Srivastava (2011); 4. Bahadur *et al*. (2011); 5. Srivastava and Roy (2012).
* mg/100 gm fresh weight.

Ascorbic and dehydroascorbic acids of *Amaranthus viridis*, growing in Spain, were reported as very high (15.4 mg/100 g). Vitamin C was earlier found to be 35.1 mg % in leaves of the plant growing in Brazil (Wasicky and Ferreira, 1951). The nitrate content of the same sample was 597 mg/100 g (Guil *et al*., 1997). The vitamins and antinutrients of the leaves of the plant growing in Spain were as follows: moisture, 81.17 ± 3.12 g; ascorbic acid, 103 ± 35; dehydroascorbic acid, 36 ± 9; carotenoids, 15.4 ± 4.1; oxalic acid 960 ± 220; and nitrate 597 ± 67 mg/100 g plant (Guil *et al*., 1997). The mean provitamin content per 100 g of edible portion was 640 retinol/equivalent for *Amaranthus viridis* growing in Netherlands (Hulshof *et al*., 1997). Carotenoids of *Amaranthus viridis*, growing in Brazil, were 4.0 g/100 g (Mercadante and Rodriguez-Amaya, 1990) and 11.5 mg/g for the plants growing in India. The relative bioavailability of β-carotene from the leaves of *Amaranthus viridis* was 16% (Graebner *et al*., 2004). *Amaranthus viridis*, growing in India contained 1,100 oxalic acid and 680 nitrate mg/100 g plant (Prakash and Pal, 1991). Raju *et al*. (2006) reported the carotenoid

composition of the leaves as follows: neoxanthin, 12.63; violaxanthin, 84.06; lutein, 90.43; zeaxanthin, 1.04; α- carotene, 6.75 and β- carotene, 58.95 mg/100 g dry weight.

In quantitative and qualitative terms, *Amaranthus viridis* was found to be an excellent source of protein. Its amino acid composition compared favourably to that of World Health Organization (WHO) for protein standard (Sena *et al*., 1998). The mean value of amino acid concentrations of *Amaranthus viridis*, growing in Egypt is shown in Table 39. The leaves of *Amaranthus viridis*, growing in Niger contained 18.4% protein; the amino acid composition of which was as follows: aspartate, 13.3; glutamate, 23.27; serine, 9.12; glycine, 9.65; histidine, 3.75; arginine, 13.7; threonine, 9.16; alanine, 10.6; proline, 10.7; tyrosine, 8.94; valine, 11.9; methionine, 2.11; isoleucine, 8.78; leucine, 16.1; phenylalanine, 10.5; lysine, 9.94; cysteine, 3.96; and tryptophan, 8.11 mg/g dry weight (Freiberger *et al*., 1998). The amino acids composition the leaves of *Amaranthus* viridis, growing in Egypt and Nigeria is shown in Table 39 and 62.

A lectin was isolated from the seeds of *Amaranthus viridis*, growing in India.The lectin have a native molecular mass of 67 kDa. It is a homodimer composed of 36.6 kDa subunits. The purified lectin was specific for both T-antigen and *N*-acetyl-D-lactosamine, markers for various carcinomas, in addition to *N*-acetyl-D-galactosamine, asialofetuin and fetuin. The lectin reacted strongly with red blood cells (RBCs) from human ABO blood groups and rat. It also reacted with rabbit, sheep, goat and guinea pig RBCs. The lectin is a glycoprotein having no metal ion requirement for its activity (Kaur *et al*., 2006).

Table 62: Amino acids composition of *Amaranthus viridis* leaves*

Amino acid	Concentration (g/100 Protein)
Lysine	3.65 ± 0.09
Histidine	2.00 ± 0.05
Arginine	4.37 ± 0.11
Aspartic acid	8.78 ± 0.23
Threonine	4.22 ± 0.11
Serine	1.95 ± 0.05
Glutamic acid	9.02 ± 0.23
Proline	2.31 ± 0.06
Glycine	3.34 ± 0.09
Alanine	4.12 ± 0.11
Cysteine	0.92 ± 0.04
Valine	3.99 ± 0.10
Methionine	0.95 ± 0.02
Isoleucine	4.13 ± 0.11
Leucine	7.81 ± 0.20
Tyrosine	3.39 ± 0.09
Phenylalanine	3.89 ± 0.10

* Umar *et al*. (2011)

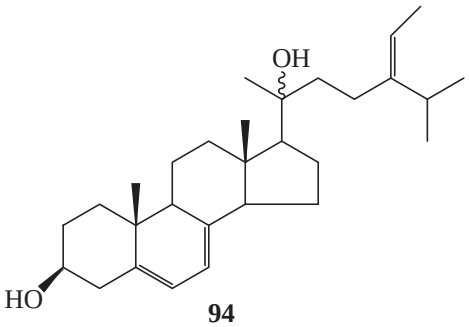
The seeds of *Amaranthus viridis* had a very low starch yield (2.0%) as compared with other *Amaranthus* species (Table 18). The thermal and textural properties of the starch are shown in Tables 48 and 49 (Wu and Corke, 1999).

Pharmacognostic evalution of the plant has been reported (Khan *et al*., 2011b).

Lipids

The lipid of *Amaranthus viridis*, growing in Egypt amounted to 8% of the air dried plant. The fatty acids (50% of the lipid) identified in the plant are: caproic (hexanoic), 0.24; caprylic (octanoic), 15.38; capric (decanoic), 1.09; lauric ($C_{12:0}$), 0.35; myristic, ($C_{14:0}$); palmitic ($C_{16:0}$), 19.42; Δ^9 oleic ($C_{18:1}$), 25.49; $\Delta^{6,9}$ linoleic ($C_{18:2}$), 20.67; $\Delta^{3,6,9}$ linolenic ($C_{18:3}$), 1.39; arachidic ($C_{20:0}$), 3.67; and behenic ($C_{22:0}$), 1.90 % of the total fatty acids (El-Hossary *et al*., 2000a). The total lipids of *Amaranthus viridis*, growing in Spain, amounted to 0.29 % of the fresh weight of which the fatty acids represented 85.93 %. The fatty acids identified in the same sample were: $C_{14:0}$, 0.78; $C_{16:0}$, 21.08; $C_{16:3\omega6}$, 0.401; $C_{16:2\omega6}$, 0.35; $C_{16:1\omega7}$, 1.59; $C_{18:0}$, 3.30; $C_{18:3\omega3}$, 24.34; $C_{18:2\omega6}$, 20.24; $C_{18:1\omega7}$, 0.33; $C_{18:1\omega9}$, 8.60; $C_{20:0}$, 0.57; $C_{20:5\omega6}$, 0.24; $C_{22:0}$, 1.75; and $C_{24:0}$, 1.18 (Guil *et al*., 1996). The fatty acids identified by Freiberger *et al*. (1999) from the leaves of *Amaranthus viridis*, growing in Niger were : $C_{16:0}$, 5.26; $C_{18:0}$, 0.72; $C_{18:1n9}$, 0.72; $C_{18:2n6}$, 0.70; $C_{18:3n3}$, 3.83; and $C_{20:0}$, 15.2 mg/g. The leaves of *Amaranthus viridis*, growing in Pakistan contain 12.521 % lipids, which were separated into neutral lipids (6.825 %) and phospholipids (2.732 %) (Khan and Khan, 1989). The latter authors identified the following fatty acids from the leaves: capric, 1.67; lauric, 2.16; myristic, 1.6; palmitic, 77.8; stearic, 4.63; and oleic, 1.85 %. *Amaranthus viridis*, growing in Spain, has been reported as a rich source of essential fatty acids ($C_{18:2\omega6}$ and $C_{18:3\omega3}$) and carotenes (Guil-Guerrero and Rodriguez-Garcia, 1999). The total fatty acid contents in the young leaves of nine wild edible plants (including *Amaranthus viridis*) growing in Australia ranged from 8.75 to 29.12 mg/g of dry matter and were predominantly comprised of alpha-linolenic acid (4.78 - 19.88 mg/g). The plants did not contain any of the longer-chain omega-3 fatty acids namely eicosapentaenoic acid, docasahexaenoic acid or docasapentaenoic acid.

24-Ethyl-22-dehydrolathosterol (24-ethyl-5α-cholesta-7, *trans*-22-dien-3β-ol, spinasterol) was the predominant component of the 4-demethylsterol fraction separated from the plant. The other identified sterols were three Δ^7-sterols (24-methyllathosterol, 24-methyl-22-dehydrolathosterol and 24-ethyllathosterol) and two Δ^5-sterols (24-ethylcholesterol and 24-ethyl-22-dehydrocholesterol) (Behari *et al*., 1986). The sterols and hydrocarbons isolated from *Amaranthus viridis*, growing in Egypt are: cholesterol, stigmasterol, β-sitosterol, *n*-octadecane ($C_{18}H_{38}$), *n*-nonadecane ($C_{19}H_{40}$), *n*-eicosane ($C_{20}H_{42}$), *n*-heneicosane ($C_{21}H_{44}$), *n*-docosane ($C_{22}H_{46}$), *n*-tricosane ($C_{23}H_{48}$), *n*-tetracosane ($C_{24}H_{50}$), *n*-hexacosane ($C_{26}H_{54}$), *n*-heptacosane ($C_{27}H_{56}$), *n*-octacosane ($C_{28}H_{60}$), squalene ($C_{30}H_{50}$), *n*-tricontane ($C_{30}H_{62}$), and ditricontane ($C_{32}H_{66}$). Squalene, *n*-hexacosane and *n*-tetracosane were the main hydrocarbons representing 17.45, 10.61 and 7.33 % of the unsaponifiable matter. Moreover, the following four compounds were isolated from the chloroform extract of the plant: 8-*n*- hexyl-heptacosane-1-ol, α-spinsterol-β-D-glucoside, 3-*O*-β-D-glucopyranosyl-2β,3β-dihydroxy-oleanolic acid and 3-*O*-β-D-glucopyranosyl- 2β-, 3β-dihydroxy-30-norolean-12.20(29)diene-23,28 dioic acid (El-Hossary *et al*., 2000a). Amasterol (**94**) ($C_{28}H_{44}O_2$, m.p. 170°C), an ecdysone precursor and a growth inhibitor was isolated from the roots of the plant (Roy *et al*., 1982).



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REPRINT

Flavonoids and Other Constituents

The following flavonoids have been identified from *Amaranthus viridis*, growing in Egypt: kaempferol 3-glucoside-7-rhamnoside, quercetin 3-glucoside-7-rhamnoside, 3,4'-dihydroxyflavone-7-glucoside, isorhamnetin 3-rutinoside, 3-hydroxyflavone-7,4'-diglucoside, daidzein 7-galactoside, and afrormosin 7-glucoside (Kawashty *et al*., 1999), quercetin, isoquercetin and rutin (El-Hossary *et al*., 2000b; Kumar *et al*., 2009b). The betacyanins and betaines identified in *Amaranthus viridis* are shown in Tables 25 and 35.

The plant contains saponin (0.4%). A triterpenoid saponin was identified as 30 β-D-glucopyranosyl-2β,3β-dihydroxyolean-12-en-28-oic acid-28-*O*-β-D-gluco-pyranosyl ester (El-Hossary *et al*., 2000b).

The trypsin-inhibitor content of *Amaranthus viridis* leaves amounted to 1.43 μg/mg dry weight of plant and its heat resistance was 100% (Vanderjagt *et al*., 2000).

Dabho'kar (1959) studied the buffer-index of the root sap of *Amaranthus viridis* and found that it can be considered as indicator of slightly alkaline soils, in addition to its role as indicator of soil rich in N.

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