8.2.2. ***Pancratium maritimum*** L., Sp. Pl., ed. 1, 291 (1753); Boulos, Fl. Egypt 4: 87 (2005).

Susan and burraid

The bulbs are often transferred into gardens and cultivated as ornamental plant under the name of *Pancratium aegyptiacum* (Rizk, 1963).

Proximate Composition, Carbohydrates, and Lipids

The proximate composition of the different parts of the plant is shown in Table 6. The different parts of *Pancratium maritimum* contain the same sugars and amino acids detected in *Pancratium arabicum* (8.2.1). The different parts of the plant contain mucilage (β-D-glucan type) in different percentages (Table 7). Karawya *et al*. (1980) reported that the bulbs contain 8.6 % cold- water extracted mucilage and 11.0 % hot-water extracted mucilage which contains a large amount of glucose along with arabinose and galacturonic acid. Sodium alginate was detected in the bulbs (Sanaa *et al*., 2010). The amino acids indentified in the plant were the same as those of *Pancratium arabicum* (8.2.1). The fatty acids of the different lipid fractions are shown in Tables 9 and 10. The unsaponifiable matter of the lipids yielded ceryl alcohol, 1,21-heneicosanediol and β-sitsterol (Rizk, 1963; Ahmed *et al*., 1964).

Alkaloids

Several alkaloids have been identified from the different parts of *Pancratium maritimum*, growing in Egypt and other countries (Table 11). *Pancratium maritimum* has been extensively studied and, consequently, over half of all of the alkaloids isolated from *Pancratium* species have been identified in this species (Cedrón *et al*, 2010). In addition to the phanthridine alkaloids (common to the family Amaryllidaceae), *Pancratium maritimum* contains betaine-type alkaloids e.g. zefbetaine and phenylalkylamine alkaloids e.g. hordenine. The alkaloids from the different parts of *Pancratium maritimum* showed the same qualitative picture but differed quantitatively (Table 10) (Ahmed *et al*., 1964). De Larentis (2007) evaluated the chemical composition of *Pancratium maritimum* (bulbs and roots) harvested in two different parts in Italy. Relevant differences were identified in alkaloidal content respectively of bulbs and roots; differences were also identified in plants gathered from the two regions. Sandberg and Michel (1963a) studied the alkaloidal constituents of the different organs of *Pancratium maritimum* (bulbs, stems, roots, seeds, and seed capsules) growing in 8 various parts of the Mediterranean region, using TLC. The maximum number of alkaloids in any one plant part was 37, the minimum 14. Nine alkaloids were isolated *viz.* lycorine, hemanthidine, tazettine, vittatine, hordenine and 4 unidentified ones. Different plant parts and plants from different habitats showed qualitative and quantitative differences of alkaloid content. Plants from Egypt and Rhodes cultivated in Stockholm produced offspring having much closer resemblances than would be expected from the different environment, indicating the presence in this species of chemical races (Sandberg and Michel, 1963a). Galanthamine content reaches its maximum in bulbs of *Pancratium maritimum*, growing in Georgia at the end of the vegetation period (Kintsurashvili and Vachnadze, 2007). The flowers of the plant contain two nitrogenous bases, thymine and uracil (Youssef, 1999).

Haemanthamine was the main alkaloid in the leaves and bulbs of *Pancratium maritimum*, whereas galanthamine was found to be the main alkaloid in roots (Berkov *et al*., 2004b). The amount of lycorine ranged between 0.05-0.14% (Kaya *et al*., 2010a). There are several reports on the analysis (e.g. Konukol and Sener, 1992), mass spectra (Wildman and Brown, 1968), crystal and molecular structures (Ide *et al*., 1996-1998) of the alkaloids isolated from *Pancratium maritimum.*

Table 11. Alkaloids of *Pancratium maritimum*

Country origin	Plant part	Alkaloids	References
1. Egypt	B	Lycorine homolycorine, hemanthidine, tazettine, lycorenine, demethylhomolycorine, pancratine, galanthamine, sickenbergine and narciclasine-4-*O*-β-D-glucopyranoside	Sandberg (1961); Sandberg and Agurell (1959, 1963); Rizk (1963); Ahmed *et al.* (1964);
		Lycorine, tazettine, pancracine, hippadine, ungermine, and zefbetaine	Abou-Donia *et al.* (1991)
		Acetyllycoramine, N-demethyllycoramine, crinine, pancritamine and	Ali *et al.* (1984c); Abou-Donia *et al.* (1992)
	F	Pancratistatin	Youssef (1999, 2003)
	F	Lycorine, maritidine, lycoramine, and galanthamine	Youssef and Frahm (1998)
2. Bulgaria	L, B,	Trispheridine, graciline, galanthamine, *N*-demethylgalanthamine, α-Dihydrocaranine, crinine, 6α-deoxytazettine, galanthane, Demethylmarithidine, haemanthamine, tazettine, pancracine, lycorine, *N*-formylgalanthamine, buphanisine and crinane-3-one.	Berkove *et al.* (2004b)
3. France	B	Lycorine	Du Merác (1954a)
4. Israel		Pancratistatine	Pettit *et al.* (1995b)
5. Italy	B	Lycorine and tazettine	Amico *et al.* (1972)
6. Russia	T	Lycorine, pancratine and tazettine	Proskurnina (1955a,b)
7. Spain		Lycorine, hippeastrine, galanthamine, hemanthamine, hamanthidine, vittatine, 11-hydroxyvittatine, 9-*O*-demethylhomolycorine, 6-*O*-hemanthidine, *O*,*N*-dimethylnorbelladine, habranthine, ungiminorine, ungiminorine *N*-oxide and hordenine	Suau *et al.* (1988); Vazquez *et al.* (1988)

Table 11. Alkaloids of *Pancratium maritimum* (cont.)

Country origin	Plant part	Alkaloids	References
8. Turkey	B	Lycorine, (+)-9-*O*-demethylhomolycorine, (+) hemanthamine, (+)-buphanisine, (-)-crinine, (-)-3β-methoxy-6α,β-dihydroxy-1,2-dehydrocrinane, (-)-6,11α,β-dihydroxy-3-methoxy-1,2-dehydrocrinane, 2(-)-3β,11α-dihydroxy-1,2-dehydrocrinane, (-)-8-hydroxy-9-methoxycrinine, *N*-demethylgalanthamine, tazettine, and (-)-2-*O*-demethylmontanine	Sener *et al.* (1993a, 1994, 1998b)
		Trisphaeridine	Sener *et al.* (1993b)
	Ap	(-)-3β,11α-Dihydroxy-1,2-dihydrocrinane and (-)-8-hydroxy-9-methoxycrinine	Sener *et al.* (1993c)
9. ….	….	Lycorine, tazettine and hippeastrine	Boit and Ehmke (1956b)
10…..	….	Norpluviine, pseudolycorine, tyramine, *N*-methyltyramine, hemanthamine, dehydrolycorine and hordenine	Sandberg and Michel (1963b, 1968)

Ap: aerial parts; B: bulbs; F: Flowers; L: leaves T: tuber

Biosynthesis

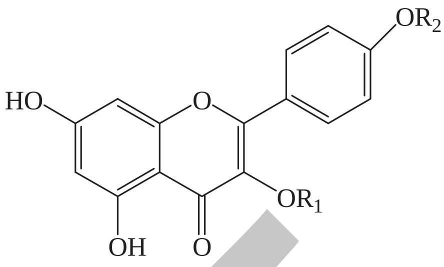
Narciclasine (**4**) was shown to be derived from vittatine (**75**) in *Pancratium maritimum* by feeding experiments (Fuganti and Mazza, 1972). Feeding experiments with specifically labeled 11-hydroxyvittatine showed its intermediacy in the biosynthesis of the lactam narciclasine. ^{3}H-labelled 11-hydroxyvittatine was obtained from *Pancratium maritimum* in several feeding experiments with *O*-methylnorbelladine-3',5'-$^3H_2$ (Fuganti, 1973). Although direct proof of the labeling pattern of 11-hydroxyvittatine was not achieved owing to the paucity of cold material available for special degradation, the tritium label was assigned to positions 2 and 4 in equal amounts, because using *O*-methylnorbelladine-3',5'-$^3H_2$,*1*-^{14}C as precursor, no tritium loss in 11-hydroxyvittatine was observed, as in vittatine, for which the aforementioned labeling pattern was demonstrated. *Pancratium maritimum* incorporated ^{3}H-labeled 11-hydroxyvittatine into narciclasine (5.5% incorporation) and into hemanthidine (3 % incorporation). The evidence which establishes the intermediacy of 11-hydroxyvittatine in the biosynthesis of the lactam narciclasine confirms the significance of hydroxylation beta to the *N* in the degradation of the alkaloidal skeletons and experimental indicates step in the biosynthetic route leading from *O*-methylnorbelladine to narciclasine with loss of the ethano bridge from the intermediates with the crinane skeleton (Fuganti, 1973).

Berkov *et al*. (2010) demonstrated that alkaloid synthesis in *Pancratium maritimum* is closely related with tissue differentiation. The highest amounts of alkaloids and presence of homolycorine and tazettine type compounds (end products of the biosynthetic pathway of the Amaryllidaceae alkaloids) were found in highly differentiated tissues. Galanthamine accumulated in the leaves of plantlets. The amount of hordenine, a proto-alkaloid, is related with the ability of tissues to synthesize alkaloids. Saturated fatty acids were found in considerably higher levels in undifferentiated callus cultures and partially differentiated shoot-clumps than in regenerated plants. Mono- and dienoic fatty acids were found at higher levels in non-photosynthesizing tissues, calli, and *in vitro* and intact bulbs, while α-linolenic acid (trienoic acid) was found in higher amounts in the photosynthesizing leaves of shoot-clumps and regenerated plants than in bulbs and calli. Fatty alcohols were found mainly in leaves, while sterols tended to accumulate in photosynthesizing and undifferentiated tissues.

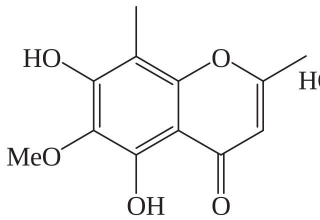
Other Secondary Metabolites

Eighteen compounds representing 77.73% of the total oil were identified from floral volatiles of thirteen populations of Tunisian *Pancratium maritimum* L. (sea daffodil), growing wild in mainland and island habitats. The major components at the species level were heptacosane (12.07%), hexadecanoic acid (11.91%), benzyl benzoate (8.17%), octacosane (8.13%), and hexacosane (7.28%). Volatile composition varied highly among populations. Four chemotypes could be reported in the Tunisian *Pancratium maritimum* populations (Sanaa *et al*., 2012). Two flavonoids were isolated from the aerial parts of *Pancratium maritimum*, growing in Egypt and were identified as kaempferol 3-*O*-xyloside (**147**) and kaempferol 3,4'-di-*O*-xyloside (**148**) (Ali *et al.*, 1981a). The bulbs contain the following chromones and flavans: 5,7-dihydroxy-6-methoxy-2,8-dimethylchromone (**149**), 5,7-dihydroxy-2-methylchromone, 5-hydroxy-7-methoxy-2-methylchromone, 4-hydroxy-5,7-dimethoxy-8-methylflavan and 4-hydroxy-7-methoxyflavan (Ali *et al.*, 1990b). The fresh flowering bulbs of *Pancratium maritimum* yielded martimin (7-hydroxy-5-methoxy-2-methylchromone) (a chromone), three flavonoids: syzalterin, (6, 8-dimethyl-5, 7, 4'-trihydroxyflavone) (-)-farrerol (6, 8-dimethyl-5, 7, 4'-trihydroxyflavone) and liquiritigenin, (7, 4'-dihydroxyflavanone) a chalcone (isoliquiritigenin) (4, 2', 4'-trihydroxychalcone) (**150**) and two polyoxygenated acetophenones (Youssef *et al*., 1998).

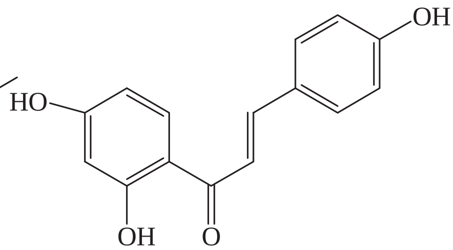
Six phenolic acids viz. protocatechuic, 4-hydroxybenzoic, vanillic, caffeic, *p*-coumaric, and ferulic acids were identified in *Pancratium maritimum* (Nikolova and Gevrenova, 2005). 3-Caffeoylquinic acid was isolated from the flowers of the plant (Youssef, 2003).



147 R_1=xyloside,R_2=H
148 R_1R_2=xyloside



149 5.7-dihydroxy-6-methoxy -2,8-dimethylchromone



150 Isoliquiritigenin