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# Antioxidant Activity of Northern and Northeastern Thai Foods Containing Indigenous Vegetables

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## ABSTRACT

Antioxidant capacities were demonstrated between 13.25–86.00 mg vitamin C equivalent (VCE) per 100 g in 10 Northern foods and 4.63–176.71 mg VCE per 100 g in 10 Northeastern foods. The food that possessed the greatest antioxidant capacity was Sup ma khuea pro, and can be displayed from high to low as Kaeng phak seing da > Kaeng dok sa lae > Kaeng hed la ngok > Kaeng phak huan > Kaeng kae > Sup phak sa meg > Kaeng ka noon on > Kaeng dok ma rum> Kaeng pum > Kaeng naw mai bai ya nang> Lap tao > Sa yod ma kham > Kaeng sai bua > Kaeng phak seil > Kaeng om gai > Kaeng phak wan ban >Kaeng yhuak kluai > Kaeng dok phak plang > Pon pla krua ma noi. Total phenolic content in 100 g of Northern and Northeastern foods ranged from 48.42–225.70 and 15.63–157.62 mg gallic acid equivalent, respectively. Content of protein, fat, total dietary fiber and energy in 100 g were as follows; in Northern foods they ranged from 3.33–13.12, 0.55–3.02, 1.20–4.70 g and 24.67-96.65 Kcal, respectively. In Northeastern foods, protein, fat, total dietary fiber and energy varied from 1.69–5.05, 0.16–1.14, 0.90–3.50 g/100 g and 12.24–64.73 Kcal/100 g, respectively. Nutritionally, all 20 selected foods can be considered as low in fat and energy level.

**Key words:** local Thai foods, indigenous vegetable, antioxidant capacity, total phenolic, nutritive value, functional foods

## INTRODUCTION

The relationship between the antioxidative properties of food and health has been extensively investigated over the past decade. Non-infectious diseases linked to oxidative and free radical reactions are aging, coronary heart disease, cancer and Alzheimer (Ames *et al.*, 1993; Smith *et al.*, 1996; Diaz *et al.*, 1997). In human body, antioxidant defense system consists of endogenous and exogenous antioxidants that work together at the molecular level to protect cell membranes, lipoproteins, and nucleic acids. Endogenous antioxidants are enzymes that are primarily physiological in origin; exogenous antioxidants include nutrients and non-nutrients enter the body through the diet. Increased intakes of dietary antioxidants may help to maintain an adequate antioxidant status, defined as the balance between antioxidant and oxidants in living organism (Halliwell *et al.*, 1995).

Plants are a good source of natural antioxidants. Vitamin C, vitamin E and β-carotene were previously emphasized as antioxidants.

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However, with their natural limitations on stability or lipophilic solubility, therefore, phenolic compounds gain more attention at present. Edible plant in Thailand has been reported to have 5,800 species available (Ponglux, *et al*., 1987). And over 250 species are consumed as vegetables in Thai cuisine (Prachasaisoradech, 1999). The Potential antioxidant activity on peroxide radicals of about 200 Thai indigenous vegetables was investigated (Nakahara and Trakoontivakorn, 1999; Trakoontivakorn and Saksitpitak, 2000).

Traditional Thai foods are of interest due to consumers' health concerns. Daily consumption of vegetable is recommended by nutritionist for preventing cancer and coronary heart disease. For culinary application, vegetables are either served as raw or cooked in curry soups. There are many local Thai foods contained vegetables as major ingredients as either fresh or cooked form. However, no reports on the antioxidant capacity of Thai foods was found. Therefore, the purpose of this study was to determine antioxidant capacity and nutritive value of 20 local Thai foods from the North and Northeast that have indigenous vegetables as main ingredients.

## MATERIALS AND METHODS

### Preparation of foods

Twenty of commonly consumed Northern and Northeastern foods, contain indigenous vegetables as their major ingredients, were selected for this study. All foods were prepared using traditional recipes. The ten Northern foods were Kaeng ka noon on, Kaeng kae, Kaeng dok phak plang, Kaeng dok sa lae, Kaeng phak sieng da, Kaeng phak siel, Kaeng phak wan ban, Kaeng yuak kuai, Kaeng phak huan and Sa yod ma kham. The other ten were Northeastern foods including Kaeng dok ma rum, Kaeng pum, Kaeng sai bua, Kaeng naw mai bai ya nang, Kaeng hed la ngok, Kaeng om gai, Sup phak sa meg, Sup ma khuea pro, Pon pla krua ma noi and Lap tao. Edible portions of each foods were homogenized and stored in a freezer (-20 °C) in 20 g per bags for further analysis

The indigenous vegetables used in preparation of 20 foods, together with their botanical names are listed in Table 1. The percent composition of major ingredients are given in Table 2.

### Foods extraction

The 20 g of frozen sample was homogenized in 40 ml 100% aqueous methanol at room temperature and centrifuged at 10,000 g for 10 min. The residue was re-extracted with 100% aqueous methanol and supernatants were pooled and made to 100 ml. The supernatants were stored in capped bottles and kept in -20°C until further use on antioxidant activity and total phenolics determination.

### DPPH radical scavenging activity

DPPH scavenging activity was determined using a modified method of Ohnishi *et al*. (1994). The free radical scavenging activity of food extracts were tested, indicated as bleaching of the stable 1,1 –diphenyl-2-picrylhydrazyl radical (DPPH). A diluted extract of the right concentration, 0.15 ml, was added to 0.9 ml of the ethanolic DPPH solution, 0.1 mM. The mixture was vertexed and allowed to stand at room temperature. After 20 min., the absorbance was recorded at 517 nm. A control consisted of 0.15 ml of 95% aqueous ethanol and 0.9 ml of 0.1 mM DPPH solution. DPPH % scavenging activity (%SA) was calculated %SA = (C-X)100/C, where C was absorbance of control and X was absorbance of extract.

### Antioxidant capacity

Interpretation of antioxidant capacity was made from the ability of food extract to scavenge free radical DPPH compared to that of an antioxidant. In order to express antioxidant

**Table 1** List of vegetables used in the 20 selected foods.

| Family/species | Common name (Thai) | Used part |
|---|---|---|
| *Acacia pennata* | Cha om | Leaf, young shoot |
| *Artocarpus heterophlyllus* | Ka noon on | Young fruit |
| *Basella alba* | Phak plang | Flower |
| *Bauhinia racemosa* | Chong kho na (siel) | Leaf |
| *Broussonetia kurzii* | Sa lae | Flower |
| *Gymnema inodorum* | Sieng da | Leaf |
| *Sauropus androgynus* | Phak wan ban | Leaf, young shoot |
| *Musa sp*. | Yhuak kluai | Stem |
| *Dregea volubilis* | Huan | Leaf |
| *Tamarindus indica* | Ma kham | Leaf |
| *Moringa oleifera* | Ma rum | Flower |
| *Wolffia globosa* | Pum | Whole plant |
| *Nymphaea lotus* var. pubescens | Sai bua | Stem |
| *Tiliacora triandra* | Ya nang | Leaf |
| *Amanita vaginata* | Hed la ngok | Mushroom |
| *Cratoxylum formosum* | Phak tew | Leaf |
| *Piper samentosum* | Cha plu | Leaf |
| *Limnophila aromatica* | Ka yaeng | Leaf, stem |
| *Eugenia grata wight* | Sa meg | Leaf |
| *Solanum melongena* | Ma khuea pro | Fruit |
| *Cissanpelos pareira* | Krua ma noi | Leaf |
| *Spirogyra sp.* | Tao | Filament (algae) |
| *Lycepersicum esculentum* | Ma khuea som | Fruit |
| *Piper sarmentosum* | Cha plu | Leaf |
| *Spilanthes acmella* | Phak ped | Leaf |
| *Colocasia esculenta* | Toon, Koon | Stem |

**Table 2** List of the major ingredients in the Northern and Northeastern foods.

| Foods | Major ingredients (%) | Vegetables, herbs and spices (%) | Major protein source (%) |
|---|---|---|---|
| Northern foods | | | |
| Kaeng ka noon on | Young jackfruit(22.1), ma khuea som(7.4), cha plu(0.4), cha om(2.2), garlic(1.3), shallot(0.9), dried chilli(0.6), galangal(0.2), lemon grass(0.6), pork spare rib(14.7), fish sauce(1.5), shrimp paste(0.4), salt(0.2) | 35.7 | 14.7 |
| Kaeng kae | Bamboo shoot(6.9), brinjal(5.5), koon(4.6), cha om(3.4), phak kee hood(3.4), ivygourd leaves(2.3), phak seing da(1.8), plate brush egg plant(1.8), mushroom(1.3), cha plu(1.2), phak ped(1.2), garlic(1.6), shallot(1.2), dried chili(0.7), lemon grass(0.9), long | 39.3 | 13.8 |

**Table 2** (Cont'd)

| Foods | Major ingredients (%) | Vegetables, herbs and spices (%) | Major protein source (%) |
|---|---|---|---|
| | coriander(0.9), galangal(0.5), coriander seed(0.1), chicken(13.8), fish sauce(2.3), vegetable oil(1.2), shrimp paste(0.5), fermented fish(1.3), salt(0.4) | | |
| Kaeng dok phak plang | Dok phak plang(23.3), ma khuea som(7.8), green chilli(4.4), shallot(2.3), lemon grass(0.4), fermented pork(8.7), fermented fish(1.2), shrimp paste(0.6), salt(0.4), fish sauce(0.9), kaffir lime juice(0.6) | 38.2 | 8.7 |
| Kaeng dok salae | Dok sa lae(17.7), ma khuea som(7.6), garlic(1.5), shallot(1.3), dried chili(0.7), galangal(0.2), roasted dried fish(5.1), tamarind paste(1.5), shrimp paste(0.5), fermented fish(1.5), salt(0.5), fish sauce(1.3) | 29.0 | 5.1 |
| Kaeng phak seing da | Phak seing da(19.4), ma khuea som(11.0), cha om(3.9), garlic(2.6), shallot(1.6), dried chili(1.3), roasted dried fish(6.4), shrimp paste(1.3), salt(1) | 39.8 | 6.4 |
| Kaeng phak siel | Phak siel(17.0), cha om(4.1), ma khuea som(10.2), garlic(2.7), shallot(1.7), dried chili(1.0), roasted dried fish(6.8), shrimp paste(1.4), salt(0.7) | 36.7 | 6.8 |
| Kaeng phak wan ban | Phak wan ban(14.6), garlic(1.0), shallot(2.0), dried chili(0.7), galangal(0.2), lemon grass(0.5), roasted dried fish(3.9), mungbean noodles(2.4), shrimp paste(0.7), salt (0.7) | 19.0 | 3.9 |
| Kaeng yhuak kluai | Yhuak kluai(30.6), cha om(2.2), cha plu(0.7), mungbean(1.1), dried chili(0.5), garlic(0.7), shallot(0.9), galangal(0.1), lemon grass(0.3), fingerroot(0.4), shrimp paste(0.3), salt(0.2), fish sauce(3.1), coconut milk(38.3) | 36.4 | 3.3 |
| Kaeng phak huan | Phak huan(17.5), ma khuea som(8.8), cha om(3.5), garlic(2.3), shallot(1.5), dried chili(1.2), roasted dried fish(1.2), shrimp paste(0.6), salt(0.5) | 34.8 | 5.8 |
| Sa yod ma kham | Young tamarind leaves(24.5), shallot(8.7), dried chili(1.2), minced pork(46.1), vegetable oil(1.7), sugar(2.3), fish sauce(3.2), shrimp paste(0.6), salt(0.3) | 34.4 | 46.1 |
| Northeastern foods | | | |
| Kaeng dok ma rum | Dok ma rum(13.2), tomato(7.7), chili(1.6), shallot(0.6), garlic(0.5), lemon grass(0.8), hairy basil leaves(0.9), striped snake-head fish(7.3), fermented fish(3.6), fish sauce(2.1) | 25.3 | 7.3 |

**Table 2** (Cont'd)

| Foods | Major ingredients (%) | Vegetables, herbs and spices (%) | Major protein source (%) |
|---|---|---|---|
| Kaeng pum | Pum(42.4), shallot(1.0), garlic(0.6), chili(0.5), hairy basil leaves(0.2), spring onion(0.8), lemon grass(0.2), striped snake-head fish(14.6), fermented fish(1.4) | 45.7 | 14.6 |
| Kaeng sai bua | Sai bua(21.1), shallot(1.0), garlic(0.5), chili(0.9), lemon grass(0.4), tomato(5.3), hairy basil leaves(1.0), chicken(7.2), fermented fish(3.1), fish sauce(1.9) | 30.2 | 7.2 |
| Kaeng naw mai bai ya nang | Bamboo shoot(21.6), corn(6.5), pumpkin(5.9), pumpkin twig(2.4), cha om(0.7), hairy basil leaves(1.0), chili(1.1), shallot(0.8), garlic(0.4), lemon grass(0.4), bai ya nang (2.4), glutinous rice(3.3), fish sauce(2.6), fermented fish(2.2) | 43.2 | - |
| Kaeng hed la ngok | Hed la ngok (mushroom)(45.6), phak tew(2.5), chili(0.9), shallot(1.5), garlic(1.0), lemongrass(0.3), hairy basil leaves(1.6), fish sauce(2.3), fermented fish(2.5) | 53.4 | - |
| Kaeng om gai | Sponge gourd(19.4), phak ka yaeng(0.8), pumpkin(7.9), pumpkin twig(1.9), cha plu(2.3), hairy basil leaves(0.7), phak chee lao (dill) (1.5), shallot(0.9), garlic(0.8), chili(0.9), lemon grass(0.8), chicken(17.9), roasted glutinous rice(1.8), fish sauce(1.8), fermented fish(1.3) | 37.9 | 17.9 |
| Sup phak sa meg | Phak sa meg(13.0), shallot(4.4), garlic(2.4), chili(1.8), lemon grass(0.3), spring onion(2.6), mint leaves(1.3), striped snake-headed fish(22.0), mungbean noodle(9.8), roasted sesame(1.7), fish sauce(2.0), fermented fish(3.3) | 25.8 | 22.0 |
| Sup ma khuea pro | Brinjal(64.6), shallot(2.2), garlic(1.2), chili(1.3), spring onion(1.4), mint leaves(0.8), coriander leaves (0.6), striped snake-headed fish(17.6) | 72.1 | 17.6 |
| Pon pla krua ma noi | Krua ma noi leaves(6.6), shallot(2.1), garlic(1.1), chili(1.2), spring onion(0.3), coriander leaves(0.3), striped snake-head fish(16.9), fish sauce(0.5), fermented fish(7.1) | 11.6 | 16.9 |
| Lap tao | Tao(43.6), brinjal (yellow) (7.4), yard long bean(11.4), galangal(2.5), lemon grass(1.7), shallot(1.0), garlic(1.0), dried chili(0.7), mint leaves(0.7), spring onion(1.2), striped snake-head fish(10.6), fish sauce(2.7), fermented fish(8.3) | 71.2 | 10.6 |

activity of food extracts in familiar terms, antioxidant capacity as mg vitamin C equivalent (VCE) /g fresh weight was introduced. A standard curve of vitamin C (ascorbic acid, Fisher Scientific) was obtained from DPPH %SA (x) plotted against various vitamin C concentrations (y). Prepared concentrations of vitamin C solution were 0.5, 1.0, 1.5, 2.0 and 2.5 mg/100 ml distilled water. The regression line was y = 0.0466x - 0.0474.

**Determination of total phenolic content**

Total phenolics were determined using the Folin-Ciocalteau reagent, adapted from Singleton and Rossi (1965). Two millilitres of suitable diluted sample extracts was transferred and reacted with 10 ml of Folin-Ciocalteau reagent (previously diluted 10 fold with distilled water) in 25 ml volumetric flask. After 30 sec. and before 8 min., 8 ml of 7.5% of sodium carbonate was added and mixed, and the contents of the flask made to volume with distilled water. Solutions were heated in a 40°C water bath for 30 min. The color was developed and absorbance measured at 765 nm. The standard curve was prepared using 0, 0.5, 1.0 and 1.5 ml of gallate stock solution (8 mg/100ml) in 25 ml volumetric flask. The regression line between absorbance (y) and gallic acid content (x) was y = 0.0046x + 0.0163. The results were expressed as mg gallic acid equivalent (GAE) /g food.

**Chemical analysis**

The moisture, protein, fat and ash content were analyzed by the AOAC(1990). Total dietary fiber was determined by enzymatic-gravimetric method (Faulks and Timms, 1985; Prosky *et al*., 1985). The carbohydrate values were obtained by difference. The caloric value was calculated by using energy conversion factors, i.e. 4 for protein and carbohydrates and 9 for fat. The elements, sodium, calcium, phosphorus, iron, zinc and copper were determined by AOAC (2000).

## RESULTS AND DISCUSSION

**Antioxidant capacity and total phenolics**

The antioxidant capacity and total phenolic content of 10 Northern and 10 Northeastern foods are shown in Table 3. From the selected Northern foods, Kaeng seing da, 86.00±2.74 mg VCE /100g, and Kaeng dok sa lae, 85.01±5.47 mg VCE/100g, showed equally high antioxidant capacity, which corresponded to their high phenolic contents, 225.70±0.01 mg GAE/ 100g and 164.71±3.05 GAE/100g, respectively. The potent on antioxidant capacity was possibly contributed by the vegetables as ingredients in the recipes. In previous studies on indigenous vegetables, Trakoontivakorn and Saksitpitak (2000 and unpublished data) found that Sieng da (*G. inodorum*) and Sa lae (*B. kurzii*) possessed high antioxidative potency, determined by β-carotene bleaching method. This study demonstrated that four foods, Kaeng phak huan, Kaeng kae, Kaeng ka noon on and Sa yod ma kham, possessed moderate antioxidant capacity ranging from 23.03-55.25 mg VCE/100g. And the rest of Northern foods had antioxidant capacity that fell in the range 13.25-18.94 mg VCE/100g.

The Northeastern foods exhibited wide variation in antioxidant capacity, that ranged from 4.63-176.71 mg VCE/100g (Table 3). Sup ma khuea pro was found to exhibit the highest antioxidant capacity, followed by Kaeng hed la ngok, 83.85±3.35 mg VCE/100g, in agreement with their high phenolic contents. Four kinds of food, Kaeng dok ma rum, Kaeng pum, Kaeng naw mai bai ya nang and Lap tao, showed similar antioxidant capacity, which ranged from 29.29-31.94 mg VCE/100g and a phenolics level ranging from 40.54-75.88 mg GAE/100g. Sup phak sa meg, provided considerable antioxidative potency, the recipe contained vegetables accounted for 25.8% with 13% sharing from Phak sa meg. Phak sa meg was reported to possess an extremely high on antioxidant capacity of 5,089 mg VCE in 100

**Table 3** Antioxidant capacity and total phenolic content in Northern and Northeastern Thai foods.

| Foods | Antioxidant capacity (mg.vit.C equiv./100 g food) | Total phenolic content (mg. gallic acid equiv./100g food) |
|---|---|---|
| Northern foods | | |
| Kaeng ka noon on | 38.15±3.35 | 75.52±2.63 |
| Kaeng kae | 54.77±0.29 | 111.69±1.45 |
| Kaeng dok phak plang | 13.25±1.72 | 56.74±2.10 |
| Kaeng dok sa lae | 85.01±5.47 | 164.71±3.05 |
| Kaeng phak seing da | 86.00±2.74 | 225.70±0.01 |
| Kaeng phak seil | 18.94±1.64 | 77.99±0.35 |
| Kaeng phak wan ban | 17.62±1.93 | 48.42±2.13 |
| Kaeng phak huan | 55.25±1.54 | 144.84±0.66 |
| Kaeng yhuak kluai | 14.78±0.39 | 75.80±1.52 |
| Sa yod ma kham | 23.03±0.70 | 64.13±0.03 |
| Northeastern foods | | |
| Kaeng dok ma rum | 31.94±2.06 | 75.88±3.24 |
| Kaeng pum | 31.76±5.08 | 40.54±0.27 |
| Kaeng sai bua | 20.15±1.56 | 42.59±0.01 |
| Kaeng naw mai bai ya nang | 30.25±1.23 | 60.79±6.57 |
| Kaeng hed la ngok | 83.85±3.35 | 110.06±2.63 |
| Kaeng om gai | 18.67±1.65 | 42.70±0.95 |
| Sup phak sa meg | 43.97±1.83 | 54.13±0.33 |
| Sup ma khuea pro | 176.71±21.53 | 157.62±1.75 |
| Pon pla krua ma noi | 4.63±1.48 | 15.63±0.44 |
| Lap tao | 29.29±6.80 | 55.16±1.97 |

g (Tangkanakul *et al*., 2005).

**Relationship between total phenolic contents and antioxidant capacity**

Previous studies have been made concerning the relationship between phenolic contents and antioxidant activity, both pro and con on correlations were demonstrated. Velioglu *et al*. (1998), Zheng and Wang (2001), and many other research groups stated that there was a positive correlation. However, Heinonen *et al*. (1998) and Kähkönen *et al*. (1999) did not find any correlation between total phenolic contents and antioxidant activity of the plant extracts.

In present study, the relationship between total phenolic content and antioxidant capacity of foods is shown in Figure 1. The statistically analysis showed a positive and significant relationships between total phenolic content and antioxidant capacity of Northern foods ($R^2$ = 0.8711; $p < 0.01$) and Northeastern foods ($R^2$ = 0.9038; $p < 0.01$)

**Proximate analysis of Northern and Northeastern Thai foods**

Data on the proximate analysis of 10 Northern Thai foods are presented in Table 4. The amount of protein in Sa yod ma kham showed the highest protein contents (13.12 g/100 g), in which came mainly from the minced pork, constituting over 45% of the whole ingredient. As expected, the foods which contain coconut milk such as Kaeng yuak kluai had the highest fat contents. This was followed by Sa yod ma kham (2.49 g/100 g)

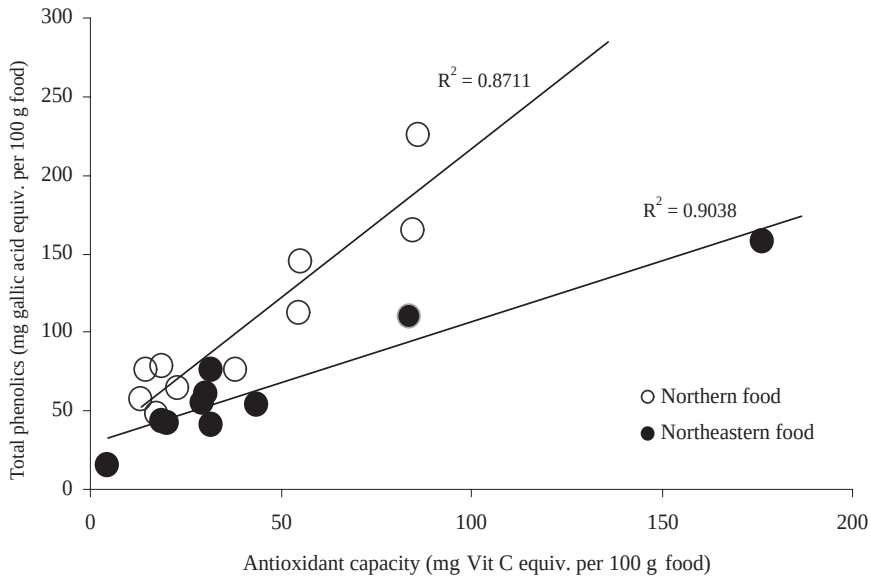


**Figure 1** Relationship between total phenolic content and antixidant capacity of 10 Northern foods and 10 Northeastern foods.

**Table 4** Nutrient composition of Northern and Northeastern Thai foods (per 100 g edible portion).

| Foods | Moisture (g) | Protein (g) | Fat (g) | Carbohydrate (g) | Dietary fiber (g) | Ash (g) | Energy (kcal) |
|---|---|---|---|---|---|---|---|
| Northern foods | | | | | | | |
| Kaeng ka noon on | 86.36 | 4.53 | 2.00 | 0.00 | 4.70 | 5.74 | 36.12 |
| Kaeng kae | 87.16 | 5.22 | 1.25 | 1.89 | 2.70 | 1.78 | 39.69 |
| Kaeng dok phak plang | 90.83 | 3.33 | 0.55 | 1.60 | 2.00 | 1.69 | 24.67 |
| Kaeng dok sa lae | 85.85 | 5.81 | 0.76 | 3.52 | 2.00 | 2.06 | 44.26 |
| Kaeng phak seing da | 84.74 | 6.48 | 1.41 | 2.36 | 2.40 | 2.61 | 48.05 |
| Kaeng phak siel | 85.58 | 6.59 | 1.16 | 2.41 | 2.50 | 1.76 | 46.44 |
| Kaeng phak wan ban | 88.46 | 4.19 | 0.91 | 3.86 | 1.20 | 1.38 | 40.39 |
| Kaeng yhuak kluai | 80.68 | 5.40 | 3.02 | 7.31 | 1.50 | 2.09 | 78.02 |
| Kaeng phak huan | 86.10 | 6.05 | 1.36 | 2.39 | 2.40 | 1.70 | 46.00 |
| Sa yod ma kham | 72.44 | 13.12 | 2.49 | 5.44 | 4.30 | 2.21 | 96.65 |
| Northeastern foods | | | | | | | |
| Kaeng dok ma rum | 91.08 | 3.05 | 0.43 | 1.74 | 1.70 | 2.00 | 23.03 |
| Kaeng pum | 90.97 | 5.05 | 0.42 | 0.59 | 1.40 | 1.57 | 26.34 |
| Kaeng sai bua | 92.74 | 2.57 | 1.03 | 1.09 | 1.00 | 1.57 | 23.91 |
| Kaeng naw mai bai ya nang | 90.55 | 1.69 | 0.25 | 4.57 | 1.50 | 1.44 | 27.29 |
| Kaeng hed la ngok | 92.51 | 2.05 | 0.09 | 1.89 | 1.70 | 1.76 | 16.57 |
| Kaeng om gai | 85.55 | 4.47 | 1.14 | 4.48 | 3.00 | 1.36 | 46.06 |
| Sup phak sa meg | 79.18 | 2.65 | 0.17 | 13.15 | 3.50 | 1.35 | 64.73 |
| Sup ma khuea pro | 88.34 | 4.13 | 0.48 | 3.07 | 2.50 | 1.48 | 33.12 |
| Pon pla krua ma noi | 95.62 | 2.32 | 0.16 | 0.38 | 0.90 | 0.62 | 12.24 |
| Lap tao | 89.06 | 3.58 | 0.66 | 1.45 | 3.40 | 1.85 | 26.06 |

and Kaeng ka noon on (2.0 g/100 g) which can be attributed to the fat derived from stir-fried minced pork and pork spare ribs. Carbohydrate was high (7.3 g/100 g) in Kaeng yuak kluai and Kaeng phak wan ban due to the presence of ground mungbean and mungbean noodles, respectively.

Dietary fiber ranged from 1.20-4.70 g/100 g with six out of ten foods indicated more than 2.0 g/100 g. The highest level was in Kaeng ka noon on due to the presence of young jackfruit which was reported to contain a relatively high concentration of dietary fiber, 7 g/100 g (Institute of Nutrition, 1999).

Protein content of ten Northeastern foods ranged from 1.69-5.05g/100g (Table 4). And the results revealed that fat contents in Northeastern foods were substantially low, 0.09-1.14 g/100 g. From the list of major ingredients, it can be concluded that chicken and fish are protein sources with low fat content (Table 2 and 4).

Comparing the amount of carbohydrate in the tested Northeastern Thai foods to the Northern foods, the results were similar at less than 10 g in 100 g, except Sup phak sa meg. Sup phak sa meg contained 13.15 g carbohydrate, accounted for by mungbean noodles that contributed 9.8 % of the ingredients. Four of ten foods provided dietary fiber in the range of 2.50-3.50 g/100 g, while the rest contained lower than 2.0 g/100 g.

Energy values of the selected Northern and Northeastern Thai foods was from 24.67-96.65 kcal and 12.24-64.73 kcal, respectively, in 100 g. The result showed that they were low energy foods, compared to other Thai foods, 41-364 kcal in 100 g, reported by Veerothai and Greenfield (1989). Other Asian foods, Chinese and Indian, as well were reported to supply energy greater than the studied foods, around 98-263 kcal and 110-337 kcal, respectively, in 100 g (Greenfield *et al*., 1981; Prasad *et al.*, 2000).

**Mineral composition**

Six minerals, sodium, calcium, phosphorus, iron, zinc, copper, composed in Northern and Northeastern Thai foods are given in Table 5. The Sodium content of Northern and Northeastern Thai foods ranged from 324.32 - 663.88 mg/100 g and from 172.91 - 592.12 mg/100 g, respectively. The sodium contents of Northern foods were derived mainly from table salt and shrimp paste. Whereas, the Northeastern foods were commonly seasoned with fish sauce and fermented fish. The sodium content of foods in the present work was considered as normal compared to Chinese foods, 230-800mg/100g, or Central Thai foods, 450-830mg/100g (Wills *et al.*, 1981; Veerothai and Greenfield, 1989). Sodium content in the selected foods can be reported relating to Thai Recommended Daily Intakes (Thai RDI) ranged in 7-28%.

The other five mineral of interest in 100 g of the tested foods can contribute approximately: 2-20% to the Thai RDI of calcium, 5-40% of phosphorus, 3-24% of iron, 1-7% of zinc and 7-17% of copper. Most of the tested foods provided iron greater than 1.00 mg in 100g foods, whereas, the top three were ranked from Kaeng sa lae (3.54), Kaeng pum (2.80) and Kaeng dok phak plang (2.01). These three foods contained iron levels comparable to meat foods, such as beef in oyster sauce (2.2mg/100g), barbecued pork (1.6mg/100g) and sausage (2.3 mg/100g), which are known to be rich in iron (Wills *et a*l., 1981). Although vegetable foods contained more iron than the meat foods, the latter is considered to be more bioavailable since it is present in heme form, unlike in vegetable foods in which it is present as inorganic salts. Copper and zinc, which are structural components of cytosolic superoxide dismutase (SOD), plays a role in inactivating superoxide radicals in cytosol and mitochondria. In this study, the contents of zinc and copper in Northern and Northeastern foods, varied within a narrow range of 0.10-1.10 mg/100g and 0.13-0.33 mg/100g, respectively. These rather low mineral contents were due to the major portion in most of

**Table 5** Mineral composition of Northern and Northeastern Thai foods (per 100 g edible portion).

| Foods | Na (mg) | Ca (mg) | P (mg) | Fe (mg) | Zn (mg) | Cu (mg) |
|---|---|---|---|---|---|---|
| Northern foods | | | | | | |
| Kaeng ka noon on | 376.91 (16) | 53.81 (7) | 135.31 (17) | 0.97 (6) | 0.8 (5) | 0.23 (12) |
| Kaeng kae | 450.48(19) | 81.48 (10) | 254.30(32) | 1.14 (8) | 0.60 (4) | 0.22 (11) |
| Kaeng dok phak plang | 457.98 (19) | 72.00 (9) | 124.97 (16) | 2.01 (13) | 0.50 (3) | 0.15 (8) |
| Kaeng dok sa lae | 473.48 (20) | 160.60 (20) | 194.12 (24) | 3.54 (24) | 0.90 (6) | 0.22 (11) |
| Kaeng phak seing da | 663.88 (28) | 102.58 (13) | 231.09 (29) | 1.34 (9) | 0.80 (5) | 0.23 (12) |
| Kaeng phak siel | 381.78 (16) | 91.40 (11) | 203.96 (25) | 1.19 (8) | 0.80 (5) | 0.18 (9) |
| Kaeng phak wan ban | 386.00 (16) | 70.51 (9) | 128.24 (16) | 0.90 (6) | 0.90 (6) | 0.29 (15) |
| Kaeng yhuak kluai | 486.55 (20) | 59.30 (7) | 150.70 (19) | 1.25 (8) | 1.10 (7) | 0.27 (14) |
| Kaeng phak huan | 324.32 (14) | 117.51 (15) | 199.92 (25) | 1.10 (7) | 0.70 (5) | 0.15 (8) |
| Sa yod ma kham | 556.85 (23) | 48.70 (6) | 323.12 (40) | 1.22 (8) | 1.10 (7) | 0.30 (15) |
| Northeastern foods | | | | | | |
| Kaeng dok ma rum | 592.12 (25) | 57.05 (7) | 105.18 (13) | 1.00 (7) | 0.20 (1) | 0.13 (7) |
| Kaeng pum | 428.86 (18) | 27.15 (3) | 168.52 (21) | 2.80 (19) | 0.20 (1) | 0.15 (8) |
| Kaeng sai bua | 454.28 (19) | 30.66 (4) | 71.38 (9) | 0.71 (5) | 0.30 (2) | 0.26 (13) |
| Kaeng naw mai bai ya nang | 431.42 (18) | 22.78 (3) | 59.12 (7) | 1.08 (7) | 0.30 (2) | 0.22 (11) |
| Kaeng hed la ngok | 543.51 (23) | 31.15 (4) | 75.06 (9) | 1.04 (7) | 1.10 (7) | 0.22 (11) |
| Kaeng om gai | 243.66 (10) | 56.46 (7) | 160.00 (20) | 1.29 (9) | 0.40 (3) | 0.21 (11) |
| Sup phak sa meg | 356.97 (15) | 37.88 (5) | 131.24 (16) | 0.75 (5) | 0.50 (3) | 0.25 (13) |
| Sup ma khuea pro | 303.67 (13) | 31.88 (4) | 124.56 (16) | 1.04 (7) | 0.30 (2) | 0.15 (8) |
| Pon pla krua ma noi | 172.91 (7) | 19.14 (2) | 42.62 (5) | 0.39 (3) | 0.10 (1) | 0.23 (12) |
| Lap tao | 392.28 (16) | 56.09 (7) | 99.89 (12) | 1.87 (12) | 0.20 (1) | 0.33 (17) |

Figures in parentheses are % Thai RDI.

Thai RDI for Na, 2400 mg; Ca, 800 mg; P, 800 mg; Fe, 15 mg; Zn, 15 mg; Cu, 2 mg.

the foods was vegetable, which was not a good source of zinc or copper. In Thai meat-based foods, greater content of zinc was reported previously such as garlic prawn (7.1 mg/100g), beef satay (5.6 mg/100g), chicken basil (4.5 mg/100g) and chicken ginger (4.6 mg/100g) (Veerothai and Greenfield, 1989).

## CONCLUSION

Edible indigenous plants were a good source of total phenolic contents. And the potent antioxidant capacity in local foods was possibly contributed by the vegetables. The relationship between phenolic contents and antioxidant capacity was a greatly positive.

The nutritive value of the foods in this study demonstrated as low in fat and energy level. Thus, consuming these foods is one way to meet the nutritionist recommendations to decrease high fat intake. They, also, provided iron, calcium and phosphorus to a lesser extent. This paper revealed that Northern and Northeastern Thai foods which contained indigenous vegetables could be classified as functional foods.

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