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 3.4 mg/100 g of 3-carotene, 22.2 mg/100 g of vitamin C, and significant amount of foli 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 antiviral activity.

Unfortunately, *krokot* is approaching extinction both physically and ethno-botanically 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 help to conserve the plant as well as encouraging sustainable agriculture.

**Keywords:** *krokot*, *Portulaca oleracea*, functional food

**INTRODUCTION**

Belong to *Portulacaceae*, *krokot* or *Portulaca oleracea* (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 ethno-botanically. 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 scarcity of the plant. Based on our observation, edible *krokot* is rare in intensively cultivated area in Bogor (West Java), Senarang (Central Java), and Blitar (East Java), but quite a lot in organic plantation in Central Kalimantan. Indeed, the IRRI (International Rice Research Institute) considers *krokot* as weed. They suggest to controlling it by frequent and continuing shallow cultivation, hoeing, or applying herbicides. However, the organization also recognizes it as vegetable, medicinals, forages and blue dye (Gallinata, 1999).

According to Solomon (1998), there are two types of edible purslane, they are wild purslane (yellow purslane) and garden purslane (green purslane, winter purslane or Montia perforata). The wild purslane has slight pink stem and small yellow flower. It is more commonly consumed in tropical countries such as Indonesia.
Table 1. Some of the Vernacular Name of Krokot

<table>
<thead>
<tr>
<th>COUNTRIES</th>
<th>NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commonwealth</td>
<td>pigweed, common purslane, purslane</td>
</tr>
<tr>
<td>France</td>
<td>pourpier</td>
</tr>
<tr>
<td>Netherlands</td>
<td>potselein or porselein</td>
</tr>
<tr>
<td>Mexico &amp; Dominican Republic</td>
<td>verdolaga</td>
</tr>
<tr>
<td>Peru</td>
<td>vertolaga</td>
</tr>
<tr>
<td>Australia</td>
<td>munyeroo (in Aborigin)</td>
</tr>
<tr>
<td>India</td>
<td>jangali palak or kulva</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>genda kola</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>bara iniya, bara ruia, gheekalam, nunia.</td>
</tr>
<tr>
<td>Egypt</td>
<td>riga</td>
</tr>
<tr>
<td>China</td>
<td>ma ch’ih hsien or kwa-tz-tsai</td>
</tr>
<tr>
<td>Japan</td>
<td>nuber-ihiyu.</td>
</tr>
<tr>
<td>Malaysia</td>
<td>called gelang pasir, segan jantan, or rumput beremi</td>
</tr>
<tr>
<td>Philippines</td>
<td>olasiman or alusiman (Bicolano), sim-sim (Bisaya), olasiman or golasiman (Tagalog), ngaluk (Ilocano), and kantataba (Pampango)</td>
</tr>
<tr>
<td>Cambodia</td>
<td>mäong däb phäaa</td>
</tr>
<tr>
<td>Laos</td>
<td>taa kôngz, bizz, nya en cyan or nya tha kong</td>
</tr>
<tr>
<td>Vietnam</td>
<td>rau sam or ram</td>
</tr>
<tr>
<td>Myanmar</td>
<td>called mye-hتا، mye pa yit, or the pa yit</td>
</tr>
<tr>
<td>Thailand</td>
<td>phakbia-ntu, phakbia-lek, or phakbia yai.</td>
</tr>
<tr>
<td>Indonesia</td>
<td>gelang(Maluku, West Java), krokot (Java, Tigabinanga, Medan, Lampung, Bogor, Tasikmalaya), and resereyan (Madura), jalu-jalu kiki (Maluku)</td>
</tr>
</tbody>
</table>

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

**METHODDOLOGY**

**Initial Survey of Portulaca oleracea in Indonesia**

The survey was conducted by direct observation, interview, and literature study. Direct observation and interview were 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 acetone 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 follows: C18 column, mobile phase methanol:water (60:40). Column temperature 27-28°C, flow rate 1 ml/min. Detector UV (λ = 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 58 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: C18 column, mobile phase acetone: methanol: dichloromethane (60:35:5), flow rate 1 ml/min, column temperature 27-28°C, detector UV (λ = 402 nm).

**RESULT**

**Portulaca oleracea as Food**

*Portulaca oleracea* is believed to be the earliest vegetable consumed by human (Susanti, 1994 in Siemonsma and Pluinek, ed., 1994). It can be eaten raw (dipped in salty fish sauce or mixed into salad), or cooked (Solomon, 1998). It is consumed in many different parts 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 Middle 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). In Sri Lanka, purslane is also stir and fried with naldive fish, garlic, leek, chili powder and lemon juice (Solomon, 1998). 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 emelet, rolled in tortillas, or added into soups and stews (Anonymous, 1998). The French mix it with sorrel and make it into French soup, botte femme. Other kind of western soup is purslane and pea soups. Western salad may consist of purslane, lettuce, chervil, borage flowers, and matigold petals, borage, and mint (Herrández, 1994). The Greece mix raw purslane with sliced potatoes, tomatoes, onions, green olives, parsley, olive oil, vinegar and salt into Tomato, Potato and Purslane Salad (Kochdias, 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 favor-
itive talo in Java. It might be cooked with tamarind.
Based on the writer's observation, in Central Java,
purslane (kroko) leaves and young stem used to be
stirred and fried with sliced shallot, garlic, red chilies,
palm sugar, salt, salasa leaves, and a slice of Alpinia
galanga (langkuas) 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. Kroko has a pleas-
ing sour taste and delicious texture. According to the
respondent, kroko was consumed in East Java (Bitar
and Thayuwangi), and also North Sumatera (Medas).

Today's, in Central Java, the popularity of kroko as
vegetable is very poor. Kroko is generally not culti-
vated but collected from the wild. Today's the avail-
ability 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 irrigating canals, and ditches (in the cities).
The growth location creates 'dirty' images on kroko,
thus medium-high educated and medium-high eco-
nomic-level society are reluctant to eat it.

Since they refused to eat it, the price of kroko is the
market is very low. As a comparison, in 1997, in
Magelang (Central Java), a bunch of local amaranth
(bayam oyo or bayam cabah) is 100 to 150 rupiah.
Meanwhile the price of a bunch of portulaca was only
35 rupiah, or 3 bunch for 150 rupiah. 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 nentong feed (a local poultry).

Since kroko is rarely found on the market, thus it is
rarely consumed. Many young generations no longer
familiar with kroko. Some of the young generation
who ever heard the name, have an image that kroko 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 be-
cause of Prof. Henry'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 com-
pounds 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 Husain (1994), the nutrient composi-
tion of Portulaca varied based on its growth stage and
organs.
<table>
<thead>
<tr>
<th>Component</th>
<th>Based on Our Analysis (%)</th>
<th>Based on the Reference (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Moisture content</td>
<td>94</td>
<td>85.9*</td>
</tr>
<tr>
<td>• Moisture content</td>
<td></td>
<td>92*</td>
</tr>
<tr>
<td>Protein</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Protein</td>
<td>1.7*</td>
<td>2.2*</td>
</tr>
<tr>
<td>• Protein</td>
<td></td>
<td>1.7*</td>
</tr>
<tr>
<td>Lipid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Crude Lipid</td>
<td>0.5*</td>
<td>0.9*</td>
</tr>
<tr>
<td>• Crude Lipid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Lipid in young leaves</td>
<td></td>
<td>3.81*</td>
</tr>
<tr>
<td>• Glycolipid in young leaves</td>
<td></td>
<td>1.60*</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Carbohydrate (by difference)</td>
<td></td>
<td>2.2</td>
</tr>
<tr>
<td>• Carbohydrate</td>
<td></td>
<td>5.0*</td>
</tr>
<tr>
<td>• Carbohydrate</td>
<td></td>
<td>3.8*</td>
</tr>
<tr>
<td>Fiber</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Soluble Fiber</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>• Insoluble Fiber</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>• Crude Fiber</td>
<td>1.6*</td>
<td></td>
</tr>
<tr>
<td>Minerals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Ash</td>
<td>1.2</td>
<td>0.7*</td>
</tr>
<tr>
<td>• Ash</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 Pilhek
5. Data calculated from Wesche-Ebeling (1995) in wet basis
<table>
<thead>
<tr>
<th>Minerals</th>
<th>Based on Our Analysis (mg/100g)</th>
<th>Based on the Reference (mg/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P on edible portion</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>3.9</td>
<td></td>
</tr>
<tr>
<td>K on edible portion</td>
<td>6.7</td>
<td></td>
</tr>
<tr>
<td>Ca on edible portion</td>
<td>3.8</td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td>103§</td>
<td></td>
</tr>
<tr>
<td>Fe on edible portion</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Fe on leaves</td>
<td></td>
<td>33.21*</td>
</tr>
<tr>
<td>Fe</td>
<td>3.6§</td>
<td></td>
</tr>
<tr>
<td>Mg on edible portion</td>
<td>3.3</td>
<td></td>
</tr>
</tbody>
</table>

Note:
1. Data from Susilatci (1994) in ed. Siemonsma and Pihuek
2. Data from Mohamed and Husein (1994)

Mohamed 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 acculate 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.

Hernando Bermejo (1994) mentioned that there are five subspecies of wild Portulaca oleracea they are oleracea, papillo-stellata, stellata, granulato-stellata, and nigra. Furthermore, Prabhakar and Ramaya (1988) in Hernando Bermejo (1994) mentioned that the protein and free amino acids of P. oleracea var. oleracea 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-carotene 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 in maintaining body immunity. They also reduce the risk of cancer. Promoting Portulaca oleracea as vegetable may help 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 tour analysis, the folic acid in Portula-
ca oleracea (Table 6) is higher than any other famous folic acid (asparagus, broccoli and spinach) source. It may cannot 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 Pajunama (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. Clef 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

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Vitamin A</th>
<th>Vitamin C</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrot</td>
<td>b-carotene 6-20 mg/100 g</td>
<td>5-10 mg/100 g</td>
<td>Van der Vossen and Sambas</td>
</tr>
<tr>
<td>Bayam (Amaranthus L.)</td>
<td>b-cryptoxanthin 4-8 mg/100 g</td>
<td>60-120 mg/100 g</td>
<td>Siemensma &amp; Piluak (ed) (1994)</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>900 (IU/100g)</td>
<td>21 mg/100 g</td>
<td>Zennie (1977)</td>
</tr>
<tr>
<td>P. oleracea</td>
<td>2550 (IU/100g)</td>
<td>25 mg/100 g</td>
<td>Sustiarti (1994)</td>
</tr>
<tr>
<td>P. oleracea</td>
<td>6100 (IU/100g)</td>
<td>26 mg/100 g</td>
<td>Siemensma &amp; Piluak (ed) (1994)</td>
</tr>
<tr>
<td>(raw)</td>
<td>Carotenoids: 99.2 mg/100 g</td>
<td>25 mg/100 g</td>
<td>Zennie (1977)</td>
</tr>
<tr>
<td></td>
<td>(on leaves)</td>
<td></td>
<td>Guil-Guerrero JL, and</td>
</tr>
<tr>
<td></td>
<td>b-carotene 5.4 mg/100 g</td>
<td>22 mg/106 g</td>
<td>Our Analysis</td>
</tr>
<tr>
<td></td>
<td>(leaves &amp; young stem)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
1. analysis with dichloroindophenol, 2. analysis with iodum.

Table 6. Folic Acid Composition of Some Food

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Folic acid (mg/100 g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asparagus (boiled for 10 min)</td>
<td>0.146</td>
</tr>
<tr>
<td>Broccoli (boiled for 10 min)</td>
<td>0.063</td>
</tr>
<tr>
<td>Spinach (Spinacea oleracea)</td>
<td>0.031</td>
</tr>
<tr>
<td>Cabbage (raw)</td>
<td>0.020</td>
</tr>
<tr>
<td>Egg yolk</td>
<td>0.13</td>
</tr>
<tr>
<td>P. oleracea</td>
<td>0.22</td>
</tr>
</tbody>
</table>

Note:
2. Beltz & Gosh (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 arthranquinone glycosides (Anonymous, 2002). Other compounds in *Portulaca oleracea* are alanine (570-1,480 ppm), alkaloids (in leaf: 300 ppm), caffeic acid, calcium oxalate, catechol, beta-cyanin, digalactosyl diacylglycerol, docosahexaenoic acid (DHA), dopa, eicosapentaenoic acid (EPA: 10 ppm), HCN, histidine (220-5,170 ppm) (Duke, 2002 and Sinopoulou et al., 1995).

*Portulaca oleracea* also has Immortin (2,590 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: 7,225 ppm), a-linolenic acid (4,000-80,000 ppm), lysine (650-13,200 ppm), methionine (90-2,814 ppm), noradrenaline, 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), phytic-p (4-40 ppm), saponin, saponic acid, b-sitosterol, tannin, threonine (470-9,400 ppm), tryptophan (160-3,400 ppm), and valine (660-13,200 ppm) (Duke, 2002 and Sinopoulou et al., 1995).

The fact that it contains omega-3 is an interesting issue. Omara-Aiwala 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 rigid fractions with high concentration of 18:3 omega-3 in the glycolipid fraction. Other researchers, Omara-Aiwala et al. (1991) reported that *Portulaca oleracea* contain 18:3-omega-3, 20:5-omega3, 22:5-omega-3, 22:6-omega-7, 18:2 omega 6, and 18:1-omega-9. They stated that the leaves have more omega-3 acids than the stem.

In the contrary, Irovetz et al. (1993) reported that purslane grown in Austria has no omega-3 fatty acids detected, but it contains fenchol, luteoalenes, hexacosane, lanostane, sebacic acid decyl esters, steigmast-5-ene-3-ol (3-b-24-S), 23-ethylcholest-52328: thiene-3-b-ol, myristic, palmitic, stearic, linoleic, and oleic acids. According to Palanswamy et al. (2002), the concentration of omega-3 fatty acids 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 in *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 Solomons, 1998).

*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, and 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-51-pyridol tested on *Salmonella typhimurium* TA98 & TA100 in the presence of S9 mix. The antimutagenic effects increased as the concentration of the mutagens increased.

In China *Portulaca* is used for aleuetic, anthrax, anthrophagus, bactericide, boil, bile (bug, snake), cold, colic, decacities, diarrhea and dysentery, diabetic, dyspepsia, ezema, edema, emollient, enteritis, erysipelas, fever, genital, herpes, intestine, larcenorrh, nausea, opacity, pil, poullee, pruritis, sote, scurry, swelling, thirst, tonic, tumor, urogenital, vermifuge, wound. In India, this vegetable is used as detergent. It is also used as or to treat stringent, bladder, diuretic, heat, kidney, lung, scurry, vulnerary (Anonymous, 2002).

In Haiti, *portulaca* used to treat dyspepsia, insomnia.
nia, kidney, and scurvy. It is also used as cardiotoxic, diuretic, hemostat, and soporific. In Trinidad, it is used to treat encephalitis, hypotension, and palpitation. It is also used as vermifuge. In Turkey it is used as emollient, alternative, arder, and sedative. The Philippines use it for bite (bug snake), diarrhea, dysentery, and heat (Anonymous, 2002). Stuart (—) reported that in Philippines, this plant is also used for eczema, diarrhea, nephritis, beriberi, edema, pulmonary tuberculosis, whooping cough, and furuncles.

Other countries use it as astringent (Sudan), denutrient (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, gonorrea, hematuria, hemoptysis, hemorrhage, hyperglycemia, inflammation, liver, mouth, scald, spleen, and toothache. Portulaca also used as antidote, fungicide, and viricide.

In Indonesia, *Portulaca oleracea* is traditionally prescribed for cardiac weakness, vermifuge, and apertent (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 Dalmartha (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 Dalmartha, this plant is also used as antipyretic, analgesic, relaxant, antitoxic, hypoglycemic, cardiotoxic, antiinflammatory, and diuretic. It also helps blood circulation. Hembing Wijayakusuma, et al (1996) mentioned this plant may cure appendicitis (mixed with jomhang: *Taraxacum officinale*), ulcer, eczema, dysentery insect bite, bloody urine (mixed with daun sendek: *Plamago major L.*) and nervous.

*Portulaca oleracea* and Agriculture

*Portulaca cultivation* probably started 4000 years ago. This plant was mentioned in various languages of ancient poetry, medicinal documents, recipe documents, and agricultural documents, especially by the Arabic. Ibn Walsiyya, Al Zahrawi, Ibn Hayyayn, Ibn Bassal, and many other agriculturists describe its cultivation and other descriptions on their writings. The plant was even included in a book of agricultural of Arab (Hernández, 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, 2,4-T, MCPB, fenoprop, Silvex, mecoprop, and 24-D MPCA (Dilley, 1998).

According to Susjarti (1994) in Siemona Pilaek (ed) 1994, this plant is not considered as dangerous weeds because of its shallow rooting. However, this plant is frequently listed as one of the world’s dangerous weeds. Indeed, many of them grow on cultivated fields. IRRI mentioned that *portulaca* could be a host of leaf mining weevil (*Hyphus bertrandii*), stemboring fly (*Lysimyza caudophaga*), nematodes (*Heteroder*a *marioni, Meloidogyne acrita, M. Acronyza. M. Arenaria, M. Helpa, M. Incognita, M. Javanica, Pratylenchus minutus, and Rotylenchus reniformis), and fungi (*Rhizoctonia solani* and *Albigo portulacae*) (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 *Aphanozymes cochlioides* zoospore motility. *Aphanozymes cochlioides* is a soil-bone phytopath-
genetic 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-lyso phosphatidic 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 salinity, toxicity from 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 m³/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 (Ohsendorf 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 dSm, 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 arabinogalactan 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., 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 depend on the solution pH (Gati et al., 1999). Portulaca oleracea gum can be synergistically combined with Tween to make a stable emulsion with medium viscosity and minimal use of emulsifier (Gati et al., 1999). Portulaca also contains portuloidse that has antimicrobial activity against Bacillus subtilis (Sakai et al., 1996). The structure of portuloidse is (35S)-1-(3',7'-dimethyloxalin-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, krokor is potential to develop as functional food ingredients. Its utilization could conserve the plant and encouraging sustainable agriculture.

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