EFFECT OF CONVENTIONAL AND MICROWAVE COOKING METHODS AND TIME DURATION ON THE LOSS OF VITAMIN C CONTENT IN FOUR GREEN LEAFY VEGETABLES

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IJAZAH: SARJANA MUDA SAINS MAKANAN DAN PENAFARAN DENGAN KEBIJIAN

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ABSTRACT

EFFECT OF CONVENTIONAL AND MICROWAVE COOKING METHODS AND TIME DURATION ON THE LOSS OF VITAMIN C CONTENT IN FOUR GREEN LEAFY VEGETABLES

Effect of cooking time (0.5, 1, 1.5, 2, 5 and 10 minutes) and cooking methods (boiling and microwave boiling) were studied for the percentage loss of vitamin C content in Chinese kale (Brassica alboglabra Bailey), water spinach (Ipomoea reptans Poir), dwarf white mustard (Brassica campestris sp. chinensis) and sweet shoot (Sauropus androgynus (L) Merr.). The vitamin C contents of the fresh vegetables and the percentage loss of vitamin C in cooked vegetables were subsequently determined by indophenol titration method. The results of the study revealed that all the studied vegetable species possess significant (p<0.05) difference in vitamin C content. The mean vitamin C content varied between 37.7 and 224.7 mg/100 g fresh weight with the highest content in sweet shoot and the lowest content in water spinach. The percentage loss of vitamin C content varied between 39.4% and 100% in Chinese kale, water spinach, dwarf white mustard and sweet shoot that were boiled for 0.5 to 10 min. While, loss in vitamin C for microwave boiling (0.5 to 10 min) ranged from 20.4% to 100% in four green leafy vegetables. The effect of different cooking time on vitamin C loss was significant (p<0.05). The % vitamin C loss for all the studied vegetables, due to boiling and microwave boiling, is in the order of 10 min > 5 min > 2 min > 1.5 min > 1 min > 0.5 min. The effect of the cooking methods on vitamin C loss was also significant (p<0.05), in which boiled leaves were found to lose more vitamin C than microwave-boiled leaves. In view of this it could be concluded that boiling and microwave boiling of vegetables though makes green leafy vegetables more palatable, however it reduces their vitamin C content drastically. Therefore, it is advised that microwave-boiled vegetables at shorter time may reduce the loss of vitamin C.
ABSTRAK

KESAN CARA MEMASAK YANG UMUM DAN MIKROGELOMBANG SERTA TEMPOH MASA TERHADAP KEHILANGAN VITAMIN C DALAM EMPAT JENIS SAYURAN BERDAUN HIJAU

Kesan masa (0.5, 1, 1.5, 2, 5 and 10 minit) dan cara memasak (perebusan biasa dan dengan oven mikrogelombang) dikaji bagi menentukan peratus kehilangan vitamin C dalam Kai-lan-coy (Brassica alboglabra Bailey), kangkung (Ipomoea reptans Poir), sawi jepun (Brassica campestris sp. chinensis) dan cekur manis (Sauropus androgynus (L) Merr.). Kandungan vitamin C dalam sayuran segar dan peratus kehilangannya akibat daripada memasak ditentukan mengikut kaedah penitratan indofenol. Keputusan kajian ini menyatakan bahawa kesemua sayuran yang dikaji mengandungi kandungan vitamin C yang berlainan dengan signifikan (p<0.05). Nilai min kandungan vitamin C berbeza di antara 37.7 dan 224.7 mg/100 g berat segar di mana cekur manis mengandungi vitamin C yang paling tinggi dan kangkung adalah yang paling rendah. Peratus kehilangan vitamin C berbeza di antara 39.4% dan 100% untuk kai-lan-coy, kangkung, sawi jepun dan cekur manis di mana direbus dari 0.5 hingga 10 minit. Pada masa yang sama, julat peratus kehilangan kandungan vitamin C untuk empat jenis sayuran berdaun hijau yang direbus dalam oven mikrogelombang (0.5 hingga 10 minit) adalah 20.4% hingga 100%. Kesaran masa memasak therhadap kehilangan vitamin C adalah signifikan (p<0.05). Peratus kehilangan vitamin C bagi kesemua jenis sayuran adalah di dalam susunan 10 minit > 5 minit > 2 minit > 1.5 minit > 1 minit > 0.5 minit. Kesaran cara memasak therhadap peratus kehilangan vitamin C dalam sayuran juga signifikan (p<0.05), di mana kehilangan vitamin C bagi sayuran yang direbus biasa lebih tinggi daripada sayuran yang direbus dalam oven mikrogelombang. Daripada kajian ini, boleh disimpulkan bahawa perebusan biasa atau dengan oven mikrogelombang mengurangkan kandungan vitamin C dengan banyak walaupun ia menjadikan sayuran lebih sedap dimakan. Maka, dengan itu, adalah dinasihatkan bahawa perebusan dengan oven mikrogelombang harus dilakukan dengan masa singkat bagi mengurangkan kehilangan vitamin C.
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<tr>
<td>AA</td>
<td>Ascorbic acid</td>
</tr>
<tr>
<td>AFR</td>
<td>Ascorbate free radical</td>
</tr>
<tr>
<td>ANOVA</td>
<td>Analysis of variance</td>
</tr>
<tr>
<td>AOAC</td>
<td>Association of Official Agricultural Chemists</td>
</tr>
<tr>
<td>BDC</td>
<td>Agri-Food Business Development Centre</td>
</tr>
<tr>
<td>DCIP</td>
<td>2,6-Dichloroindophenol</td>
</tr>
<tr>
<td>DHAA</td>
<td>Dehydroascorbic acid</td>
</tr>
<tr>
<td>DKGA</td>
<td>diketo-L-gulonic acid</td>
</tr>
<tr>
<td>DNA</td>
<td>Deoxyribonucleic acid</td>
</tr>
<tr>
<td>et al</td>
<td>et alia (and other)</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization</td>
</tr>
<tr>
<td>FAMA</td>
<td>Federal Agricultural Marketing Authority</td>
</tr>
<tr>
<td>HHS</td>
<td>Department of Health and Human Services (United States)</td>
</tr>
<tr>
<td>HPLC</td>
<td>High performance liquid chromatography</td>
</tr>
<tr>
<td>IOM</td>
<td>Institute of Medicine</td>
</tr>
<tr>
<td>MOH</td>
<td>Ministry of Health Malaysia</td>
</tr>
<tr>
<td>NCCFN</td>
<td>National Coordinating Committee on Food and Nutrition</td>
</tr>
<tr>
<td>NSM</td>
<td>Nutrition Society of Malaysia</td>
</tr>
<tr>
<td>RDA</td>
<td>Recommended Dietary Allowance</td>
</tr>
<tr>
<td>RNI(s)</td>
<td>Recommended Nutrient Intake(s)</td>
</tr>
<tr>
<td>RNS</td>
<td>Reactive nitrogen species</td>
</tr>
<tr>
<td>ROI(s)</td>
<td>Reactive oxygen intermediates</td>
</tr>
<tr>
<td>ROS</td>
<td>Reactive oxygen species</td>
</tr>
<tr>
<td>SD</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>SPSS</td>
<td>Statistical Package of Social Science</td>
</tr>
<tr>
<td>TSC</td>
<td>Technical Sub-Committee</td>
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<tr>
<td>UL(s)</td>
<td>Tolerable upper intake level(s)</td>
</tr>
<tr>
<td>USDA</td>
<td>United States Department of Agriculture</td>
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<td>WHO</td>
<td>World Health Organization</td>
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LIST OF SYMBOLS

>       More than
<       Less than
/       Per
+       Plus
×       Multiply
±       Plus or minus
β       beta
α       alpha
%       Percentage
°C      Degree Celsius
Cm      centimeter
kg      kilogram
g      gram
mg      milligram
ml      milliliter
MHz     Megahertz
W       Watt
µM      microMolar
Mt      Metric tones
Cu²⁺    Cupric
Fe²⁺    Ferrous
Fe³⁺    Ferric
Hyp     Hydrosyproline
Hyl     Hydroxylysine
HPO₃⁻   Metaphosphoric acid
NaHCO₃  Sodium bicarbonate
OH      Hydroxyl group
p       Probability level
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CHAPTER 1

INTRODUCTION

1.1 Vegetables, vitamin C and its relation to health

Vegetables are herbaceous plants which are grown for food in the world (Onyeike et al., 2003). Vegetables account for a small part of our daily caloric intake, even so nutritional importance of vegetables can not be neglected. Their benefits to health surpass their caloric contribution, due to the presence of significant levels of certain vitamins, pro-vitamins and minerals (Amin et al., 2004). For this reason, a diet rich in vegetables (more than 5 servings per day) is recommended along with fruits and whole grains (Amin & Cheah, 2003; USDA/HHS, 2004).

In recent years increasing attention has been paid to the role of diet in human health. In 1997, Ministry of Health Malaysia held a Healthy Lifestyle campaign which aimed to encourage and promote the benefits of eating more fruits and vegetables (MOH, 1997). Besides that, several epidemiological studies that greater consumption of fruits and vegetables is associated with reduced risk of chronic disease such as cardiovascular disease, cancer, stroke and hypertension (Temple, 2000; Joshipura et al., 2001; Bazzano et al., 2002; Gundgaard et al., 2003; Riboli & Norat, 2003).

The most important vitamin in fruits and vegetables for human consumption are vitamin A, vitamin B complex and vitamin C. Fruits and vegetables supply more
than 85% vitamin C in human diets (Davey et al., 2000). Generally, local markets offer a variety of vegetables ranging from leafy to tubers for consumption in Malaysia. Locally known as Chinese kale or kai-lan-coy (*Brassica alboglabra* Bailey), water spinach or kangkung (*Ipomoea reptans* Poir), dwarf white mustard or sawi jepun (*Brassica campestris* sp. *chinensis*) and sweet shoot or cekur manis (*Sauropus androgynus* (L) Merr.) are commonly available in the local market. The Chinese kale, water spinach and sweet shoot are frequently consumed by Malaysians (Amin & Cheah, 2003; Amin et al., 2004; Liu et al., 2007).

Vitamin C, known as ascorbate or ascorbic acid, is a water soluble vitamin where it occurs as L-ascorbic acid and its oxidized form dehydro-L-ascorbic acid, both of which biological active (Sánchez-Mata et al., 2000). Ascorbic acid can be easily oxidized in a irreversibly to 2,3-diketogulonic acid, which has no biological activity (Parviainen & Nyyssonen, 2000). Vitamin C is required for the prevention of scurvy and maintenance of healthy skin, gums, teeth and blood vessels and aids in the absorption of iron (Grosvenor & Smolin, 2002; NCCFN, 2005). It also as an antioxidant that donates electrons in biochemical reactions has received much attention over the past decade (Eitenmiller & Landen, 1999; Grosvenor & Smolin, 2002).

Ascorbic acid is unstable and sensitive to oxidation which is accelerated by light, heat, low acid condition, and presence of oxygen, contact with copper and iron cooking utensils (Eitenmiller & Landen, 1999). The vitamin C content of food is strongly influenced by season, transportation to market, shelf life, time of storage, cooking practices and chlorination of water (NCCFN, 2005). The conditions of storage, processing and preparation such as high temperatures, low relative humidity,
physical damage, chilling injury, oxidation, presence of alkali have adverse effects on vitamin C in vegetable (Parviainen & Nyyssonen, 2000; Kumar & Aalbersberg, 2006b).

Vegetables are either consumed in raw or cooked form depending on type. (Onyeike, 2003; Kala & Prakash, 2004). Most of the vegetables require cooking for the improvement of digestibility and palatability. Cooking processes brings about a number of changes in physical characteristics and chemical composition of vegetables and other food materials (Rehman et al., 2003; Zhang & Hamauzu, 2004). The most common cooking methods are steaming, boiling, sautéing, pan-frying, stir-frying, braising, baking, roasting, broiling, grilling, deep frying and microwave (Gisslen, 1999; Mizer et al., 2000). The selection of the desirable cooking method is mostly influenced by the type of vegetable, desire for variety and nutrient retention (Gisslen, 1999; Mizer et al., 2000; Drummond & Brefere, 2004).

1.2 Significance of the study

Food composition data, necessary for epidemiological and nutritional studies, are merely representative of foodstuffs consumed in the raw state (Hels et al., 2004; Amin et al., 2006; Kumar & Aalbersberg, 2006a). Many food composition databases never take into consideration the fact that concentration of nutrients and their activity may change through cooking practices. However many foods are eaten after being processed for safety and quality, stored and prepared in various ways that may each affect at least some of the nutrient levels (Amin et al., 2006; Kumar & Aalbersberg, 2006a). Therefore, a great number of investigations have been carried out on the effects of different types of processing and cooking on nutrient contents of foods (Kumar & Aalbersberg, 2006b).
Numerous researches have been carried out on vitamins, minerals and antioxidant activity; and yet, there are very little information regarding the nutrient losses in Chinese kale (Brassica alboglabra Bailey), water spinach (Ipomoea reptans Poir), dwarf white mustard (Brassica campestris sp. chinensis) and sweet shoot. Besides that, sensitivity of ascorbic acid under several process or cooking conditions and its nutritional benefits make it a good quality indicator. Therefore, it is important to determine the behaviour of ascorbic acid under several conditions (Serpen & Gökmen, 2007).

1.3 Objectives

1. To determine the vitamin C content and its loss in boiling and microwave boiling of four green leafy vegetables, Chinese kale (Brassica alboglabra Bailey), water spinach (Ipomoea reptans Poir), dwarf white mustard (Brassica campestris sp. chinensis) and sweet shoot (Sauropus androgynus (L) Merr.) at different cooking time.

2. To assess the effect of cooking time and methods on the percentage of vitamin C loss for the above green leafy vegetables.
CHAPTER 2

LITERATURE REVIEW

2.1 Leafy vegetables

Sabah is the second large state in Malaysia has vast wealth of natural resources and hence, there are a lots of vegetables cultivated in region of Sabah. The main producers of vegetables in Sabah are Ranau, Keningau, Lahad Datu, Sandakan, Tuaran and Papar (Department of Agriculture Sabah, 2004). The edible parts of vegetable include leaves, buds or flowers, fruits, stalks, pods or roots depending on one’s knowledge of them and their availability (Onyeike et al., 2003). Meanwhile, leafy greens are a special variety of vegetables characterized by their green colour, resulting from their chlorophyll content (Mizer et al., 2000).

In Malaysia, the local markets offer a variety of vegetables, of which about 50 species are grown commercially, ranging from leafy to tubers for consumption. Analysis that conducted by Federal Agricultural Marketing Authority (FAMA) 2003/2004 showed that the proximate average demand of vegetables in Malaysia is 83,490 Mt per month in year 2006 (Agricultural Commodities Market Outlook, 2006). Malaysians mostly consume green vegetables such as Chinese kale, swamp cabbage dwarf white mustard and sweet shoot because of frequent availability and demand in the market, which are the indicators of their popularity (Agte et al., 2000; Amin & Cheah, 2003; Amin et al., 2004).
The English, local and botanical names of four green leafy vegetables were identified through “Report on Crops Hectare and Production in Sabah 2004” published by the Department of Agriculture of Sabah as shown in Table 2.1. The photograph of four green leafy vegetables are shown in Appendix A. The total production of vegetables in Sabah in year 2004 amounted to 28,041 Mt and out of the total, 51.8% are leafy vegetables. The production of sweet shoot had a total 1,428.9 Mt, water spinach had 830.4 Mt, Chinese kale had 537.4 Mt, and dwarf white mustard had 37.5 Mt (Department of Agriculture Sabah, 2004).

Table 2.1: Nomenclature of four green leafy vegetables analysed

<table>
<thead>
<tr>
<th>English name</th>
<th>Local name</th>
<th>Botanical name</th>
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<tr>
<td>Chinese kale</td>
<td>Ka-lan-coy</td>
<td><em>Brassica alboglabra</em> Bailey</td>
</tr>
<tr>
<td>Water spinach</td>
<td>Kangkung</td>
<td><em>Ipomoea reptans</em> Poir</td>
</tr>
<tr>
<td>Dwarf white mustard</td>
<td>Sawi jepun or siow pak choy</td>
<td><em>Brassica campestris sp. chinensis.</em></td>
</tr>
<tr>
<td>Sweet shoot</td>
<td>Cekur manis or sayur manis</td>
<td><em>Sauropus androgynus</em> (L) Merr.</td>
</tr>
</tbody>
</table>

Source: Department of Agriculture Sabah, 2004

In 2003, the World Health Organization has highlighted the fact that low fruit and vegetable intake is among the top ten selected risk factors for global mortality. Recognizing this important fact, WHO organized an international expert group meeting to discuss ways to promote greater consumption of fruits and vegetables (WHO, 2003). Overwhelming scientific data, from epidemiological studies, indicates that diets rich in fruits and vegetables are associated with a lower risk of several degenerative disease (Amin & Cheah, 2003), such as cancers (Cohen et al., 2000; Van’t Veer et al., 2000; Hunter & Fletcher, 2002), cardiovascular (Liu et al., 2000; Van’t Veer et al., 2000; Kris-Etherton et al., 2002; Alia et al., 2003), cerebrovascular diseases (Hunter & Fletcher, 2002; Alia et al., 2003), and atherosclerosis (Gundgaard et al., 2003; Gossallau & Chen, 2004).
Green leafy vegetables, in general are rich sources of micronutrients such as β-carotene, ascorbic acid, folic acid and calcium (Negi & Roy, 2001; Gayathri et al., 2004; Amin et al., 2004). Ascorbic acid is the micronutrient most readily associated with green vegetables (Gökmén et al., 2000; Giannakourou & Taoukis, 2003; Oboh, 2005a; Kumar & Aalbersberg, 2006b) and considerably variable among species, geographical cultivation, seasonal or climatic, maturity state and storage conditions after harvest (Lee & Kader, 2000; Bernhardt & Schlich, 2006). In generally, the vitamin C amount increases with maturation (Ciancaglini et al., 2001). In literature, Chinese kale, water spinach, dwarf white mustard and sweet shoot have been found to contain about 48.5-136.0 mg of vitamin C/100 g edible portion (Tee et al., 1997; NSM, 2001).

2.1.1 Chinese kale (Brassica alboglabra Bailey)

Chinese kale is one of the vegetable that belongs to Cruciferae family (Podsędek, 2007). The botanical name of Chinese kale is Brassica alboglabra Bailey or Brassica oleracea var. alboglabra or Brassica oleracea var. acephala (DC.) Alef or Brassica oleracea var. albiflora O. Kunze (Tee et al., 1997; Halimathul, 1998; Creasy, 2000; Amin et al., 2004; Department of Agriculture Sabah, 2004; Noichinda et al., 2007). It is more commonly known in Asian markets by its Cantonese name, kai-lan-coy (Hutton, 1996; Department of Agriculture Sabah, 2004).

Chinese kale originated in China, however different cultivars of them can be grown successfully all year round in a wide range of climatic conditions including cool winters, warm summers and even hot and humid conditions (Issarakraisila et al., 2007; Noichinda et al., 2007). It is particularly popular with commonly Chinese cooks
throughout Southeast Asia and also a most common leafy vegetable consumed in Malaysia (Halimathul, 1998; Amin & Cheah, 2003; Amin et al., 2004). Commercial cultivars of Chinese kale differ considerably in leaf colour and shape. There are three types of cultivars of Chinese kale, which are white flowered Chinese kale, wrinkled leaf Chinese kale or curly kale and red flowered Chinese kale (Noichinda et al., 2007).

The market form of Chinese kale are harvested at the maturity period is about 8 to 9 weeks or 45 to 50 days (Halimathul, 1998). It has dull or glossy thick bluish-green; oval, often glaucous leaves and elongated fleshy inflorescences, yellow or white flowers, and thick stems (Halimathul, 1998; Creasy, 2000). The stems have a better flavour and texture than the tough, somewhat bitter leaves. Besides that, small plants which known as “baby” Chinese kale grown in crowded conditions have been harvested for sale in the markets (Hutton, 1996). According to the Nutrient Composition of Malaysian Foods (1997) and Nutrition Society of Malaysia (2001), Chinese kale contains 107.0 mg/100 g of vitamin C in its fresh form. It can be cooked in a variety of ways (Creasy, 2000).

2.1.2 Water spinach (*Ipomoea reptans* Poir)

Water spinach is a member of the Morning Glory Family, Convolvulaceae, which contains 1600 species of tropical and subtropical plants (Stephens, 1994; Hutton, 1996). The water spinach was first cultivated in southern China, has been distributed throughout the tropics of the world since (Halimathul, 1998). There seem to be more English names for this leafy green than almost any other tropical vegetable; water convolvulus, water morning glory, water spinach and swamp cabbage being the most common (Tee et al., 1997; Palada & Crossman, 1999; Palada & Chang, 2003; Amin
et al., 2004; Department of Agriculture Sabah, 2004). Nowadays, the water spinach is a widely cultivated throughout Southeast Asia (Hutton, 1996; Palada & Crossman, 1999; Huang et al., 2005) and consumed vegetable in Malaysia (Kok et al., 1991; Stephens, 1994, Halimathul, 1998, Palada & Crossman, 1999; Amin & Cheah, 2003; Amin et al., 2004).

There are two cultivated forms of water spinach. One is upland or dry form; known as kangkong puteh (Ipomoea reptans), propagated from seed or stem cuttings but requires plenty of water. The other variety is semi-aquatic or swamp form; known as water kangkong (Ipomeoa aquatica) which grown from stem cuttings is cultivated in swampy ground or near water, for instance rice fields (Stephens, 1994; Hutton, 1996; Halimathul, 1998). The water spinach requires plenty of water because of its high succulence and easily wilts during a prolonged dry spoil (Palada & Chang, 2003). In Malaysia, the land form is commonly grown for the market. The dry culture has hollow stem and slick surfaced leaves which are narrow, lanceolate, slender five to six inches long, and pointed. Whereas, the wet culture is broad and ovate-shaped leaf types, which look a lot like sweet potato plants (Hutton, 1996, Halimathul, 1998; Palada & Chang, 2003; BDC, 2006).

Water spinach is a perennial plant and adapted to a wide range of climate and soil conditions but requires relative high soil moisture for optimum growth, depending of type of varieties (Kok et al., 1991; Palada & Chang, 2003). In dry land system, the plants are ready for harvest in 42 to 60 days after sowing (Stephens, 1994; Palada & Crossman, 1999); while in wet land culture is harvested begins 30 days after planting (Stephens, 1994; Halimathul, 1998; Palada & Chang, 2003; BDC, 2006). Plants may be harvested once or several times. For, once-over harvesting, the entire plant is pulled up, washed and packed for transport to market. For multiple
harvesting, stems or shoots 15 to 25 cm in length are cut close to the ground (Halimathul, 1998; Palada & Chang, 2003).

Their leaves are good source of iron, calcium, vitamin A and protein (Hutton, 1996; Palada & Chang, 2003). In accordance with the Nutrient Composition of Malaysian Foods (1997) and Nutrition Society of Malaysia (2001), the water spinach contains 48.5 mg/100 g of vitamin C in its fresh form. Almost all parts of the young plants are preferred since older stems become fibrous (Stephens, 1994). The young leaves and stems are cooked stir fried, blanched in boiling water, or braised in the most area of Southeast Asia (Hutton, 1996).

2.1.3 Dwarf White Mustard (Brassica campestris sp. chinensis)

There are so many different cultivars of brassica or cabbage grown commercially in Asia that identification often difficult. Brassica sp. is belong to Cruciferae family, has four cultivars which are Chinese mustard (Brassica chinensis var. parachinensis), Chinese white cabbage (Brassica chinensis L.), dwarf white mustard (Brassica campestris sp. chinensis), and Indian mustard (Brassica juncea (L.) Czern and Cosson) (Department of Agricultural Sabah, 2004). Brassica campestric sp. chinensis also known as Brassica rapa var. chinensis, Brassica chinensis L., or Brassica oleracea var. chinensis (Hutton, 1996; Tee et al., 1997; Amanda et al., 2002; Department of Agricultural Sabah, 2004). Dwarf white mustard is originated from Eastern Asia and locally known as siow pak choy in Cantonese and sawi jepun in Malays language. (Department of Agricultural Sabah, 2004).
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