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Antioxidant capacity, total phenolic content and nutritional composition of Asian foods after thermal processing

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Abstract: Asian foods were studied for antioxidant capacity, total phenolics, and nutritional value. Varieties of commonly consumed foods were selected for the present study. They are chicken curry, spicy stir-fried pork, spicy sausage, curry dip, sate sauce (peanut sauce), and a dessert from black glutinous rice. The foods were packed in retort pouches and sterilized to understand the effect of heat on natural antioxidants to scavenge peroxyl radicals (ORAC assay) and DPPH radicals. One hundred grams of examined foods exhibited antioxidant capacity and total phenolic content ranging from 154.15 to 1499.63 µmole trolox equivalent from 7.46 to 40.16 mg vitamin C equivalent (VCE) and from 14.53 to 145.93 mg gallic acid equivalent, respectively. The top three highest foods in antioxidant capacity were Mu phat phrik khing (40.16 mgVCE/100g), Khua kling mu (31.38 mgVCE/100g) and Nam phrik ong (23.54 mgVCE/100g). The results showed that natural antioxidants retained their activity after thermal processing. Total phenolic content have a positive high correlation ($r^2 = 0.90$) with antioxidant capacity. The determined content of protein, fat, total dietary fiber and energy ranged 1.97-22.74, 2.28-24.97, 1.72-6.77 g/100 g and 125-342 Kcal/100 g, respectively.

Keywords: antioxidant capacity, total phenolic, nutritional composition, Thai foods, thermal process

Introduction

Thai food is currently attracting considerable interest because of its harmonious blend of flavors, aromas and health benefits. Thai vegetables commonly used for flavor and/or condiment have been reported to possess antitumor properties and antimutagenicity (Murakami *et al*., 1994 and 1995; Nakahara *et al*., 2002). The antioxidative property of culinary herbs and spices extensively used in Thai cooking such as lemon grass, kaffir lime, mints, and basil have been documented (Tachakittirungrod *et al*., 2007). In particular, the genus *Ocimum* (sweet basil, holy basil, hairy basil and wild basil) is known for its antioxidant activity (Jayasinghe, *et al*., 2003; Javanmardi, *et al*., 2003; Chanwitheesuk *et al*., 2005). Galangal is another common ingredient applied in both Thai chili paste and Malaysian dishes which has demonstrated high antioxidant activity and total phenolic contents (Cheah, *et al*., 2000; Jayasinghe, *et al*., 2003). In addition, tumeric and tomato have been reported to have antioxidant activity and total phenolic contents (Kaur and Kapoor, 2002).

These health promoting culinary herbs and spices are commonly used in Central Thai foods. Traditional Thai foods from other regions of the country contain various kinds of indigenous vegetables other than herbs and spices. Thai local vegetables exhibited their health benefits such as antitumor, antimutagen and antioxidant properties (Murakami, *et al*., 1995; Nakahara *et al*., 2002; Chanwitheesuk *et al*., 2005). After cooking, vegetables present in assayed foods still provide considerable antioxidant capacity (Tangkanakul, *et al*., 2006). The antioxidant capacity of foods after thermal sterilization process is of interest to our research group.

Thai foods are not only rich in plant species which contain a variety of phytochemicals, but they also provided nutrient contents. An earlier publication reported the proximate analysis, energy content, P/M/S fatty acids ratio and cholesterol content of 14 popular Thai foods offered in Australia (Veerothai and Greenfield, 1989).

Nowadays, busy lifestyles are also driving the development of healthy convenience foods. Other developments that encourage the convenience trend

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are more working women, who have less time to cook, and smaller families. Ready meals are the product category that provides the ideal answer to the need for convenience. Thus traditional Thai foods in ready-to-eat form were developed in our laboratory, employing state-of-the-art food processing techniques. Total phenolic contents, oxygen radical absorbance capacity (ORAC), antioxidant capacity against DPPH and nutrient contents of the sterilized foods were determined.

Materials and Methods

Preparation of foods

Seven commonly consumed foods were selected for the present study. They are Kaeng Kari Gai (Chicken curry with coconut milk), Mu phat phrik khing (Central spicy stir-fried pork), Khua kling mu (Southern spicy stir-fried pork), Sai-ua (spicy sausage), Nam phrik ong (mince pork curry dip), Sate sauce, and Khaoniaodam piak phueak (black glutinous rice and taro with coconut cream). All foods were prepared according to their original recipes and standardized by Thai cooking specialists.

Spices, both fresh and dried, were purchased from local markets in Bangkok, Thailand. In order to minimize source effect on the determined properties, spices used in Kaeng Kari Gai, Sai-ua and Nam phrik ong were the same batch. While, those in Mu phat phrik khing and Khua kling mu were from the same sources.

The selected foods were further developed into ready-to-eat products. Six out of seven selected foods were packed in a stand-up type of aluminum pouch (PET12/NY15/AL 9/CPP80, 120 x 180x 35 mm). The remaining food, sausage, was packed in a flat-type of nylon pouch (NY15/CPP60 140 x 200 mm). They were sealed with HENKOVAC, and sterilized by hot water spray retort (HISAKA, Model RCS-60 SPXTG), at different temperature and duration times as follows.

Sate sauce, Kaeng Kari Gai and Nam phrik ong at 120°C for 30, 32 and 36 min, respectively. Mu phat phrik khing and Khua kling mu were sterilized in the same conditions, 118°C for 30 min. Sai-ua was processed at 110°C for 12 min, followed by 120°C for 15 min.

The percentage distributions of various ingredients used in the processing of the different products employed in the present study are given in Table 1.

Sample extraction

Samples were extracted in 100% methanol at room temperature. Extracting ratio of sample to methanol was 1:20 for dried spices, 1:10 for raw ingredients and 1:5 for homogenized foods. The supernatants were stored in capped bottles and kept at -20°C until further use to determine ORAC values, antioxidant activity and total phenolic content. The results are expressed as mean ± standard deviation (SD) from three independent samples.

DPPH radical scavenging activity

DPPH scavenging activity was determined using a modified method of Ohnishi *et al*. (1994). A diluted extract of the right concentration, 0.15 ml, was added to 0.9 ml of the methanolic DPPH solution, 0.1 mM. After 20 min., the absorbance of the mixture was recorded at 517 nm. Pure methanol was the control. Percentage of DPPH scavenging activity (%SA) was calculated from the equation (1-X/C)*100, where X is absorbance of extract and C is absorbance of control.

Antioxidant capacity

Antioxidant capacity was determined based on the ability of food extract to scavenge free radical DPPH compared to that of an antioxidant. In order to express antioxidant activity of food extracts in familiar terms, antioxidant capacity as mg vitamin C equivalent (VCE)/100 g food was introduced. A standard curve of vitamin C 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.

ORAC assay

Methanol in food sample extracts was evaporated with N_2, and redissolved with the same volume of acetone. A dilution of 1:100 was prepared by 50% acetone (v/v). ORAC assays were carried out according to Huang *et al*. (2002) on a Tecan microplate reader (Infinite M200), which was equipped with an injection pump. Fluorescence conditions were as follows: excitation, 485 nm; emission, 520 nm; cycle number, 35; cycle time, 210 s; shaking mode, 8 s orbital shaking before each cycle; injection speed, 300 µl/s. Area under curve (AUC) was calculated followed Wu *et al*. (2004).

Determination of total phenolic content

Total phenolics were determined using the Folin-Ciocalteu reagent, adapted from Singleton and Rossi (1965). Two milliliters of suitable diluted sample extracts were reacted with 10 ml of Folin-Ciocalteau reagent (previously diluted tenfold with distilled water) in a 25 ml volumetric flask. After 30 sec. and

Table. 1 List of seven Thai foods in retort pouch and their ingredients

Foods	Major ingredients (%)	Herb, Spice and Vegetable (%)	Major protein source (%)
Kaeng Kari Gai (curry soup, coconut milk, contains curry powder, potato, chicken)	shallot (1.9), garlic (0.9), dried chili (0.3), ginger (0.4), lemon grass (0.3), coriander seeds (0.2), cumin (0.1), potato (29.1), salt (0.3), curry powder (0.3), shrimp paste (0.1), chicken meat (39.7), fish sauce (1.8), palm sugar (1.1), vegetable oil (0.3), coconut milk (23.3)	33.5	39.7
Mu phat phrik khing (stir-fried pork with herbs)	shallot (5.7), garlic (4.6), dried chili (2.5), lemon grass (1.7), galangal (0.7), kaffir lime leaves (0.5), kaffir lime peel (0.5), salt (0.6), shrimp paste (0.6), pork (42.9), vegetable oil (5.7), palm sugar (4.0), fish sauce (1.4), water (28.6)	16.2	42.9
Khua kling mu (stir-fried pork with herbs)	shallot (3.2), garlic (3.2), bird chili (2.5), dried chili (1.1), lemon grass (2.5), fresh turmeric (1.3), kaffir lime leaves (0.9), pepper (0.6), galangal (1.0), salt (0.6), shrimp paste (2.5), pork (63.1), vegetable oil (3.2), fish sauce (1.3), sugar (0.8), water (12.6)	16.3	63.1
Nam phrik ong (curry dip with pork and herb)	shallot (14.0), garlic (2.3), dried chili (1.2), shrimp paste (0.4), salt (0.9), pork (34.0), hard fat (3.8), tomato (18.9), vegetable oil (1.3), fish sauce (1.9), palm sugar (0.9), water (20.2)	36.4	34.0
Sai-ua (sausage with spices)	shallot (5.7), garlic (3.4), dried chili (0.8), lemon grass (2.3), coriander root (1.1), galangal (0.6), fresh turmeric (0.4), kaffir lime leaves (0.8), coriander leaves (0.4), white pepper (0.1), shrimp paste (1.1), salt (0.6), pork (56.2), hard fat (24.1), soy protein isolate (1.0), fish sauce (0.6), sugar (0.8)	15.6	56.2
Sate sauce (peanut sauce)	shallot (4.1), garlic (2.1), dried chili (0.9), lemon grass (1.5), galangal (0.5), shrimp paste (1.0), coriander seeds (0.4), cumin (0.2), coconut milk (45.2), palm sugar (13.6), tamarind juice (3.4), salt (1.0), ground peanut (11.3), water (14.8)	13.1	11.3
Khaoniaodam piak phueak (Black glutinous rice pudding)	black glutinous rice (31.9), taro (19.9), sugar (15.9), palm sugar (8.0), coconut milk (23.9), salt (0.5)	51.8	-

before 8 min., 8 ml of 7.5% of sodium carbonate was added and 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 the 25 ml reaction mixture. 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)/100g food.

Proximate analysis

Proximate analysis of foods was determined following AOAC (2000) procedures and included the following: moisture by hot air oven (AOAC method 925.45); protein by Kjeldahl method, N x 6.25 was used, (AOAC method 991.20); fat by ether extraction (AOAC method 989.05); ash by dry ashing method (AOAC method 938.08); dietary fiber by enzymatic-gravimetric method (AOAC method 985.29); and carbohydrate calculated by difference.

Sodium, iron, phosphorus and calcium were analyzed by acid digestion (AOAC method 984.2 and 999.10). The solutions were determined by using an Inductively Couple Plasma Atomic Emission Spectrometer (ICP) (model Optima 2000DV, Perkin Elmer, USA).

Results and Discussion

Antioxidant capacities and total phenolic contents

Twenty-one edible plants used to prepare seven selected foods were extracted with methanol, and their antioxidant capacity and total phenolic contents were determined. The tested plants are common ingredients used in Thai foods, as shown in Table 1. It should be pointed out that herbs and spices employed in Thai cuisines mostly are in fresh form rather than in dried form. This is unlike Indian dishes, in which most of the ingredients are spices in dried form (Prasad *et al*., 2000). The results of antioxidant capacities were expressed as mg VCE/100 g, as shown in Table 2.

Antioxidant capacities of the ingredients ranged widely from 2.29 to 1126.12 mg VCE/100 g. Considering the large variation, the ingredients were divided into four groups: very high (> 500 mg VCE/100 g), high (200-500 mg VCE/100 g), medium (100-200 mg VCE/100 g) and low (< 100 mg VCE/100 g). Fresh turmeric exhibited very high antioxidant capacity followed by dried cumin and curry powder. Curry powder is a mixture of spices usually including coriander, turmeric, cumin, and fenugreek in their blends (Internet, 2009). These three spices - turmeric, cumin and curry powder - were used in Kaeng Kari Gai, Khua kling mu and Sate sauce with small amounts in the range of 0.1-1.3% of ingredients (Table 1). The antioxidant capacity of lemon grass, kaffir lime leaves and galangal were 120.57, 106.64 and 98.61 mg VCE/100 g, respectively. Some components in these herbs were found to possess antitumor activities (Murakami, *et al*., 1994). The low activity group was represented by garlic and shallot which are major ingredients in chili paste of Thai foods. The amounts of garlic and shallot used in six selected foods accounted for 0.9-4.6 and 1.9-14% of total ingredients, respectively.

Total phenolic compounds have been shown to be responsible for the antioxidant activity of plant materials (Rice-Evans *et al*., 1996). Therefore, the amount of total phenols in the extracts was investigated by the Folin-Ciocalteu method. The content of total phenols was expressed as gallic acid equivalent concentration (GAE/100 g). As shown in Table 2, it was found that total phenolic content of 21 ingredients also showed considerable variation, ranging from 16.20-1340.70 mg GAE/100 g. Total phenolic content in fresh turmeric from this study was higher than what we found in another study, 825.58 mg GAE/100 g or previous report which was 175.5 mg catechol eq./ 100 g (Kaur and Kapoor, 2002). Wide variation of phenolic content was also investigated in dried turmeric with the range from 1.72 to 7.46 g GAE/ 100 g (Wojdylo *et al*., 2007; Surveswaran *et al*., 2007; Saengprakai *et al*., 2007). Fresh turmeric is the major herb used in most Southern Thai food, containing very high total phenolic content. This was followed by kaffir lime leaves, cumin, white pepper and chili which exhibited high total phenolic contents. It could be shown that the phenolic compounds present in turmeric and cumin played an important role in their antioxidant activities. Contrarily, kaffir lime leaves, white pepper, chili and galangal showed to be relatively low in antioxidant activity, even though their total phenolic was higher than lemongrass, dried bird chili and curry powder.

It is clear that each plant ingredient employed in Thai foods supplies antioxidants to some extent. However, the influence of the cooking process, especially sterilization, on antioxidant capacity and phenolic content in Asian foods was limited in the literature. There are a few reports on the effect of high heat (110-150°C) on phenolics content, and antioxidant activity of individual spices. Total phenolics, and antioxidant activity of onion were enhanced with increased heating temperatures and exposure times (Woo *et al.*, 2007). For spices used in Asian foods such as turmeric, chili, and black pepper, Suresh *et al.* (2007) reported that losses in curcumin in turmeric, capsaicin in chili and piperine in black

Table 2. Antioxidant capacity and total phenolic content of herbs, spices and vegetables applied in the assayed foods based on fresh weight basis or as otherwise indicated

Vegetables	Antioxidant capacity (mg VCE[1]/100 g)	Total phenolic content (mg GAE[2]/100 g)
Turmeric (*Curcuma longa*)	1126.12 ± 94.26	1340.70 ± 54.27
Cumin, dried * *(Cuminum cyminum)*	302.26 ± 0.91	526.74 ± 7.69
Curry powder *	236.55 ± 7.96	103.15 ± 6.92
Black glutinous rice *(Oryza sativa)*	145.07 ± 1.22	97.93 ± 2.69
Bird chili, dried * (*Capsicum frutescens* var. frutescens*)*	130.36 ± 2.76	129.88 ± 11.24
Lemongrass (*Cymbopogon citratus*)	120.57 ± 5.46	152.93 ± 4.61
White pepper, dried * (*Piper nigrum*)	108.47 ± 5.46	447.23 ± 10.38
Kaffir lime leaf (*Ctrus hystrix*)	106.64 ± 1.97	526.85 ± 18.45
Kaffir lime peel (*Ctrus hystrix*)	88.44±3.33	476.16±12.33
Galangal (*Alpinia galangal*)	98.61 ± 2.13	216.63 ± 3.33
Coriander (leave and stem) (*Coriandrum sativum*)	92.18 ± 62.99	90.02 ± 17.04
Coriander seed, dried * (*Coriandrum sativum*)	53.54 ± 6.97	97.26 ± 2.50
Coriander root (*Coriandrum sativum*)	2.29 ± 0.20	31.84 ± 0.85
Ginger (*zingiber offcinale*)	62.24 ± 0.19	99.70 ± 0.58
Chili, dried * (*Capsicum annuum*)	53.07 ± 6.63	112.33 ± 4.61
Tomato (*Lycopersicom esculentum*)	22.97 ± 4.85	62.48 ± 7.91
Tamarind juice *(Tamarindus indica)*	13.44 ± 0.07	23.84 ± 0.82
Shallot (*Allium ascalonicum*)	11.93 ± 2.36	88.90 ± 4.69
Potato (*Solanum tuberosum*)	11.65 ± 2.85	16.20 ± 0.96
Garlic (*Allium sativum*)	8.77 ± 1.93	63.51 ± 3.67

[1] vitamin C equivalent, [2] gallic acid equivalent
* based on dry weight basis

Table 3. Antioxidant capacity and total phenolic content (mean ±SD) of seven Thai foods in retort pouch

Foods	ORAC value (µmole Trolox eq./100 g food)	Antioxidant capacity (mg VCE/100 g food)	Total phenolic content (mg GAE/100 g food)
Kaeng Kari Gai	274.91 ± 17.73	10.85 ± 0.44	32.98 ± 0.52
Mu phat phrik khing	541.71 ± 108.1	40.16 ± 1.47	145.93 ± 0.00
Khua kling mu	1499.63 ± 8.48	31.38 ± 0.69	131.10 ± 0.41
Nam phrik ong	457.14 ± 35.98	23.54 ± 0.40	55.93 ± 4.14
Sai-ua	483.68 ± 85.08	19.08 ± 1.41	58.28 ± 1.73
Sate sauce	514.82 ± 0.12	14.40 ± 1.05	64.42 ± 1.21
Khaoniaodam piak phueak	154.15 ± 49.17	7.46 ± 1.01	14.53 ± 0.33

pepper occurred after boiling, and they found a greater loss in pressure cooking. At a higher temperature of 130°C for 5 min, antioxidant activity of black pepper was significantly decreased; however, it increased in phenolic content (Horvathova *et al.,* 2007).

Antioxidant capacities of seven foods in retort pouches are shown in Table 3. The products varied widely in antioxidant activity depending on the type and amounts of herbs and spices in their ingredients. The antioxidant capacity and total phenolic contents ranged from 7.46-40.16 mg VCE/100 g food and 14.53-145.93 mg GAE/100 g food, respectively. Processed Mu phat phrik khing exhibited the highest antioxidant capacity (40.16 mg VCE/100 g food) and total phenolic contents (145.93 mg GAE/100 g food), followed by processed Khua kling mu. Khua kling mu is a typical food in the Southern region of Thailand. Sterilized Khua kling mu provided relatively high antioxidant capacity of 31.38 mg VEC/100 g food. This could indicate that the antioxidant capacity was contributed by phenolic compounds in food (131.10 mg GAE/100 g food). Both Mu phat phrik khing and Khua kling mu are stir-fried pork-based foods with similar percentages of herbs and spices, about 16%.

ORAC values of some selected foods were in the same trend as determined with DPPH assay. Antioxidants in Mu phat phrik khing demonstrated less efficient to scavenge peroxyl radicals derived from 2,2'-azobis(2-amidinopropane) dihydrochloride (AAPH) than DPPH radicals, as shown in Table 3. This may explain that most of existing antioxidants terminate free radicals by single electron transferring, not by hydrogen atom transferring (Huang *et al*., 2005).

The test foods that contained similar herbs and spices are Mu phat phrik khing, Khua kling mu and Sai-ua. Shallot, garlic, dried chili, lemon grass, galangal and kaffir lime leaves are the six ingredients in common. The additional ingredients are kaffir lime peel in Mu phat phrik khing; fresh turmeric and pepper in Khua kling mu; and coriander root, coriander leaves, fresh turmeric and white pepper in Sai-ua. These three foods are comparable for antiradical power due to comparable moisture content and percentage of used herbs (Tables 1 and 4). Mu phat phrik khing contains a lower number of herbs and spices; however, it possessed the greatest antioxidant capacity which agreed well with the greatest phenolic content observed. This result indicates that the dissimilar herbs did not elevate the antioxidative power of the processed Khua kling mu and Sai-ua. It can be interpreted that antioxidants in fresh turmeric and white pepper were deactivated during the thermal process, which was confirmed in the findings of Suresh *et al*. (2007).

Nam phrik ong, very popular in Northern Thailand, is a kind of curry dip with pork, herbs and tomato, exhibiting 23.54 mg VCE/100 g food. The food is composed of up to 18% tomato (Table 1). Tomato may play an important role as an antioxidant source in processed Nam phrik ong. This can be explained by a study of Dewanto *et al.* (2002) which reported that thermal processing increased total antioxidant activity of tomato.

Khaoniaodam piak phueak, a type of dessert, contains antioxidant activity and consists of black glutinous rice as its major ingredient. It has been shown that the active components in black rice bran are anthocyanin compounds which were identified as cyanidin-3-glucoside and cyanidin. Both of them were

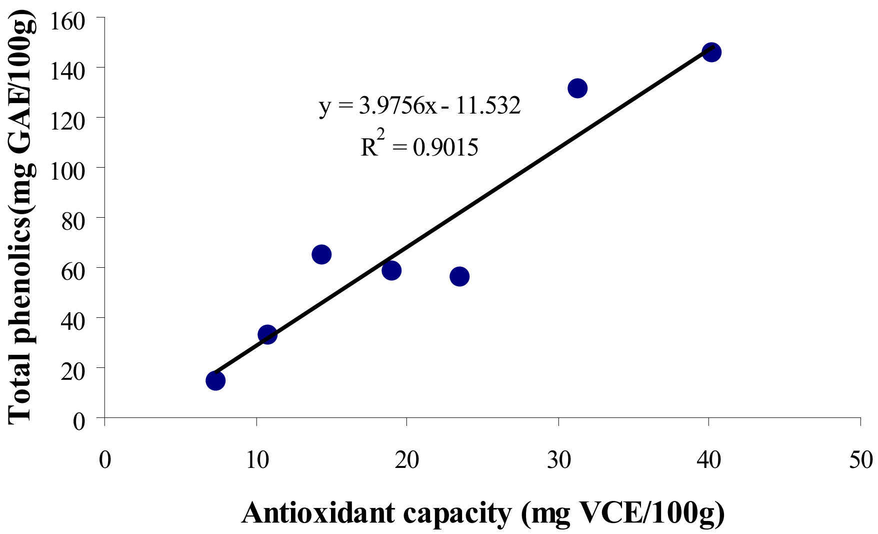

Figure 1. Relationship between total phenolic content and antioxidant capacity of seven selected food products

the active components involved in the antioxidative activity of black rice bran extracts (Kaneda *et al.,* 2006; Xia *et al.,* 2006).

Relationship between phenolic content and antioxidant capacity in sterilized foods

The results show that Mu phat phrik khing had a high phenolic content and also contained a high antioxidant capacity. Also, Khaoniaodam piak phueak and Kaeng Kari Gai had low phenolic contents as well as low antioxidant capacities. The relationship between phenolic content and antioxidant capacity of selected food products showed a positive high correlation (r^2 = 0.90, Y = 3.9756X-11.532), as shown in Figure 1. This result indicates that phenolics remained as dominant antioxidant constituents in the sterilized foods.

Proximate composition of food products

Data on the proximate composition of seven ready-to-eat foods are given in Table 4. Protein contents were high in Sai-ua and Khua kling mu which are derived from pork, accounting for 56.2% and 63.1% of total ingredients (Table 1). These were followed by Mu phat phrik khing and Kaeng Kari Gai with protein contents of 16.56% and 16.24%. Khaoniaodam piak phueak, being a rice-based product, had the lowest protein and fat content of 1.97% and 2.28%, respectively.

Fat content was highest in Sai-ua (24.97%) due to 24.1% of hard fat. That was followed by Sate sauce, which provided moderate levels of fat derived from coconut milk and ground peanuts. Kaeng kari gai, containing 23.3% coconut milk, showed relatively low fat content (3.6%). Fat content of Kaeng kari gai in our study was low compared with a previous study by Veerothai and Greenfield (1989), who reported that Thai curry containing coconut milk (chicken curry, chicken galangal, beef panang) provided fat levels ranging from 5.8-13.2%.

Carbohydrate contents, as expected, were high in the rice-based dessert, following by Sate sauce, which is derived from ground peanuts and palm sugar. Total dietary fiber of all foods ranged from 1.72-6.77% depending on the amounts and varieties of vegetables in each food. The highest was noted in Khua kling mu followed by Mu phat phrik khing, which was due to the presence of 16.2-16.3% of high dietary fiber herbs and low water contents in these foods.

Energy levels were lowest in Kaeng Kari Gai (125 kcal) and highest in Sai-ua (342 kcal) due to variations in fat content. However, other selected foods provided relatively high energy levels, ranging from 136-227 Kcal., compared to our previous study of local foods. Northern and Northeastern Thai foods which contained vegetables as the major portion, 12-72%, only provided energy of 12-97 Kcal. (Tangkanakul *et al.,* 2006). Other Asian foods, i.e. Chinese and Indian, supplied comparable energy to the present studied foods, around 98-263 kcal/100g and 110-337 kcal/100 g, respectively (Greenfield *et al.,* 1981; Prasad *et al.,* 2000).

The mineral compositions are given in Table 4 for four minerals: sodium, calcium, phosphorus and iron. Sodium content was highest in Sai-ua (1100 mg/100g) due to the salts in the recipe, and may be from pig's intestine which was added in a large amount for preservation. On the other hand, the

Table 4. Proximate composition of seven Thai foods in retort pouch per 100 g edible portion

Foods	Moist (g)	Prot (g)	Fat (g)	CHO (g)	Ash (g)	TDF (g)	Eng. (Kcal)	Na (mg)	Ca (mg)	P (mg)	Fe (mg)
Kaeng Kari Gai	69.53	16.24	3.60	6.94	1.71	1.98	125	360	12.32	150	1.06
Mu phat phrik khing	55.26	16.56	12.06	7.00	3.03	6.09	203	600	34.26	150	1.85
Khua kling mu	55.58	21.54	10.43	1.75	3.93	6.77	187	940	86.04	220	2.10
Nam phrik ong	72.25	10.27	8.31	5.03	2.42	1.72	136	680	19.60	130	1.09
Sai-ua	43.08	22.74	24.97	6.64	2.57	2.27	342	1100	77.18	460	3.92
Sate sauce	55.35	5.79	13.50	20.60	2.28	2.48	227	560	40.94	130	1.12
Khaoniaodam piak phueak	63.12	1.97	2.28	28.19	0.63	3.81	141	100	9.61	67	0.86

sodium content was low in the case of the dessert, Khaoniaodam piak phueak, wherein a small amount of salt was added. Generally, sodium content in Thai foods is derived mainly from table salt, shrimp paste, and fish sauce. The sodium content of foods in the present work is considered as normal compared to Chinese foods, which ranged from 230-800 mg/100 g. (Wills *et al*., 1981).

Calcium content of all the products varied from 9.61-86.04 mg/100g, and was highest in Khua kling mu (86.04 mg/100 g) followed by Sai-ua (77.18 mg/100 g). In all these research products except Khaoniaodam piak phueak, dietary calcium content mainly derived from shrimp paste (1380 mg/100 g), some herbs and spices such as kaffir lime leaves (1029 mg/100 g), cumin (765 mg/100 g), and coriander seed (512 mg/100 g) (Institute of Nutrition, 1999). The calcium contents obtained for our studies showed similar results for Thai foods as reported earlier (Veerothai and Greenfield, 1989; Tangkanakul *et al*., 2006). However, these products had lower content than those found in the western fast foods containing cheese (>100 mg/100g) (Greenfield *et al*., 1988).

Phosphorus contents were highest in spice pork sausage, followed by stir-fried pork foods, due to the phosphorus content of raw materials used such as pork, shrimp paste, dried chili and cumin which have been reported high in phosphorus concentration (Institute of Nutrition, 1999). Iron contents were low in the dessert (0.86mg/ 100 g), and ranged from 1.06-2.10 mg/100 g in the other foods apart from Sai-ua which was highest in iron at 3.92 mg/100 g.

Conclusion

This paper attempts to contribute knowledge of functional and nutritional properties of some Thai foods, which have been only partially documented to date. The study shows that the selected Thai foods in retort pouches provide antioxidant capacity. Also, antioxidative activity was derived from total phenolic, which is mainly from various herbs and spices used as ingredients. The results illustrated that the health benefits from plant sources remained in the products after thermal sterilization process.

The nutritive value of the foods in this study can be considered as low to moderate in fat and energy levels. They provided dietary fiber, calcium, phosphorus and iron as well, to some extent.

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