The Potency of *Krokot* (*Portulaca oleracea*) as Functional Food Ingredients

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ABSTRACT

Indonesia has many auxiliary plants that may have nutritional and or environmental benefits, so that it may increase the yield of the main crops. Krokot (Portulaca oleracea), one of the auxiliary plants, was traditionally consumed in many parts of the world for its delicacy and medicinal benefits. Our research indicated that krokot has high potency to improve the health status of the community. It has 5.4 mg/100 g of b-carotene, 22.2 mg/100 g of vitamin C, and significant amount of folic acid (0.2 mg/100 g). Krokot was traditionally used to treat scurvy, and various of infectious and skin diseases. Literature review revealed that krokot has essential fatty acid, it also has antimutagenic, and antimicrobial activity.

Unfortunately, krokot is approaching extinction both physically and ethnobotanically because they are considered as useless plants or even weed. Our survey on 103 agricultural university students revealed that only 24% of the respondents knew krokot. Krokot is especially difficult to find in intensively cultivated area. Along with other indigenous vegetables, Portulaca oleracea is almost never served again in Indonesian cuisine. Utilization of krokot as functional food ingredients might helps to conserve the plant as well as encouraging sustainable agriculture.

Keywords: krokot, Portulaca oleracea, functional food

INTRODUCTION

Belong to Portulacaceae, *krokot* or *Portulaca oleraceae* (Figure 1) was widely distributed in tropical & subtropical areas (Table 1) and widely used as food and medicine. However, in Indonesia, *krokot* is approaching extinction ethnobotanically. Our survey on 103 agricultural university students revealed that only 24% of the respondents knew *krokot*. The research is aimed to study the potency of krokot as functional food ingredients.

The extinction process is coherent with the scarity of the plant. Based on our observation, edible krokot is rare in intensively cultivated area in Bogor (West Java), Semarang (Central Java), and Blitar (East Java), but quite a lot in organic plantation in Central Kalimantan. Indeed, the IRRI (International Rice Research Institute) consider *krokot* as weed. They suggest to controlling it by frequent and continuing shallow cultivation, hoeing, or applying herbicides. However, the organization also recognize it as vegetable, medicine, forages and blue dye (Gallinato, 1999).

According to Solomon (1998[a]), there are two types of edible purslane, they are wild purslane (yellow portulaca) and garden purslane (green purslane, winter purslane or Montia perfoliata). The wild purslane has slight pink stem and small yellow flower. It is more commonly consumed in tropical countries such as Indonesia.

Figure 1. Picture of *Portulaca oleracea* L. (Ochse and van den Brink, 1980)

Table 1. Some of the Vernacular Name of *Krokot*

COUNTRIES	NAME
Commonwealth	pigweed, common purslane, purslane
France	pourpier
Netherlands	potselein or porselein
Mexico & Dominican Republic	verdolaga
Peru	vertolaga
Australia	munyeroo (in Aborigin)
India	jangali palak or kulva
Sri Lanka	genda kola
Bangladesh	bara lniya, bara nuia, ghee kalam, nunia.
Egypt	rigla.
China	ma ch'ih hsien or kwa-tsz-tsai
Japan	suberi-hiyu.
Malaysia	called gelang pasir, segan jantan, or rumput beremi
Philippines	olasiman or alusiman (Bicolano), sim-sim (Bisaya), olasiman or golasiman (Tagalog), ngaluk (Ilocano), and kantataba (Pampango)
Cambodia	mâong dâb phkaa
Laos	taa kôngz, biaz, nya en eyan or nya tha kong
Vietnam	rau sam or sam
Myanmar	called mye-htauk, mye pa yit, or the pa yit
Thailand	phakbia-nu, phakbia-lek, or phakbia yai.
Indonesia	gelang (Maluku, West Java), krokot (Java, Tigabinanga, Medan, Lampung, Bogor, Tasikmalaya), and resereyan (Madura). jalu-jalu kiki (Maluku)

Source: Anonymous (1998), Anonymous (2002), Backer and van Slooten (1924), Sivin (1999), Gallinato (1999), Solomon (1998[a]), Lemmens and Bunyaprahatsara in de Padua, et al. (1999), Heyne (1950), and our survey in Indonesia .

Krokot is a succulent plant. It is an erect or ascending annual herb, up to 50 cm tall. The leaves are obovate to spathulate, 2-40 mm x 1-20 mm. It has ovoid fruit 4 mm x 3 mm with granulate seeds 0.5-1.2 mm in diameter (Susiarti in Siemonsma and Piluek (ed), 1994).

METHODOLOGY

Initial Survey of *Portulaca oleracea* in Indonesia

The survey was conducted by direct observation, interview, and literature study. Direct observation and interview was conducted in Jogjakarta, Semarang (Central Java), Blitar (East Java), and Bogor (West Java). In this activity, ethnobotanical information, and the availability of the plant in the aforementioned locations were also collected.

Nutritional Value

Nutritional value was studied by chemical analysis and by literature review. Prior to analysis, the plant was organically cultivated in pots. Major nutritional values were analyzed with standard method (AOAC, 1984). The conversion factor from total N to protein was 4.39 instead of 6.25 (Fujihara et al., 2001). The minerals were measured by AAS, while the vitamin C content was analyzed with iodine method.

Folic acid analysis was conducted by macerating 10 grams of sample in 25 ml acetonitrile for 5 minutes. Followed by filtration with Whatman paper No. 45 and vacuum evaporation, the filtrate was diluted with 5 ml of methanol before HPLC analysis. The HPLC condition was as followed: C18 column, mobile phase methanol: water (60:40). Column temperature 27-28°C, flow rate 1 ml/min. Detector UV (l = 254 nm).

Beta carotene analysis was conducted by macerating 5 g of sample in 50 ml of KOH-methanol (60 g KOH in 50 ml of water diluted by methanol into 1 l). The suspension was stirred and heated at 60°C for 1 hour, at which point, the suspension was dissolved into 20 ml hexane and 50 ml aquadest. The hexane layer was separated from the aqueous layer by twice extraction and partition between them. The hexane layers combined were concentrated with a vacuum evaporator to get the b-carotene extract. The extract was analyzed by HPLC with the following condition: C-18 column, mobile phase acetonitrile : methanol : dichloromethane (60:35:5), flow rate 1 ml/min, column temperature 27-28°C, detector UV (l = 462 nm).

RESULT

Portulaca oleracea as Food

Portulaca oleracea is believed to as the earliest vegetable consumed by human (Susiarti, 1994 in Siemonsma and Piluek (ed), 1994). It can be eaten raw (dipped in salty fish sauce or mixed into salad), or cooked (Solomon, 1998[a]). It is consumed in many different part of the world such as China, India, Middle East countries, South East Asia, Netherlands, Mexico, and United States (Ohio and Kentucky). According to Mohamed and Hussein (1994), in Midd'e East, purslane (*krokot*) can be consumed raw as salad, or soups. The seeds may be ground into flour as ingredient in mush bread.

The Chinese stir and fry this vegetable with garlic, sesame oil, and light soy sauce (Solomon, 1998[b]). In Sri Lanka, purslane is also stir and fried with maldive fish, garlic, leek, chili powder and lemon juice (Solomon, 1998[c]). Anonymous(—) mentioned that in the United States, purslane may also cooked into casserole, pickle, pancakes, and Lamb's Quarter and purslane salad.

In Mexico, purslane is a favorite snack food. It is rolled in an omelet, rolled in tortillas, or added into soups and stews (Anonymous, 1998). The French mix it with sorrel and make it into French soup, bonne femme. Other kind of western soup is purslane and pea soups. Western salad may consist of purslane, lettuce, chervil, borage flowers, and marigold petals, borage, and mint (Hernándo, 1994).

The Greece mix raw purslane with sliced potatoes, tomatoes, onions, green chilies, parsley, olive oil, vinegar and salt into Tomato, Potato and Purslane Salad (Kochilas, 2001). The Dutch make it into soup called sop selam krokot. The soup is made of local celery (sederij), lokal leek (prei), citrus, sweet soy

sauce (kecap manis). From the herbs, spices and sauces being used, the dishes might be brought from Indonesia.

According to Heyne (1950), this plant was a favorite *lalab* in Java. It might be cooked with tamarind. Based on the writers observation, in Central Java, purslane (krokot) leaves and young stem used to be stirred and fried with sliced shallot, garlic, red chillies, palm sugar, salt, salam leaves, and a slice of *Alpinia galanga* (lengkuas) to make cuisine called oseng-oseng. It may also boiled or steamed, and then served with other vegetable (local spinach, mung bean sprout, long bean, *Marsilea crenata*, etc), and poured with peanut sauce to make cuisine called *pecel*. *Krokot* has a pleasing sour taste and delicious texture. According to the respondent, *krokot* was consumed in East Java (Blitar and Banyuwangi), and also North Sumatera (Medan).

Today's, in Central Java, the popularity of *krokot* as vegetable is very poor. *Krokot* is generally not cultivated but collected from the wild. Today's the availability of the plant in 'clean places' such as rice field is getting rare (it might indicate that the plant is prone to synthetic pesticides and synthetic fertilizer commonly used in rice field). Most of the remaining plant grow near or in irrigation canals, and ditches (in the cities). The growth location creates 'dirty' images on *krokot*, thus medium-high educated and medium-high economic-level society are reluctant to eat it.

Since they refused to eat it, the price of *krokot* in the market is very low. As a comparison, in 1997, in Magelang (Central Java), a bunch of local amaranth (*bayam oyot* or *bayem cabut*) is 100 to 150 rupiahs. Meanwhile the price of a bunch of portulaca was only 35 rupiahs, or 3 bunch for 100 rupiahs. Only a poor old women who has no rice field and too old to work as agricultural labor was willing to collect it and sell it on market-day (once in five days), in Kalegen village (Kecamatan Bandongan, Kabupaten Magelang, Central Java). Local people are rarely buying it for food, they prefer to use it as *menthog* feed (a local poultry).

Since *krokot* is rarely found on the market, thus it is rarely consumed. Many young generations are no longer familiar with *krokot*. Some of the young generation who ever heard the name, have an image that *krokot* is an ornamental flowering Portulaca, not the commonly consumed. Only a few of the young generation knows that this plant is edible. Many of the few know it because of Prof. Hembing's show on television (explaining traditional medicine from China & Indonesia), and some read it in articles about traditional medicine.

Composition of *Portulaca oleracea*

P. oleracea contains many biologically active compounds and it is a source of many nutrients. The major nutrient data (Table 2) and the mineral data (Table 3) varied significantly between analysis. According to Mohammed and Husein (1994), the nutrient composition of *Portulaca* varied based on its growth stage and organs.

Table 2. Major Nutrient in *Portulaca oleracea*

Component	Based on Our Analysis[1] (%)	Based on the Reference (%)
Moisture		
• Moisture content	94	
• Moisture content		85.9[3]
• Moisture content		92[4]
Protein		
• Protein	1.7[2]	
• Protein		2.2[5]
• Protein		1.7[4]
Lipid		
• Crude Lipid	0.5[2]	
• Crude Lipid		0.9[5]
• Lipid in young leaves		3.81[6]
• Glycolipid in young leaves		1.60[6]
Carbohydrate		
• Carbohydrate (by difference)	2.2	
• Carbohydrate		5.0[5]
• Carbohydrate		3.8[4]
Fiber		
• Soluble Fiber	1.1	
• Insoluble Fiber	3.5	
• Crude Fiber		1.6[5]
Minerals		
• Ash	1.2	
• Ash		0.7[5]

Note:

1. Raw vegetable, per 100 g edible portion
2. The selection of conversion factor for protein is based on Fujihara (2001).
3. Data from Wesche-Ebeling (1995)
4. Data from Susiarti (1994) in (ed) Siemonsma and Piluek
5. Data calculated from Wesche-Ebeling (1995) into wet basis
6. Data from Guil-Guerrero & Rodriguez-Garcia (1999)

Table 3. Minerals Composition of *Portulaca oleracea*

Minerals	Based on Our Analysis (mg/100g)	Based on the Reference (mg/100g)
P on edible portion	2.3	
P	39[1]	
K on edible portion	6.7	
Ca on edible portion	3.8	
Ca	103[1]	
Fe on edible portion	16	
Fe on leaves		33.21[2]
Fe	3.6[1]	
Mg on edible portion	3.3	

Note:
1. Data from Susiarti (1994) in (ed) Siemonsma and Piluek
2. Data from Mohammed and Husein (1994)

Mohammed and Husein (1994) also reported that total P, Fe and Mn content in leaves was significantly higher than those found in stems. According to Grieve and Suarez (1996), Ca, Mg, and S tends to acculumate on *Portulaca oleracea* leaves, while K tends to accumulate on the stem. Indeed, different analysis method, season, growth location, and varieties (subspecies) may have significant influence on the data.

Hernándo Bermejo (1994) mentioned that there are five subspecies of wild *Portulaca oleracea* they are *oleracea, papillato-stellulata, stellata, granulato-stellulata,* and *nitida*). Furthermore, Prabhakar and Ramayya (1988) in Hernándo Bermejo (1994) mentioned that the protein and free amino acids of *P. oleracea* var. ophemera is significantly different from *P. oleracea* var. oleracea sativa.

Table 4 revealed that *Portulaca oleracea* is potential source of provitamin A and vitamin C. Its b-caroten was not significantly different from common vegetable which is well known as 'rich in vitamin A such as bayam (*Amaranthus* L) and carrot. Its vitamin C is higher than tomato, which is famous as vitamin C source. Both b–carotene and vitamin C play important roles on maintaining body immunity. They also reduce the risk of cancer. Promoting *Portulaca oleracea* as vegetable may helps to improve community health, especially the low-income society who lives in polluted environment. However, its availability and safety need to be further examined.

According toour analysis, the folic acid in *Portulaca oleracea* (Table 6) is higher than any other famous folic acid (asparagus, broccoli and spinach) source. It may caused by heat treatment. Raw asparagus has 0.175 mg of folic acid/100g fresh weight. The reduction occurs in all vegetables treated with boiling. However, Gregory (1996) in Fennema (1996) mentioned that folic acid stability in complex food is less well understood.

Folic acid is highly recommended for women in order to prevent low birth weights, premature infants, and neural tube defects. Cleft Lips and Palate organization also recommend it to prevent cleft lips and (or) palate defect. The organization even encourage people to donate green leafy vegetable seed to underdeveloped countries where folic acid deficiency and congenital malformation are prevalent (Cleft Lips and Palate Organization, 2002). Folic acid deficiency is also related with anemia and growth retardation (National Institute of Health, 2002).

Easily cultivated, *Portulaca oleracea* is potential as folic acid source for urban community. It only needs

Table 5. Vitamin A and Vitamin C Content of Some Vegetables

Vegetable	Vitamin A	Vitamin C	Source
Carrot	b-carotene 6-20 mg/100 g	5-10 mg/100 g	Van der Vossen and Sambas Siemonsma & Piluek (ed) (1994)
Bayam (*Amaranthus* L.)	b-carotene 4-8 mg/100 g	60-120 mg/100 g	Siemonsma & Piluek (1994)
Tomatoes	900 (IU/100g)	23 mg/100 g	Zennie (1977)
P. oleracea	2550 (IU/100g)	25 mg/100 g	Susiarti (1994) in Siemonsma & Piluek (ed) (1994)
P. oleracea	6100 (IU/100g)	26[1] mg/100 g	Zennie (1977)
P. oleracea	Carotenes: 89.2 mg/100 g (on leaves)		Guil-Guerrero JL, and Rodriguez-Garcia I (1999).
P. oleracea (raw)	b-carotene 5.4 mg/100 g (leaves & young stem)	22[2] mg/100 g	Our Analysis

Note:
1 analysis with dichloroindophenol,
2 analysis with Iodium

Table. 6 Folic Acid Composition of Some Food

Vegetable	Folic acid (mg/100 g)
Asparagus (boiled for 10 min)	0.146 [1]
Broccoli (boiled for 10 min)	0.065[1]
Spinach (Spinacea oleracea) (boiled for 10 min)	0.031[1]
Cabbage (raw)	0.030[1]
Egg yolk	0.15[2]
P. oleracea	0.2[3]

Note:
1. Gregory (1996) in (ed) Fennema (1996),
2. Belitz & Grosch (1999)
3. Our analysis (rawa state)

sunlight to grow well, and no synthetic pesticides or fertilizer is required. It can be grown as ornamental plant at public places, or grown in pots at the house fence, windows or roof in densely populated areas.

Some of the biologically active (and, in some case, potentially toxic compounds) in *Portulaca oleracea* are coumarins, glycosides, and anthraquinone glycosides (Anonymous, 2002). Other compounds in *Portulaca oleracea* are alanine (570-13,400 ppm), alkaloids (in leaf: 300 ppm), caffeic acid, calcium oxalate, catechol, beta-cyanin, digalactosyldiacylglycerol, docosahexaenoic acid (DHA), dopa, eicosapentaenoic acid (EPA: 10 ppm), HCN, histidine (220-5,170 ppm) (Duke, 2002 and Simopoulos et al., 1995).

Portulaca oleracea also has l-noradrenalin (2,500 ppm), linoleic acid (in herb: 704-18,245 ppm while in seed 67,686 ppm), linolenic acid (in herb: 3,221-64,315 ppm, while in seed: 7,226 ppm), a-linolenic acid (4,000-80,000 ppm), lysine (650-13,200 ppm), methionine (90-2,814 ppm), norepinephrine, oleic acid (in herb: 16-

2,160 ppm while in seed 49,935 ppm), omega-3's (30,000 ppm), oxalates (in shoots), oxalic acid (1,679-16,790 ppm), phytin-p (4-40 ppm), saponin, sinapic acid, b-sitosterol, tannin, threonine (470-9,400 ppm), tryptophan (160-3,400 ppm), and valine (660-13,200 ppm) (Duke, 2002 and Simopoulos et al.,1995).

The fact that it contains omega-3 is an interesting issue. Omara-Alwala et al. (1991) reported that in Eastern Mediterranean countries, *Portulaca oleracea* is eaten extensively either as soups or salads. In the area, the incidence of heart disease and cancer is low. The fact might relate with essential fatty acids in the vegetable. Guil-Guerrero, and Rodriguez-Garcia (1998) revealed that analysis with GC showed the major fatty acids in *Portulaca* were 18:3 omega-3, 18:2 omega-6, and 16:0 in all lipid fractions with high concentration of 18:3 omega-3 in the glycolipid fraction. Other researchers, Omara-Alwala et al. (1991) reported that *Portulaca oleracea* contain 18:3-omega-3, 20:5-omega3, 22:5-omega-3, 22:6-omega-3, 18:2 omega 6, and 18:1-omega-9. They stated that the leaves have more omega-3 acids then the stem.

In the contrary, Jirovetz et al. (1993) reported that purslane grown in Austria has no omega-3 fatty acids detected, but it contains fenchol, pentacosane, hexacosane, lanostane, sebacic acid octyl ester, stigmast-5-ene-3-ol (3-b-24-S), 23-ethylcholesta-52328-triene-3 b-ol, myristic, palmitic, stearic, linoleic, and oleic acids. According to Palaniswamy et al. (2002), the concentration of omega-3 fatty acid as well as oxalates in purslane were influenced by a number of environmental factors, such as mineral nutrition in the growing medium.

The oxalates content on *Portulaca oleracea,* may become a troublesome on people with kidney problems. Oxalates may also reduce calcium absorption. Lathika et al. (1995) has investigated to reduce its oxalate content by using alginate entrapped banana oxalate oxidase. They mix 10 g of oxalate oxidase containing alginate beads into 10% aqueous *Portulaca oleracea* leaf homogenate. The mixture was incubated at room temperature with occasional stirring. The oxalate decreases significantly in 45 minutes. However, the mashing process may reduce its preference among Indonesian consumers.

Portulaca oleracea as Medicine

The latest research in Western medicine reveals that it has an anti-inflammatory effect. This vegetable is rich in iron and vitamin C. The Aborigines use it to prevent and to treat scurvy. They eat it both raw and cooked. The Aborigines also grind the nutritious seeds into flour. Besides, they also use this plant as poison (Anonymous, 2002, and Solomon, 1998[a]).

Portulaca oleracea function to treat scurvy is also famous in China, Haiti, India and Turkey. Perhaps it is due to its high vitamin C content. The other famous function is for treating tumor (Brazil, China, Colombia and Gabon), diuretic (China, Haiti, India, Sudan and Turkey), and vermifuge (China, Dominican Republic, Iraq, Java, Trinidad and Venezuela). In the Dominican Republic, all parts of *Portulaca oleracea* are mixed with other plants (such as *Chenopodium ambrosioides*) (Anonymous, 2002) to treat internal parasites. However, scientific information about its efficacy against common internal parasites has not been found.

As anti tumor, Seung et al. (1997) reported that *Portulaca oleracea* juices strongly inhibited mutagenesis induced by benzo[a]pyrene,2-amino-fluorene, 3-amino-14-dimethyl-5H-pyridol tested on *Salmonella typhimurim* TA98 or TA100 in the presence of S-9 mix. The antimutagenic effects increased as the concentration of the mutagens increased.

In China portulaca is used for alexiteric, anthrax, antiphlogistic, bactericide, boil, bite (bug, snake), cold, colic, dermatitis, diarrhea and dysentery, diuretic, dyspepsia, eczema, edema, emollient, enteritis, erysipelas, fever, genital, herpes, intestine, leucorrhea, nausea, opacity, pile, poultice, pruritis, sore, scurvy, swelling, thirst, tonic, tumor, urogenital, vermifuge, wound. In India, this vegetable is used as detergent. It is also used as or to treat astringent, bladder, diuretic, heat, kidney, lung, scurvy, vulnerary (Anonymous, 2002).

In Haiti, portulaca used to treat dyspepsia, insom-

nia, kidney, and scurvy. It is also used as cardiotonic, diuretic, hemostat, and soporific. In Trinidad, it is used to treat empacho, hypotension, and palpitation. It is also used as vermifuge. In Turkey it is used as emollient, alterative, ardor, and sedative. The Philippines use it for bite (bug snake), diarrhea, dysentery, and heat (Anonymous, 2002). Stuart (—) reported that in Philippine, this plant is also used for eczema, diarrhea, nephritis, beriberi edema, pulmonary tuberculosis, whooping cough, and furuncles.

Other countries use it as astringent (Sudan), demulcent (Sudan), diuretic (Sudan and Turkey), emollient (Dominican Republic, and Turkey), ophthalmia (Malaya), scurvy (Turkey), tumor (Brazil, Colombia, and Gabon), urogenital (Kurdistan, and Spain), and wart (Japan, Mexico, and Peru). Anonymous (2002) also reported that portulaca is used or to treat burn, dysuria, ear ache, gonorrhea, hematuria, hemoptysis, hemorrhage, hyperglycemia, inflammation, liver, mouth, scald, spleen, and toothhache. Portulaca also used as antidote, fungicide, and viricide.

In Indonesia, *Portulaca oleracea* is traditionally prescribed for cardiac weakness, vermifuge, and aperient (Java) (Anonymous, 2002). According to the agricultural university students, this plant is also used as medicine in Purbalingga, Central Java (for hypertension), and Sumatera (uses unknown). Most of the agricultural university students do not know that this plant is used as medicine.

This plant is also used to treat hepatitis. Setiawan Dalimartha (1999) mentioned that this plant should be washed, chopped, and then boiled with 3 glass of water until the remaining water is a half of the initial boiled. The extract should be separated from the waste and left cold. It should be consumed three times a day; half glass each. Pregnant women are not allowed to use this prescription. According to Setiawan Dalimartha, this plant is also used as antipyretic, analgesic, relaxant, antitoxic, hypoglycemic, cardiotonic, antiinflamation, and diuretic. It also helps blood circulation. Hembing Wijayakusuma, et al (1996) mentioned this plant may cure appendicitis (mixed with *jombang*: *Taraxacum officinale*), ulcer, eczema, dysentery insect bite, bloody urine (mixed with daun sendok: *Plantago mayor* L.) and nervous.

Portulaca oleracea and Agriculture

Portulaca cultivation probably started 4000 years ago. This plant was mentioned in varieties of ancient poetry, medicinal documents, recipe documents, and agricultural documents, especially by the Arabic. Ibn Wahsiyya, Al Zahrawi, Ibn Hayyay, Ibn Bassal, and many other agriculturists describe it and its cultivation on their writings. The plant was even included in Calendario agrícola of Arib (Hernándo, 1994).

Portulaca is easily cultivated. It grows well in arid or moist soil, pH 5.6-7.8 as long as it gets the sun light. The seed is still viable upon animal digestion and long storage. Wind or birds easily spread the seeds. The stem is also easily to root. Its rapid growth makes it a good soil binder (Dilley, 1998 and Gallinato, et al.1999). However, *portulaca* is prone to alachlor, DCPA, nitrofen, ethalfluralin, 245-T, MCPB, fenoprop (Silvex), mecoprop, and 24-D MPCA (Dilley, 1998).

According to Susiarti (1994) in Siemonsma Piluek (ed) 1994) this plant is not considered as dangerous weeds because of shallow rooting. However, this plant is frequently listed as one of the world's dangerous weeds. Indeed, many of them grows on cultivated fields. IRRI mentioned that *portulaca* could be a host of leafmining weevil (*Hypurus bertrandi*), stemboring fly (*Lyriomyza caulophaga*), nematodes (*Heterodera marioni, Meleeidogyne acrita, M. Acronea, M. Arenaria, M. Hapla, M. Incognita, M. Javanica, Prattylenchus minutus,* and *Rotylenchus reniformis),* and fungi (*Rhizoctonia solani* and *Albugo portulacaceae*) (Gallinato, et al.1999). The facts that *portulaca* can be host for several insects is not always detrimental. Portulaca might be used as scavenger to prevent insects from disturbing the main crops.

Mizurani et al. (1998) mentioned that root extracts of *Portulaca oleracea* completely inhibited *Aphanomyces cochlioides* zoospore motility. *Aphanomyces cochlioides* is a soil-borne phytopatho-

genic fungus that attack spinach (*Spinacia oleracea* L.) and sugar beet (*Beta vulgaris* var. rapa Dum.), Chenopodiaceae and Amaranthaceae. The auxiliary (beneficial) compounds of *Portulaca root* are 1-linoleoyl-2-lysophosphatidic acid monomethyl ester (a zoospore-repellent).

Portulaca is also beneficial for phytoremediation of contaminated water and soil. Grieve and Suarez (1997) mentioned that *portulaca* was highly tolerant to salinities dominates by chloride and sulfate (from industrial wastewater). It even grows well in saline condition. In 3 weeks, the yield of *portulaca* grown in 15 dS/m salinity was 139 ton/ha. During this period, it absorbs 3,500 m^3/ha of saline water (wastewater).

The plant is also a moderate selenium accumulator in sulfate system. Elevated selenium concentration on drainage water has reported to cause aquatic birds deformity in Keterson Reservoir (Ohlendorf and Santolo (1994), in Grieve and Suarez (1997). The ability of *portulaca* to accumulate selenium decreased by the increasing of salinity of the growth medium. At Se 2.3 mg/l and salinity 15.2 dS/m, the Se accumulation in shoots was 4.08, leaves 9.1, and stems 3.69 mg/kg dry weight (Grieve and Suarez,1997). The dietary allowance of selenium for adult is 55 to 70 mg/day (National Research Council, 1989). Thus, if a person consume 100 g of fresh *portulaca* leaves (moisture content 94.35%), the Se will be 51.42 mg. For 100 g of fresh *portulaca* stem, the Se level will be 20.85 mg. Thus, based on the Se point of view, the crop is still safe for consumption.

Other Potential Uses of *Portulaca oleracea*

Not merely as food or medicine, *Portulaca oleracea* is also a prospective source of food additive. *Portulaca oleracea* leaves and stems have arabinoglycan gum that functions as good emulsifier. Portulaca leaves is a good source of ionic, non-viscosity building, water-soluble surface-active gum (Gati et al.[a], 1999). *Portulaca oleracea* exhibit strong emulsifying capacity in dilute oil-water emulsions (Gati, 1999). The physicochemical properties of *Portulaca oleracea* gum are similar to gum arabic. Its activity is interfere by casein depends on the solution pH (Gati et al.[b], 1999). *Portulaca oleracea* gum can be synergistically combined with Tween to make a stabile emulsion with medium viscosity and minimal use of emulsifier (Gati et al.[c], 1999). *Portulaca* also contains portuloside that has antimicrobial activity against *Bacillus subtilis* (Sakai et al., 1996). The structure of portuloside is (3S)-3-(3,7-dimethyloct-a-1,7-dien-6-only),-b-D-glucopyranoside.

CONCLUSION

As a good source of functional compounds (folic acid, beta-carotene, vitamin C, and w-3 fatty acids, *krokot* is potential to develop as functional food ingredients. Its utilization could conserve the plant and encouraging sustainable agriculture.

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