*Food Chemistry* **40** (1991) 251–262

# Determination of Macronutrient and Micronutrient Levels in Thai Foods: An Evaluation of the Thai Food Composition Table

Andries J. Speek,[a] Supinun Speek-Saichua[b] & Wil H. P. Schreurs[a]

[a] TNO–CIVO Toxicology & Nutrition Institute, Department of Clinical Biochemistry, PO Box 360, 3700 AJ Zeist, The Netherlands
[b] Khon Kaen University, Faculty of Associated Medical Sciences, Khon Kaen 40002, Thailand

(Received 19 July 1989; revised version received and accepted 20 July 1990)

*ABSTRACT*

*The reliability of the current (1978) Thai Food Composition Table was estimated by determining the contents of crude fat, total carbohydrate, protein, calcium, iron, vitamin A activity, vitamin $B_1$, vitamin $B_2$ and niacin of eight food groups, each composed of related foods. These food groups were: rice and cereals, fruit, meat, eggs, vegetables, fish, dessert and poultry. The composition of each group was proportional to the contribution of the individual foodstuffs to the average daily intake of children aged 3–8 living in north-eastern Thailand. The groups covered circa 95% of their daily intake. Foods were prepared according to traditional local habits prior to weighing, mixing and analysis.*

*Within the rice/cereals group—contributing 63% to the daily food intake of the children—all nutrient levels calculated using the 1978 Thai Food Composition Table (TFT) were higher than those measured, whereas most of the TFT-based values were below measured values in the groups meat and fish.*

*The intakes by Thai children—when using TFT values—of fat, total carbohydrate, protein, energy and vitamin $B_2$ are considerably overestimated (10–35%), while the intakes of iron, vitamin A-active compounds, vitamin $B_1$ and niacin are highly overestimated (56–243%); the intake of calcium is underestimated by 16%. The rice/cereals group contributes most to the overestimations except for vitamin A activity. The overestimation of the*



*Food Chemistry* 0308-8146/91/$03·50 

*intake of the latter nutrient originates primarily from the fruit group. The underestimation of the calcium intake originates mainly from the fish group.*

*It is recommended to revise the Thai Food Composition Table by analysing the processed foods with the classical methods for macronutrients and with more selective analytical methods for micronutrients.*

## INTRODUCTION

Food composition tables are based on many sources without proper check on correctness of the presented data and without critical evaluation of the analytical methods applied. Many data derived from ancient investigations must have been obtained with outdated methods which are usually less selective than modern ones. This may lead to overestimation of the calculated intake of nutrients. Evidence of overestimation of vitamin A activity has been given by Zakaria & Simpson (1979) for tomatoes, by Simpson & Tsou (1986) for various foods and by Speek *et al.* (1988) for tropical vegetables and fruits.

To evaluate the Thai Food Composition Table we analysed eight food groups consisting of a mixture of related foods for nutrients. A comparison is made between contents measured by chemical analysis and contents calculated using this table. Furthermore, the impact of the observed differences with respect to the estimation of the daily nutrient intake among children aged 3–8 years was calculated.

## MATERIALS AND METHODS

### Food consumption inquiry

Food consumption data were collected at the end of the dry season (May 1985), by a single application of the 24-h recall method (Marr, 1971; Lechtig *et al.*, 1976), from a random subsample ($n = 108$) of the 1472 children present in 12 rural and 4 urban day-care centres (aged 3–5 years) and from the two junior forms of adjacent primary schools (aged 6–8 years). The day-care centres and primary schools were randomly chosen and were all situated in the north-eastern province of Sakhon Nakhon (Egger *et al.*, 1985). All children had the Thai nationality and were of Thai origin. Both children and parents or guardians were interviewed at the day-care centres and primary schools by trained nutritionists of the Department of Nutrition, Faculty of Public Health of the Khon Kaen University (Khon Kaen, Thailand). The composition of each of the eight food groups is proportional to the contribution of the composing foods to the mean daily intake by the children and these are shown in Table 1. For each food group the mean daily intake of a composing food is calculated by dividing the sum of the intakes per child of the relevant food by the number of children (108). The mean total daily intake per food group was calculated by dividing the sum of the total intakes of the composing foods by the number of children.

## Collection and preparation of foods

Foods recorded in the 24-h recall as being eaten were purchased at the end of the dry season (May 1988) at the local market of Sakhon Nakhon, the capital of Sakhon Nakhon province. Per type of food, three portions of at least 250 g were bought at different market stalls and—not more than three hours later—were stored at −20°C for 14 days until transport to The Netherlands. During transport by air, the samples were kept frozen under dry ice whereafter they were stored at −20°C prior to preparation. Of each type of food the total amount was prepared according to local customs. Thereafter amounts of foods of the same group were mixed to provide a composite sample representative to the mean food consumption for each group as recorded by the 24-h recall. The composite samples were directly homogenized and stored at −20°C prior to analysis. Foods were prepared as follows.

| | |
|---|---|
| Cereals/rice: | rice 20 min, noodles 3 min cooked in boiling tap water |
| Fruit: | peeled, no further preparation |
| Meat: | beef 10 min cooked in boiling tap water or 5 min fried in vegetable oil; pork 20 min roasted above glowing charcoal; frog meat 5 min fried in vegetable oil |
| Eggs: | 8 min in boiling tap water |
| Vegetables: | leafy vegetables and onions 5–10 min cooked in boiling tap water; pepper, cucumber, papaya and tomatoes not prepared |
| Fish: | 5 min fried in vegetable oil; fermented fish 3–4 month storage at room temperature with salt (bought as such) |
| Dessert: | no preparation |
| Poultry: | 10 min fried in vegetable oil |

## Analysis of nutrients

The composite samples were thawed in the dark at room temperature and directly analysed. Micronutrients were determined in duplicate while for all samples a recovery test was carried out. Macronutrients were determined in duplicate without recovery tests. Results were accepted if duplicate

**TABLE 1**

Composition of the Food Groups According to the Mean Daily Consumption by Children Aged 3–8 ($n = 108$) from North-Eastern Thailand

| *Food groups and foods* | *No. in TFT* | *Consumption (mean, g/day)* |
|---|---|---|
| *Rice and cereals* | | |
| Glutinous rice, cooked | 33 | 231·9 |
| Mung bean noodles, boiled | 89 | 4·1 |
| Rice, milled, cooked | 11 | 34·4 |
| Rice noodles, round, cooked | 4 | 11·9 |
| Wheat flour | 37 | 1·5 |
| | | + |
| Total rice and cereals | | 283·8 |
| *Fruit* | | |
| Mango, ripe | 76 | 39·9 |
| Mango, unripe | 74 | 13·4 |
| Orange | 141 | 0·4 |
| Rambutan | 14 | 1·6 |
| | | + |
| Total fruit | | 55·3 |
| *Meat* | | |
| Beef, medium fat | 72 | 5·9 |
| Beef ball, cooked | 85 | 3·8 |
| Frog meat | 28 | 8·4 |
| Pork, medium fat | 101 | 9·8 |
| Pork, roasted | 106 | 2·7 |
| Beef, dried/baked | 77 | 2·6 |
| Pork sausage | 111 | 2·5 |
| | | + |
| Total meat | | 35·7 |
| *Eggs* | | |
| Hen egg, boiled | 4 | 21·6 |
| *Vegetables* | | |
| Bamboo shoots, boiled | 260 | 5·2 |
| Chinese cabbage, prepared | 166 | 1·6 |
| Chili pepper, red | 210 | 0·3 |
| Cucumber, large | 60 | 2·4 |
| Onion, young green, tops only | 55 | 0·7 |
| Papaya, unripe | 247 | 7·7 |
| Tomato, ripe | 237 | 1·7 |
| | | + |
| Total vegetables | | 19·6 |

TABLE 1—*contd.*

| *Food groups and foods* | *No. in TFT* | *Consumption (mean, g/day)* |
|---|---|---|
| *Fish* | | |
| Chub mackerel | 79 | 5·1 |
| Fermented fish | 119 | 2·2 |
| Fish sauce | 22 | 2·3 |
| Snakehead, murrel | 58 | 4·0 |
| | | + |
| Total fish | | 13·6 |
| *Dessert* | | |
| Lod chong (local name), consisting of: | | 10·0 |
| 2 g rice flour | 14 | |
| 7 g coconut milk | 57 | |
| 1 g sugar | 1 | |
| *Poultry* | | |
| Chicken meat, mature, fried | 4 | 9·1 |

differences were below 10% and if the recovery was in the range of 90–110%. The reproducibility of each method under routine conditions in our laboratory is continuously established using a representative control sample in each series of samples and is given as the between-assay coefficient of variation (CV) for a period of at least one year.

*Fat (EEC method, 1971)*

After acid hydrolysis, followed by white spirit extraction, the crude fat content was determined gravimetrically. The CV for the control sample′ containing 8% is 5·2%.

*Total carbohydrate (TCH) (Van de Kamer, 1941)*

The reducing sugars present in the sample after treatment with boiling water, digestion with pancreatic amylase and acid hydrolysis, were determined titrimetrically using a modification of the Luff–Schoorl method and were expressed as starch. The CV of the control sample containing 12% is 6·3%.

*Protein (Tkachuk, 1969)*

This macronutrient was determined with the Kjeldahl method. After catalytic digestion with sulphuric acid and distillation, the liberated ammonia was titrated. The crude protein content was calculated by multiplying the N content obtained by the conventional factor of 6·25. The CV of the control sample containing 8% is 5·1%.

*Energy*

The energy content of a food was calculated with the formula: energy (kJ) = 38 × crude fat (g) + 17 × total carbohydrate (g) + 17 × crude protein (g).

*Calcium and iron (Thompson, 1969; Perkin Elmer manuals)*

These micronutrients were determined after ashing at 500°C and dissolution in hydrochloric acid by normal (Perkin Elmer AAS type 5000) and flameless (Perkin Elmer type 430 with HGA 500) atomic absorption spectrometry, respectively. The CV values of the control samples containing 240 and 12 mg/kg are 2·5 and 5·1%, respectively.

*Vitamin A (total all-*trans *retinol), total carotenoids, β-carotene and vitamin A activity*

Samples were saponified in ethanolic potassium hydroxide whereafter all fat-soluble vitamins were extracted in diisopropyl ether (Speek *et al.*, 1986*a*). All-*trans* retinol in the extract was determined by normal-phase high-performance liquid chromatography (HPLC) with fluorometric detection (Speek *et al.*, 1986*b*). The CV of the control sample containing 7 mg/kg is 4·2%. The total carotenoids content of the extract was calculated from its absorbance at 445 nm and expressed as β-carotene (Speek *et al.*, 1986*a*). The CV of the control sample containing 40 mg/kg is 4·6%.

β-Carotene in the extract was determined by reversed-phase HPLC with detection by on-line measurement of its absorbance at 445 nm (Speek *et al.*, 1986*a*). The CV of the control sample containing 5 mg/kg is 8·6%. The vitamin A activity of the sample, expressed as retinol equivalents (RE), was calculated with the in-vivo conversion factors given by the World Health Organization: 6 μg of β-carotene or 12 μg of other mixed dietary carotenoids are equivalent to 1 μg of retinol (WHO, 1982). One RE has the biological activity of 1 μg of retinol.

*Vitamins $B_1$ (total thiamin) and $B_2$ (total riboflavin)*

The sample was extracted with hydrochloric acid. Thiamin phosphate esters and riboflavin nucleotides present in the extract were hydrolysed enzymatically with Taka-Diastase (Van de Weerdhof *et al.*, 1973).

Total thiamin was determined by normal-phase HPLC with post-column reaction fluorometric detection. The CV of the control sample containing 9 mg/kg is 3·4%.

Total riboflavin was determined by reversed-phase HPLC with fluorometric detection. The CV of the control sample containing 12 mg/kg is 2·6%.

Niacin (nicotinic acid and nicotinamide) (Difco Manual, 1984; Williams, 1984)—the sample was extracted with hydrochloric acid whereafter niacin in the extract was determined microbiologically using *Lactobacillus plantarum* (ATCC 8014). The CV of the control sample containing 67 mg/kg is 8·8%.

## RESULTS AND DISCUSSION

The nutrient contents of the food groups as measured and as calculated from the contents given in the 1978 TFT are given in Table 2.

The mean nutrient intakes per food group of the Thai children aged 3–8 have been calculated from the 24-h recall using the measured nutrient contents as well as the nutrient contents given in the 1978 TFT. The results per food group including the observed overestimations by the Thai Table are summarized in Table 3.

The mean total intake per nutrient calculated from the 24-h recall using measured contents and the contents given in the 1978 Thai Food Composition Table, including the observed overestimations by the Thai Table are summarized in Table 4.

### Limitations of the 24-h recall method

This method recalls the actual food intake on a specific day. The main advantage of recall methods is that they place minimal burdens on the subjects. A main disadvantage is the large intra-individual or day-to-day variation found in many groups. For this reason a single 24-h recall should only be used in studies examining the mean level of food intake of a group of individuals. However, this disadvantage plays a minor role in our study on the reliability of the TFT. Nutrient contents of the food groups based on this table and based on analysis show remarkable differences resulting in proportional differences in nutrient intake data and consequently, to over- or underestimations. Variations in food intake data do not influence the extent of these over- or underestimations but determine their significance.

### Nutrient contents

To establish differences between the nutrient contents of the food groups calculated from their composition using the values given in the 1978 TFT and those measured (Table 2), Wilcoxon's rank order test has been applied per nutrient over all food groups and per food group over all nutrients. We consider the magnitude of the CV values (2·5–8·6%) of the applied methods of analysis too small to explain the observed large differences. Therefore, irrespective of interspecies variations, the following conclusions concerning nutrient contents can be drawn.

**TABLE 2**

Mean Nutrient Contents of the Food Groups as Measured (meas.) and as Calculated from the 1978 Thai Food Composition Table (TFT)

| *Nutrient* | *Unit* | *Rice/cereals* | | *Fruit* | | *Meat* | | *Eggs* | | *Vegetables* | | *Fish* | | *Dessert* | | *Poultry* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *meas.* | *TFT* | *meas.* | *TFT* | *meas.* | *TFT* | *meas.* | *TFT* | *meas.* | *TFT* | *meas.* | *TFT* | *meas.* | *TFT* | *meas.* | *TFT* |
| Crude fat | % | 0·4 | 1·4 | 0·2 | 0·3 | 19·4 | 22·2 | 11·5 | 11·5 | 0·4 | 0·2 | 8·0 | 1·1 | 5·0 | 19·9 | 21·2 | 25·0 |
| TCH | % | 53·3 | 67·4 | 10·9 | 15·7 | 4·0 | 1·0 | 1·2 | 0·8 | 2·4 | 4·7 | 1·7 | 2·1 | 19·5 | 27·2 | 0·3 | 0·0 |
| Crude protein | % | 4·4 | 7·3 | 0·8 | 0·6 | 23·1 | 18·9 | 15·4 | 12·9 | 1·8 | 1·3 | 20·4 | 16·0 | 1·1 | 4·5 | 31·1 | 18·0 |
| Energy | MJ/kg | 9·8 | 13·0 | 2·0 | 2·9 | 11·8 | 11·6 | 7·2 | 2·1 | 0·8 | 1·0 | 6·6 | 3·3 | 5·4 | 10·9 | 1·3 | 0·3 |
| Calcium | mg/kg | 45 | 143 | 80 | 104 | 390 | 229 | 520 | 610 | 380 | 306 | 4 370 | 1 370 | 270 | 125 | 160 | 140 |
| Iron | mg/kg | 1·4 | 11·0 | 3·0 | 3·3 | 31·0 | 26·9 | 23·0 | 32·0 | 7·0 | 4·4 | 20·0 | 8·5 | 9·0 | 13·6 | 12·0 | 15·0 |
| Retinol[a] | mg/kg | — | — | — | — | 0·1 | — | 3·5 | — | — | — | 0·1 | — | 0·0 | — | 0·4 | — |
| Carotenoids | mg/kg | 0·1 | — | 3·7 | — | 0·3 | — | 4·9 | — | 22·4 | — | 0·5 | — | 1·6 | — | 21·0 | — |
| β-Carotene | mg/kg | 0·0 | — | 1·3 | — | 0·1 | — | 0·3 | — | 3·6 | — | 0·0 | — | 0·2 | — | 0·0 | — |
| Vitamin A act.[b] | mg/kg | 0·0 | — | 0·4 | 7·0 | 0·1 | — | 3·9 | 5·9 | 2·2 | 3·6 | 0·2 | — | 0·2 | 0·0 | 2·2 | 2·4 |
| Vitamin $B_1$ | mg/kg | 0·1 | 1·3 | 0·5 | 0·6 | 4·3 | 2·3 | 1·2 | 1·0 | 0·6 | 0·4 | 0·3 | 0·6 | 0·1 | 0·6 | 0·4 | 0·8 |
| Vitamin $B_2$ | mg/kg | 0·2 | 0·5 | 0·6 | 0·5 | 2·8 | 1·9 | 4·4 | 3·7 | 0·5 | 0·5 | 2·3 | 1·0 | 0·1 | 0·2 | 1·4 | 1·6 |
| Niacin | mg/kg | 3·0 | 20·1 | 10·0 | 5·9 | 55 | 42 | 0·8 | 1·0 | 6·0 | 2·8 | 48·0 | 4·0 | 7·0 | 7·0 | 130 | 80 |

[a] The vitamin A data in the TFT are given as IU vitamin A per 100 g (1 IU is 0·3 μg retinol). It is not mentioned whether the vitamin is retinol or retinol equivalents calculated from carotenoids. We converted these data into mg retinol per kg and present them as vitamin A activity in this table.
[b] The measured vitamin A activity = retinol + 1/12 × (total carotenoids − β-carotene + 1/6 × β-carotene, all in mg/kg.

**TABLE 3**

Mean Daily Nutrient Intake by Thai Children Aged 3–8 Calculated from the Food Consumption Inquiry using Measured Contents (meas.) and the 1978 Thai Food Composition Table (TFT), the Overestimation of Nutrient Intake by the TFT per Food Group Expressed as Contribution (ov, % in % units) to the Total Overestimation of the Nutrient in Question

| Food group | Intake (g/day) | Crude fat (g) | | | Carbohydrate (g) | | | Crude protein (g) | | | Energy (kJ) | | | Calcium (mg) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | meas. | TFT | ov (%) | meas. | TFT | ov (%) | meas. | TFT | ov (%) | meas. | TFT | ov (%) | meas. | TFT | ov (%) |
| Rice/cereals | 283·8 | 1·1 | 3·9 | 19 | 151 | 191 | 25 | 12·4 | 20·7 | 27 | 2 820 | 3 747 | 24 | 12·7 | 40·5 | 25 |
| Fruit | 55·3 | 0·1 | 0·2 | 1 | 6·0 | 8·7 | 2 | 0·4 | 0·3 | 0 | 113 | 161 | 1 | 4·4 | 5·8 | 1 |
| Meat | 35·7 | 6·9 | 7·9 | 7 | 1·4 | 0·4 | −1 | 8·2 | 6·7 | −5 | 425 | 421 | 0 | 13·9 | 8·1 | −5 |
| Eggs | 21·6 | 2·5 | 2·5 | 0 | 0·3 | 0·2 | 0 | 3·3 | 2·8 | −2 | 156 | 146 | 0 | 11·2 | 13·2 | 2 |
| Vegetables | 19·6 | 0·1 | 0·1 | 1 | 0·5 | 0·9 | 0 | 0·4 | 0·3 | 0 | 19 | 24 | 0 | 7·4 | 6·0 | −1 |
| Fish | 13·6 | 1·1 | 0·2 | −6 | 0·2 | 0·3 | 0 | 2·8 | 2·2 | −2 | 93 | 50 | −1 | 59·4 | 18·6 | −36 |
| Dessert | 10·0 | 0·5 | 2·0 | 10 | 1·9 | 1·7 | 0 | 0·1 | 0·5 | 1 | 53 | 103 | 1 | 2·7 | 1·2 | −1 |
| Poultry | 9·1 | 1·9 | 2·3 | 3 | 0·0 | 0·0 | 0 | 2·8 | 1·6 | −4 | 120 | 115 | 0 | 1·4 | 1·3 | 0 |
| Total | 449 | 14 | 19 | 35 | 161 | 203 | 26 | 30 | 35 | 15 | 3 799 | 4 767 | 25 | 113 | 95 | −16 |

| Food group | Intake g/day | Iron (μg) | | | Vitamin A act. (RE) | | | Vitamin $B_1$ (μg) | | | Vitamin $B_2$ (μg) | | | Niacin (μg) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | meas. | TFT | ov (%) | meas. | TFT | ov (%) | meas. | TFT | ov (%) | meas. | TFT | ov (%) | meas. | TFT | ov (%) |
| Rice/cereals | 282·9 | 396 | 3 112 | 99 | 0·0 | — | — | 36·8 | 379 | 130 | 45·1 | 144 | 31 | 849 | 5 686 | 89 |
| Fruit | 55·3 | 166 | 183 | 1 | 22·1 | 387 | 203 | 25·5 | 32·1 | 3 | 32·1 | 27·7 | −1 | 554 | 327 | −4 |
| Meat | 35·7 | 1 102 | 956 | −5 | 3·6 | — | — | 153 | 80 | −28 | 98 | 66 | −10 | 1 955 | 1 479 | −9 |
| Eggs | 21·6 | 497 | 691 | 7 | 84 | 127 | 23 | 26·6 | 21·6 | −2 | 95 | 80 | −5 | 17·3 | 21·6 | 0 |
| Vegetables | 19·6 | 137 | 86 | −2 | 43 | 71 | 16 | 11·4 | 7·6 | −1 | 9·8 | 9·0 | 0 | 118 | 55 | −1 |
| Fish | 13·6 | 272 | 116 | −6 | 2·7 | — | — | 4·6 | 7·8 | 1 | 31·3 | 13·9 | −5 | 653 | 54 | −11 |
| Dessert | 10·0 | 90 | 135 | 2 | 2·0 | — | — | 0·5 | 5·5 | 2 | 1·0 | 2·4 | 0 | 70 | 70 | 0 |
| Poultry | 9·1 | 109 | 136 | 1 | 20·0 | 21·8 | 1 | 3·9 | 7·2 | 1 | 13·0 | 14·5 | 1 | 1 178 | 725 | −8 |
| Total | 449 | 2 769 | 5 415 | 96 | 177 | 607 | 243 | 262 | 541 | 106 | 326 | 358 | 10 | 5 394 | 8 418 | 56 |

**TABLE 4**
Mean Daily Intake of Nutrients by a Group of Thai Children Aged 3–8 Calculated from the Food Consumption Inquiry using Measured Contents and the Contents Given in the 1978 Thai Food Composition Table (TFT)

| *Nutrient* | *Unit* | *Daily intake* | | *Overestimation by TFT (%)* |
|---|---|---|---|---|
| | | *Measured* | *TFT* | |
| Crude fat | g | 14·2 | 19·1 | 35 |
| TCH | g | 161 | 203 | 26 |
| Crude protein | g | 30·4 | 35·1 | 15 |
| Energy | MJ | 3·8 | 4·8 | 25 |
| Calcium | mg | 113 | 95 | −16 |
| Iron | μg | 2 769 | 5 415 | 96 |
| Vitamin A act[a] | μg | 177 | 607 | 243 |
| Vitamin $B_1$ | μg | 262 | 541 | 106 |
| Vitamin $B_2$ | μg | 326 | 358 | 10 |
| Niacin | mg | 5·4 | 8·4 | 56 |

[a] The measured vitamin A activity is: retinol + 1/12 × (total carotenoids − β-carotene) + 1/6 × β-carotene, all in mg/kg.

All nutrient contents in the rice/cereals group—contributing 63% to the daily food intake by Thai children—as calculated from the TFT are higher than those measured. This may be explained by the use of less selective analytical methods to collect the data for the TFT and/or by the current tendency towards more refined milling, e.g. milling of wheat causes losses of nutrients ranging from 11% for crude protein to 66% for vitamin $B_1$ (Paul & Southgate, 1979).

The nutrient contents of the meat and fish groups as calculated from the TFT are generally lower than the measured contents ($0.005 < p < 0.025$ and $p < 0.005$, respectively, where $p$ is the level of significance).

The nutrient contents of the fruit, eggs, vegetable, dessert and poultry groups as calculated from the TFT and as measured generally do not differ significantly.

## Intake of nutrients

From Table 3 it is concluded that the impact of the observed differences between contents of nutrients given in the TFT and those measured on mean daily nutrient intake of the group of children is high. The intake of nutrients by Thai children calculated from TFT values is overestimated for all nutrients but calcium. The overestimation is considerable for fat, total carbohydrate, protein, energy and vitamin $B_2$ (range 10–35%), and high for iron, vitamin A activity, vitamin $B_1$ and niacin (range 56–243%), whereas the intake of calcium is underestimated by 16%.

All nutrient contents in the rice/cereals group seem to be overestimated by the TFT. This group contributes most to the overestimations, except for vitamin A. Calculation of nutrient intakes from this food group using the TFT leads to overestimations from 19% (fat) to 130% (vitamin $B_1$) for this category of children. The overestimation of the vitamin A intake originates mainly from the fruit group (203%). There is good agreement between TFT-based values and calculated values for calcium intake except for the rice/cereals group (25% overestimated in the TFT) and the fish group (36% underestimated in the TFT). There is also fair agreement between TFT-based values and calculated values for vitamin $B_1$ intake except for the rice/cereals group (130% overestimated by the TFT) and the meat group (28% underestimated by the TFT).

From the mean total daily nutrients intake of the children based on TFT values and on measured values, summarized in Table 4, it is concluded that application of the TFT in a food consumption inquiry may give rise to erroneous conclusions concerning nutrient intake data, especially for iron and the vitamins A, $B_1$ and niacin.

We recommend to revise the Thai Food Composition Table by analysing processed foods with the classical methods for macronutrients and with more selective analytical methods for micronutrients.

## REFERENCES

*Difco Manual* (1984). *Dehydrated Culture Media and Reagents for Microbiology*, 10th edn. Difco Laboratories, Detroit, USA, pp. 1066–7, 1072–3, 1097–8.

EEC (1971). Publication paper no. L 279: pp. 17–18.

Egger, R. J., Wedel, M. & Schreurs, W. H. P. (1985). Health problems in Asia and the Federal Republic of Germany. How to solve them? In *Medizin in Entwicklungsländern*. Vol. 21, ed. F. P. Schelp. Verlag Peter Lang, Frankfurt am Main, FRG, p. 307–14.

Lechtig, A., Yarbrough, C., Martorell, R., Delgado, H. & Klein, R. E. (1976). The one day recall dietary survey: a review of its usefulness to estimate protein and caloric intake. *Arch. Latinoam. Nutr.*, **26**, 243–58.

Marr, J. W. (1971). Individual dietary surveys: purposes and methods. *World Rev. Nutr. Dietet.*, **13**, 105–64.

Paul, A. A. & Southgate, D. A. T. (1979). *The Composition of Foods*. Elsevier Publishing Company, Amsterdam.

Simpson, K. L. & Tsou, S. C. S. (1986). Vitamin A and provitamin A composition of foods. In *Vitamin A Deficiency and its Control*, ed. J. C. Bauernfeind. Academic Press, Orlando, pp. 461–78.

Speek, A. J., Temalilwa, C. R. & Schrijver, J. (1986*a*). Determination of $\beta$-carotene content and vitamin A activity of vegetables by high-performance liquid chromatography and spectrophotometry. *Food Chem.*, **19**, 65–74.

Speek, A. J., Wongkham, C., Limratana, N., Saowakhonta, S. & Schreurs, W. H. P. (1986*b*). Microdetermination of vitamin A in plasma using high-performance liquid chromatography with fluorescence detection. *J. Chromatog.*, **382**, 284–9.

Speek, A. J., Speek-Saichua, S. & Schreurs, W. H. P. (1988). Total carotenoid and $\beta$-carotene content of Thai vegetables and the effect of processing. *Food Chem.*, **27**, 245–58.

Thompson, M. H. (1969). Collaborative study on the determination of sodium and potassium in fish and other marine products. *J. Ass. Offic. Anal. Chem.*, **52**, 55–61.

Tkachuk, R. (1969). Nitrogen-to-protein conversion factors for cereals, oilseed and meals. *Cereal Chem.*, **46**, 419–23.

Van de Kamer, J. H. (1941). Determination of starch with pancreatic amylase. *Chemisch Weekblad*, **38**, 286–88 (in Dutch).

Van de Weerdhof, T., Wiersum, M. L. & Reissenweber, H. (1973). Application of liquid chromatography in food analysis. *J. Chromatog.*, **19**, 455–60.

WHO (1982). *Technical Report Series No. 672. Control of vitamin A deficiency and xerophthalmia.* Report of a joint WHO/UNICEF/USAID/Helen Keller International/IVACG meeting.

Williams, S. (ed.) (1984). *Official Methods of Analysis of the Association of Official Analytical Chemists*, Microbiological methods. 14th edn. AOAC Inc., Arlington, USA, pp. 862–73.

Zakaria, M. & Simpson, K. (1979). Use of reversed-phase high-performance liquid chromatographic analysis for the determination of provitamin A carotenes in tomatoes. *J. Chromatog.*, **176**, 109–17.