Influences of Different Soup Stocks on Chemical and Organoleptic Properties of Tom Yum

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บทคัดย่อ

ต้มยำเป็นอาหารไทยที่มีชื่อเสียงเป็นที่รู้จักกันอย่างแพร่หลายทั้งในกลุ่มคนไทยและคนต่างชาติ สมุนไพรหลายชนิดถูกนำมาใช้เพื่อทำน้ำซุปต้มยำ เนื้อสัตว์ที่นิยมใส่ในต้มยำคือกุ้งสด ต้มยำแบ่งเป็น 2 ประเภทหลัก ได้แก่ ต้มยำน้ำใส (TYNS) และต้มยำน้ำข้น (TYNK) งานวิจัยนี้มีวัตถุประสงค์เพื่อพัฒนาสูตรต้มยำน้ำใสและน้ำข้น พร้อมกับรายงานคุณค่าทางสุขภาพของต้มยำ ผลทางเคมีและประสาทสัมผัส รวมทั้งการยอมรับของผู้บริโภคต่อผลิตภัณฑ์ ต้มยำทั้งสองสูตรได้รับการพัฒนาจากเชฟผู้เชี่ยวชาญอาหารไทยที่มีชื่อเสียง ซึ่งอยู่ในวงการนานกว่า 30 ปี สูตรน้ำซุปที่ศึกษาสำหรับต้มยำน้ำใส 3 ชนิด คือ (1) น้ำเปล่า (2) น้ำต้มเปลือกกุ้ง และ (3) น้ำต้มกระดูกไก่ สำหรับต้มยำน้ำข้น ชนิดน้ำซุปที่ศึกษา 3 ชนิด คือ (1) น้ำต้มเปลือกกุ้งเติมด้วยนมข้นจืด (2) น้ำต้มเปลือกกุ้งเติมด้วยน้ำกะทิ และ (3) น้ำต้มเปลือกกุ้งเติมด้วยวิปปิ้งครีมผสมน้ำกะทิ ทั้งสามสูตรของต้มยำแต่ละชนิดถูกคัดเลือกด้วยการประเมินความชอบแบบ 9-point hedonic scale โดยใช้ผู้ทดสอบที่ผ่านการฝึกฝนจำนวน 20 คน ผลที่ได้พบว่า ต้มยำน้ำใสและน้ำข้นได้รับคะแนนความชอบโดยรวมระดับชอบปานกลาง เท่ากับ 6.35 และ 7.40 ตามลำดับ สำหรับต้มยำน้ำใส กลิ่นสมุนไพร ($p=0.024$) กลิ่นรสสมุนไพร ($p=0.088$) และความเผ็ด ($p=0.075$) เป็นสามคุณลักษณะที่แตกต่างกันอย่างมีนัยสำคัญทางสถิติ ในขณะที่ทุกคุณลักษณะที่ศึกษาในต้มยำน้ำข้นมีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ ($p\leq0.001$) รวมทั้งเกลือด้วย (แต่แตกต่างกันเพียง $p=0.013$) ต้มยำที่ได้รับคะแนนความชอบสูงสุดจากทั้งสองสูตรนำมาศึกษาการยอมรับจากผู้บริโภคทั่วไปจำนวน 200 คน ด้วยการประเมินความชอบแบบ 9-point hedonic scale ผลตอบรับของต้มยำทั้งสองสูตรเป็นที่น่าพอใจและสอดคล้องกับการทดลองก่อนหน้านี้ที่ใช้ผู้ทดสอบที่ผ่านการฝึกฝน ผลทางเคมีไม่พบไขมันชนิดทรานส์ในต้มยำทั้งสองสูตรที่พัฒนาได้ (TYNS และ TYNK) มีเกลือโซเดียมคลอไรด์เล็กน้อย (0.67 และ 1.10 กรัม/ 100 กรัม) ให้พลังงานน้อย (32.18 และ 41.20 กิโลแคลอรี/ 100กรัม) ให้กรดกลูตามิคมาก (656.93 และ 772.52 มิลลิกรัม/ 100กรัม) ทั้งยังมีค่าการต้านอนุมูลอิสระเป็นบวก (17.55 และ 25.44 เทียบเท่ามิลลิกรัม/ โทรลอค/ 100กรัม) ดังนั้นต้มยำจึงถือว่าเป็นอาหารเพื่อสุขภาพที่ควรได้รับการส่งเสริมประชาสัมพันธ์ต่อไป

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Abstract

'Tom Yum,' a delicious Asian soup originating from Thailand, has been widely known as one of the most popular foods among Thais and foreigners. Bundles of fresh herbs are normally added into

soup stock of Tom Yum and a choice of meat is usually shrimp or prawn. Tom Yum (TY) can be classified into two types which are Tom Yum Nam Sai (TYNS) and Tom Yum Nam Khon (TYNK). This research aimed to develop recipes (TYNS and TYNK) as well as to report the health aspects based on the chemical and organoleptic properties including consumer acceptability of TYs. The TY recipes were developed by a famous master-chef of Thai foods with over three decades of experience in the creation of an authentic taste of TYs who has worked with food industries around the world. For each TY recipe, three kinds of stock, (1) still water, (2) stock made from shrimp shells, and (3) stock made from chicken bones, were investigated in TYNS recipe. Another three kinds of stock, (1) stock with added evaporated milk, (2) stock with added coconut milk, and (3) stock with added whipping cream plus coconut milk were investigated in TYNK recipe. Three of each TY recipe were selected using 9-point hedonic scale by twenty professional panelists in Thai food. Overall liking scores of TYNS and TYNK were rated “like moderate” at 6.35 and 7.40 respectively. For TYNS, three out of nine attributes had significant differences, TY herbs aroma ($p=0.024$), TY flavor ($p=0.088$), and hot ($p=0.075$). For TYNK, all studied attributes had significant differences ($p\leq0.001$) except salty ($p=0.013$). The developed recipes were repeated for consumer acceptability. Two hundred consumers rated them using a 9-point hedonic scale. The consumer acceptability was in relation to a previous study rated by the professional panelists. TYNS and TYNK performed nil trans fat (not detected), low sodium chloride (0.67 and 1.10g/ 100g), low total energy (32.18 and 41.20 kcal/ 100g), high glutamic acid (656.93 and 772.52 mg/ 100g) and antioxidant values (17.55 and 25.44 mg eq/ Trolox/ 100g). Both TY recipes, as a consequence, can be identified as healthy nutritional soups due to the positive chemical properties and Tom Yum can be promoted as healthy for consumers.

Keywords: Tom Yum: Recipe development: Chemical property: Organoleptic property: Consumer acceptability

Introduction

‘Tom Yum,’ a delicious Asian soup originating from Thailand, has been widely known as one of the most popular foods among Thais and foreigners. Tom Yum is consumed worldwide because of its tastes, colors, and health benefits. Tom Yum is hot and sour and the basic soup stock is usually made from bundles of fresh herbs such as lemongrass, kaffir lime, galangal, parsley, chili, coriander, and lime juice. Three main ingredients (lemongrass, kaffir lime and galangal), play a vital role in health as anti-cancer and anti-tumor agents [1], [2], [3]. Thai herbs used for flavors or condiments were revealed as inducers of viral early antigen and possible anti-tumor [2]. Similarly, essential oils of lemongrass also showed anti-fungal ability [4], [5]. Capsaicin, the active component of chili, was recognized as an inhibitor of the growth of gastric pathogen and as an anti-microbial agent [6]. Capsaicin is a main source of beta-carotene and it has antioxidant effects as a natural preservative agent [7]. Tom Yum mix was claimed to have anti-bacterial activities of *E.coli* O157: H7, P. flourescens, S. aureus and L. monocytogens. Coriander was used as a medicinal plant comprised of flavonoids, tannins, saponin, and several triterpenoids [7]. A study reported that coriander

had anti-inflammatory action, anti-convulsant activity, and selective antibacterial activity against *Salmonella* species and the *Erwinia genus* of bacteria [8].

Tom Yum (TY) can be classified into two types, Tom Yum Nam Sai (TYNS) and Tom Yum Nam Khon (TYNK). In Thai, 'Tom' refers to boiling while 'Yum' is a kind of hot and sour salad. Tom Yum is characterized by its distinct taste with fragrant herbs used in soup stock. TYNS is a Thai hot and sour clear soup. TYNK is made from the same soup stock as TYNS but with added milk or coconut milk in the stock. Therefore, TYNK is usually known as Thai hot and sour creamy soup. A choice of meat for Tom Yum is usually shrimp or prawn. Shrimp meat is identified as a first-class source of protein as well as calcium [9]. It contains unsaturated fatty acid such as eicosapentaenoic and docosahexaenoic acids which are considered as essential [10].

Previous studies have been carried out to examine materials of Tom Yum and report their physical and chemical properties individually. Most of them focused on production of Tom Yum paste, Tom Yum mix, and Tom Yum dried seasoning provided in powder and cube forms [11], [12], [13], [14], [15]. Little research has been carried out applying chemical, physical, and organoleptic analyses to Tom Yum. This research aimed to develop TYNS and TYNK recipes as well as to analyze the chemical and organoleptic properties, and consumer acceptability.

The hypothesis was the utilization of different soup stocks can impact on chemical and physical properties alongside liking scores and consumer acceptability. This was investigated in two main sections.

1. Organoleptic determination and consumer acceptability.
2. Physical and chemical determinations.

Materials and Methods

A study of recipe development

Development of TYNS and TYNK were focused on different soup stocks. Both TY recipes were developed by a famous master-chef of Thai foods with over three decades of experience in the creation of an authentic taste of Tom Yum and who has worked with food industries around the world, including Suan Dusit International Culinary School.

For TYNS, three kinds of soup stocks: (1) still water, (2) stock made from shrimp shells, and (3) stock made from chicken bones were investigated. For TYNK, another three kinds of soup stocks: (1) stock with added evaporated milk, (2) stock with added coconut milk, and (3) stock with added whipping cream plus coconut milk were investigated.

TYNS - SW was prepared by heating 2.5L of still water to boiling point (95$\pm$5ºC). Once it reached boiling temperature, slightly pounded lemongrass (50g) cut into 2 cm length was added, and boiling was maintained for 3 min before adding thin sliced lemongrass (25g), and sliced galangal (7g). Boiling was maintained for another minute. Straw mushrooms (100g), shrimp (540g), chili (5g), and kaffir lime leaves (4g) were added and heated for another minute before reducing the heat to low. The heat was turned off before adding fish sauce (75g), lime juice (50g), aromatic shrimp paste (50g), and coriander leaves (8g) were sprinkled on top.

TYNS – SS (the second TYNS soup stock) was prepared using 2.5L of still water and brought to boiling point (95$\pm$5ºC). Once it reached

boiling, slightly pounded lemongrass (50g) and cut into 2 cm length was added, followed by 500g of shrimps' gills and claws (named shrimp shells). Boiling was maintained for 3 min. The heat was reduced and the shrimp shells were separated out of the soup. At this stage 1.8±0.2L of the filtered soup remained. Thin sliced lemongrass (25g) and sliced galangal (7g) were added and boiling was maintained for another minute. Straw mushrooms (100g), shrimp (540g), chili (5g), and kaffir lime leaves (4g) were added and the heat was maintained for another minute before reducing to low. The heat was turned off before adding fish sauce (75g), lime juice (50g), aromatic shrimp paste (50g), and coriander leaves (8g) sprinkled on top.

TYNS – CB (the third TYNS soup stock) was prepared in the same way as the second one, except using chicken bones instead of shrimps' gills and claws. The heat was reduced and the chicken bones were separated out of the soup. At this stage 1.8±0.2L of the filtered soup remained. The rest of the ingredients were added in the same sequence as previously mentioned in TYNS - SS.

TYNK - EM was prepared by heating 2.5L of still water to boiling point (95±5ºC). Once it reached boiling, slightly pounded lemongrass (50g) and cut into 2 cm length was added, followed by 500g of shrimps' gills and claws, and boiling was maintained for 3 min. The heat was reduced and the shrimp shells were separated out of the soup, leaving 1.8±0.2L of the filtered soup.

The soup stock was brought to the high heat until it was bubbling (95±5ºC) for a minute, then thin sliced lemongrass (20g) and sliced galangal (6g) were added, andboiled for another minute. Straw mushrooms (80g), shrimp (674g), chili (4g), and kaffir lime leaves (3g) were added and the heat was maintained for another minute before reducing to low. The soup stock was seasoned using evaporated milk (160g), and kept boiling for another minute. The heat was turned off before adding fish sauce (110g), lime juice (50g), aromatic shrimp paste (40g), chili paste (40g) sprinkled on top with chopped parsley (4g) and coriander leaves (4g).

TYNK – CM (the second TYNK) was prepared in the same way as TYNK – EM but coconut milk was used instead of evaporated milk. The rest of the ingredients were added in the same sequence as previously mentioned in TYNK - EM.

TYNK - WC (the third TYNK) was prepared in the same way as TYNK – EM but whipped cream plus coconut milk (ratio one to one) was used instead of evaporated milk. The rest of the ingredients were added in the same sequence as previously mentioned in TYNK - EM.

A study of organoleptic properties

Three of each TY recipes were selected using 9-point hedonic scale (9 = like extremely; 5 = neither like nor dislike; 1 = dislike extremely) by twenty professional panelists in Thai foods who were chef trainees aged between 25 and 55 years. Nine attributes were assessed: appearance, TY herbs aroma, TY flavor, sour, salty, sweet, umami, hot, and overall liking, to select the highest scores of both to use as standard recipes. All samples were served to the panelists at 70±5ºC in white paper cups for hot food (4 oz.). The ingredients of each sample were identically set (that is each cup contained a shrimp, four sliced lemongrass, two sliced

galangal, two straw mushrooms, a piece of chili, a kaffir lime leaf, a pinch of chopped parsley, and two coriander leaves with 50mL of soup stock). The samples were served one at a time labeled with random 3-digit blind codes. Balanced presentation were used as per the series set of three, meaning that the three samples of TYNS were presented in balanced design and then another three samples of TYNK followed the same pattern. The panelists were asked to cleanse the palate by eating a stick of cucumber and drinking ¼ cup of room temperature water between samples. There was a 5 min break between samples and no discussion about the samples during the break.

A study of consumer acceptability

To affirm the standards of TYNS and TYNK, two hundred consumers tasted the developed recipes. The consumers were a variety in age (16-69 yr), gender, ethnicity (Thai, Lao, American, Australian), careers (students, lecturers, government officers, private employees, retirees, athletes, photographers, journalists, press-reporters). All consumers were familiar with Tom Yum and realized that there were two kinds of Tom Yum. This acceptance test, called CLT (central location test), was done at Raktakanishta Building (Main Hall of Suan Dusit Rajabhat University) in Open House: Healthy & Green Village Fair (organized by the Office of Business Affairs).

The consumers were asked to taste and rate the developed TYNS and TYNK recipes using a 9-point hedonic scale (9 = like extremely; 5 = neither like nor dislike; 1 = dislike extremely). Nine attributes of the two TY recipes were assessed: appearance, TY herbs aroma, TY flavor, sour, salty, sweet, umami, hot, and overall liking.

A study of physical and chemical property

The developed recipes of TYNS and TYNK were taken to determine the physical and chemical properties. The studied physical properties were color (L, a, b) and viscosity [16]. The chemical compositions consisted of moisture, fat, protein, ash and crude fiber [16], carbohydrate content, and calories including total calories and calories from fat [17]. Additionally, other chemical properties were also analyzed for *trans* fat [16], total soluble solid (^{o}Brix), total sugar (fructose, glucose, sucrose, maltose and lactose) using high performance liquid chromatography [17], total acid as citric acid [16], pH, sodium chloride content [16], glutamic acid content [18], capsaicin content [16], antioxidant activity (EQ. Trolox) by using DPPH method.

Experimental design and statistical analysis

In the design of experiments, randomized complete block design were used to study the effects of one primary factor (soup stock) without alteration of other variables of Tom Yum.

Data collected from the organoleptic determination were compared as a set of three (Set A, 3 samples of TYNS; Set B, 3 samples of TYNK). Analysis of variance (ANOVA) using SPSS (version 15) was used to analyze the differences. A multiple comparison test was conducted by post-hoc analysis of Duncan's at 95% confidence level to indicate significant differences between samples of each data set; the significance at this stage is noted with a single asterisk (*). Data showed p-value between 0.05 and 0.10 were discussed or noted as 'a trend' of significance; whereas, a p-value 0.0001

or lower was reported as prominent significance and noted with double asterisks (**).

Data collected from the acceptance test (consumer acceptability) were calculated as means with standard deviation (μ±SD) using XLSTAT 2013.5.

The physical and chemical data were conducted in triplicate. Results were reported in means for a set of three using XLSTAT 2013.5; this means three kinds of soup stocks to make TYNS were examined in one set whilst another three kinds of soup stocks to make TYNK were examined in another set.

Results and Discussion

Recipe Development of Tom Yum

Recipes of Tom Yum Nam Sai (TYNS) and Tom Yum Nam Khon (TYNK) were initiated by Assistant Professor Naruemon Nantaragsa, one of researchers in charge of the study. She is a master-chef of Thai foods who has been keen on the authentic taste of Tom Yum in her career for over three decades. During recipe development, she carefully formulated different kinds of soup stocks to use as standard recipes, henceforth termed the developed TYNS recipe 'TYNS - SW' and the developed TYNK recipe 'TYNK - EM'. The former recipe comprised of soup stock, shrimp, straw mushrooms, fish sauce, lime juice, aromatic shrimp paste, lemongrass, coriander leaves, galangal, chili, and kaffir lime leaves at 66.71, 22.48, 3.34, 2.50, 1.67, 1.67, 0.83, 0.27, 0.23, 0.17 and 0.13% respectively. The latter recipe comprised of soup stock, shrimp, evaporated milk, fish sauce, straw mushrooms, lime juice, aromatic shrimp paste, chili paste, lemongrass, galangal, coriander leaves, chili, chopped parsley, and kaffir lime leaves at 60.13, 20.30, 6.01, 4.13, 3.01, 1.88, 1.50, 1.50, 0.75, 0.23, 0.15, 0.15, 0.15 and 0.11% respectively.

Organoleptic determination

For TYNS, Table 1 suggests that TYNS - SW had the highest score of mean overall liking amongst the samples but it did not significantly ($p>0.05$) differ, although was close to the point significant interval of 80% ($p=0.274$). TY herbs aroma was significantly ($p=0.024$) different to other different soup stocks; TYNS - SW had the highest liking score although was not significant. Nonetheless, TY flavor and hot showed a tendency ($0.05<p<0.10$) of liking for TYNS. TYNS - CB had the lowest liking score of TY flavor and hot whereas the rest (TYNS - SW and TYNS - SS) were higher but non-significant ($p=0.088$ and $p=0.075$) between each other respectively. Consequently, TYNS - SW was the one to take to consumers as it showed the highest overall liking score as well as the highest liking score of significant attribute (TY herbs aroma, $p=0.024$).

For TYNK, Table 2 suggests that all studied attributes were substantially ($p\leq0.001$) different, except salty ($p=0.013$). TYNK - EM showed the highest liking scores of all attributes which were appearance, TY herbs aroma, TY flavor, sour, salty, sweet, umami, hot, and overall liking. TYNK - CM showed a slight potential trend of being used for TYNK when compared to TYNK - EM, particularly in umami that was non-significant to the highest one. Unfortunately, comments were made about TYNK - CM as an unfamiliar flavor of Tom Yum, reminding respondents of Tom Kha with spicy chicken curry in coconut milk with added lemongrass, kaffir leaves, galangal, coriander, chili, straw mushrooms, fish sauce, and lime juice. The TYNK - WC which added whipped cream plus

coconut milk was not an answer for 'Tom Yum' as whipped cream altered the viscosity of the characteristic with regards to Tom Yum. Therefore, evaporated milk added into the soup stock of TYNK in this study and TYNK - EM was taken to consumers for investigation of the acceptance test.

Although in Table 1, overall liking scores were not significant (p=0.274), there was a trend showing TYNS - SW had the highest overall liking scores at 6.35, followed by TYNS - SS (6.15) and TYNS - CB (5.70). Moreover, TYNS - SW showed the highest scores of the TY herbs aroma and TY flavor, both significant at p=0.024 and p=0.088 respectively. Table 2 shows substantial (p=0.001) differences in overall liking scores in which TYNK - EM had the highest one (7.40), besides TYNK - EM performed the highest scores of all studied attributes. Thus, these two developed recipes (TYNS - SW and TYNK - EM) were thence taken for affirmation in the next study for consumer acceptability.

Table 1 How much twenty professional panelists liked or disliked these TYNS samples**?**

Attribute	TYNS - SW	TYNS - SS	TYNS - CB	p-value
Appearance^{ns}	5.90	6.30	5.60	0.345
TY herbs aroma*	6.70^{a}	6.05^{ab}	5.35^{b}	0.024
TY flavor	6.40^{a}	6.10^{ab}	5.45^{b}	0.088
Sour^{ns}	6.50	6.60	5.80	0.248
Salty^{ns}	5.10	5.20	5.00	0.922
Sweet^{ns}	6.40	6.05	5.75	0.191
Umami^{ns}	6.45	6.15	6.00	0.584
Hot	5.55^{ab}	5.75^{a}	4.75^{b}	0.075
Overall liking^{ns}	6.35	6.15	5.70	0.274

Note: TYNS - SW = Tom Yum Nam Sai where its stock made from still water. TYNS - SS = Tom Yum Nam Sai where its stock made from shrimp shells. TYNS - CB = Tom Yum Nam Sai where its stock made from chicken bone. Means liking scores are reported based on 9-point hedonic scale. The p-values show significant differences by ANOVA (F-test) at 95% (*) confidence level unless stated otherwise; non-significant differences (p>0.05, ^{ns}); ^{ab} between samples according to Duncan's indicates significant difference.

Table 2 How much twenty professional panelists liked or disliked these TYNK samples**?**

Attribute	TYNK - EM	TYNK - CM	TYNK - WC	p-value
Appearance**	7.35[a]	5.60[b]	4.85[c]	0.000
TY herbs aroma**	7.45[a]	5.10[b]	4.80[b]	0.000
TY flavor**	7.10[a]	5.20[b]	5.05[b]	0.000
Sour**	7.30[a]	5.70[b]	5.25[b]	0.000
Salty*	7.55[a]	5.35[b]	5.50[b]	0.013
Sweet**	7.20[a]	6.10[b]	5.75[b]	0.000
Umami*	7.30[a]	5.40[ab]	5.35[b]	0.001
Hot**	7.35[a]	6.00[b]	5.80[b]	0.000
Overall liking*	7.40[a]	5.55[b]	5.20[b]	0.001

Note : TYNK - EM = Tom Yum Nam Khon where its stock with added evaporated milk. TYNK - CM = Tom Yum Nam Khon where its stock with added coconut milk. TYNK - WC = Tom Yum Nam Khon where its stock with added whipping cream plus coconut milk. Means liking scores are reported based on 9-point hedonic scale. The p-values show significant differences by ANOVA (F-test) at 95% (*) confidence level or at 99.99% (**) confidence level, unless stated otherwise; [abc] between samples according to Duncan's indicates significant difference.

Table 3 Mean liking scores of developed TYNS and TYNK, rated by two hundred consumers

Attribute	Developed TYNS	Developed TYNK
Appearance	6.38 (1.39)	6.99 (1.23)
TY herbs aroma	6.31 (1.48)	6.77 (1.32)
TY flavor	6.37 (1.59)	6.95 (1.24)
Sour	6.16 (1.62)	6.27 (1.74)
Salty	5.96 (1.50)	6.43 (1.49)
Sweet	5.94 (1.60)	6.23 (1.54)
Umami	6.48 (1.49)	6.97 (1.47)
Hot	6.04 (1.64)	6.35 (1.62)
Overall liking	6.61 (1.34)	7.10 (1.26)

Note Developed TYNS = Tom Yum Nam Sai where its stock made from still water (previously called TYNS - SW in Table 1). Developed TYNK = Tom Yum Nam Khon where its stock with added evaporated milk (previously called TYNK - EM in Table 2). Means liking scores are reported based on 9-point hedonic scale. Numbers inside parenthesis are their standard deviation.

Consumer acceptability

Table 3, with regards to consumer acceptability, shows that developed TYNS and developed TYNK were rated, for nine attributes, between 5.94 and 7.10 (based on 9-point hedonic scale) that fell into like slightly and like moderately. The overall liking scores of both developed TY recipes were rated at "like moderately" at 6.61 and 7.10 respectively. This

was in line with the previous investigation (Table 1 and Table 2).

In comparison both developed TY recipes, developed TYNK showed higher liking scores for all studied attributes. This led to a conclusion that consumers prefer Tom Yum Nam Khon to Tom Yum Nam Sai. Nevertheless, it was not an objective of the study to compare TYNS and TYNK. Two hundred consumers tasted the developed TY recipes and no one rejected the samples as all liking scores were positive values with optimistic comments.

Physical and chemical determination

Three main physical properties of Tom Yum were determined. Color quality (L, a, b) of TYNK - EM were lighter (L), more red (a) and more yellow (b) than TYNS – SW. This was due to different ingredients of the soup stocks. Evaporated milk caused lightness whilst chili paste caused redness and yellowness of TYNK - EM. Moreover, TYNK - EM was more viscous than TYNS - SW. Furthermore, evaporated milk and chili paste also evoked higher viscosity value of TYNK - EM. On the other hand, the total soluble solid content was reversed as the TYNS - SW performed 1.5-fold higher °Brix in comparison to TYNK – EM. Having mentioned that lower °Brix (4.50, see Table 4) received higher liking scores of sweet taste for both developed recipes (7.20 see Table 2; 6.23, see Table 3).

Chemical properties of Tom Yum were determined in ten main groups which were (1) Chemical composition (moisture, fat, protein, ash, crude fiber and carbohydrate); (2) Calories (total calories and calories from fat); (3) *Trans* fat; (4) Total sugar (fructose, glucose, sucrose, maltose and lactose); (5) Total acid (as citric acid); (6) pH; (7) Sodium chloride; (8) Glutamic acid; (9) Capsaicin and (10) Antioxidant activity. The physical and chemical values are shown in Table 4.

TYNS - SW and TYNK - EM demonstrated chemical composition in gram per hundred grams (g/ 100g). All chemical composition were approximately in close range to each other, except carbohydrate in TYNK - EM (0.70 g/ 100g) was 3.5-fold higher compared to TYNS - SW (0.20 g/ 100g). This was in agreement with total sugar content where TYNK - EM indicated 0.59 g/ 100g and TYNS - SW was not detected.Table 4 designates that consuming 100g of TYNS - SW or TYNK - EM received total calories of 32.18 or 41.20 kcal/ 100g, respectively. The latter had calories from fat higher than the former at 3.42 kcal/ 100g (13.32 - 9.90). In addition, both developed TY recipes had nil *trans* fat. For pH values, TYNS - SW and TYNK - EM were classified as low acid food at pH values equal to 5.13 and 5.28 respectively. This pH spectrum resulted in sour liking scores ranging from 6.16 to 7.30 (see Table 1-3). Total acid values of TYNS - SW and TYNK - EM were relative to their pH values (Table 4).

Sodium chloride is known as table salt and consuming too much sodium can raise high blood pressure leading to serious health consequences such as cardiovascular disease [19]. Excess levels of sodium cause high blood pressure, stroke, heart failure, headaches, weight gain and so forth. Consumption of sodium should be less than 100% of daily value or less than 2,300 mg of sodium each day regarding to the recommendation of USDA [20]. This amount equals about one teaspoon and 6 g of salt per day. The present study supported using less than

2,300 mg per day (<6 g of salt) of sodium according to the result in Table 4.

The amounts of glutamic acid in TYNS - SW and TYNK - EM were 656.93 and 772.52 mg/100g respectively and high glutamic acid levels were found in both TY recipes naturally. Natural foods rich in glutamic acid are meats, vegetables, yeast extract, and hydrolyzed vegetable [18], [21], [22], and proteins are also rich in glutamic acid, particularly shrimp reported to be rich in glutamic acid at around 1,800 mg/ 100g [23]. Moreover, the same study also reported shrimps contain other amino acids such as glycine, alanine, serine, threonine, arginine, phenylalanine, isoleucine, leucine, valine, methionine, and histidine. Furthermore, glutamic acid was derived from straw mushrooms, reported to range from 7.72 to 21.00 mg/ g dry weight [24]. The contents of glutamic and aspartic acids were varied during the development of fruiting bodies. Fish sauce, another ingredient in Tom Yum, was found to be high in glutamic acid ranging from 847.80 to 1,520.70 mg/100g depending on the type and freshness of the fish [25]. Glutamic acid contributes the taste of umami. Its common source is known as monosodium glutamate. However, in the present study 'Tom Yum' used only natural umami ingredients, thus avoiding some concerns. Umami, the fifth taste, is known in English as a savory taste alongside the classically known tastes of sweet, salty, sour, and bitter. Utilizing natural ingredients rich in glutamic acid showed the potential role of flavor enhancement in foods [21], [22] and the potential role in reducing dietary sodium intake [22], [26].

Last but not least, with regards to the chemical values shown in Table 4, some chemical properties of Tom Yum are related to positive effects of health such as nil trans fat, low sodium chloride (0.67 and 1.10g/ 100g), low total energy (32.18 and 41.20 kcal/ 100g), high glutamic acid (656.93 and 772.52 mg/ 100g), and positive antioxidant values (17.55 and 25.44 mg eq/ Trolox/ 100g) for TYNS - SW and TYNK - EM respectively.

Conclusion

The developed Tom Yum Nam Sai recipe (TYNS - SW) comprised of soup stock, shrimp, straw mushrooms, fish sauce, lime juice, aromatic shrimp paste, lemongrass, coriander leaves, galangal, chili, and kaffir lime leaves at 66.71, 22.48, 3.34, 2.50, 1.67, 1.67, 0.83, 0.27, 0.23, 0.17, and 0.13% respectively.

The developed Tom Yum Nam Khon recipe (TYNK - EM) comprised of soup stock, shrimp, evaporated milk, fish sauce, straw mushrooms, lime juice, aromatic shrimp paste, chili paste, lemongrass, galangal, coriander leaves, chili, chopped parsley, and kaffir lime leaves at 60.13, 20.30, 6.01, 4.13, 3.01, 1.88, 1.50, 1.50, 0.75, 0.23, 0.15, 0.15, 0.15, and 0.11% respectively.Both developed TY recipes can be identified as healthy nutritional soups due to the positive chemical properties. TYNS - SW and TYNK - EM showed nil trans fat, low sodium chloride (0.67 and 1.10g/ 100g), low total energy (32.18 and 41.20 kcal/ 100g), high glutamic acid (656.93 and 772.52 mg/ 100g), and antioxidant values (17.55 and 25.44mg eq/ Trolox/ 100g) respectively. Organoleptic results from twenty professional panelists showed that TYNS - SW and TYNK - EM were rated, for nine attributes, between 5.94 and 7.10 (based on a 9-point hedonic scale) that fell into like slightly and like moderately. The developed recipes assessed for

consumer acceptability by two hundred consumers who rated using a 9-point hedonic scale. The overall liking scores of both developed TY recipes (TYNS - SW and TYNK - EM) were rated at “like moderately” at 6.61 and 7.10 respectively. This was in line with the previous examination by the professional panelists. In comparison, both developed TY recipes, TYNK - EM performed higher liking scores for all studied attributes. This led to a conclusion that consumers preferred Tom Yum Nam Khon than Tom Yum Nam Sai. Two hundred consumers tasted the developed TY recipes and no one rejected the samples as all liking scores were positive values with optimistic comments. To summarize, both TY recipes, as a consequence, were recognized as healthy nutritional food due to taste and health benefits and Tom Yum can be promoted as health to consumers worldwide.

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Table 4 Physical and chemical properties of developed TYNS and TYNK.

	Developed TYNS	Developed TYNK
Physical properties		
Color		
L	16.66	19.75
a	4.84	5.52
b	11.10	14.00
Viscosity (cP, Spinder No. 1, 100 rpm, 25°C)	19.70	34.50
Chemical properties		
Chemical composition (g/ 100g)		
Moisture	92.26	90.03
Fat	1.10	1.48
Protein	5.37	6.27
Ash	1.07	1.52
Crude fiber	0.47	0.31
Carbohydrate	0.20	0.70
Calories		
Total calories (kcal/ 100g)	32.18	41.20
Calories from fat (kcal/ 100g)	9.90	13.32
Trans fat	ND	ND
Total soluble solid (°Brix)	7.00	4.50
Total sugar (g/ 100g)	ND	0.59
Fructose	ND	ND
Glucose	ND	ND
Sucrose	ND	< 0.50
Maltose	ND	ND
Lactose	ND	0.59
Total acid (as citric acid)	0.30	0.35
pH	5.13	5.28
Sodium chloride (NaCl) (g/ 100g)	0.67	1.10
Glutamic acid (mg/ 100g)	656.93	772.52
Capsaicin (mg/ kg)	< 1.00	< 1.00
Antioxidant activity (mg eq/ Trolox/ 100g)	17.55	25.44

Note: Developed TYNS (TYNS - SW) = Tom Yum Nam Sai where its stock made from still water. Developed TYNK (TYNK - EM) = Tom Yum Nam Khon where its stock with added evaporated milk. Means of physical and chemical properties were conducted in triplicate reporting as means. ND = Not Detect

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