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An Annotated Account of Korean Economic Seaweeds for Food, Medical and Industrial Uses

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韓國産 有用海藻 特히 食用, 藥用 및 工業用 海藻에 대한 註解

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A few records of the economic seaweeds used for the food, medicine and industry in Korea have been summarized as a floristic list. They are systematically annotated under the currently accepted nomenclature for each species. The annotated list includes names of 164 taxa comprising 33 green, 33 brown and 98 red algae, which become ca. 25% of all species recognized in Korea. In view of marine resources, the edible seaweeds are counted 87 taxa, the medicals 54 and industrials 74, respectively. It is expected that this annotated catalog will serve as a basis for further biological investigations on useful seaweeds in Korea.

Key Words: economic seaweeds, food, medical, industrial uses

INTRODUCTION

Seaweeds, primary producers of the oceans, have served as human foodstuff, medicine, manure, animal fodder and so on, since ancient times. The earlier records of seaweed utilization appeared in Chinese herbals of 300-800 B.C. At the time seaweeds were chiefly used as food sources and medicine by coastal inhabitants (Waaland, 1981).

Especially in Orient, seaweeds often had been eaten toward off starvation in times of famine caused by failure of terrestrial crops (Newton, 1951). In contrast, Europeans minorly used seaweeds not as foodstuff but as medicine for wounds and diseases (Chapman and Chapman, 1980).

Ilyon, a buddist and scholar of Goryo Dynasty, formerly recorded the utilization and distribution of *Laminaria* (Dashima) traditionally used as foodstuff in the era of Shilla Dynasty in ancient Korea (ca. A.D. 157) (Park, 1966). Several centuries later, many kinds of seaweeds were described for their uses. In 1451, Chung, I.J., a scholar of Yi Dynasty, recorded 14 species of seaweeds according to their uses for foodstuff (Kang, 1981). Chung, Y.J. (1814) also described 35 species collected from Huksando Island located in south-western coast of Korea, referring to their uses in detail. Being written in Chinese characters, however, these books have been scarcely referred to workers engaged in algal study. Among these algae, some edible seaweeds such as *Undaria* (Miyok) and *Porphyra* have been extensively cultivated in southern coast of Korea since 1300's (Park, 1966;

Kang, 1970; Kang and Koh, 1977). The others were not so much noticed for their uses until now.

Recently, seaweeds have been reevaluated as food sources, medical and industrial uses in Korea (Lee, 1987; Boo, 1990). Lee and Kang (1986) reported a check list of Korean seaweeds with 624 species including 48 blue green, 81 green, 135 brown and 360 red algae up to the time. In this paper, based on this check list of Korean marine algae, we attempted to survey the useful seaweeds growing in Korean coasts, and to evaluate their utilities with special reference to medical and industrial uses as well as foodstuff.

In order to investigate economic and beneficial uses of seaweeds, floristic data (Lee and Kang, 1986) and specimens collected along the coasts of Korea as well as traditional records of local utilization of seaweeds were used in this study (Fig. 1, 2).

Chlorophyta

Ulvales

1. *Capsosiphon fulvescens* (C. Agardh) Setchell et Gardner 매생이

Distribution: Growing abundantly on rocks or wooden poles in laver farm in southern coast of Korea, mixed with *Enteromorpha* spp..

Use: Foodstuff (Kang, 1968).

Monostroma spp. 홑파래류

Eight species were reported in Korea (Lee and Kang, 1986), all of which were used as foodstuff.

2. *M. nitidum* Wittrock 참홑파래

Distribution: Growing on rocks in calm intertidal zone in southern coast.

Use: Foodstuff (Kang, 1968; Bonotto, 1976; Abbott and Cheney, 1982), and hypocholesterolemic (Tsuchiya, 1969).

Enteromorpha spp. 파래류

Seven species were reported in Korea (Lee and Kang, 1986), all of which were also used as foodstuff.

3. *E. clathrata* (Roth) Greville 격자파래

Distribution: Growing on rocks in calm intertidal zone in southern coast.

Use: Foodstuff (Kang, 1968; Tseng, 1983), and relief from heat (Anonymous, 1978).

4. *E. compressa* (L.) Greville 납작파래

Distribution: Growing on rocks or other substrates facing open sea in southern coast.

Use: Foodstuff (Kang, 1968; Bonotto, 1976), hypocholesterolemic (Nisizawa, 1979), and animal fodder (Bonotto, 1976).

5. *E. intestinalis* (L.) Link 창자파래

Distribution: Growing on rocks or other substrates in intertidal zone, common in whole coasts.

Use: Foodstuff (Kang, 1968; Bonotto, 1976; Madlener, 1977), antimitotic, cytotoxic (Chénieux *et al.*, 1980), polysynoptic blocker (Baker, 1984), aphthae, back pain, paronychia, lymphatic swellings and goiter (Anonymous, 1978).

6. *E. linza* (L.) J. Agardh 잎파래

Distribution: Growing on rocks or other substrates in calm intertidal zone, popular in whole coasts.

Use: Foodstuff (Kang, 1968; Bonotto, 1976; Hotta *et al.*, 1989), and antiviral to influenza A (Fassina and Berti, 1962).

7. *E. prolifera* (Oder) J. Agardh 가시파래

Distribution: Growing on rocks in intertidal zone of whole coasts.

Use: Foodstuff (Kang, 1968; Bonotto, 1976; Tseng, 1983), hypocholesterolemic (Tsuchiya, 1969), aphthae, back pain, paronychia, lymphatic swellings, goiter, cough, bronchitis, antipyretics, sunstroke treatment, tonsillitis, asthma, nosebleeds and sore-hand (Anonymous, 1978; Tseng and Zhang, 1984; Tokuda *et al.*, 1986).

8. *Ulva conglobata* Kjellman 모란갈파래

Distribution: Specifically growing on rocks in intertidal zone in southern coast and Cheju Island.

Use: Foodstuff (Tseng, 1983), antipyretics and sunstroke treatment (Tseng and Zhang, 1984; Tokuda *et al.*, 1986).

9. *Ulva lactuca* L. 참갈파래

Distribution: Growing on rocks in intertidal zone facing open sea in southern coast and Cheju Island.

Use: Foodstuff, animal fodder and manure (Bonotto, 1976; Madlener, 1977; Tseng, 1983), gout,

scrofula (Hoppe, 1979), sore throat, laryngitis, lymphatic tuberculosis, antipyretics, halitosis, urinary problems, dropsy, goiter and boils (Bonotto, 1976; Tseng and Zhang, 1984; Tokuda *et al.*, 1986), and antibiotics (Hornsey and Hide, 1974, 1976a, 1976b).

10. *U. pertusa* Kjellman 구멍갈파래

Distribution: Growing commonly on rocks in lower intertidal zone of whole coasts, one of the most popular marine algae in Korea.

Use: Foodstuff (Kang, 1968; Bonotto, 1976; Tseng, 1983; Hotta *et al.*, 1989), fever (Hoppe, 1979), heat stroke, urinary problems, lymphatic swellings, antipyretics, goiter, high blood pressure, dropsy (Bonotto, 1976; Anonymous, 1978; Tseng and Zhang, 1984; Tokuda *et al.*, 1986), wounds (Mshigeni, 1983), burn treatment (Waaland, 1981), antimicrobial (Baik and Kang, 1986), and animal fodder (Bonotto, 1976), and agglutinin (Shiomi, 1983).

11. *U. reticulata* Forsskal 그물갈파래

Distribution: Growing on rocks in intertidal zone of southern coast.

Use: Hemolytic (Hashimoto *et al.*, 1972).

Cladophorales

12. *Chaetomorpha crassa* (C. Agardh) Kützing 굵은염주말

Distribution: Growing on rocks in intertidal zone of eastern to southern coast and Cheju Island.

Use: Foodstuff (Madlener, 1977).

13. *Cladophora rupestris* (L.) Kützing 바위대마디말

Distribution: Growing on rocks in lower intertidal zone from eastern to southern coasts and Cheju Island.

Use: Cytotoxic, antimitotic (Chénieux *et al.*, 1980), and agglutinin (Shiomi, 1983).

14. *Rhizoclonium riparium* (Roth) Harvey 돌헛뿌리말

Distribution: Growing on rocks or other algae in tide-pools of upper intertidal zone from western to southern coasts and Cheju Island.

Use: Wounds (Hoppe, 1979).

Codiales

15. *Bryopsis hypnoides* Lamouroux 이끼깃털말

Distribution: Growing on rocks in calm intertidal zone of southern coast.

Use: Agglutinin (Shiomi, 1983).

16. *B. plumosa* (Hudson) C. Agardh 참깃털말

Distribution: Growing commonly on rocks in middle to lower intertidal zone of whole coasts.

Use: Antiviral to influenza A (Fassina and Berti, 1962), and antimicrobial (Hornsey and Hide, 1974).

17. *Caulerpa okamurae* Weber van Bosse 옥덩굴

Distribution: Growing on rocks from intertidal to subtidal zones of Ulreungdo, south-eastern coast and Cheju Island.

Use: Foodstuff (Arasaki and Arasaki, 1983; Hotta *et al.*, 1989).

18. *Codium adhaerens* (Cabrera) C. Agardh 떡청각

Distribution: Adhering on rocks in shady intertidal to subtidal zones of southern coast.

Use: Toxic to mice (Hashimoto *et al.*, 1972), antibacterial (Biard *et al.*, 1980), and inotropic (Baker, 1984).

19. *C. dichotomum* (Hudson) S.F. Gray 개청각

Distribution: Growing on rocks in subtidal zone of southern coast and Cheju Island

Use: Foodstuff (Bonotto, 1976)

20. *C. fragile* (Suringar) Hariot 청각

Distribution: Growing commonly on rocks or shells in intertidal to subtidal zones of whole coasts.

Use: Foodstuff (Kang, 1968; Kang and Koh, 1977; Bonotto, 1976; Madlener, 1977; Tseng, 1983; Hotta *et al.*, 1989), antibacterial (Kamimoto, 1955; Hornsey and Hide, 1974, 1976a, 1976b), vermifuge, urinary problems and dropsy (Tseng and Zhang, 1984; Tokuda *et al.*, 1986).

21. *C. divaricatum* Holmes 말청각

Distribution: Growing on rocks in subtidal zone of southern coast and Cheju Island.

Use: Foodstuff (Bonotto, 1976).

22. *C. latum* Suringar 넓청각

Distribution: Growing on rocks in subtidal zone of southern coast and Cheju Island.

Use: Antibacterial (Ohta, 1979).

23. *C. tenue* (Kützing) Kützing 애기청각

Distribution: Growing on rocks in lower intertidal to subtidal zones southern coast and Cheju Island.

Use: Foodstuff (Bonotto, 1976).

Phaeophyta

Ectocarpales

1. *Pilayella littoralis* (L.) Kjellman 가온열매실말

Distribution: Growing on rocks in intertidal zone of western coast.

Use: Antimitotic (Chénieux *et al.*, 1980).

Dictyotales

2. *Dictyota dichotoma* (Hudson) Lamoutoux 참그물바탕말

Distribution: Growing commonly on rocks in intertidal zone facing open sea of whole coasts.

Use: Antibacterial (Hornsey and Hide, 1974, 1976a; Chapman and Chapman, 1980).

Chordariales

3. *Chordaria flagelliformis* (Müller) C. Agardh 민가지말

Distribution: Growing on rocks in intertidal to subtidal zones of southern coast.

Use: Foodstuff, drugs (Bonotto, 1976), antimicrobial (Hornsey and Hide, 1974), anticoagulant (Hoppe, 1979), and agglutinin (Shiomi, 1983).

4. *Ishige okamurae* Yendo 패

Distribution: Growing on rocks in intertidal zone of southern coast and Cheju Island.

Use: Foodstuff (Tseng, 1983).

5. *Ishige sinicola* (Setchell et Gardner) Chihara 넓패

Distribution: Growing on rocks in middle intertidal zone of southern coast and Cheju Island, mixed with *Ishige okamurae.*

Use: Foodstuff (Kang, 1968; Tseng, 1983).

Scytosiphonales

6. *Petalonia fascia* (Müller) Kuntze 개미역쇠

Distribution: Growing on rocks in lower intertidal zone from eastern to southern coasts and Cheju Isalnd.

Use: Foodstuff (Bonotto, 1976; Madlener, 1977).

7. *Scytosiphon lomentaria* (Lyngbye) Link 고리매

Distribution: Growing commonly on rocks in upper intertidal zone in winter of whole coasts.

Use: Foodstuff (Kang, 1968; Bonotto, 1976; Tseng, 1983; Hotta *et al.*, 1989), dry coughs, laryngitis, lymphatic tuberculosis (Anonymous, 1978), and antimitotic (Chénieux *et al.*, 1980).

Desmarestiales

8. *Desmarestia ligulata* (Stackhouse) Lamouroux 참산말

Distribution: Growing on rocks in subtidal zone from south-eastern to southern coast.

Use: Agglutinin (Shiomi, 1983), animal fodder (Hotta *et al.*, 1989), and antimicrobial (Hornsey and Hide, 1974).

9. *D. tabacoides* Okamura 담배산말

Distribution: Growing on rocks in subtidal zone of western to southern coasts and Cheju Island.

Use: Foodstuff (Madlener, 1977), and animal fodder (Hotta *et al.*, 1989).

10. *D. viridis* (Müller) Lamouroux 쇠꼬리산말

Distribution: Growing on rocks in lower intertidal zone of Ulreungdo, south-eastern to southern coasts.

Use: Agglutinin (Shiomi, 1983).

Laminariales

11. *Undaria peterseniana* (Kjellman) Okamura 넓미역

Distribution: Growing on rocks in subtidal zone of Udo (Cheju Island).

Use: Foodstuff (Kang, 1968; Okazaki, 1971; Bonotto, 1976; Hotta *et al.*, 1989).

12. *U. pinnatifida* (Harvey) Suringar 미역

Distribution: Growing commonly on rocks in lower intertidal to subtidal zones of whole coasts, one of the most popular edible seaweeds in Korea under cultivation.

Use: Foodstuff, cultivation (Kang, 1968; Kang and Koh; 1977; Okazaki, 1971; Bonotto, 1976; Madlener, 1977; Tseng, 1983; Hotta *et al.*, 1989), nicotine poisoning cure, antihypertensives (Takagi, 1975), stomach ailments, hemorrhoids, anal fistulas, leucorrhea, nocturnal enuresis, urinary disea-

ses and dropsy (Tseng and Zhang, 1984).

13. *Chorda filum* (L.) Stackhouse 끈말

Distribution: Growing on rocks in subtidal zone of western to southern coasts.

Use: Foodstuff (Bonotto, 1976; Madlener, 1977; Tseng, 1983; Hotta *et al.*, 1989).

14. *Agarum cribrosum* Bory 구멍쇠미역

Distribution: Growing on rocks in subtidal zone of mid-eastern coast.

Use: Foodstuff (Kang, 1968), and alginates (Kang, 1968; Bonotto, 1976).

15. *Costaria costata* (C. Agardh) Saunders 쇠미역사촌

Distribution: Growing on rocks in subtidal zone of mid- to northern part of eastern coast.

Use: Foodstuff (Bonotto, 1976)

16. *Kjellmaniella crassifolia* Miyabe 개다시마

Distribution: Growing on rocks in subtidal zone of mid-eastern coast, mixed with *Laminaria japonica.*

Use: Foodstuff (Kang, 1968).

17. *Ecklonia cava* Kjellman 감태

Distribution: Growing abundantly on rocks in subtidal zone of Cheju Island.

Use: Antihypertensives (Takagi, 1975), and alginates (Kang, 1968; Bonotto, 1976; Hotta *et al.*, 1989).

18. *Ecklonia stolonifera* Okamura 곰피

Distribution: Growing on rocks in subtidal zone of Ulreungdo and eastern to southern coasts.

Use: Foodstuff (Kang, 1968; Hotta *et al.*, 1989).

19. *Eisenia bicyclis* (Kjellman) Setchell 대황

Distribution: Growing abundantly on rocks in subtidal zone of Ulreungdo.

Use: Foodstuff, antihypertensives (Takagi, 1975), and alginates (Kang, 1968; Bonotto, 1976; Madlener, 1977; Hotta *et al.*, 1989).

20. *Laminaria japonica* Areschoug 다시마

Distribution: Growing on rocks in subtidal zone of mid-eastern coast.

Use: Foodstuff (Kang, 1968; Okazaki, 1971; Bonotto, 1976; Madlener, 1977; Tseng, 1983; Hotta *et al.*, 1989), dropsy (Read and How, 1927), high blood pressure (Anonymous, 1978), anticoagulant, hypocholesterolemic (Nisizawa, 1979), normalizing blood pressure, hyperthyroidism, goiter, dropsy, scrofula, stomach ailments, hemorrhoids, urinary problems, anal fistulas (Bonotto, 1976; Hoppe, 1979; Tseng and Zhang, 1984; Tokuda *et al.*, 1986), and alginates (Bonotto, 1976; Tokuda *et al.*, 1986).

21. *L. religiosa* Miyabe 애기다시마

Distribution: Growing on rocks in subtidal zone of mid-eastern coast.

Use: Foodstuff (Kang, 1968; Bonotto, 1976; Hotta *et al.*, 1989), menstrual disorders (Read and How, 1927), anticoagulant (Nisizawa, 1979), and antimicrobial (Baik and Kang, 1986).

Fucales

22. *Pelvetia siliquosa* Tseng et Chang 뜸부기

Distribution: Growing on rocks in intertidal zone of western coast.

Use: Foodstuff (Kang, 1968; Tseng, 1983), and alginates (Kang, 1968).

23. *Hizikia fusiformis* (Harvey) Okamura 톳

Distribution: Growing abundantly on rocks in intertidal zone of western to southern coasts and Cheju Island during winter and spring seasons.

Use: Foodstuff (Kang, 1968; Bonotto, 1976; Madlener, 1977; Hotta *et al.*, 1989).

24. *S. confusum* C. Agardh 알쏭이모자반

Distribution: Growing on rocks in lower intertidal to subtidal zones of eastern to southern coasts and Cheju Island.

Use: Animal fodder and alginates (Arasaki and Arasaki, 1983).

25. *Sargassum fulvellum* (Turner) C. Agardh 모자반

Distribution: Growing on rocks in lower intertidal to subtidal zones of whole coasts, one of the representative edible seaweeds in Korea.

Use: Foodstuff and medicine (Kang, 1968; Bonotto, 1976; Madlener, 1977).

26. *S. hemiphyllum* (Turner) C. Agardh 짝잎모자반

Distribution: Growing on rocks in lower intertidal zone, plentiful on Cheju Island, rare on eastern and southern coasts.

Use: Goiter, scrofula, alginates (Tseng, 1983; Tseng and Zhang, 1984; Tokuda *et al.*, 1986), and manure (Bonotto, 1976).

27. *S. horneri* (Turner) C. Agardh 괭생이모자반

Distribution: Growing commonly on rocks in subtidal zone of whole coasts.

Use: Foodstuff, goiter (Tokuda *et al.*, 1986), animal fodder and alginates (Kang, 1968; Bonotto, 1976; Tseng, 1983).

28. *S. micracanthum* (Kützing) Endlicher 잔가시모자반

Distribution: Growing commonly on rocks in subtidal zone of whole coasts.

Use: Alginates (Bonotto, 1976).

29. *S. miyabei* Yendo 미아베모자반

Distribution: Growing abundantly on rocks in subtidal zone of eastern to southern coasts and Cheju Island.

Use: Drugs and alginates (Tseng, 1983).

30. *S. sagamianum* Yendo 비틀대모자반

Distribution: Growing on rocks in subtidal zone of eastern coast.

Use: Antimicrobial (Baik and Kang, 1986), and alginates (Bonotto, 1976).

31. *S. serratifolium* (C. Agardh) C. Agardh 톱니모자반

Distribution: Growing rarely on rocks in subtidal zone of western coast.

Use: Foodstuff and alginates (Bonotto, 1976).

32. *S. siliquastrum* (Turner) C. Agardh 꽈배기모자반

Distribution: Growing commonly on rocks in lower intertidal to subtidal zones of whole coasts.

Use: Foodstuff (Tseng, 1983), and goiter (Tokuda *et al.*, 1986).

33. *S. thunbergii* (Roth) Kuntze 지충이

Distribution: Growing abundantly on rocks in lower intertidal zone of whole coasts, one of the most common marine algae in Korea.

Use: Foodstuff (Kang, 1968), vermifuge (Bonotto, 1976; Tseng, 1983), animal fodder and manure (Bonotto, 1976).

Rhodophyta

Bangiales

1. *Bangia atropurpurea* (Dillwyn) Lyngbye 김파래

Distribution: Growing on rocks or other substrates in upper intertidal zone in winter, common in whole coasts.

Use: Foodstuff (Madlener, 1977; Tseng, 1983).

Porphyra spp. 김류

Thirteen species were reported in Korea (Lee and Kang, 1986), all of which are used as popular foodstuff. *Porphyra* as well as *Undaria* is most popular edible seaweeds in Korea under cultivation.

2. *P. dentata* Kjellman 잇바디돌김

Distribution: Growing on rocks in intertidal zone of southern coast and Cheju Island.

Use: Foodstuff (Kang, 1968; Okazaki, 1971; Bonotto, 1976; Tseng, 1983), goiter, cough, bronchitis, edema, measles (Anonymous, 1978), and prevention of scurvy (Dawes, 1981).

3. *P. suborbiculata* Kjellman 둥근돌김

Distribution: Growing on rocks or other substrates in intertidal zone of western to southern coasts.

Use: Foodstuff (Kang, 1968; Okazaki, 1971; Bonotto, 1976; Madlener, 1977; Tseng, 1983), clearing lungs, relieve tension and anxiety, pulmonary and lymphatic tuberculosis, goiter, toothache, high blood pressure and kidney-urinary problems (Anonymous, 1978).

4. *P. tenera* Kjellman 참김

Distribution: Growing on rocks in intertidal zone of western to southern coasts and Cheju Island, one of the representative *Porphyra* in Korea.

Use: Foodstuff, cultivation (Kang, 1968; Okazaki, 1971; Bonotto, 1976; Madlener, 1977; Tseng, 1983), hypocholesterolemic (Tsuchiya, 1969), antioxidants (Fujimoto and Kaneda, 1980), and antiulcer (Sakagami *et al.*, 1982).

Nemaliales

5. *Nemalion vermiculare* Suringar 참국수나물

Distribution: Growing on rocks in intertidal zone especially of eastern coast.

Use: Foodstuff (Tseng, 1983).

6. *Asparagopsis taxiformis* (Delile) Trevisan 바다고리풀

Distribution: Growing on rocks in lower intertidal zone of western to southern coasts and Ulreungdo.

Use: Foodstuff (Tseng, 1983; Abbott and Cheney, 1982).

7. *Bonnemaisonia hamifera* Hariot 갈고리풀

Distribution: Growing on rocks or other algae in lower intertidal zones of whole coasts.

Use: Antimicrobial (Hornsey and Hide, 1974)

Gelidiales

8. *Acanthopeltis japonica* Okamura 새발

Distribution: Growing on rocks in lower intertidal zone of Cheju Island.

Use: Foodstuff and agar (Kang, 1968; Okazaki, 1971; Bonotto, 1976).

9. *Pterocladia capillacea* (Gmelin) Bornet 개우무

Distribution: Growing on rocks in lower intertidal zones of whole coasts, mixed with *Gelidium amansii.*

Use: Agar (Kang, 1968), and antimicrobial (Baik and Kang, 1986).

Gelidium spp. 우뭇가사리류

Nine species were reported in Korea (Lee and Kang, 1986), all of which were agarophytes.

10. *G. amansii* (Lamouroux) Lamouroux 우뭇가사리

Distribution: Growing on rocks in lower intertidal to subtidal zones, common in whole coasts.

Use: Agar (Kang, 1968; Okazaki, 1971; Bonotto, 1976; Madlener, 1977; Hotta *et al.*, 1989), intestinal disorders (Dawes, 1981), and antimicrobial (Baik and Kang, 1986).

11. *G. divaricatum* Martens 애기우뭇가사리

Distribution: Growing abundantly on rocks in intertidal zone, common in whole coasts.

Use: Foodstuff, agar (Kang, 1968; Okazaki, 19 71; Bonotto, 1976; Tseng, 1983), dysentery, blood platelet diseases, stomach ailments, hemorrhoids and anal fistulas (Anonymous, 1978; Tseng and Zhang, 1984; Tokuda *et al.*, 1986).

12. *G. johnstonii* Setchell et Gardner 존스튼우뭇가사리

Distribution: Growing on rocks in lower intertidal zone of southern coast and Cheju Island, mixed with *G. amansii.*

Use: Agar (Okazaki, 1971; Bonotto, 1976).

13. *G. pacificum* Okamura 왕우뭇가사리

Distribution: Growing on rocks or tide-pools in intertidal zone of south eastern to southern coasts and Cheju Island.

Use: Foodstuff and agar (Okazaki, 1971; Bonotto, 1976; Tseng, 1983).

14. *G. pusillum* (Stackhouse) Le Jolis 실우뭇가사리

Distribution: Growing on rocks in middle intertidal zone of eastern to southern coasts.

Use: Agar (Okazaki, 1971; Bonotto, 1976).

15. *G. tenue* Okamura 엷은우뭇가사리

Distribution: Growing on rocks in lower intertidal zone of western to southern coasts and Cheju Island.

Use: Agar (Okazaki, 1971; Bonotto, 1976).

16. *G. vagum* Okamura 막우뭇가사리

Distribution: Growing on rocks in intertidal zone of eastern to southern coasts and Cheju Island.

Use: Agar (Kang, 1968; Okazaki, 1971; Bonotto, 1976; Tseng, 1983).

Cryptonemiales

17. *Corallina officinalis* Linnaeus 산호말

Distribution: Growing abundantly on rocks in intertidal zone, common in whole coasts.

Use: Vermifuge (Dawson, 1966; Bonotto, 1976; Dawes, 1981; Tokuda *et al.*, 1986; Hotta *et al.*, 1989).

18. *Jania rubens* (Ellis et Solander) Lamouroux 붉은애기산호말

Distribution: Growing on rocks or other algae in intertidal zone of southern coast and Cheju Island.

Use: Hypoglycemic, fibrinolytic and lipolytic (Hoppe, 1979).

19. *Grateloupia divaricata* Okamura 뻐지누아리

Distribution: Growing on rocks in intertidal zone of eastern coast.

Use: Foodstuff, agglutinin (Kang, 1968; Okazaki, 1971; Bonotto, 1976; Hotta *et al.*, 1989).

20. *G. filicina* (Wulfen) C. Agardh 참지누아리

Distribution: Growing on rocks in calm intertidal zone, common in whole coasts.

Use: Foodstuff and agglutinin (Kang, 1968; Okazaki, 1971; Bonotto, 1976; Hotta *et al.*, 1989).

21. *G. okamurae* Yamada 털도박

Distribution: Growing on rocks in calm intertidal zone of eastern to southern coasts.

Use: Foodstuff and agglutinin (Kang, 1968; Okazaki, 1971; Bonotto, 1976).

22. *Grateloupia sparsa* (Okamura) Kylin 명주도박

Distribution: Growing on rocks in intertidal zone or tide-pools in eastern to southern coasts and Cheju Island.

Use: Agglutinin (Kang, 1968).

23. *G. turuturu* Yamada 미끌도박

Distribution: Growing on rocks in intertidal zone or tide-pools of whole coasts.

Use: Agglutinin (Arasaki and Arasaki, 1983).

24. *P. elliptica* (Holmes) Yamada 참도박

Distribution: Growing commonly on rocks in lower intertidal to subtidal zones of eastern to southern coasts and Cheju Island.

Use: Foodstuff, agglutinin (Kang, 1968; Okazaki, 1971; Bonotto, 1976), and antimicrobial (Baik and Kang, 1986).

25. *Pachymeniopsis lanceolata* Yamada 개도박

Distribution: Growing commonly on rocks in lower intertidal to subtidal zones of eastern to southern coasts and Cheju Island.

Use: Agglutinin (Kang, 1968).

26. *P. yendoi* Yamada 쐐기꼴도박

Distribution: Growing commonly on rocks in lower intertidal to subtidal zones of eastern to southern coasts and Cheju Island.

Use: Agglutinin (Kang, 1968).

27. *Gloiopeltis complanata* (Harvey) Yamada 애기풀가사리

Distribution: Growing on rocks in lower intertidal zone of southern coast and Cheju Island.

Use: Agglutinin, food stabilizer and homogenizer (Kang, 1968; Bonotto, 1976; Hotta *et al.*, 1989).

28. *G. furcata* (Postels et Ruprecht) J. Agardh 불등가사리

Distribution: Growing abundantly on rocks in middle to upper intertidal zones of western to southern coasts and Cheju Island.

Use: Agglutinin, foodstuff (Kang, 1968; Okazaki, 1971; Bonotto, 1976; Madlener, 1977; Tseng, 1983; Hotta *et al.*, 1989), cough, bronchitis, tonsillitis, asthma, stomach ailments, hemorrhoids, anal fistulas, rheumatic arthritis and tuberculosis, goiter (Tseng and Zhang, 1984; Tokuda *et al.*, 1986).

29. *G. tenax* (Turner) J. Agardh 풀가사리

Distribution: Growing on rocks in intertidal zone of southern coast and Cheju Island.

Use: Foodstuff (Tseng, 1983), agglutinin (Kang, 1968; Okazaki, 1971; Bonotto, 1976), stomach ailments, hemorrhoids, anal fistulas, goiter, scrofula, rheumatic arthritis, tuberculosis, cough, bronchitis, tonsillitis and asthma (Tseng and Zhang, 1984; Tokuda *et al.*, 1986).

Gigartinales

30. *Meristotheca papulosa* (Montagne) J. Agardh 갈래곰보

Distribution: Growing abundantly on rocks in subtidal zone of southern part of Cheju Island.

Use: Foodstuff (Kang, 1968; Bonotto, 1976; Tseng, 1983; Hotta *et al.*, 1989), and food stabilizer (Okazaki, 1971).

31. *Hypnea charoides* Lamouroux 참가시우무

Distribution: Growing on rocks in intertidal to subtidal zones of southern coast and Cheju Island.

Use: Foodstuff and agar (Kang, 1968; Okazaki, 1971; Tseng, 1983; Hotta *et al.*, 1989).

32. *H. japonica* Tanaka 갈고리가시우무

Distribution: Growing on rocks or other algae in intertidal zone of southern coast and Cheju Island.

Use: Foodstuff and agar (Kang, 1968; Okazaki, 1971; Bonotto, 1976; Tseng, 1983; Hotta *et al.*, 1989).

Gracilaria spp. 꼬시래기류

Eight species were reported in Korea (Lee and Kang, 1986), all of which were agarophytes.

33. *G. bursa-pastoris* (Gmelin) Silva 각시꼬시래기

Distribution: Growing on rocks in lower intertidal zone facing open sea of whole coasts.

Use: Agar (Kang, 1968; Bonotto, 1976).

34. *G. chorda* Holmes 개꼬시래기

Distribution: Growing on rocks in lower intertidal to subtidal zones of southern coast.

Use: Agar (Kang, 1968; Bonotto, 1976).

35. *G. textorii* (Suringar) Hariot 잎꼬시래기

Distribution: Growing on rocks in lower intertidal to subtidal zones of southern coast.

Use: Foodstuff and agar (Kang, 1968; Bonotto, 1976; Tseng, 1983; Hotta *et al.*, 1989).

36. *G. verrucosa* (Hudson) Papenfuss 꼬시래기

Distribution: Growing on rocks in intertidal zone or sandy mudflat in calm intertidal zone, common in whole coasts.

Use: Foodstuff, agar (Kang, 1968; Okazaki, 1971; Bonotto, 1976; Madlener, 1977; Mshigeni, 1983; Tseng, 1983; Hotta *et al.*, 1989), antimicrobial (Hornsey and Hide, 1974), pulmonary tuberculosis, stomach disorders (Dawson, 1966; Dawes, 1981), urinary diseases, dropsy, goiter (Tseng and Zhang, 1984; Tokuda *et al.*, 1986).

37. *Gymnogongrus flabelliformis* Harvey 부챗살

Distribution: Growing on rocks in intertidal zone or tide pool, common in whole coasts.

Use: Foodstuff, agar (Bonotto, 1976; Tseng, 1983), and agglutinin (Okazaki, 1971).

38. *Chondrus ocellatus* Holmes 진두발

Distribution: Growing on rocks in lower intertidal to subtidal zones, common in whole coasts.

Use: Foodstuff (Tseng, 1983), agglutinin, carrageenan (Kang, 1968; Okazaki, 1971; Bonotto, 1976), food tranquilizer and homogenizer (Hotta *et al.*, 1989), intestinal disorders (Dawes, 1981), and antimicrobial (Baik and Kang, 1986).

39. *Chondrus crispus* Stackhouse 주름진두발

Distribution: Growing on rocks in lower intertidal zone of southern coast and Cheju Island.

Use: Foodstuff (Bonotto, 1976; Madlener, 1977), diarrhea, urinary disorders, chronic pectoral infections (Dawson, 1966), antimicrobial (Hornsey and Hide, 1974, 1976a, 1976b), and carrageenan (Bonotto, 1976; Abbott and Cheney, 1982).

40. *C. pinnulatus* (Harvey) Okamura 깃꼴진두발

Distribution: Growing on rocks in lower intertidal zone of southern coast.

Use: Agglutinin (Kang, 1968; Okazaki, 1971; Bonotto, 1976).

41. *Gigartina intermedia* Suringar 애기돌가사리

Distribution: Growing on rocks or other algae in intertidal zone of whole coasts.

Use: Foodstuff (Tseng, 1983), and carrageenan (Bonotto, 1976).

42. *G. tenella* Harvey 돌가사리

Distribution: Growing on rocks in lower intertidal zone of southern coast.

Use: Agar sub-stuff (Kang, 1968; Okazaki, 1971; Bonotto, 1976), food tranquilizer and homogenizer (Hotta *et al.*, 1989).

43. *G. teedii* (Roth) Lamouroux 가시돌가사리

Distribution: Growing on rocks or tide-pools in intertidal zone of whole coasts.

Use: Agglutinin (Kang, 1968; Bonotto, 1976).

44. *Rhodoglossum japonicum* Mikami 붉은은행초

Distribution: Growing on rocks in subtidal zone of southern coast.

Use: Agglutinin (Kang, 1968; Bonotto, 1976).

Ceramiales

45. *Callithamnion corymbosum* (Smith) Lyngbye 술외깃풀

Distribution: Growing on rocks or other algae in lower intertidal zone of southern coast.

Use: Agglutinin (Shiomi, 1983).

46. *Campylaephora crassa* (Okamura) Nakamura 굵은석묵

Distribution: Growing on rocks or other algae in intertidal zones in western to southern coast.

Use: Agar (Okazaki, 1971)

47. *Campylaephora hypnaeoides* J. Agardh 석묵

Distribution: Growing on rocks or other algae in lower intertidal zone of western to southern coasts.

Use: Foodstuff and agar (Kang, 1968; Okazaki, 1971; Bonotto, 1976; Tseng, 1983).

48. *Centroceras clavulatum* (J. Agardh) Montagne 가시풀

Distribution: Growing on rocks or other algae in lower intertidal to subtidal zones of southern coast and Cheju Island.

Use: Agar (Okazaki, 1971), and headache (Chapman and Chapman, 1980).

Ceramium spp. 비단풀류

Thirteen species were reported in Korea (Lee and Kang, 1986), most of which were potential agarophytes (Okazaki, 1971).

49. *Ceramium boydenii* Gepp 단박

Distribution: Growing on rocks or other algae in lower intertidal zone of western to southern coasts and Cheju Island.

Use: Agar (Kang, 1968; Okazaki, 1971; Bonotto, 1976; Tseng, 1983).

50. *Ceramium kondoi* Yendo 비단풀

Distribution: Growing on rocks or mixed with other algae in intertidal zone of western to southern coasts and Cheju Island.

Use: Foodstuff (Tseng, 1983), and agglutinin (Bonotto, 1976; Shiomi, 1983).

51. *Spyridia filamentosa* (Wulfen) Harvey 큰사돈비단풀

Distribution: Growing on rocks in lower intertidal zone of southern coast.

Use: Agglutinin (Shiomi, 1983).

52. *Caloglossa leprieurii* (Montagne) J. Agardh 참각시혀

Distribution: Growing on rocks in subtidal zone of western to southern coasts and Cheju Island.

Use: Foodstuff (Bonotto, 1976), and vermifuge (Tseng, 1983).

53. *Chondria crassicaulis* Harvey 개서실

Distribution: Growing on rocks in intertidal zone, common in whole coasts.

Use: Foodstuff (Kang, 1968).

54. *C. dasyphylla* (Woodward) C. Agardh 각시서실

Distribution: Growing on rocks in lower intertidal to subtidal zone of whole coasts.

Use: Antimicrobial (Hornsey and Hide, 1974), antimitotic (Chénieux *et al.*, 1980), and inotropic (Baker, 1984).

55. *Laurencia* spp. 서실류

Fifteen species were reported in Korea (Lee and Kang, 1986), all of which were potential agarophytes (Mshigeni, 1983).

Distribution: Growing on rocks in intertidal to subtidal zone, common in whole coasts.

Use: Foodstuff (Bonotto, 1976), agar (Mshigeni, 1983; Zablackis and McDermid, 1988), and antimicrobial (Hornsey and Hide, 1974).

56. *Neorhodomela aculeata* (Perestenko) Masuda 새빨간검둥이

Distribution: Growing on rocks in calm intertidal zone of whole coasts.

Use: Bromine-stuff (Hotta *et al.*, 1989), antimicrobial (Hornsey and Hide, 1974), and antimitotic (Chénieux *et al.*, 1980).

57. *Polysiphonia morrowii* Harvey 모로우붉은실

Distribution: Growing on rocks in intertidal zone in whole coasts.

Use: Antimicrobial (Hornsey and Hide, 1974).

DISCUSSION

Seaweeds have been used as prime materials for human uses due to their diversity and abundance mainly in the maritime countries in the world (Dawson, 1966; Bonotto, 1976; Chapman and Chapman, 1980; Dawes, 1981; Waaland, 1981; South and Whittick, 1989). Edible seaweeds such as *Laminaria, Undaria* and *Porphyra* contain carbohydrates, proteins, fats, vitamins and small amounts of iodine, etc. Their nutritive value, however, is not high because of lacking suitable enzymatic systems in human body (Bonotto, 1976). Nevertheless, many seaweeds were used as important food resources in East Asian countries (Chapman and Chapman, 1980; Waaland, 1981; Lee, 1987; Trono, 1990). Due to their importance of resources, techniques and studies on their cultivation have been extensively developed in Korea, Japan and China (Dawson, 1966; Okazaki, 1971; Bonotto, 1976; Kang and Koh, 1977; Tokuda *et al.*, 1986; Trono, 1990).

Historically, seaweeds served as important food sources in Korea. From the earliest times as previously mentioned, three major seaweeds; *Laminaria* (Dashima), *Undaria* (Miyok) and *Porphyra* (Gim) have been cultivated in the western to southern coasts (Park, 1966; Kang and Koh, 1977; Kang, 1981, 1990). It is also known that various kinds of seaweeds were locally used as vermifuge, manure and livestock fodder as well as foodstuff (Kang, 1968). According to Korean traditional records, practice and application of seaweeds to medicine and manure were made as early as Chinese activities (Park, 1966).

Since 1960 in Korea biochemical studies on seaweeds were carried out together with taxonomic and floristic studies. Many analytical studies were attempted: analyses of free amino acids (Kwon and Lee, 1960; Lee *et al.*, 1961, 1962; Lee, 1965; Kim, 1974), fats and lipids (Lee *et al.*, 1974; Ha, 1977), agar and carrageenan (Park *et al.*, 1967, 1976; Park, 1969; Kim and Park, 1978), and alginic acid (Yang, 1962; Lee *et al.*, 1968; Park, 1969). Re-

cently, Lee (1987) discussed three major aspects, medical uses, industrial uses, and foodstuff of seaweeds, additionally referring to their economic values.

Based on the data of Lee and Kang (1986) and Lee (1987), potentially useful seaweeds common in Korean coasts can be summarized in this investigation as 164 species including 33 green, 33 brown and 98 red algae, respectively. Among them, 54 species were able to use for medical uses, 87 species for foodstuff and 74 species for industrial uses (Table 1).

Medical applications of seaweeds are almost as old as food uses (Dawson, 1966). Species of *Sargassum* and Laminariales were used for treatment of goiter and glandular troubles in ancient China. *Laminaria* plants were practiced in surgical tool as well as childbirth for expansion of the cervix (Dawson, 1966). A long European medical history also recorded that *Chondrus crispus* (Irish moss) was used for treatments of diarrhea, urinary disorders and chronic pectoral infections, while *Corallina officinalis* as popular vermifuge (Chapman, 1950; Dawson, 1966).

In Korea, *Codium fragile* (Chonggak) and *Sargassum thunbergii* (Jichungeui) were actually used as vermifuge at coastal areas and *Undaria pinnatifida* soup was traditionally eaten for postpartum care. Potential sources for medical uses of seaweeds investigated were shown in Table 2. Several sources of foodstuff generally eaten excluding three major seaweeds were variously used according to local people. *Grateloupia filicina* abundantly growing in intertidal zone together with *Enteromorpha* spp. and *Hizikia fusiformis* are favorite foodstuff in eastern coast. *Enteromorpha* spp., *Codium fragile, Sargassum fulvellum,* and *Hizikia fusiformis* are usually eaten in southern coast including Cheju Island. *Pelvetia siliquosa* is an important foodstuff source in western coast.

Seaweeds used as industrial source in Korea are scarce considering their production; *Ecklonia cava, Gelidium* spp., *Gracilaria* spp., *Chondrus* spp., *Grateloupia* spp., etc. Among them, *Ecklonia cava, Gelidium* spp. and *Chondrus* spp. are mainly harvested from Cheju Island, *Gracilaria* spp. from western to southern coasts, and *Grateloupia* spp. from eastern coast, respectively. In addition, *Sargassum* spp. (Mojaban) have been used as manure and *Ulva pertusa* as livestock fodder in Cheju Island.

Recently, seaweeds were focused on their three major uses; pharmacological and medical appli-

Table 1. A number of species for potential sources of seaweeds occurring in Korean coasts

Division \ Use	Medical Use	Foodstuff	Industrial Use
Chlorophyta	16	25	3
Phaeophyta	17	23	18
Rhodophyta	21	39	53
Total	54	87	74

Table 2. Major members of seaweeds for medical, foodstuff and industrial uses in Korea

Medical uses
Codium fragile, Sargassum thunbergii, Corallina officinalis
Foodstuff
Enteromorpha spp., *Monostroma* spp., *Codium fragile, Hizikia fusiformis, Pelvetia siliquosa, Sargassum fulvellum, Agarum cribrosum, Undaria pinnatifida, Laminaria japonica, Porphyra* spp.
Industrial uses
Ecklonia cava, Gelidium amansii, Gracilaria verrucosa, Grateloupia spp.

cations, resources for human nutritions and lastly alginate sources (Bonotto, 1976; Waaland, 1981; Tseng, 1983). The present situation of algal industries in Korea made little progress excluding cultivation of a few major foodstuff seaweeds. Therefore, the evaluation and utilization of seaweeds in Korea should be focused more on medical and pharmaceutical uses in future.

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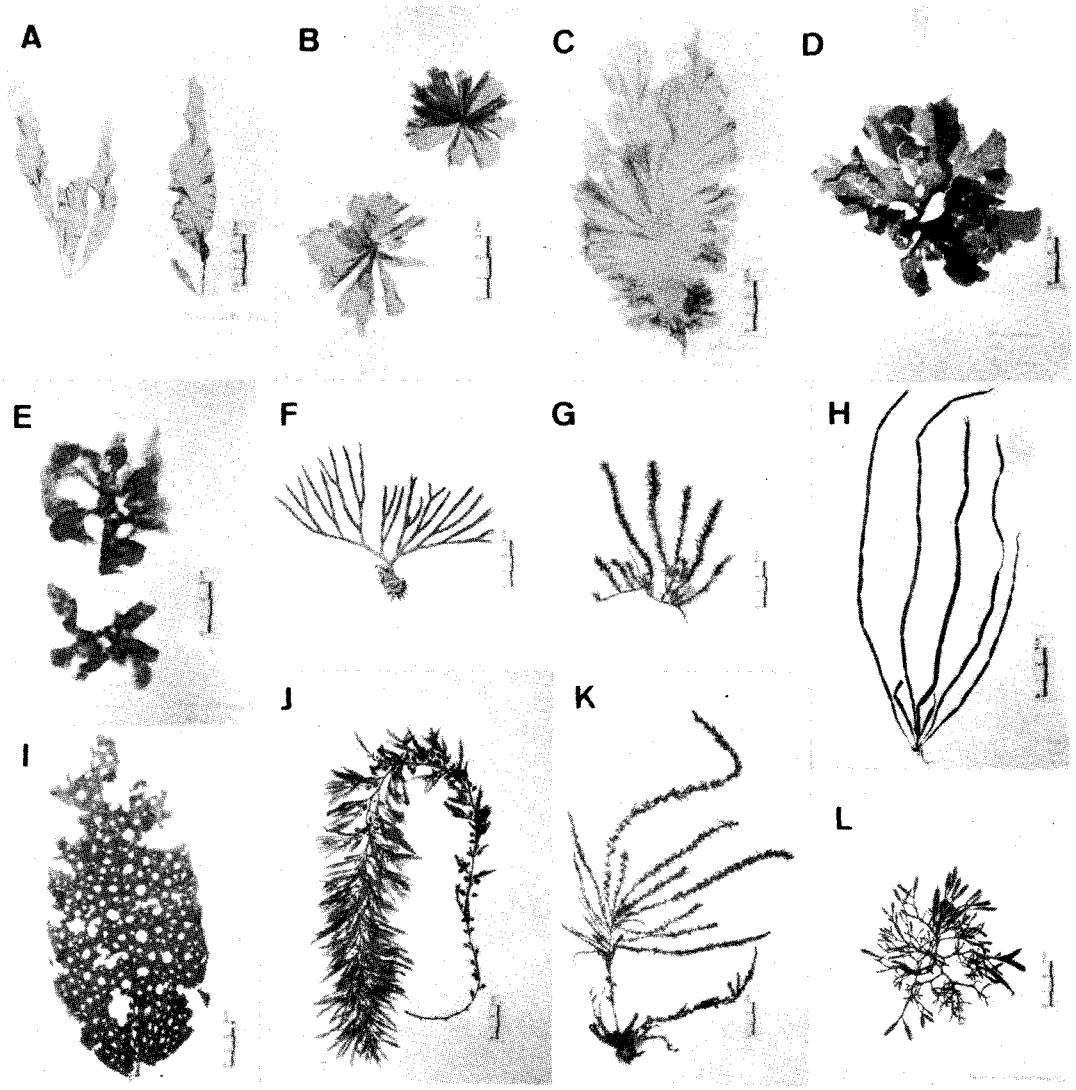

Fig. 1. Potential sources of seaweeds commonly occurring in Korean coasts.
A. *Enteromorpha linza* (L.) J. Agardh, B. *Monostroma nitidum* Wittrock, C. *Ulva lactuca* Linnaeus, D. *Ulva pertusa* Kjellman, E. *Codium adhaerens* (Cabrera) C. Agardh, F. *C. fragile* (Suringar) Hariot, G. *Caulerpa okamurae* Weber van Bosse, H. *Scytosiphon lomentaria* (Lyngbye) Link, I. *Agarum cribrosum* Bory, J. *Sargassum fulvellum* J. Agardh, K. *S. thunbergii* (Roth) Kuntze, L. *Pelvetia siliquosa* Tseng and Chang.

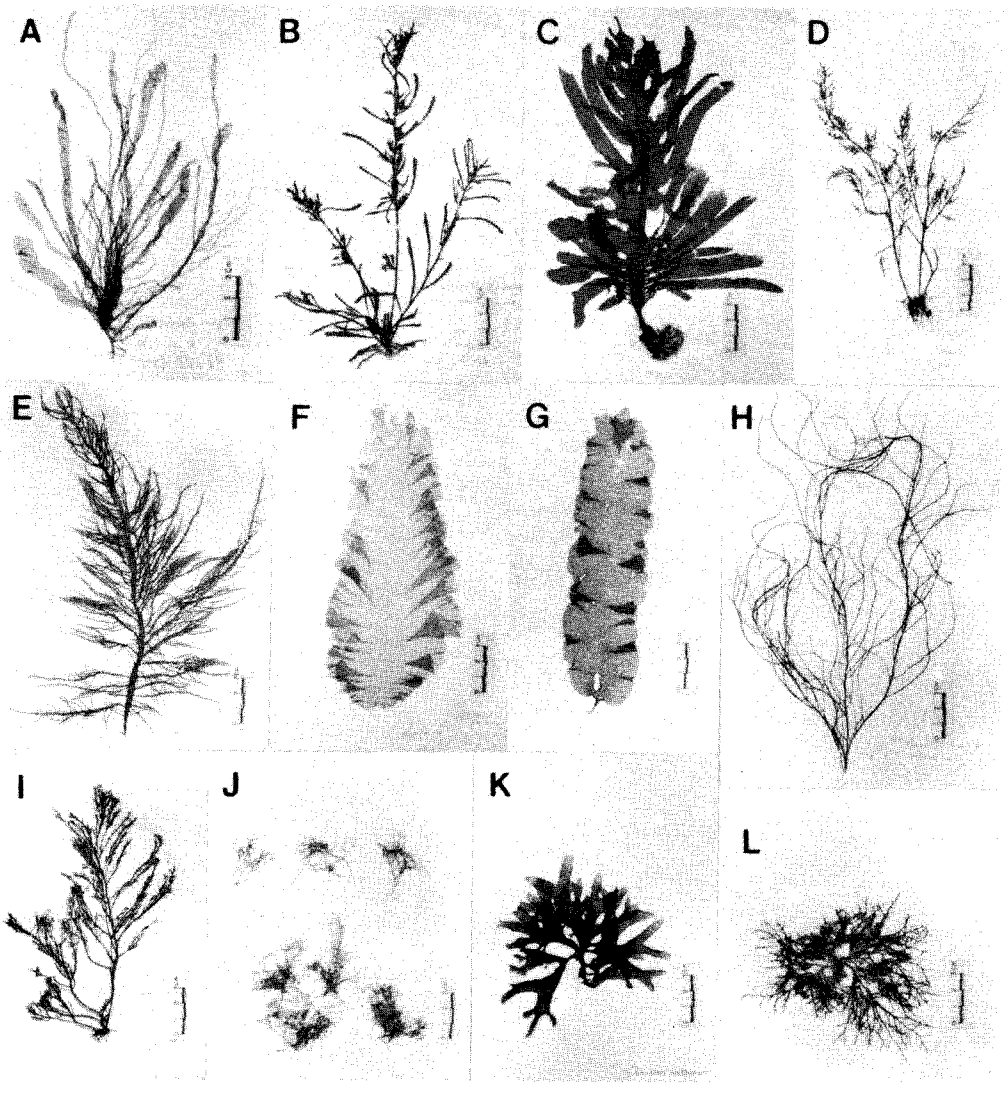

Fig. 2. Potential sources of seaweeds commonly occurring in Korean coasts.
A. *Enteromorpha compressa* (L.) Greville, B. *Hizikia fusiformis* (Harvey) Okamura, C. *Undaria pinnatifida* (Harvey) Suringar, D. *Laurencia okamurae* Yamada, E. *Grateloupia filicina* (Lamouroux) C. Agardh, F. *Porphyra yezoensis* Ueda, G. *Grateloupia turuturu* Yamada, H. *Gracilaria verrucosa* (Hudson) Papenfuss, I. *Chondria crassicaulis* Harvey, J. *Ahnfeltia plicata* (Hudson) Fries var. *tobuchiensis* Kanno et Matsubara, K. *Chondrus ocellatus* Holmes, L. *Gelidium amansii* (Lamouroux) Lamouroux.