Afyon Kocatepe Üniversitesi
FEN BİLİMLERİ DERGİSİ

7 (1)
35-48

Afyon Kocatepe University
JOURNAL OF SCIENCE

CAPPARIS SPINOSA L. (CAPPARIDACEAE) : A REVIEW

Merve POLAT

Education Faculty of Demirci, Celal Bayar University,
Manisa, Turkey

e-mail: merve.polat@bayar.edu.tr

ABSTRACT

Capparis spinosa L., known as a native Mediterranean plant, is important source for food, chemical, pharmaceutical and cosmetic industries and commonly used by Mediterranean people in their cuisine and in the treatment of several diseases. In this review article, its morphological and ecological properties, chemical constituents, the food and medicinal uses and importance for Turkey are reported.

Keywords: Caper, Capparidaceae, *Capparis spinosa* L.

CAPPARIS SPINOSA L. (CAPPARIDACEAE): BİR DERLEME

ÖZET

Doğal bir Akdeniz bitkisi olarak bilinen *Capparis spinosa* L., (kapari) gıda, kimya, eczacılık ve kozmetik endüstrisi için önemli bir kaynaktır ve Akdeniz Bölgesi insanları tarafından gerek mutfaklarında, gerekse bazı hastalıkların tedavisinde kullanılır. Bu derleme, *Capparis spinosa* L. 'nin morfolojik ve ekolojik özellikleri, kimyasal bileşenleri, gıda ve tıbbi amaçlı kullanışı ve Türkiye için önemi bildirilmiştir.

Anahtar kelimeler: Kapari, Kapari otugiller, *Capparis spinosa* L.

1. INTRODUCTION

Capparis spinosa L. (caper) species belonging to the Capparidaceae (or Capparaceae) family is a perennial bush found throughout the tropical and subtropical regions of the world. It is widely spread as a native plant on the low, arid soil of the Mediterranean basin area that grows end flowers entirely in summer [1]. There are 650 species all over the world. Its range mainly extends from the Atlantic coasts of Spain-Morocco into Jordan and Iran.

Capers probably originated from dry regions in West or Central Asia. Capers of commerce are immature flower buds which have been pickled in vinegar or preserved in granular salt. Semi-mature fruits and young shoots with small leaves may also be pickled for use as a condiment [2]. Dry heat and intense sunlight make the preferred environment for caper plants, and easily survive summertime temperatures higher than 40°C. Common used names of capers where cultivated and collected in their natural dispersion all over the Mediterranean Sea region, are given in Table 1.

Table 1. Common names of capers used in around Mediterranean Sea region (compiled from [2-4]).

Country	Name
Arab literature	Kabar, kabur, kabbar, azuf
Cyprus	Kapar, kapara
Egypt	Lussef
English literature	Caper, caperberry, caperbush
France	Câprier, câpres, taperier, tapenier
German literature	Kaper, capern , kapernstrauch, kapernbaum
Greece	Kappari
Iran	Kabar, cebir, curak
Israil	Ezov
Italy	Capparo, cappero, capperone
Malta	Caper, cappar, cappara, capparo, cappero
Portugal	Alcaparra(s)
Russia	Kapersovyi, kapersy, kust
Spain	Alcaparra, caparra, alcaparrón, tápana, taparera
Syrie	Kabar
Turkey	Kapari, kebere, gebere

This plant is reported as a liver protector, and contains considerable amounts of antioxidant flavonoid which reduces risk of mortal coronary heart disease. Capers are essential for several Mediterranean cuisines and are mostly associated with Italian and Spanish foods. In Turkey, people collect the caperberries of the plant before blooming. They keep them in salty water to obtain pickled capers and which mainly sell to export without consuming.
Except for the Mediterranean, capers are not much known, although the pickled fruits of some Caucasus mountains and Central Asian species (*e.g.,*

C. aphylla, cartilaginea, decidua, sepiaria, zeylanica) are occasionally used as a flavouring in Afghanistan, Pakistan and India [3]. In the flora of Turkey, the genus caper is represented by two species. This paper summarizes the available literature on the *C. spinosa* with special references. The studies presented in this paper will be useful in elucidating the value and importance of capers as an industrial plant both for Mediterranean countries and Turkey.

2. *CAPPARIS SPINOSA* L.

C. spinosa L. is a stenohydric plant, mostly free of competition for water [5-7]. It is one of the few perennial bush that grows and flowers entirely in summer, from mid-April until the end of September which this period presents of higher temperature and lower soil water availability [8]. Its vegetative canopy covers soil surfaces which helps to conserve water reserves of soil.

C. spinosa is grown commercially. Pruning of caperbush is crucial for high production. Heavy branch pruning is necessary, as flower buds arise on one year old branches. Grown from seed, caperbushes of the Mediterranean region begin to flower in the first year. However, some flowering from the fourth year transplants for the caper outside of the region has also been reported [2]. Value of the plant is proportional with the smallness of the size. They are picked daily, since the youngest flower buds have the highest quality.

C. spinosa is used in chemistry, food, medicine and cosmetic industries mainly by Mediterranean communities [9].

Main morphological and ecological characteristics of *C. spinosa*

The genus caper is represented by two species (*C. spinosa* L. *and C. ovata* Desf.) and six varieties (*spinosa, aegyptia* Boiss, *inermis* Turra, *canescens* Heywood, *herbacea* Zoh, *palaestina* Zoh.) in the flora of Turkey [10]. *C. spinosa* buds are more firm and spherical than *C. ovata*, and widely observed all over the country except Thrace and Black Sea regions. Villagers collect the green buds of *C. spinosa* before blooming. They keep them in 20-23% salty water for preservation [11] to obtain pickled capers.

This salt-tolerant and flourish plant grows about one meter upright [2] with numerous branches, bearing a pair of hooked spines at the base of each leaf stalk. Large extensive root systems penetrate deeply into the earth. Leaves are differed from, round to ovate, thick and glistening. Flowers are about 50

mm in diameter [10], white with numerous violet stamens, and very pleasant in appearance (Figure 1a). Seeds are large, kidney shaped, and gray-brown in color (Figure 1b and 1c). In nature, plants can grow spontaneously in cracks and fissures of rocks and stone walls (Figure 1d), dry and bare clay soils. *C. spinosa* plantings will last 20 to 30 years [2].

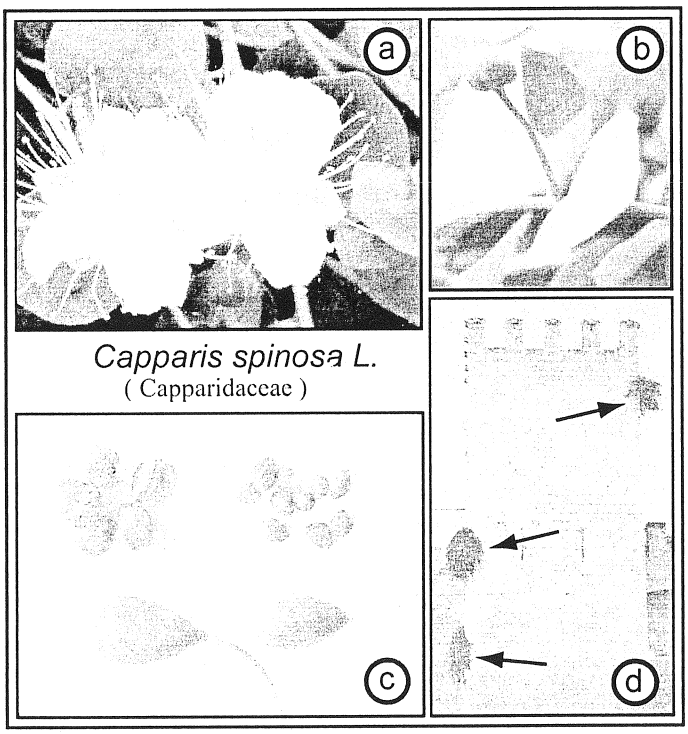


Figure 1. *Capparis spinosa* a native Mediterranean plant (pictures are compiled from [3-4]) **a)** flower, **b)** unopened caper blossom and flower bud, **c)** pickled capers and caperberries (semi-mature fruits), **d)** caper bushes on the cracks and fissures of the castle walls.

Studies in chemistry on *C. spinosa*

Research on the chemistry of *C. spinosa* aims systematic investigations for new value-added plant-derived products. Attentions are mainly focused on the plant constituents that they can be used as precursors in the production of pharmaceuticals. Chemical researches are concentrated on extraction, separation, elucidation of structure, and modification of structure to enhance potency.

Chemical properties of *C. spinosa* are given below :

Water, crude fibre, crude oil, total carotenoids and starch values of buds in June, and water, reducing sugars, total carotenoids, alcohol-soluble extract and ether-soluble extract values in August were observed to increase by size of buds. In general, highest crude protein and ash were found in small buds. Crude contents of small and middle size buds in June were higher than that of August. June was established as most suitable harvest time. Crude energy values of both species were higher in June than those of August. However, fibre, crude ash, reducing sugars, crude energy and ascorbic acid values of *C. spinosa* buds decrease in August, therefore harvest and producing time could be diminished. This situation due to species could be disadvantaged. When the components crude protein and ash decrease by size of bud, the quality of small buds increase. Crude protein (except for middle and large buds of *C. spinosa* in August), crude fibre, ascorbic acid (except for large size) and total carotenoids (except for large size of *C. spinosa* in August) values of buds in June being higher than those of August. Water, protein, ash, fibre and oil values in buds are affected chiefly by variety, growth conditions and bud size [12].

Values of water, fibre, protein, oil, pH, reducing sugars, in water and ether-soluble extracts were similar to those of given literature [13-16]. While protein values of small buds were higher than those of given in some references, the values of oil and fibre were lower. These differences could be resulted in variety/cultivar, environmental and growth conditions and bud size.

Several papers have been published to identify flavonoid and glycoside constituents of the plant from its aerial parts. Their reports are as below :

Glycosides are used in pharmaceutically treatment. They are strong cytotoxins and inhibit the growth of several viruses such as, inactivating herpes simplex virus particles irreversibly [17]. Flavonoids, a group of phenolic compounds widely occurring in the plants, have been reported to possess strong antioxidant activity [18-22]. Four thousands of flavonoids are known. Quercetin, kaempferol, quercitrin are common flavonoids forming nearly 70% of the flavonoid constituents of the plants.

The relation of nectar characteristics and flower age of *C. spinosa* have been studied and the results showed that sucrose/hexose ratio decreases considerably with flower age while the glucose/fructose ratio remains constant [23]. The aerial parts of *C. spinosa* were investigated for its

flavonoid constituents and thirteen flavonoid glycosides were identified. Those are respectively; kaempferol 7-rhamnoside, kaempferol 3-rutinoside, kaempferol 3,7-dirhamnoside, kaempferol 3-glucoside-7-rhamnoside, kaempferol 8-rhamnoside-7-glucoside, quercetin 7-rhamnoside, quercetin 3-rutinoside, quercetin 7-rutinoside, quercetin 3,7- dirhamnoside, quercetin 3-glucoside-7-rhamnoside, isorhamnetin 3-rutinoside, isorhamnetin 3,7-dirhamnoside and apigenin 6,8-di-C-glucoside [24]. In addition to routine, quercetin 3-*O*-glucoside and quercetin 3-*O*-glucoside-7-*O*-rhamnoside the methanolic extract of the aerial parts of *Capparis spinosa* yielded a new flavonoid 3-*O*-[6"-α-L-rhamnosyl-6"-β-D-glucosyl]-β-D-glucoside [25, Figure 2].

On the basis of spectral and chemical evidences 1*H*-indole-3 acetonitrile glycoside has been isolated by Çalış et al. [26, Figure 3]. In a later study, they isolated three new glycosides compounds from caperberries [27, Figure 4]. These are :

((+)-(*6S,9S*)-9-O-β-D-glucopyranosyloxy-6-hydroxy-3-oxo-α-ionol, (*6S,9S*)-roseoside), ((*6S,9S*)-6-hydroxyinamoside,((-)-(*6S,9S*)-9-*O*-β-D-glucopyranosyloxy-6,13-dihydroxy-3-oxo-α-ionol)) and ((*9S*)-drummondol-9-*O*-β-D-glucopyranoside) [27].

In addition, the evolutionary trends of *C. spinosa* in the Mediterranean region are discussed, and a comparative study was carried out in order to investigate the variability of the polymorphic *C. spinosa*. Results revealed a parapatric distribution of the species and support their present taxonomic treatment [28]. Based on the similar reasons, the chemical composition of different sized buds of raw and pickled *C. spinosa* was determined by Giuffrida et al. [29]. They found that water and carbohydrate contents increase as bud size increased, whereas flavonoid, mineral, lipid and protein contents decrease as bud size increased. It is also reported that pickled capers had much lower content of flavonoids and lipids. They indicated that small

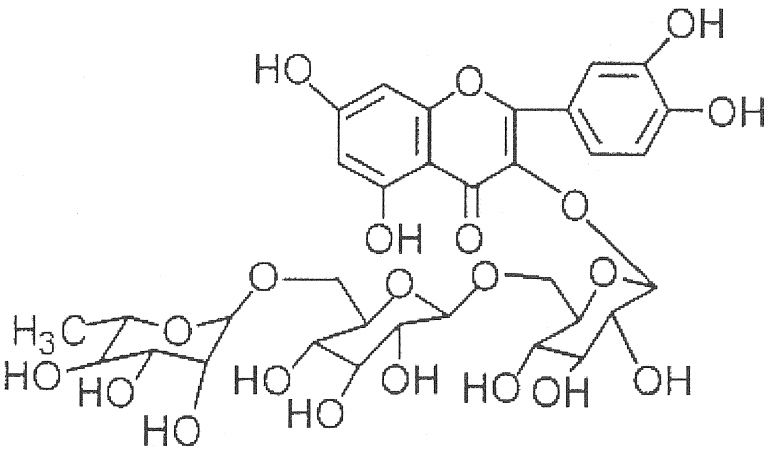
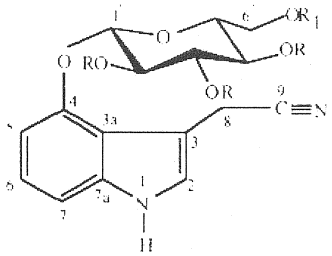


Figure 2. Isolation of new flavonoid quercetin 3-*O*-[6"-α-L-rhamnosyl-6"-β-D-glucosyl]-β-D-glucoside [25].



1: R = R_1 = H
1a: R = R_1 = $COCH_3$
2: R = H, R_1 = glucose

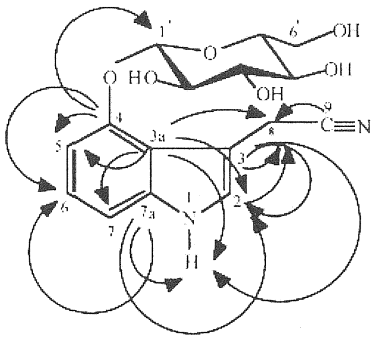
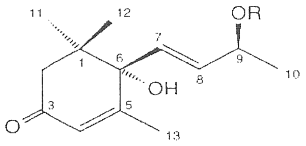
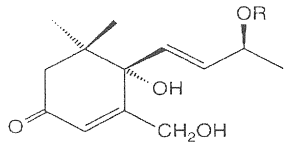


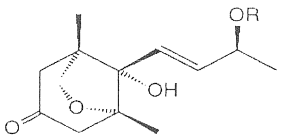
Figure 3. Significant long-range correlations of *1*H-Indole-3 acetonitrile glycosides [26].

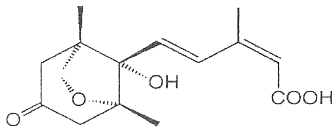




1 R = β-D-glucose
1a R = β-D-glucose (OAc)4
1b R = H
1c R = (*R*)-MTPA
1d R = (*S*)-MTPA

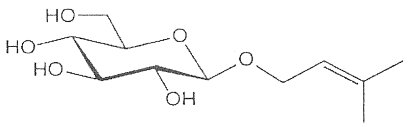
2 R = β-D-glucose





3 R = β-D-glucose
3a R = β-D-glucose (OAc)4
3b R = H
3c R = (*R*)-MTPA
3d R = (*S*)-MTPA

4



5

Figure 4. Isolation of three (*6S*)-Hydroxy-3-oxo-α-ionol glucosides (**1-3**), (*6S*)-configuration is assigned for phaseic acid (**4**), and a prenyl glucoside (**5**) from *Capparis spinosa* fruits [27].

raw buds are more suitable for processing due to their chemical properties. Brevard et al. [30] have reported the presence of the monoterpenoid linalol and its oxygenated derivative *cis*-linalol oxide in the floral bud of the *C. spinosa*. They did not detect monoterpenoids in the fruit and root oils of the examined plant. On the other hand, the mentioned oils consisted chiefly of the glucosinolates degradation products, namely methyl, isopropyl and *sec*-butyl isothiocyanates. Khanfar et al. [31] have been isolated and characterized two new compounds from *C. spinosa* Jordanian origin have been isolated and characterized. These are: β-sitosterylglucoside-6'-octadecanoate and 3-methyl-2-butenyl-β-glucoside.

Studies in Medicinal Uses

As medicinal plant, *C. spinosa* is a significant source of the treatment of a number of diseases. They are said to reduce flatulence and to be anti-rheumatic and amenorrheaic plants [32]. In ayurvedic medicine, it is recorded as hepatic stimulant and protector by improving liver function [33-37], and anti-inflammatory effects [38-39]. Infusions and decoctions from the root bark have been traditionally used in treatment of dropsy, anemia, arthritis and gout [40]. *C. spinosa* contains great amounts of the antioxidant bioflavonoid rutin [2, 40]. Their extracts and pulps are used in cosmetics, but there are some reports on contact dermatitis and sensitivity from their use [41]. It is also determined that the risk of the death from coronary heart disease is reduced dramatically when the diet contains more flavonoids [19, 21, 42, 43].

Recent studies reveal that *C. spinosa* has a very strong antimicrobial [44-45] and antifungal [46] activity. *C. spinosa* agglutinated and killed the parasites of the *Leishmania* major disease. This activity could be inhibited by specific carbohydrates. This indicates that it is as a result of various lectins in the extract. The results indicate that the lectins and toxins found in the tissue of *C. spinosa* may decrease the transmission of the parasite [47-48]. Mansour et al. [49] have been reported that extract of *C. spinosa* has good potential for acaricidal activity against the carmine spider mite, and should be subjected for further investigations.

Studies in Food Industry

C. spinosa is essential for several Mediterranean cuisines (Greece, Italy, Morocco, Spain, Turkey) and is mostly applied to tomato or wine sauces, and fit well to poultry and fish. The floral buttons of *C. spinosa* are also used as flavouring in cooking and for making pickles [32]. Furthermore, they are popular with cold meat and frequently used for pizza. They harmonize with most other Mediterranean spices and are combined with pickled olives [3]. Akgül and Özcan [50] evaluated *C. spinosa* seeds for weight, sizes, moisture, ash, protein, oil, energy and fiber. They determined the relative density, refractive index, free fatty acids, peroxide value, iodine value, saponification value and unsaponifiables in the seed oils. The seeds were found rich in protein, oil, and fiber, and showed similar composition to unsaturated fatty acids, suggesting that they may be valuable for food usage [51].

Existence of significant amount of minerals has been revealed in the root vessels of *C. spinosa* [7]. Based on the similar reasoning, Germano et al. [22] demonstrated the nutritional value of the flowering buds which are widely used as a source of flavor was demonstrated. In addition to this Giuffrida et al. [29] determined Na, Mg, Ca and K minerals were in the pickled capers. A more detailed micro mineral content study has been performed by Turan et al. [52] with wild plants which mainly consumed at the Eastern Anatolia (Turkey). As a summary, researches on capers still continue and several papers including a recent review [53] by Rivera et al. have recently been published.

Its Importance for Turkey

Turkey is a rich country in medical and aromatic plants with their considerable amount of 500 aromatic plants which are being used. Başer [54] estimates that third of the flora of Turkey consists of aromatic plants which are used for fragrance, flavouring or containing essential oil. Whole or parts of plants of about 250 species are also exported [55].

Pickled caper is became an important export product during last 10-15 years. Especially, caperberries are requested by Mediterranean countries (mainly by Spain which is the biggest producer and exporter of capers in the world) because of protein, vitamin and mineral contents. Exportation value of the capers has been reached up to 3500-4000 tones with an amount of 8.5 million $ in 1999, and took a place of 17 % [56]. The best quality products are obtained from the Aegean region since they do not contain undesirable brush-wood and are not maggoty. June is more suitable to harvest the small buds processing for physical and chemical properties. Pickling time was determined as 40 to 50 days in regard of end-product flavour and odour, brine acidity and pH, and LAB activity [12, 57]. As a result, capers are pharmaceutics and aromatic plants of Turkey where spread almost all over the country. The plant is consumed in cuisines traditionally and also protected people against many diseas.

3. DISCUSSION AND CONCLUSIONS

Several topics regarding the nature of capers have emerged from the papers cited in this review; the origin, common and scientific names, the ecology and habitat, main constituents, the culinary-chemical-pharmaceutical uses, the crop culture, the harvesting and processing, cultivars and varieties, economic growth and importance for Turkey. The main interpretations of reviewed articles are given in previous sections.

In this paper the data concerning the uses being fundamentally alimentary, chemical or medicinal has been presented. Investigations of the data lead to the following conclusions for the species *C. spinosa* L. :

a. Production Practices : The general use of flower buds, fruits and shoots, preserved in different ways (salt, brine, vinegar), is as food. Caperberries, fruits of perennial shrubs of *C. spinosa*, have medical and aromatic properties. Their flower buds, root, fruits and young shoots are used as foodstuffs. Some parts of the plants are used for the production of medicines, cosmetics, insecticides, food for grazing animals and also to provide erosion control.

b. Harvesting : The unopened flower buds should be picked on a dry days. Water, crude fiber, crude oil, total carotenoids and starch values of species in both harvests increased as bud size increased. Hardness is a property desired in order to resist against environmental conditions during harvest, transport, fermentation and storage. Plants should be pruned in winter to remove dead wood and watersprouts. Pruning is crucial to high production. Heavy branch pruning is necessary, as flower buds arise on one year old branches.

c. Processing : Small buds should be harvested in June were more suitable to processing for physical and chemical properties. Values of analyses were variously affected by species, size and harvest date. *C. spinosa* plays an important role in the food industry; the flower buds are stored brine and have become a costly product during recent years. Although the world production has changed with time, approximately 10.000 tons are produced annually and the main producers and manufacturer countries are Spain, Morocco and Italy. Turkey has become a major exporter of capers in the last decades, and exports 3.000-5.000 tons of processed *C. spinosa.*

5. REFERENCES

1. Zohary M., The Species of Capparis in The Mediterranean and The Near Eastern Countries, Bull. Res. Counc., Israel, 8D, 49-64, (1969).
2. Alkire B., New Crop Factsheet : Capers, Center of New Crops and Plant Products, Purdue University, USA (1998). On Internet: http://www.hort.purdue.edu/newcrop/cropfactsheets/caper.html
3. Katzer G., Caper: Capparis spinosa L. (2002). On Internet: http://www-ang.kfunigraz.ac.at/~katzer/engl/Capp_spi.html
4. Anonymous A., The Mediterranean Garden Society (2003). On Internet : http://www.mediterraneangardensociety.org/plants/Capparis.spinosa

5. Rhizopoulou S., Heberlein K., Kassianou A., Field Water Relations of Capparis Spinosa, Journal of Arid Environments, 36, 237-248, (1997).
6. Rhizopoulou S., Psaras G.K., Development and Structure of Drought-Tolerant Leaves of The Mediterranean Bush Capparis Spinosa, Annals of Botany, 92, 377-383, (2003).
7. Psaras G.K., Sofroniou I., Wood Anatomy of Capparis Spinosa From an Ecological Perspective, Iawa Journal, 20:(4), 419-429, (1999).
8. Sozzi O.G., Caper Bush: Botany and Horticulture, Horticultural Reviews, 27, 125-188, (2001).
9. Stephens J.M., Capers:Capparis Spinosa L., University of Florida, USA, (2001). On Internet : http://edis.ifas.ufl.edu/pdffiles/MV/MV04000.pdf
10. Davis P.H., Flora of Turkey and the East Aegean Islands, 2nd Edition, Vol:1, Edinburgh University Press, Scotland, 842p (1965).
11. Kızmaz M., Medicinal, Culinary and Aromatic Plants Production in Turkey, Proceedings of the International Expert Meeting on Medicinal, Culinary and Aromatic plants in the Near East on May 19-21, Cairo-Egypt (1997).
12. Özcan M., Akgül A., Influence of Species, Harvest Date and Size On Composition of Capers (Capparis spp.) Flower Buds, Nahrung-Food, 42:(2), 102-105, (1998).
13. Aktan N., Bilgin B., Elgin E., Medicinal Plants, Ege Üniversitesi Ziraat Fakültesi Dergisi, 18, 1152-1154, (1992).
14. Nosti V., Ramos, R., Medicinal Plants, Grasas y Aceites, 38, 173-175 (1987).
15. Rodrigo M., Lazaro M.J., Alvarruiz A., Giner V.J., Food Sci., 57, 1152-1154 (1992).
16. Özcan M., Akgül A., Tıbbi ve Aromatik Bitkiler, Ege Üniversitesi Ziraat Fakültesi : Workshop, Bornova-İzmir (1995).
17. Pompei R., Antiviral Activity of Glycosides, Experientia, 36, 304-305, (1980).
18. Markham J.R., Techniques of Flavonoid Identification, Academic Press, London, 376p (1982).
19. Wollenweber E., Occurrence of Flavonoid Aglycones in Medicinal Plants, in Plant Flavonoids in Biology and Medicine, Editors; Cody V., Middleton E., Harborne J., Beretz A., Liss, A:R., New-York Publishers, USA, 45-55sf (1988).
20. Saija A., Scalese M., Lanza M., Marzullo D., Bonina F., Castelli F., Flavonoids as Antioxidant Agents: Importance of Their Interaction With Biomembranes, Free Radic Biol Med, 19:(4), 481-485, (1995).
21. Harborne J., Williams C., Advances in Flavonoid Research Since 1992, Phytochemistry, 55, 481-504, (2000).
22. Germano M.P., Depasquale R., D'angelo V., Catania S., Silvari V., Costa C., Evaluation of Extracts and Isolated Fraction from Capparis Spinosa L. Buds as an Antioxidant Source, J. Agric. Food Chem., 27, 50:(5), 1168-1171, (2002).
23. Petanidou T., Vanlaere A.J., Smets E., Change in Floral Nectar Components from Fresh To Senescent Flowers of Capparis Spinosa (Capparidaceae), A Nocturnally Flowering Mediterranean Bush, Plant Systematics and Evolution. 199:(1-2), 79-92, (1996).

24. Sharaf M., Elansari M.A., Saleh N.A.M., Flavonoids of Four Cleome and Three Capparis Species, Biochemical Systematics and Ecology, 25:(2), 161-166, (1997).
25. Sharaf M., Elansari M.A., Saleh N.A.M., Quercetin Triglycoside from Capparis Spinosa, Fitoterapia, 71:(1), 46-49, (2000).
26. Çalış İ., Kuruüzüm A., Ruedi P., 1*H*-indole-3 acetonitrile glycosides from Capparis Spinosa Fruits, Phytochemistry, 50:(7), 1205-1208, (1999).
27. Çalış İ., Kuruüzüm-Uz A., Lorenzetto P.A., Ruedi P., (6S)-Hydroxy-3-oxo-a-ionol Glucosides from C. Spinosa Fruits, Phytochemistry, 59, 451-457, (2002).
28. Fici S., Intraspecific Variation and Evolutionary Trends in Capparis Spinosa L. (Capparaceae), Plant Systematics and Evolution, 228:(3-4), 123-141, (2001).
29. Giuffrida D., Salvo F., Ziino M., Toscano G., Dugo G., Initial Investigation On Some Chemical Constituents of Capers (Capparis Spinosa L.) from the Island of Salina, Italian Journal of Food Science, 14:(1), 25-34, (2002).
30. Brevard H., Brambilla M., Chaintreau A., Marion, J.P., Diserens H., Occurrence of Elemantal Sulphur in Capers (Capparis Spinosa L.) and First Investigation of The Flavour Profile, Flavour Fragrance J., 7, 313-321, (1992).
31. Khanfar M., Sabri S, Abuzarga M., Zeller K.P., The Chemical Constituents of Capparis Spinosa of Jordanian Origin, Natural Product Research, 17:(1), 9-14, (2002).
32. Baytop T., Therapy With Medicinal Plants (Past and Present), Istanbul University Publications, Istanbul (1984).
33. Handa S.S., Sharma A., Chakraborti K.K., Natural Products and Plants as Liver Protecting Drugs, Fitoterapia, 57, 307-349, (1986).
34. Gadgoli C., Mishra, S.H., Primarily Screening C. spinosa for Antihepatotoxic Activity, Fitoterapia, 66, 319, (1995).
35. Gadgoli C., Mishra, S.H., Antihepatotoxic Activity of p-methoxy benzoic acid From Capparis Spinosa, Journal of Ethnopharmacology, 66, 187-192, (1999).
36. Gez S., Çelik A., C. Spinosa in Analjezik ve Antimikrobial Etkileri Yönünden Bir Ön Çalışma, Kocatepe Tıp Dergisi, 3, 169-72, (2000).
37. Gez S, Çelik A. Çivrilin Tıbbi Bitkileri, Pamukkale Üniversitesi (2001). On Internet : http://www.civril.gov.tr/1/soy/tibbibitki.htm
38. Alsaid M.S., Abdelsattar E.A., Khalifa S.I., Elferaly F.S., Isolation and Identification of an Anti-Inflammatory Principle From Capparis Spinosa, Pharmazie, 43:(9), 640-641, (1988).
39. Rimbau V., Risco E., Canigueral S., Iglesias J., Antiinflammatory Activity of Some Extracts From Plants Used in The Traditional Medicine of North-African Countries, Phytotherapy Research, 10:(5), 421-423, (1996).
40. FAO, Contributions to Rural Households (1997).
Internet: http://www.fao.org/DOCREP/003/W8801E/w8801e00.htm
41. Bonina F., Puglia C., Ventura D., Aquino R., Tortora S., Sacchi A., Saija A., Tomaino A., Pelegrino M.L., in Vitro Antioxidant and in Vivo Photoprotective Effects of a Lyophilized Extract of Capparis Spinosa L. Buds, Journal of Cosmetic Science, 53:(6), 321-335, (2002).
42. Williams D.G., Quercetin:Protect Your Health With This Important Flavonoid, (1994). On Internet: http://www.prohealthnetwork.com/library/

43. Inocencio C., Rivera D., Alcaraz F., Tomas-Barberan F.A., Flavonoid Content of Commercial Capers (Capparis Spinosa, C-Sicula and C-Orientalis) Produced in Mediterranean Countries, European Food Research and Technology, 212:(1), 70-74, (2000).
44. Mahasneh A.M., Abbas J.A., Eloglah A.A., Antimicrobial Activity of Extracts of Herbal Plants Used in The Traditional Medicine of Bahrain, Phytotherapy Research, 10:(3), 251-253, (1996).
45. Mahasneh A.M., Screening of Some Indigenous Qatari Medicinal Plants For Antimicrobial Activity, Phytotherapy Research, 16:(8), 751-753, (2002).
46. Alshtayeh M.S., Abughdeib S.I., Antifungal Activity of Plant Extracts Against Dermatophytes, Mycoses, 42:(11-12), 665-672, (1999).
47. Jacobson R.L., Schlein Y., Lectins and Toxins in The Plant Diet of Phlebotomus Papatasi (Diptera : Psychodidae) Can Kill Leishmania Major Promastigotes in The Sandfly and in Culture, Annals of Tropical Medicine and Parasitology, 93:(4), 351-356, (1999).
48. Jacobson R.L., Schlein Y., Phlebotomus Papatasi and Leishmania Major Parasites Express Alpha-Amylase and Alpha-Glucosidase, Acta Tropica, 78:(1), 41-49, (2001).
49. Mansour F., Azalzeh H., Saad B., Tadmor Y., Abo-Moch F., Said O., The Potential of Middle Eastern Flora as a Source of New Safe Bio-Acaricides To Control Tetranychus Cinnabarinus, The Carmine Spider Mite, Phytoparasitica, 32:(1), 66-72, (2004).
50. Akgül A., Özcan M., Some Compositional Characteristics of Capers (Capparis spp.) Seed and Oil, Grasas y Aceites, 50:(1), 49-52, (1999).
51. Özcan M., Pickling and storage of caperberries (Capparis spp.), Z Lebensm. Unters, Forsch. A., 208:(379-382), (1999).
52. Turan M., Kordali S., Zengin H., Dursun A., Sezen Y., Macro and Micro Mineral Content of Some Wild Edible Leaves Consumed in Eastern Anatolia, Acta Agriculturae Scandinavica Section B-Soil and Plant Science, 53:(3), 129-137, (2003).
53. Rivera D., Inocencio C., Obón C., Alcaraz, F., Review of Food and Medicinal Uses of Capparis L. Subgenus Capparis (Capparidaceae), Economic Botany, 57:(4), 515-534, (2003).
54. Başer H.C., Essential oils of Anatolian Labiatae: A profile, Acta Horticultureae, 333, 217-238, (1993).
55. Koyuncu M., Medicinal and Aromatic Plants in Turkey, Ankara University Press, 2nd Edition , 345p, Ankara (1995).
56. Koç H., Aksu B., Kurtoğlu A., Turkey's Foreign Trade of The Non-Wood Forest Product, Seminar on Harvesting of Non-Wood Forest Products, İzmir (2000).
57. Özcan M., Akgül A., Pickling Process of Capers (Capparis spp.) Flower Buds, Grasas y Aceites, 50:(2), 94-99, (1999)