Research Article

Nutrient Profiles of Thai Cuisine: A Comprehensive Survey and Computation using Nutrient Analysis Software

Pakpadsorn Sarachantapong[1], Pornnutcha Sopawong[1,2], Wantanee Kriengsinyos[2]*, Pimnapanut Sridonpai[2], Chanida Pachotikarn[3]

[1]Health and nutrition promotion section, Ajinomoto Co., (Thailand) Ltd., Thanon Phaya Thai, Ratchathewi, Bangkok, Thailand

[2]Human Nutrition Unit, Food and Nutrition Academic and Research Cluster, Institute of Nutrition, Mahidol University, Salaya, Phuthamonthon, Nakhon Pathom, Thailand.

[3]Thai Dietetic Association, Lat Yao, Chatuchak, Bangkok, Thailand

ABSTRACT

This study aimed to categorize Thai cooked food and calculate the nutrient profile of Thai side dishes and combined meals, as grounded in Thai food culture. This observational descriptive study collected and calculated the nutritional value of recipes from cookbooks, online media, and regular diets prepared in hospital settings. Energy (kcal), protein (g), total fat (g), vegetables (g), added sugar (g), and sodium (mg) were evaluated per common serving, which was defined by weighing food that was served in hospital. Differences among categories were tested using the Mann Whitney U-test with a p-value ≤ 0.05. Categories were separated if nutrient profile showed a significant difference. Two meal patterns were created, namely, a combination of one staple and two side dishes as well as a single dish set. The nutrient profiles of these two meal patterns were compared to the nutrient target values (NTVs). A total of 2,347 recipes were analyzed and classified into 14 categories: 11 side dishes, 2 single dishes, and 1 staple dish. Categories were distinguished based on at least one nutrient differing significantly from others (p-value < 0.05 for all pairwise comparisons). A total of 57 possible model meals with varying nutrient profiles were assessed. Some model meals met the NTVs for energy, protein, fat, vegetables, and added sugar, while all meals exceeded the NTV for sodium. This study highlighted the diversity of Thai food, with each category exhibiting unique characteristics that may impede a complete nutrition profile. However, good side dish combinations can enhance meal quality to meet NTVs. Consequently, developing recipes that maintain traditional Thai flavors while enhancing nutritional quality and promoting healthy eating has the most potential for optimizing consumer health.

Keywords: Healthy meal, Thai cuisine, Prepared food, Food category, Nutrient profile

Received: 18 January 2025 Accepted: 24 February 2025 Available online: 6 March 2025

* Correspondence: wantanee.krieng@mahidol.ac.th

บทความวิจัย

โปรไฟล์คุณค่าทางโภชนาการของอาหารไทย: การสำรวจและคำนวณโดยโปรแกรมคำนวณสารอาหารอย่างรอบด้าน

ภักษ์ภัสสร สระฉันทพงษ์[1], พรนัชชา โสภะวงศ์[1,2], วันทนีย์ เกรียงสินยศ[2]*, พิมพ์นภาณัท ศรีดอนไผ่[2], ชนิดา ปโชติการ[3]

[1]กองส่งเสริมโภชนาการด้านสุขภาพ บริษัท อายิโนะโมะโต๊ะ (ประเทศไทย) จำกัด ถนนพญาไท ราชเทวี กรุงเทพมหานคร [2]หน่วยมนุษยโภชนาการ กลุ่มวิชาการและวิจัยด้านอาหารและโภชนาการ สถาบันโภชนาการ มหาวิทยาลัยมหิดล ศาลายา พุทธมณฑล นครปฐม

[3]สมาคมนักกำหนดอาหารแห่งประเทศไทย ลาดยาว จตุจักร กรุงเทพมหานคร

บทคัดย่อ

การวิจัยนี้มีวัตถุประสงค์เพื่อจำแนกหมวดหมู่อาหารไทยที่ปรุงสุกและคำนวณโปรไฟล์สารอาหารของกับข้าวและอาหารจานเดียว ที่มีพื้นฐานมาจากวัฒนธรรมอาหารไทย การศึกษาเชิงพรรณนานี้เก็บข้อมูลและคำนวณคุณค่าทางโภชนาการของสูตรอาหารจาก ตำราอาหาร สื่อออนไลน์ สูตรอาหารธรรมดาจากโรงพยาบาล คำนวณพลังงาน (กิโลแคลอรี) โปรตีน (กรัม) ไขมัน (กรัม) ผัก (กรัม) น้ำตาลที่ใส่เพิ่มในอาหาร (กรัม) และโซเดียม (มิลลิกรัม) ต่อหนึ่งหน่วยบริโภคทั่วไป กำหนดหน่วยบริโภคทั่วไปโดยการชั่งน้ำหนักอาหารที่จัดเสิร์ฟในโรงพยาบาล ทดสอบความแตกต่างระหว่างหมวดหมู่อาหารโดยใช้ Mann Whitney U-test ด้วยค่านัยสำคัญทางสถิติที่ ≤ 0.05 หมวดหมู่ของอาหารจะถูกแบ่งออกเมื่อโปรไฟล์ของสารอาหารแตกต่างกัน จำลองมื้ออาหารตัวอย่างเป็น 2 รูปแบบ ได้แก่ ข้าวและกับข้าว 2 ชนิด และชุดอาหารจานเดียว โปรไฟล์สารอาหารของมื้ออาหารตัวอย่างเหล่านี้ถูกเปรียบเทียบกับค่าเป้าหมายสารอาหาร (Nutrient Target Value; NTV) สูตรอาหารที่รวมรวมได้ในการศึกษานี้มี 2347 ตำรับอาหาร, ถูกแบ่งเป็น 14 หมวดหมู่; กับข้าว 11 หมวด อาหารจานเดียว 2 หมวด, และข้าวแป้ง 1 หมวด โดยพิจารณาจากค่าทางโภชนาการที่แตกต่างกันอย่างมีนัยสำคัญระหว่างหมวดหมู่ (p-value < 0.05 ในทุกคู่เปรียบเทียบ) มีมื้ออาหารตัวอย่างที่เป็นไปได้ทั้งหมด 57 ชุดที่มีโปรไฟล์สารอาหารที่แตกต่างกัน มีมื้ออาหารบางชุดที่มีสารอาหารใกล้เคียงกับ NTV ของพลังงาน โปรตีน ไขมัน ผัก และน้ำตาลที่ใส่เพิ่มในอาหาร ขณะที่มื้ออาหารตัวอย่างทุกชุดมีปริมาณโซเดียมเกินค่า NTV การศึกษานี้พบว่าอาหารไทยมีความหลากหลาย แต่ละหมวดหมู่ของอาหารไทยมีลักษณะเฉพาะที่อาจมีสารอาหารไม่ครบถ้วน แต่การเลือกจับคู่กับข้าวที่ดีสามารถเพิ่มคุณภาพของมื้ออาหารจนถึง NTVs ได้ นอกจากนี้การพัฒนาตำรับอาหารที่รักษารสชาติดั้งเดิมแบบไทยแต่ส่งเสริมการรับประทานอาหารที่ดีต่อสุขภาพอาจเป็นประโยชน์ต่อผู้บริโภคได้

คำสำคัญ: มื้ออาหารสุขภาพ, อาหารไทย, อาหารที่ต้องปรุง, หมวดหมู่อาหาร, การจำแนกอาหารตามมาตรฐานโภชนาการ

* Correspondence: wantanee.krieng@mahidol.ac.th

INTRODUCTION

Non-communicable diseases (NCDs) pose a significant health challenge globally, contributing to mortality and exerting financial pressure on healthcare systems for treatment[1]. Unhealthy dietary habits are a major cause of NCDs, especially the excessive intake of fats, sugar, and sodium, coupled with low consumption of vegetables[2]. Numerous programs and policies are being undertaken to decrease the incidence of NCDs and promote healthy eating, including regulations on food labeling, taxes on sugary drinks, restrictions on advertising unhealthy foods especially to children, promoting school nutrition programs, and increasing access to fruits and vegetables[3,4].

Playing a part in such initiatives, the nutrient profiling model is a systematic methodology that classifies or ranks food items based on their nutritional composition[5]. It has been used as a foundation for developing tools to underpin various nutrition-related public health strategies, such as regulating marketing strategies aimed at children, evaluating the nutritional value of baby food, determining food taxes, promoting healthy and sustainable diets, and designing front-of-pack labels[6-8]. On its part, Thailand has implemented the “Healthier Choice Logo” which appears on front-of-pack labels to promote healthier eating habits[9-10]. The eligibility for using this logo is determined using the nutrient profiling system (NPS) that classifies packaged foods within the food and beverage industry. However, other than these foods, a high proportion of the Thai people also rely on “cooked food” for their meals, which includes foods prepared and sold by vendors in restaurants and street food stalls, as well as homemade dishes[11].

At its core, a healthy diet consists of meals that provide energy and nutrients in proportion to energy expenditure and nutritional requirements, as defined by the World Health Organization (WHO)[12]. However, when making dietary choices, individuals may mistakenly believe that certain foods are inherently unhealthy due to their high or low nutrient content, without considering their personal nutritional needs and overall meal composition. Consequently, the overall dietary pattern is more important than the consumption of individual foods or food types. Understanding the characteristics of dietary patterns, whether within a single meal, across a day, or on an occasional basis, is crucial for promoting healthy eating habits within the context of Thai food culture and encouraging healthier food choices. Given the limited research on the specific nutritional characteristics of Thai cooked foods, this study investigated the nutrient profiles (NP) of Thai cooked dishes, categorized by food type, and analyzed the NP of common Thai meal patterns.

MATERIALS AND METHODS

Recipe gathering and nutrient calculation

The Thai recipes used in this study were sourced from reputable and popular sources in Thailand including cookbooks[13-38], culinary school textbooks[39-40], hospital recipes, research studies[41-43], recipe websites[44-47]. YouTube cooking channels with more than 100,000 subscribers were also selected based on the assumption that a higher number of subscribers indicates that the YouTuber provides widely accepted recipes in terms of taste and has gained credibility among their audience[48-55]. The recipes were selected based on specific inclusion and

exclusion criteria. Recipes were included if they provided information on the quantity of raw ingredients in grams and their development team included a chef. Recipes were excluded if they included mixed seasonings without providing specific information for preparing those seasonings, as well as those recipes for dishes that were rarely consumed in the current year. The chosen recipes were initially categorized according to Thai cuisine categories as identified through a literature review[56-58].

Due to variation in serving sizes among the recipes, the “common serving size” was adjusted based on the standard serving size used in hospitals. The nutritional values of each recipe were calculated based on ingredients used in the common serving size. Energy content (kcal) as well as that of six vital nutrients—carbohydrates (g), protein (g), total fat (g), saturated fatty acid (g), dietary fiber (g), and sodium (mg)—were calculated using the INMUCAL-Nutrients V.4.0 program[59]. Additionally, two food groups for each dish were identified and calculated from recipes including vegetables (including any fruits cooked in the recipe) (g) and added sugar (g).

Setting dish categories

All recipes were organized into several dish categories based on the amount of four specific nutrients and food types per common serving: energy (kcal), protein (g), total fat (g), and vegetables (g), using a fractional factorial design. If at least one of these four nutrients or food types differed, the categories were separated. However, if there was no difference in any of these elements, they were placed in the same dish category. Additionally, the NP of each dish category was identified

Nutrient profiles of Thai meals

A sample Thai meal was structured based on a standard serving of a staple food and two distinct side dishes, considering all possible combinations. A single dish set, commonly served with any soup and small side dish, was also considered as a meal. The median (P25, P75) of energy, the six nutrients, and two food groups in each category were calculated. The NP of a Thai meal was determined by summing up the median of the components of these sample meals.

Nutrient target value identification

Nutrient target values (NTVs) were determined based on the Thai Recommended Daily Intake (Thai RDI) and food-based dietary guidelines (FBDG). The calculations for energy (kcal), protein (g), total fat (g), and sodium adhered to Thai RDI guidelines[60]. Vegetable calculations were based on FBDG and used a 2000 kcal energy base[61], consistent with Thai RDI nutrients derived 45 g of carbohydrate from three servings of fruit and 12 g of carbohydrate, 8 g of protein, and 8 g of fat from one serving of milk were subtracted from the nutrient daily target since this study focused solely on main dishes.

To determine the NTVs for a single meal (assuming three meals are consumed daily), the nutrients were divided into three portions. The recommended daily intake of fruit and vegetables was 400 g (five servings), with three servings of fruit (240 g) based on FBDG and two servings assumed to be vegetables at 160 g which was further divided among three meals[61-63]. These per-meal nutrient and food quantities were utilized as NTVs. Added sugar was calculated at 5% of the total energy, equating to 25 grams of sugar per day[61]. It was assumed that 80% of the

added sugar came from snacks and beverages, with the remaining 20% incorporated into the main dish. Hence, 5 grams of sugar were deemed suitable for the main dish per day, which was further divided among three meals. The NP of both Thai dishes and meals were compared with the NTVs to assess the healthiness of the dish and meal.

Data analysis

Statistical analyses were conducted using the SPSS Statistics for Windows, version 18 program. The significance level for all statistical tests was established at p-value ≤ 0.05. Data on the nominal and ordinal scale were presented as frequency or percentage. The normality of all nutritional data was evaluated using the Kolmogorov-Smirnov test. The Mann Whitney U-test was used to test the differences in means of energy, nutrient content, and food group quantities across various dish categories. Categorical variables were presented as proportions (%). Due to the predominantly skewed distributions of nutrient and food data in the dishes and meals, these were presented as medians with percentiles (P25–P75).

RESULTS

Recipes, dish categories, and common serving size

The study included 2,347 recipes that were sourced from various platforms, namely, 715 from cookbooks and culinary school textbooks, 392 from hospitals, 578 from recipe websites, 61 from research studies, 35 from INMUCAL-Nutrients V.4.0., and 566 from YouTube cooking channels. The difference of energy, protein, fat, and vegetable profile between 2 dish categories are presented in supplementary **Table S.1** (p-value < 0.05 at least one nutrient for all couple categories). So, these recipes were classified into 14 dish categories, i.e., 11 side dishes, 2 single dish sets, and 1 staple. The side dish categories included: 1) soup with coconut milk (SWC), 2) soup without coconut milk (SOC), 3) mixed stir-fried (X-SF), 4) meat stir-fried (M-SF), 5) vegetable stir-fried (V-SF), 6) spicy salad (SS), 7) steamed (SM), 8) fried (FR), 9) grilled (GR), 10) paste (PA), and 11) small meat side dish (M-SD). The single dish sets were divided into two categories: less-fat (boiled single dish: B-SG) and high-fat (stir-fried single dish: SF-SG). Lastly, a staple category (SP) was included, given that Thais typically consume meals as a combination of a staple and a side dish. The common serving sizes were calculated and shown in **Table 1**. Among the side dishes, SWC and SOC, which are types of broth-based soups, have larger serving sizes compared to other side dishes. The serving size for other side dishes is 140 g, except for small side dishes that had a serving size half that of normal side dishes (70 g). Similar to SWC and SOC, B-SG is typically cooked or served with broth and had a higher weight compared to SF-SG (525 g for B-SG and 425 g for SF-SG). The staple dishes were determined based on two portions of rice (120 g).

Nutrient profiles of Thai dish separated by dish categories

The nutrient profile of dish (NP-D) is shown in **Table 1**. Among all side dishes, this result is likely due to the high fat content in coconut milk and oil, which are the main ingredients in both SWC and FR. Consistent with their high fat content, SWC and FR also had the highest fat

content, with 25.6 g (17.8, 31.5) for SWC and 25.6 g (14.3, 37.3) for FR.

The top three side dishes with the highest protein content were GR (18.9 g [15.3, 21.0]), FR (17.1 g [13.3, 21.2]), and M-SF (16.9 g [13.8, 20.5]), respectively, all of which predominantly contained meat as an ingredient. Conversely, V-SF had the lowest protein content of 4.1 g (2.9, 4.8), since its main ingredient was vegetables. On the other hand, V-SF had the highest vegetable content among all side dishes, with 101.5 g (82.3, 109.1), while M-SD had the lowest vegetable content, at 0.0 g (0.0, 0.3). As for added sugar, the top three side dishes with the highest added sugar were GR (3.6 g [1.3, 8.9]), SWC (2.8 g [1.4, 5.3]), and SS (2.0 g [0.5, 4.5]). The dish with the lowest added sugar was SOC, with 0.0 g (0.0, 1.8). Regarding sodium content, the top three side dishes with the highest sodium were SWC (989 mg [788, 1316]), GR (928 mg [667, 1,352]), and SS (847 mg [558, 1,144]). The side dish with the lowest sodium content was M-SD at 443 mg (153, 760). For the single dish, SF-SG had higher energy, nutrient content, and food quantity than B-SG. However, the protein content in both categories was nearly similar with 28.6 g (21.7, 37.0) for SF-SG and 27.6 g (22.1, 34.0) for B-SG. For staple foods, calculations were based on natural energy, protein, fat and sodium, excluding vegetables and sugars obtained from cooking.

Nutrient profiles of model meals

NTVs of the concerned nutrients and the nutrient profile of various model meals are shown in **Table 2**. There were 57 possible model meals based on combinations of one common serving of a staple and two side dishes. Each model meal provided energy levels exceeding 80% of the NTV, ranging from 80.4% to 170.8%. Five model meals (8.7%) exceeded 150% of the NTV for energy, namely, M-SF and FR (150.5%), M-SF and SWC (152.9%), FR and FR (165.4%), SWC and FR (168.1%), and SWC and SWC (170.8%). These five meals also had the highest fat content, ranging from 234.2% to 274.4% of the NTV. The model meal with the lowest protein content was V-SF and V-SF (78.8% of NTV), but it had the highest vegetable content (382.9% of NTV). Conversely, the GR and GR model meal had the highest protein content (276.7% of NTV) and the lowest vegetable content (11.2% of NTV). Regarding added sugar, only 10 model meals (17.5%) contained less than 100% of the NTV. The model meal with the highest added sugar content was GR and GR (448.8% of NTV). For sodium, all model meals exceeded 150% of the NTV. The meal with the lowest sodium content was X-SF and X-SF (178.9% of NTV), while the highest was SWC and SWC (300.1% of NTV).

Table 1. Nutrient profiles of each dish category and percentage of nutrients compared to the nutrient target value

No.	Dish Categories	n	Characteristics	Common Serving (g)	Energy		Protein		Total Fat		Added sugar		Vegetable		Sodium	
					kcal	%NTV	g	%NTV	g	%NTV	g	%NTV	g	%NTV	mg	%NTV
Nutrient Target value of a meal					**533**	**100**	**14**	**100**	**19**	**100**	**1.6**	**100**	**53**	**100**	**666**	**100**
Side Dish:																
1	SWC	183	Food cooked by boiling, added coconut milk	250	362 (284, 428)	68.0	14.9 (12.2, 19.0)	98.7	25.6 (17.8, 31.5)	134.2	2.8 (1.4, 5.3)	175.6	50.2 (29.1, 70.4)	94.7	989 (788, 1,316)	148.4
2	SOC	419	Food cooked by boiling, added broth without coconut milk	250	144 (102, 204)	27.0	12.3 (8.7, 16.5)	82.0	6.5 (3.0, 11.6)	33.9	0.0 (0.0, 1.8)	0.0	44.9 (16.4, 77.4)	84.8	836 (552, 1,173)	125.5
3	X-SF	303	Food cooked by stir-frying, mixed between vegetable and meat	140	190 (145, 250)	35.6	11.8 (8.7, 15.2)	78.7	11.3 (7.2, 17.9)	59.2	1.2 (0.5, 2.3)	73.8	43.6 (20.7, 65.9)	82.2	585 (397, 848)	87.9
4	M-SF	146	Food cooked by stir-frying, mainly protein sources (meat, egg, tofu, etc.)	140	268 (212, 346)	50.2	16.9 (13.8, 20.5)	112.7	18.1 (12.1, 26.2)	95.2	1.6 (0.8, 2.9)	99.4	6.9 (3.0, 11.0)	13.0	725 (527, 898)	108.9
5	V-SF	30	Food cooked by stir-frying, mainly vegetable	140	133 (96, 224)	25.0	4.1 (2.9, 4.8)	27.1	9.2 (5.8, 19.8)	47.9	1.1 (0.0, 1.7)	69.4	101.5 (82.3, 109.1)	191.4	710 (570, 1,510)	106.6
6	SS	244	Food cooked by mixed ingredients with seasoning mixed sauce	140	186 (126, 249)	34.9	13.5 (9.2, 17.2)	90.0	7.8 (3.0, 13.4)	40.9	2.0 (0.5, 4.5)	122.5	44.7 (21.9, 67.7)	84.3	847 (558, 1,144)	127.1

Table 1. Nutrient profiles of each dish category and percentage of nutrients compared to the nutrient target value (cont.)

No.	Dish Categories	n	Characteristics	Common Serving (g)	Energy		Protein		Total Fat		Added sugar		Vegetable		Sodium	
					kcal	%NTV	g	%NTV	g	%NTV	g	%NTV	g	%NTV	mg	%NTV
Nutrient Target value of a meal					**533**	**100**	**14**	**100**	**19**	**100**	**1.6**	**100**	**53**	**100**	**666**	**100**
Side Dish: (cont.)																
7	SM	82	Protein sources cooked by steaming	140	174 (143, 242)	32.7	14.8 (11.9, 19.0)	98.7	9.5 (5.5, 16.0)	50.2	0.5 (0.0, 2.5)	29.4	13.0 (3.5, 28.8)	24.5	683 (433, 979)	102.6
8	FR	147	Protein sources cooked by frying in oil	140	348 (255, 443)	65.3	17.1 (13.3, 21.2)	114.0	25.6 (14.3, 37.3)	134.8	0.8 (0.0, 3.3)	51.3	4.2 (0.4, 14.3)	7.8	645 (454, 913)	96.8
9	GR	55	Protein sources cooked by grilling without using oil	140	241 (182, 291)	45.1	18.9 (15.3, 21.0)	126.0	13.1 (6.1, 17.2)	68.9	3.6 (1.3, 8.9)	223.8	3.0 (1.7, 8.6)	5.6	928 (667, 1,352)	139.4
10	PA	172	Dipping sauce prepared by pounding herbs and spices served with vegetable side dish	140	165 (105, 221)	31.0	7.2 (5.3, 11.1)	47.3	5.7 (2.0, 10.1)	29.7	1.4 (0.0, 6.7)	88.8	35.9 (12.6, 59.5)	67.7	754 (512, 1,116)	113.2
11	M-SD	32	Protein sources served in small portions usually eaten with main dishes	70	185 (140, 235)	34.7	11.1 (9.0, 22.0)	73.3	11.3 (6.2, 19.3)	59.5	0.6 (0.0, 3.5)	34.4	0.0 (0.0, 0.3)	0.0	443 (153, 760)	66.5

Table 1. Nutrient profiles of each dish category and percentage of nutrients compared to the nutrient target value (cont.)

No.	Dish Categories	n	Characteristics	Common Serving (g)	Energy		Protein		Total Fat		Added sugar		Vegetable		Sodium	
					kcal	%NTV	g	%NTV	g	%NTV	g	%NTV	g	%NTV	mg	%NTV
Nutrient Target value of a meal					**533**	**100**	**14**	**100**	**19**	**100**	**1.6**	**100**	**53**	**100**	**666**	**100**
Single dish: (cont.)																
12	B-SG	98	Food usually eaten without side dish, cooked without oil	525	428 (353, 589)	80.4	27.6 (22.1, 34.0)	184.0	16.4 (9.2, 24.7)	86.4	2.0 (0.0, 6.0)	125.6	32.1 (8.8, 56.2)	60.6	1,557 (1,063, 2,129)	233.8
13	SF-SG	423	Food usually eaten without side dish, cooked with oil	415	647 (513, 795)	121.3	28.6 (21.7, 37.0)	190.0	27.0 (17.8, 39.0)	141.9	3.6 (0.9, 7.8)	226.3	46.1 (20.6, 81.9)	86.9	1,686 (1,195, 2,444)	253.1
Staple:																
14	SP	13	Carbohydrate source usually eaten with side dish	120	185 (151, 214)	34.7	3.7 (3.0, 4.0)	24.8	0.9 (0.5, 2.9)	4.5	0.0 (0.0, 0.0)	0.0	0.0 (0.0, 0.0)	0.0	22 (8, 169)	3.2

Data presented in median (P25, P75), %NTV: percentage of nutrient content compared to nutrient target value

Table S.1 *P*-value of energy, protein, fat, and vegetable differentiation between two different dish categories.

Dish categories 1	Dish categories 2	*P*-value			
		Energy	Protein	Fat	Vegetable
SWC	SOC	0.000*	0.113	0.000*	0.426
	X-SF	0.000*	0.000*	0.000*	0.093
	M-SF	0.000*	0.009*	0.000*	0.000*
	V-SF	0.000*	0.000*	0.000*	0.000*
	SS	0.000*	0.125	0.000 *	0.290
	SM	0.000*	0.003*	0.000 *	0.000*
	FR	0.974	0.000*	0.762	0.000*
	GR	0.000*	0.000*	0.000*	0.000*
	PA	0.000*	0.000*	0.000*	0.000*
	SM-SD	0.000*	0.021*	0.000*	0.000*
	B-SG	0.000*	0.000*	0.000*	0.035*
	SF-SG	0.000*	0.000*	0.030*	0.499
	SP	0.011*	0.000*	0.000*	0.000*
SOC	X-SF	0.000*	0.100	0.000*	0.778
	M-SF	0.000*	0.000*	0.000*	0.000*
	V-SF	0.964	0.000*	0.004*	0.000*
	SS	0.000*	0.516	0.231	0.752
	SM	0.000*	0.000*	0.000*	0.000*
	FR	0.000*	0.000*	0.000*	0.000*
	GR	0.000*	0.000*	0.000*	0.000*
	PA	0.000*	0.000*	0.000*	0.000*
	SM-SD	0.013*	0.854	0.000*	0.000*
	B-SG	0.000*	0.000*	0.000*	0.260
	SF-SG	0.000*	0.000*	0.000*	0.472
	SP	0.000*	0.000*	0.004*	0.000*

Table S.1 *P*-value of energy, protein, fat, and vegetable differentiation between two different dish categories. (cont.)

Dish categories 1	Dish categories 2	*P*-value			
		Energy	Protein	Fat	Vegetable
X-SF	M-SF	0.000*	0.000*	0.000*	0.000*
	V-SF	0.005*	0.000*	0.374	0.000*
	SS	0.078	0.018*	0.000*	0.568
	SM	0.268	0.000*	0.034*	0.000*
X-SF	GR	0.002*	0.000*	0.997	0.000*
	PA	0.000*	0.000*	0.000*	0.008*
	SM-SD	0.611	0.490	0.998	0.000*
	B-SG	0.000*	0.000*	0.001	0.000*
	SF-SG	0.000*	0.000*	0.000*	0.178
	SP	0.825	0.000*	0.000*	0.000*
M-SF	V-SF	0.000*	0.000*	0.000*	0.000*
	SS	0.000*	0.033*	0.000*	0.000*
	SM	0.000*	0.703	0.000*	0.116
	FR	0.008*	0.051	0.000*	0.014*
	GR	0.000*	0.000*	0.000*	0.000*
	PA	0.000*	0.006*	0.003*	0.000*
	SM-SD	0.000*	0.000*	0.068	0.000*
	B-SG	0.000*	0.000*	0.000*	0.000*
	SF-SG	0.001*	0.000*	0.000*	0.000*
	SP	0.000*	0.000*	0.000*	0.000*

Table S.1 *P*-value of energy, protein, fat, and vegetable differentiation between two different dish categories. (cont.)

Dish categories 1	Dish categories 2	*P*-value			
		Energy	Protein	Fat	Vegetable
V-SF	SS	0.094	0.000*	0.026*	0.000*
	SM	0.063	0.000*	0.586	0.000*
	FR	0.000*	0.000*	0.000*	0.000*
	GR	0.000*	0.000*	0.569	0.000*
	PA	0.779	0.000*	0.000*	0.000*
	SM-SD	0.071	0.000*	0.612	0.000*
	B-SG	0.000*	0.000*	0.013*	0.000*
	SF-SG	0.000*	0.000*	0.000*	0.000*
	SP	0.104	0.326	0.000*	0.000*
SS	SM	0.907	0.000*	0.015*	0.000*
	FR	0.000*	0.000*	0.000*	0.000*
	GR	0.000*	0.000*	0.001*	0.000*
	PA	0.000*	0.000*	0.000*	0.000*
	SM-SD	0.653	0.998	0.005*	0.000*
	B-SG	0.000*	0.000*	0.000*	0.103
	SF-SG	0.000*	0.000*	0.000*	0.963
	SP	0.085	0.000*	0.004*	0.000*
SM	FR	0.000*	0.064	0.000*	0.002*
	GR	0.000*	0.003*	0.200	0.007*
	PA	0.000*	0.000*	0.000*	0.561
	SM-SD	0.870	0.142	0.205	0.000*
	B-SG	0.000*	0.000*	0.000*	0.000*
	SF-SG	0.000*	0.000*	0.000*	0.000*
	SP	0.000*	0.000*	0.000*	0.000*

Table S.1 *P*-value of energy, protein, fat, and vegetable differentiation between two different dish categories. (cont.)

Dish categories 1	Dish categories 2	*P*-value			
		Energy	Protein	Fat	Vegetable
F	GR	0.000*	0.081	0.000*	0.921
	PA	0.000*	0.000*	0.000*	0.000*
	SM-SD	0.000*	0.004*	0.000*	0.000*
	B-SG	0.000*	0.000*	0.000*	0.000*
	SF-SG	0.000*	0.000*	0.186	0.000*
	SP	0.021*	0.000*	0.000*	0.000*
G	PA	0.000*	0.000*	0.000 *	0.307
	SM-SD	0.024*	0.002*	0.833	0.000*
	B-SG	0.000*	0.000*	0.014*	0.000 *
	SF-SG	0.000*	0.022*	0.000*	0.000 *
	SP	0.086	0.000*	0.000*	0.000 *
P	SM-SD	0.069	0.000*	0.000*	0.000 *
	B-SG	0.000*	0.000*	0.000*	0.000*
	SF-SG	0.000*	0.000*	0.000*	0.000*
	SP	0.000*	0.000*	0.703	0.000*
SM-SD	B-SG	0.000*	0.000*	0.068	0.000*
	SF-SG	0.000*	0.000*	0.000*	0.000*
	SP	0.980	0.000*	0.000*	0.051
B-SG	SF-SG	0.000*	0.142	0.000*	0.147
	SP	0.000*	0.000*	0.000*	0.000*
SF-SG + SP	SP	0.000*	0.000*	0.000*	0.000*

Data presented in *p*-value. Soup with coconut milk (SWC), Soup without coconut milk (SOC), Mixed stir-fried (X-SF), Meat stir-fried (M-SF), Vegetable stir-fried (V-SF), Spicy salad (SS), Steamed (SM), Fried (F), Grilled (G), Paste (P), Small meat side dish (SM-SD), Boiled single dish (B-SD), Stir-fried single dish (SF-SD), and Staple (SP).

Table 2. Nutrient profile of model meal combinations compared with nutrient target value

Model Meal	Energy		Protein		Fat		Vegetable		Added sugar		Sodium	
	kcal	%NTV	g	%NTV	g	%NTV	g	%NTV	g	%NTV	mg	%NTV
Nutrient Target value	**533**	**100**	**14**	**100**	**19**	**100**	**53**	**100**	**1.6**	**100**	**666**	**100**
Side dish combination (1 Staple + 2 Side dishes):												
SWC + SWC	910	170.8	33.3	222.0	51.9	273.2	100.4	189.4	5.6	350.6	1,999	300.1
SWC + SOC	692	129.8	30.8	205.3	32.9	172.9	95.1	179.5	2.8	175.0	1,846	277.2
SWC + X-SF	738	138.4	30.3	202.0	37.7	198.2	93.8	176.9	4.0	248.8	1,595	239.5
SWC + M-SF	815	152.9	35.4	236.0	44.5	234.2	57.1	107.7	4.4	274.4	1,735	260.6
SWC + V-SF	681	127.7	22.6	150.4	35.5	186.8	151.7	286.1	3.9	244.4	1,720	258.3
SWC + SS	734	137.6	32.0	213.3	34.2	179.8	94.9	179.0	4.8	297.5	1,857	278.8
SWC + SM	722	135.4	33.3	222.0	35.9	189.2	63.2	119.2	3.3	204.4	1,693	254.2
SWC + FR	896	168.1	35.6	237.3	52.0	273.8	54.3	102.5	3.6	226.3	1,655	248.5
SWC + GR	788	147.8	37.4	249.3	39.5	207.9	53.2	100.3	6.4	398.8	1,938	291.1
SWC + PA	713	133.7	25.6	170.7	32.1	168.7	86.1	162.4	4.2	263.8	1,764	264.8
SOC + SOC	473	88.8	28.3	188.7	13.8	72.6	89.9	169.6	0.0	0.0	1,694	254.3
SOC + X-SF	519	97.4	27.8	185.3	18.6	97.9	88.5	167.0	1.2	73.8	1,443	216.6
SOC + M-SF	597	112.0	32.9	219.3	25.4	133.9	51.8	97.8	1.6	99.4	1,583	237.7
SOC + V-SF	462	86.7	20.1	133.7	16.5	86.6	146.4	276.2	1.1	69.4	1,568	235.4
SOC + SS	515	96.6	29.5	196.7	15.1	79.6	89.6	169.1	2.0	122.5	1,704	255.9
SOC + SM	504	94.5	30.8	205.3	16.9	88.9	57.9	109.2	0.5	29.4	1,541	231.3
SOC + FR	677	127.1	33.1	220.7	33.0	173.5	49.1	92.6	0.8	51.3	1,502	225.6
SOC + GR	570	106.9	34.9	232.7	20.5	107.6	47.9	90.4	3.6	223.8	1,786	268.2
SOC + PA	494	92.7	23.1	154.0	13.0	68.4	80.8	152.5	1.4	88.8	1,611	242.0

Table 2. Nutrient profile of model meal combinations compared with nutrient target value (cont.)

Model Meal	Energy		Protein		Fat		Vegetable		Added sugar		Sodium	
	kcal	%NTV	g	%NTV	g	%NTV	g	%NTV	g	%NTV	mg	%NTV
Nutrient Target value	**533**	**100**	**14**	**100**	**19**	**100**	**53**	**100**	**1.6**	**100**	**666**	**100**
X-SF + X-SF	565	106.0	27.3	182.0	23.4	123.2	87.2	164.5	2.4	148.8	1,192	178.9
X-SF + M-SF	643	120.6	32.4	216.0	30.2	159.2	50.5	95.2	2.8	174.4	1,332	200.0
X-SF + V-SF	508	95.3	19.6	130.4	21.3	111.8	145.1	273.7	2.3	144.4	1,317	197.7
X-SF + SS	561	105.2	29.0	193.3	19.9	104.8	88.3	166.6	3.2	197.5	1,453	218.2
X-SF + SM	549	103.1	30.3	202.0	21.7	114.2	56.6	106.7	1.7	104.4	1,290	193.6
X-SF + FR	723	135.7	32.6	217.3	37.8	198.8	47.7	90.1	2.0	126.3	1,251	187.9
X-SF + GR	615	115.5	34.4	229.3	25.3	132.9	46.6	87.8	4.8	298.8	1,535	230.5
X-SF + PA	540	101.3	22.6	150.7	17.8	93.7	79.5	150.0	2.6	163.8	1,361	204.3
M-SF + M-SF	720	135.1	37.5	250.0	37.1	195.2	13.8	26.0	3.2	199.4	1,472	221.1
M-SF + V-SF	586	109.9	24.7	164.4	28.1	147.8	108.4	204.4	2.7	169.4	1,457	218.8
M-SF + SS	639	119.8	34.1	227.3	26.8	140.8	51.6	97.3	3.6	222.5	1,594	239.3
M-SF + SM	627	117.6	35.4	236.0	28.5	150.2	19.9	37.5	2.1	129.4	1,430	214.7
M-SF + FR	801	150.3	37.7	251.3	44.6	234.8	11.0	20.8	2.4	151.3	1,392	208.9
M-SF + GR	693	130.0	39.5	263.3	32.1	168.9	9.9	18.6	5.2	323.8	1,675	251.5
M-SF + PA	618	115.9	27.7	184.7	24.6	129.7	42.8	80.7	3.0	188.8	1,501	225.3
V-SF + V-SF	451	84.7	11.8	78.8	19.1	100.5	202.9	382.9	2.2	138.1	1,442	216.5
V-SF + SS	504	94.6	21.3	141.7	17.8	93.5	146.2	275.8	3.1	191.3	1,578	237.0
V-SF + SM	493	92.4	22.6	150.4	19.5	102.8	114.4	215.9	1.6	98.1	1,415	212.4
V-SF + FR	666	125.0	24.9	165.7	35.6	187.5	105.6	199.3	1.9	120.0	1,376	206.7
V-SF + GR	559	104.8	26.7	177.7	23.1	121.6	104.4	197.0	4.7	292.5	1,660	249.3
V-SF + PA	483	90.7	14.9	99.1	15.7	82.4	137.4	259.2	2.5	157.5	1,486	223.1

Table 2. Nutrient profile of model meal combinations compared with nutrient target value (cont.)

Model Meal	Energy		Protein		Fat		Vegetable		Added sugar		Sodium	
	kcal	%NTV	g	%NTV	g	%NTV	g	%NTV	g	%NTV	mg	%NTV
Nutrient Target value	**533**	**100**	**14**	**100**	**19**	**100**	**53**	**100**	**1.6**	**100**	**666**	**100**
SS + SS	557	104.5	30.7	204.7	16.4	86.5	89.4	168.6	4.0	247.5	1,715	257.5
SS + SM	545	102.3	32.0	213.3	18.2	95.8	57.7	108.8	2.5	154.4	1,551	232.9
SS + FR	719	134.9	34.3	228.7	34.3	180.5	48.8	92.2	2.8	176.3	1,513	227.1
SS + GR	611	114.7	36.1	240.7	21.8	114.6	47.7	89.9	5.6	348.8	1,797	269.7
SS + PA	536	100.6	24.3	162.0	14.3	75.4	80.6	152.1	3.4	213.8	1,622	243.5
SM + SM	534	100.1	33.3	222.0	20.0	105.2	25.9	48.9	1.0	60.6	1,388	208.4
SM + FR	708	132.8	35.6	237.3	36.1	189.8	17.1	32.3	1.3	82.5	1,349	202.6
SM + GR	600	112.5	37.4	249.3	23.5	123.9	15.9	30.0	4.1	255.0	1,633	245.2
SM + PA	524	98.4	25.6	170.7	16.1	84.7	48.9	92.2	1.9	120.0	1,459	219.0
FR + FR	882	165.4	37.9	252.7	52.1	274.4	8.3	15.7	1.6	101.3	1,311	196.8
FR + GR	774	145.2	39.7	264.7	39.6	208.5	7.1	13.4	4.4	273.8	1,595	239.4
FR + PA	698	131.0	27.9	186.0	32.2	169.3	40.1	75.6	2.2	138.8	1,420	213.2
GR + GR	666	124.9	41.5	276.7	27.1	142.6	5.9	11.2	7.2	448.8	1,878	282.0
GR + PA	591	110.8	29.7	198.0	19.7	103.4	38.9	73.3	5.0	313.8	1,704	255.8
PA + PA	515	96.6	17.9	119.3	12.2	64.2	71.8	135.5	2.8	176.3	1,529	229.6
Single dish set:												
B-SG	428	80.4	27.6	184.0	16.4	86.4	32.1	60.6	2.0	125.6	1,557	233.8
SF-SG	647	121.3	28.5	190.0	27.0	141.9	46.1	86.9	3.6	226.3	1,685	253.1

Data presented is summed median of staple and 2 side dishes. Side dish combination: 1 staple + 2 side dishes, and 1 staple in this study = 120 g followed by food exchange table; Soup with coconut milk (SWC), Soup without coconut milk (SOC), Mixed stir-fried (X-SF), Meat stir-fried (M-SF), Vegetable stir-fried (V-SF), Spicy salad (SS), Steamed (SM), Fried (FR), Grilled (GR), Paste (PA), Small meat side dish (SM-SD), Boiled single dish (B-SG), Stir-fried single dish (SF-SG), and Staple (SP).

DISCUSSION

Dish categories

In this study, Thai dishes were divided into 14 categories: 11 side dishes, 2 single dishes, and 1 staple based on their significant difference in nutrient profiles (**Table S.1**). An earlier study by Keeratichamroen et al.[57] categorized Thai school menu items into a single dish and six side dishes, including clear soup, soup with coconut milk, stir-fried dishes, spicy salad, deep-fried dishes, and steamed dishes. Furthermore, the Easy Dietary Assessment for chronic kidney disease patients (EDA)[58] classified side dishes into six categories: soup with coconut milk, spicy soup and paste, clear soup, Tom yam, vegetable stir-fried, and spicy salad. Additionally, they divided single dishes into five categories: noodles with soup, noodles without soup, stir-fried noodles, rice with side dishes, and boiled rice. Compared with the present study, boiled noodles with soup and boiled noodles without soup were combined. The rationale behind this was that noodles are typically served with soup, with the only difference being whether they are served in the same or separate bowls. For the current study, single dishes were classified based on the type of fat and oil used. Consequently, when considering fat content, boiled rice was grouped with boiled noodles.

When examining food categories from these studies, it is evident that Thai dishes are often defined by their cooking methods. These methods correspond to critical ingredients that impact nutrient content. For instance, dishes with coconut milk are high in fat, fried foods contain high levels of oil-derived fat, and spicy salads are low in fat due to the minimal use of oil. This classification method aligns with how dishes are typically categorized in Thai restaurants, making it easier to communicate with patrons.

Another food group issue when classifying dish categories in this study concerns meat and vegetable composition. Dishes using the same cooking method but differing in meat and vegetable composition were separated; for instance, vegetable stir-fried, meat stir-fried, and mixed stir-fried that were cooked using the same cooking method but varied in meat and vegetable composition. The rationale is that protein and fiber profiles of these dishes are different and, in terms of communication, knowing these differences will help people to more easily develop a complete meal.

Common serving size

In this study, common serving size was determined based on raw ingredients, considering the quantity that one person would typically consume in a meal, which includes one staple and two side dishes. Most recipes posted on recipe sites usually indicate the number of servings without specifying the quantity for a single serving. Additionally, it is uncommon for food vendors to weigh the final product of cooked food. To feasibly calculate the NP of cooked food, this study defined the common serving size using the raw weight of the recipe, referring to the amount of food typically served in a hospital meal, consisting of one staple and two side dishes. It is important to note that no other studies have defined the common serving size of cooked food in this manner.

Nutrient profile of dishes

When considering the nutritional value of each dish category, it is important to note that these values are calculated based on the

ingredients prepared for cooking, rather than what is actually served or consumed. For instance, in the case of grilled food, the meat is seasoned and marinated before grilling. However, not all the seasoning is absorbed into the meat; some remain on utensils or drip off during cooking[64]. Additionally, when grilling, some fat from the meat melts and drips away, reducing the fat content in the final dish. Similarly, when making soup, sufficient water or liquid is added to boil the ingredients. However, all the broth might not be consumed, and some seasoning may remain in the liquid rather than being ingested. As a result, the actual intake of certain components, such as fat, sodium, and sugar from soups, may be lower than initially calculated.

Thai model meal and percent of nutrient target value

Nutritional data from a dish was combined into a meal, consisting of one staple and two side dishes. A total of 57 potential model meals were calculated and subsequently compared with NTVs for each meal. The NTVs were calculated based on the Thai Recommended Daily Intake (Thai RDI)[60], excluding energy and nutrients from milk, fruit, and sugar from snacks. NTVs were set as follows: energy 533 kcal, fat 19 g, protein 14 g, added sugar 1.6 g, sodium 666 mg, and vegetables 53 g. In Thailand, the Bureau of Nutrition under the Ministry of Public Health (MOPH) (65) has defined the nutritional value of a healthy meal as follows: energy ≤ 600 kcal, fat ≤ 10 g, sugar ≤ 2 g, and sodium ≤ 600 mg, without including criteria for protein and vegetables. In addition, a study by Pongutta et al.[56] also set criteria for classifying meals into 3 levels: suitable, moderate, and unsuitable. For the suitable level, they set the nutrient level as follows: energy ≤ 480 kcal, sugar ≤ 2 g, total fat ≤ 15 g, sodium ≤ 600 mg, protein ≥ 12 g, and fiber 6 g. Moreover, they were also concerned about saturated fatty acid, cholesterol, iron, calcium, vitamin C, vitamin A, Vitamin B1, and vitamin B2. Besides, the Healthier Choice Logo Program (HCL) defined criteria for the ready-to-eat food category[66], setting the energy range per serving at 250–500 kcal and assessing eight key nutrients: protein, calcium, iron, dietary fiber, total fat, saturated fat, total sugar, and sodium per 100 kcal. The evaluation is based on a rating scale (0–5 points for each nutrient), with a total possible score of 40. To qualify as a healthier choice, a meal must score at least 20 points while ensuring that total fat, saturated fat, and total sugar do not exceed 3.25 g, 1 g, and 1.25 g per 100 kcal, respectively. Additionally, sodium, protein, calcium, and iron content must be within the range of 75–125 mg, 0.5-25 g, 8-750 mg, 0.14-11.25 mg per 100 kcal, respectively.

When comparing this study with previous studies, including the Ministry of Public Health (MOPH) criteria, Pongutta et al.'s classification system, and the Healthier Choice Logo (HCL) program[56, 65-66], several key differences and areas for potential refinement emerge. The NTV for energy in the present study is slightly higher than reported in the study by Pongutta but lower than the MOPH criteria. Added sugar in this study is slightly lower than both previous studies. While the NTV for fat and sodium were slightly higher. Further, the NTV of protein was slightly higher compared with that reported in the study by Pongutta but there are no protein criteria for MOPH criteria. The NTV for vegetables cannot be compared due to previous studies[56, 65-66] focusing on dietary fiber rather than vegetable.

However, the current study does not define criteria for a healthy or unhealthy meal but rather sets a target to reach for a meal. For defining healthy meal criteria, the MOPH applies strict cut-off values, whereas Pongutta et al.[56] and the HCL program use scoring systems that provide more flexible assessments based on nutrient content.

When evaluating nutrient profile of the model meal comparing to NTV, all energy, nutrients, and food groups displayed a %NTV both below and above 100%, except for sodium. Sodium was unique in that it only exceeded the %NTV, ranging from 178.9% to 300.1%. Although the sugar content also surpassed the %NTV, it reached a peak of 448.8%, which is more than four times the set criteria. However, NTVs were calculated based on a 2,000 kcal diet. Some target groups may require energy and nutrients either less than or more than those NTVs.

These observations suggest that meal recommendations can be optimized to promote healthier choices, especially when selecting dishes that fulfill nutritional needs in terms of energy, protein, fat, and vegetables. However, sugar and sodium content, which often come from seasonings used in recipes, cannot be improved merely by changing meal combinations. Instead, they require modifications in the recipe itself and a shift in taste preferences. The strength of our study is the use of recipes from a variety of sources, including non-professional cooks, chefs, and hospitals. This ensures a diverse range of Thai food recipes, encompassing both taste-focused and nutrition-focused preparations. This study has some limitations. The collected recipes were not prepared or tested for acceptance before being included in the database. However, all recipes were sourced from reliable and widely recognized sources in Thailand, ensuring a reasonable level of credibility. Additionally, nutritional values were estimated using software calculations. Future studies should incorporate laboratory analysis to accurately determine the nutrient content.

CONCLUSION AND RECOMMENDATION

This study of the NP of Thai food revealed an extensive variety and categorization based on the nutritional content and characteristics of the dishes. Thai cuisine is unique in its consumption pattern, with a combination of side dishes forming the main meal. The variety of these side dishes allows for countless model meals, some of which align closely with the NTVs, while others exceed or fall short of it. Despite this variance, the findings from our study provide valuable insights into the nutrient profile of Thai food. Moreover, based on our results, it is recommended to develop consumer guidelines that suggest optimal combinations of side dishes to ensure balanced nutrition, promote healthier eating habits, and improve overall health outcomes.

For food vendors, our findings can be beneficial for their menu planning, recipe development, and food promotion. By adjusting recipes to improve their nutritional value and align more closely with NTVs, as well as to promote the healthiness of the foods that they are preparing along these lines, vendors can contribute positively to the food decisions and health of consumers. Finally, further research should also be conducted to explore how these recommendations are received and implemented by both consumers and vendors, as well as their impact on public health in the long term.

CONFLILCT OF INTEREST DECLARATION

This study was a collaborative effort between Ajinomoto Co., (Thailand) Ltd., the Institute of Nutrition at Mahidol University, and the Thai Dietetic Association (TDA). The authors affirm that they have no conflict of interest in undertaking this work

ACKNOWLEDGEMENTS

The authors would like to extend their heartfelt appreciation to Ms. Karaked Tongdonpho, a research technician at the Institute of Nutrition Mahidol University (INMU), for her invaluable advice on selecting reliable recipe sources and assistance in recording the INMUCAL program. Her extensive experience in culinary preparation following diverse recipes has greatly enriched our study. We are also deeply grateful to the Institute of Nutrition Mahidol University (INMU) for providing us with the INMUCAL-Nutrients V.4.0 program support throughout this study. We would like to express our deepest gratitude to the Thai Dietetic Association (TDA) for their invaluable assistance in coordinating and gathering recipe data from 81 hospitals across all 13 Health Regions in Thailand. We would also like to acknowledge the tireless efforts of the nutritionists from the nutrition units in these hospitals who meticulously collected data from both hospital recipes that were served as regular diets and weighed food portions to establish a common serving size used as a standard in this study. Your support has been instrumental to the success of this study.

REFERENCES

1. Bloom DE, Cafiero ET, Jané-Llopis E, Abrahams-Gessel S, Bloom LR, Fathima S et al. The global economic burden of non-communicable diseases. World Economic Forum; 2011 [cited 2025 Feb 28] Available from: https://www3.weforum.org/docs/WEF_Harvard_HE_GlobalEconomicBurdenNonCommunicableDiseases_2011.pdf
2. World Health Organization, United Nation Thailand, and Ministry of Public Health Thailand. Prevention and Control of Noncommunicable Diseases in Thailand – The Case for Investment Thailand [Internet]. 2021 [cited 2024 May 31]. Available from: https://thailand.un.org/en/159788-prevention-and-control-noncommunicable-diseases-thailand-%E2%80%93-case-investment
3. Allen LN, Wigley S, Holmer H, Barlow P. Non-communicable disease policy implementation from 2014 to 2021: a repeated cross-sectional analysis of global policy data for 194 countries. Lancet Glob Health. 2023;11(4):e525-e533. doi:10.1016/S2214-109X(23)00042-6
4. Chairatanapiwong S, Wungrat J, Na Lampang K. Healthy Eating Promotion via Food Stalls in Chiang Mai University. J Nutr Assoc Thailand. 2019;54(2):68-79. Available from: https://he01.tci-thaijo.org/index.php/JNAT/article/view/191037
5. World Health Organization. Nutrient Profiling: Report of a WHO/IASO Technical Meeting. 2010 [cited 2025 Feb 28]. Available from: https://iris.who.int/bitstream/handle/10665/336447/9789241502207-eng.pdf?sequence=1&isAllowed=y
6. UK Department of Health and Social Care Food Standards Agency. The Nutrient Profiling Model. 2011 [cited 2025 Feb 28]. Available online at:

https://assets.publishing.service.gov.uk/media/5a7cdac7e5274a2c9a484867/dh_123492.pdf

7. Julia C, Etilé F, Hercberg S. Front-of-pack nutri-score labelling in France: an evidence-based policy. Published Online February 23, 2018. doi:10.1016/ S2468-2667(18)30009-4
8. Government of Australia. Health Star Rating System. 2022 [cited 2025 Feb 28]. Available from: http://www.healthstarrating.gov.au/internet/healthstarrating/publishing.nsf/Content/Home
9. Nguyen NH, Photi J, Tangsuphoom N, Kriengsinyos W. Uptake of front-of-package nutrition labeling scheme after 5 years of adoption in Thailand: an analysis of new launched pre-packaged food and beverages products. Nutrients. 2023;15(14):3116. doi: 10.3390/nu15143116
10. Pongutta S, Tantayapirak P, Paopeng C. Packaged food consumption and understanding of front-of-pack labels in urban Thailand. Public Health. 2019; 172: 8-14. doi: 10.1016/j.puhe.2019.04.004. Epub 2019 May 27.
11. Ornkamol Puranabhandu O. Thailand's Food and Restaurant Trends in 2023. Bangkok, Thailand: United States Department of Agriculture, Foreign Agricultural Service; 2023 Jun. Report No.: TH2023-0036 [cited 2025 Feb 28]. https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Thailand%27s%20Food%20and%20Restaurant%20Trends%20in%202023_Bangkok_Thailand_TH2023-0036.pdf
12. World Health Organization. Healthy diet [internet]. 2020 [cited 2020 April 29]. Available from: https://www.who.int/news-room/fact-sheets/detail/healthy-diet
13. Bureau of Nutrition, Department of Health, Ministry of Public Health. 84 menus healthy vegetable chili paste menu. Nonthaburi: Department of Health, Ministry of Public health; 2012. [in Thai]
14. Kongpun S. Top 10 Thai food in foreign countries. 2nd edition. Bangkok: Sangdad publishing; 2005. [in Thai]
15. Kongpun S, Suwanpong M. Rice gruel - rice porridge - Chinese food. 3rd edition. Bangkok: Sangdad publishing; 1990. [in Thai]
16. Kongpun S. A professional kitchen guideline. 3rd edition. Bangkok: Sangdad publishing; 2002. [in Thai]
17. National Food Institute: NFI. Thai food from past to present. Bangkok: National Food Institute; 2008. [in Thai]
18. Maeban publishing. Snacks. Bangkok: Maeban publishing; 2020. [in Thai]
19. Mahaphon S. 50 recipes scent of Thai food. Bangkok: STEP 4 LIMITED., Partnership; 2004. [in Thai]
20. Deesawad U. 55 Menus Thai food 5 stars. Bangkok: Thai quality books; 2013. [in Thai]
21. Hetrakul P, Hunchin C, Phoemsap R, Prasongsuk A, Nambud S, Thongkhao P, Maithiamklang P. Editors. Khanom chin. Bangkok: Maeban publishing; 2012. [in Thai]
22. Sangdad publishing. Khao kha moo (Thai braised pork leg rice). Bangkok: Sangdad publishing; 2016. [in Thai]
23. Sangdad publishing. Khao man gai and Khao man prayuk (Thai Style Hainanese Chicken Rice). Bangkok: Sangdad publishing; 2008. [in Thai]

24. Aimsabai A. Chinese restaurant food kitchen. 2nd editions. Bangkok: Sangdad publishing; 2007. [in Thai]
25. Sangwasri S, Chunhabandit P. Editors. Single dish menu. Bangkok: Amarin cuisine Amarin printing and publishing; 2012. [in Thai]
26. Hongwiwat T. Editor. Favorite Thai dish. Bangkok: Sangdad publishing; 2017. [in Thai]
27. Phokasuwibun P. Popular chili paste and dipping. Bangkok: Phetpraguy publishing; 2017. [in Thai]
28. Hetrakul P, Phoemsap R, Prasongsuk A, Nambud S, Thongkhao P, Pangwong Y, et al. Editors. Chili paste for sale, easy to make, sells quickly. Bangkok: Maeban publishing; 2018. [in Thai]
29. Devakula K. Sumrub 1. 2nd ed. Bangkok: Srisara Publishing; 2021. [in Thai]
30. Bangsud S. Editor. Delicious every meal and fusion food. Bangkok: Sangdad publishing; 2013. [in Thai]
31. Kongpun S. Registered food National intangible cultural heritage. Bangkok: so.so.so.so; 2013. [in Thai]
32. Hongwiwat T. Editor. Thai food. Bangkok: Sangdad publishing; 2007. [in Thai]
33. Hetrakul P, Phoemsap R, Prasongsuk A, Pangwong Y, Srichanin R, Poyum A. Editors. Authentic Thai food. Bangkok: Maeban publishing; 2018. [in Thai]
34.. Aimsabai A. Spicy Thai food. 2nd editions. Bangkok: Sangdad publishing; 2007. [in Thai]
35. Deesawad U. Noodle dishes. Bangkok: Phetpraguy publishing; 2016. [in Thai]
36. Songpranam P. Thai food. Bangkok: SE-Education; 2004. [in Thai]
37. Nopphan J. Food theory 1: Regional food 4 regions. Bangkok: Odion store; 1982. [in Thai]
38. Kongpun S, Suwanpong M, Thotsanon C. Restaurant food textbook. Bangkok: United books; 1991. [in Thai]
39. Sadpun S. Food-dessert. Bangkok: Food and dessert department Bangkok Polytechnic college; 1985. [in Thai]
40. Suan Dusit International Culinary School, Suan Dusit University. Thai food. 3rd ed. Bangkok: Suan Dusit International Culinary School, Suan Dusit University; 2016. [in Thai]
41. Charoenkiatkul S, Kosanwat W, Chavasit V, Kosanwat S, Rojroongwasinkul N, Boonpraderm A. Nutritive values of healthy Thai foods. Nakhon Pathom: Institute of Nutrition, Mahidol University; 2002. [in Thai]
42. School Lunch Project Fund Bureau, Office of the Permanent Secretary, Ministry of Education. Recipes for school-age children. Bangkok: Ministry of Education; 2004.
43. Chittchang U, Egkantrong P, Banjong O, Sirichakwal P, Kriengsinyos W, Chaipai S. The establishing of food ingredients and seasonings database (3rd year): Local food of the Central Region of Thailand. Nakhon Pathom: Institute of Nutrition Mahidol University; 2016. [in Thai]
44. Krua.co [Internet]. Bangkok: Sangdad media group; [cited 2023 Aug 7]. Available from: https://krua.co/recipe
45. Cheewajit. Healthy Food: Recipe [Internet]. Bangkok: Amarin group; [cited 2023 Aug 15]. Available from:

https://cheewajit.com/healthy-food/recipe/224605.html

46. Phol food mafia [Internet]. Bangkok: Phol food mafia network; [cited 2023 Aug 21]. Available from: https://www.pholfoodmafia.com/recipe/
47. Northen Thai Information Center (NTIC), Chiang Mai University Library, Chiang Mai University. Lanna food. Chiang Mai: Northen Thai Information Center (NTIC), Chiang Mai University Library, Chiang Mai University; [cited 2023 Aug 21]. Available from: https://lannainfo.library.cmu.ac.th/lannafood/
48. Youtube. GinDaiAroiDuay [Internet]. n.p.: 2018. [cited 2023 Aug 28]. Available from: https://www.youtube.com/@GinDaiAroiDuay
49. Youtube. PlaoCooking [Internet]. n.p.: 2012 [cited 2023 Aug 28]. Available from: https://www.youtube.com/@plaocooking8035
50. Youtube. FoodTravelTVChannel [Internet]. n.p.: 2012 [cited 2023 Aug 28]. Available from: https://www.youtube.com/channel/UCZiboBUA0U1tn31MyHoMYLQ
51. Youtube. Tomjoke Foodtv [Internet]. n.p.: 2016 [cited 2023 Aug 28]. Available from: https://www.youtube.com/@TomJokeFoodtv
52. Youtube. Aroypoong [Internet]. n.p.: 2011 [cited 2023 Aug 28]. Available from: https://www.youtube.com/@aroypoong
53. Youtube. TidReview [Internet]. n.p.: 2011 [cited 2023 Aug 28]. Available from: https://www.youtube.com/@Tid_Review
54. Youtube. Enter the kitchen [Internet]. n.p.: 2019 [cited 2023 Aug 28]. Available from: https://www.youtube.com/@enterthekitchen796
55. Youtube. Eatdincooking [Internet]. n.p.: 2019 [cited 2023 Aug 28]. Available from: https://www.youtube.com/@diid
56. Pongutta S, Sirichakwal P, Chittchang U, Puwastien P, Rojroongwasinkul N, Sranacharoenpong K, Inthararak P, Chongviriyaphan N, Saleephan S, Moh-Suwan L, Suthutvoravut U. Nutrient Profiling: a Tool to Strengthen Nutrition Intervention in Thailand. J Health Sci Thai [Internet]. 2017Nov.24 [cited 2024 May 16];24(6):1030-4. Available from: https://thaidj.org/index.php/JHS/article/view/556
57. Keeratichamroen A, Praditsorn P, Churak P, Srisangwan N, Sranacharoenpong K, Ponprachanuvut P, et al. Applying the concept of Thai nutrient profiling as a model for the Thai school lunch planner. Journal of Public Health and Development 2024; 22:224-236. doi: 10.55131/jphd/2024/220117
58. Pachotikan C, Weratean K, Kansumrit K, Saetie E. Workshop: Nutritional Assessment and Dietary Intervention for CKD [Internet]. 2018 [cited 2024 May 16]; 2018. Available from: https://www.rajavithi.go.th/rj/wp-content/uploads/2018/03/2.Case-study-CKD-Nutr-assessment.pdf
59. Thailand, Mahidol University, Institute of Nutrition. Nutrients calculation software: INMUCAL-Nutrients V.4.0 Database version NB.4. 2018.
60. Changbumrung S, Mo-suwan L, Phonrat B, Suthutvoravut U, Udomkesmalee E, Chongviriyaphan N, et al., editors. Dietary Reference Intake Table for Thais 2020. Bureau of Nutrition, Department of Health, Ministry of Public Health; 2020.
61. Sirichakwal PP, Sranacharoenpong K and Tontisirin K. Food based dietary guidelines (FBDGs) development and promotion in Thailand. Asia Pac J Clin Nutr 2011;20 (3):477-483. Available from:

https://apjcn.nhri.org.tw/server/APJCN/20/3/477.pdf

62. Kriengsinyos W, Butryee C. Vegetables and Fruits Consumption 400 g Per Day for Health: Vegetables and Fruits Consumption 400 g Per Day for Health conference; 2017 Sep 21-22; Bangkok, Thailand. Bangkok: Nutrition Society of Thailand under royal patronage. Bangkok: Phanyamit printing company limited; 2017. [in Thai]
63. Butryee C. Vegetables and Fruits Consumption at Least 400 g Per Day for Health: Evidence-based Approach. J Nutr Assoc Thailand [internet]. 2020 Apr. 2 [cited 2025 Feb. 21];55(1):53-65. available from: https://he01.tci-thaijo.org/index.php/JNAT/article/view/235378
64. Kwan A. The impact of cooking methods on nutrient retention: Boil, bake, or grill? J Food Sci Nutr. 2024;7(5):261. doi:10.35841/aajfsn-7.5.261.
65. Ministry of Public Health. Announcement of the Ministry of Public Health (Issue 182) 1998, nutrition labeling. Ministry of Public Health; 1998.
66. Healthier Choice Logo. Guidelines for applying the “Healthier Choice” nutritional logo [Internet]. [cited 2025 Feb 7]. Available from: http://healthierlogo.com/version-eng/