Research article

Comparison of Free Glutamate Content of Condiments and Seasonings between those Manufactured from Thailand and Germany

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ABSTRACT

Monosodium glutamate (MSG), the sodium salt of glutamic acid, is used as a flavor-enhancing additive worldwide. The negative side effects of consuming MSG and the level at which they occur are controversial. This study therefore aims to determine the level of free glutamate content in 13 German and 14 Thai condiments randomly selected from local markets. The glutamate levels were determined in three replicates, using Enzymatic Bio Analysis and spectrophotometry. Samples included condiment sauce (thick, thin and sweet black soy sauce, fish sauce and sour sauce), ketchup (tomato and chili), flavor enhancers and lovage. The average glutamate content was higher in German condiments (3,491.67±1520.28 mg/100 g) than in Thai (1,872.22±572.60 mg/100 g) condiments. The most popular German products, condiment sauces and tomato ketchup, contained 8,416.67±144.34 and 226.00±8.22 mg glutamate/100 g, respectively, whereas the most popular in Thailand were condiment sauces and fish sauce, containing 2,533.33±115.47 and 741.67±14.43 mg glutamate/100 g, respectively. In Germany, tomato salad is frequently consumed with a glutamate content of 443.81 mg per serving, while in Thailand, red curry contains 113.33 mg glutamate per serving. Our study found that the glutamate content in different German and Thai commercial condiments and seasonings could reveal the daily consumption of glutamate. The difference in the levels of glutamate between the two countries depends on the product processing, local ingredients and food consumption behaviors.

Keywords: Free glutamate; Condiment; Flavor enhancer; Cultural foods; Food additive

Received: 17 July 2024 Accepted: 11 June 2025 Available online: 25 June 2025

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บทความวิจัย

การเปรียบเทียบปริมาณกลูตาเมตอิสระของเครื่องปรุงรสและผลิตภัณฑ์ปรุงรสระหว่างที่ผลิตจากประเทศไทยและประเทศเยอรมนี

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บทคัดย่อ

โมโนโซเดียมกลูตาเมต (Monosodium glutamate, MSG) เป็นเกลือโซเดียมของกรดกลูตามิก นิยมใช้เป็นสารปรุงแต่งรสอาหารอย่างแพร่หลาย อย่างไรก็ตามผลข้างเคียงเชิงลบด้านสุขภาพต่อปริมาณการบริโภคยังไม่มีหลักฐานยืนยันอย่างชัดเจน ดังนั้นการศึกษาครั้งนี้จึงมีวัตถุประสงค์เพื่อหาปริมาณของกลูตาเมตอิสระในเครื่องปรุงรสจากประเทศเยอรมนีจำนวน 13 รายการและจากประเทศไทยจำนวน 14 รายการ ซึ่งทำการคัดเลือกผลิตภัณฑ์แบบสุ่มจากตลาดในท้องถิ่น ระดับของกลูตาเมตในเครื่องปรุงรสถูกประเมินโดยวิธีการวิเคราะห์ทางชีวภาพของเอนไซม์ (Enzymatic Bio Analysis) ด้วยเครื่องสเปกโตรโฟโตเมตรี (Spectrophotometry) โดยตัวอย่างทั้งหมดจะถูกวิเคราะห์จำนวน 3 ซ้ำ ประกอบด้วย กลุ่มซอสหรือเครื่องปรุงรส (Condiment sauce) เช่น ซีอิ๊วดำข้น (Thick soy sauce) ซีอิ๊วขาว (Thin soy sauce) ซีอิ๊วดำหวาน (Sweet black soy sauce) น้ำปลา และซอสเปรี้ยว (Sour sauce) กลุ่มซอสมะเขือเทศและซอสพริก สารปรุงแต่งรสอาหาร (flavor enhancers) และผักชีฝรั่ง (lovage) ผลการศึกษาพบว่าปริมาณกลูตาเมตเฉลี่ยในเครื่องปรุงรสของประเทศเยอรมนี เท่ากับ 3,491.67±1520.28 มิลลิกรัมต่อ 100 กรัม ซึ่งสูงกว่าเมื่อเปรียบเทียบกับเครื่องปรุงรสจากประเทศไทยโดยเท่ากับ 1,872.22±572.60 มิลลิกรัมต่อ 100 กรัม ผลิตภัณฑ์ยอดนิยมของประเทศเยอรมนี ได้แก่ ซอสปรุงรสและซอสมะเขือเทศ (Tomato ketchup) มีกลูตาเมตในปริมาณ 8,416.67±144.34 และ 226.00±8.22 มิลลิกรัมต่อ 100 กรัม ตามลำดับ ในขณะที่ผลิตภัณฑ์ยอดนิยมของประเทศไทยได้แก่ ซอสปรุงรสและน้ำปลา (Fish sauce) มีกลูตาเมต 2,533.33±115.47 and 741.67±14.43 มิลลิกรัมต่อ 100 กรัม ตามลำดับ ทั้งนี้เมื่อพิจารณาถึงอาหารบริโภคซึ่งประชาชนส่วนใหญ่ในประเทศเยอรมนีมักชื่นชอบการบริโภคสลัดมะเขือเทศ (Tomato salad) ที่มีกลูตาเมตในปริมาณ 443.81 มิลลิกรัมต่อหนึ่งหน่วยบริโภค ในขณะที่แกงเผ็ดของประเทศไทยมีกลูตาเมตในปริมาณ 113.33 มิลลิกรัมต่อหนึ่งหน่วยบริโภค การศึกษาครั้งนี้ชี้ให้เห็นว่าปริมาณกลูตาเมตในเครื่องปรุงรสเชิงพาณิชย์ของประเทศเยอรมนีและประเทศไทยสามารถบอกได้ถึงปริมาณของกลูตาเมตที่บริโภคในแต่ละวันได้ ซึ่งความแตกต่างของระดับกลูตาเมตระหว่างสองประเทศนี้ขึ้นอยู่กับกระบวนการผลิต ส่วนผสมในท้องถิ่นและพฤติกรรมการบริโภคอาหารในแต่ละท้องถิ่นด้วย

คำสำคัญ: กลูตาเมตอิสระ; เครื่องปรุงรส; สารปรุงแต่งรส; วัฒนธรรมทางอาหาร; วัตถุเจือปนอาหาร

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INTRODUCTION

Glutamic acid (Glu) (or glutamate in its ionic form) is an α-amino acid that is the most abundant naturally-occurring non-essential amino acid[1]. In humans, cellular metabolism can produce remarkable quantities of glutamate that act as an important neurotransmitter in the brain[2-3]. Free glutamate and glutamate compounds occur in many natural foods, such as tomatoes, mushrooms, seaweed, meats, cheese and soy sauce[4-5]. This free glutamate is responsible for the savory flavor or umami taste in many foods. Umami has also been recognized as the fifth taste, alongside sweet, salty, sour and bitter[4,6]. Monosodium glutamate (MSG), also known as sodium glutamate, the sodium salt of glutamic acid, is one of the most common food additives and commonly used in the food industry and in domestic cooking[7]. MSG is a powerful flavor enhancer often added to seasonings and condiments, especially in Asian cuisine and also used in food processing as a food additive[4-5,8].

In 1968, unpleasant symptoms were reported occurring 20 min after eating meals in Chinese restaurants in the United States[9-11]. Several further reports also supported this evidence suggesting that this syndrome was caused by the over-consumption of MSG, which is widely used in the preparation of Chinese food. The range of side effects and symptoms from consuming high amounts of MSG include migraine headaches, nausea, numbness at the back of the neck, weakness, ringing ears, a tingling mouth, asthma, heart palpitations and sweating and came to be known as Chinese restaurant syndrome (CRS) or MSG syndrome complex (MSC)[7]. The worst effects of MSG were also exhibited in both animal and human models[12]. In animal studies, MSG intake was reported to lead to the development of obesity and insulin resistance[13]. In contrast, human studies reported physiological complications associated with MSG toxicity such as becoming overweight, metabolic syndrome, and impairment of brain function and the endocrine system[12,14]. However, the medical evidence on glutamate toxification is still controversial with many studies making methodical mistakes leading to unreliable conclusions[3,12,15]. The effect of glutamate also depends upon the dose, the route of administration and the exposure time[3]. A study of German foods found high amounts of glutamate in lasagna, peas and meat goulash soup with only small amounts found in Thai and Chinese condiments[3,16]. However, few condiments from Thailand have yet been investigated. Traditionally, both Thai and German consumers prefer to add condiments to their foods. The present study therefore aimed to determine the levels of free glutamate in condiments available to German and Thai consumers and to compare these levels based on their use in local recipes.

MATERIALS AND METHODS

Product collection

The condiments and seasonings, ranging from meat extract powder to bouillon cubes, condiment sauces and soy sauce, were purchased from local markets in Bangkok, Thailand (14 products) and in Münster, Germany (13 products) with details shown in **Table 1**.

Table 1. Range of condiment and seasoning products from Germany and Thailand.

Country	Product	Product Abbreviation
Germany	Condiment sauce (1)	G-MW
	Condiment sauce (2)	G-WRP
	Condiment sauce (3)	G-KAp
	Condiment sauce (4)	G-Kss
	Tomato Ketchup	G-Htk
	Chili Ketchup	G-Hck
	Chicken flavor paste	G-MK
	Seasoning powder	G-MFS
	Yeast extract paste	G-Efn
	Sweet black soy sauce	G-DSS
	Sour sauce (1)	G-AWs
	Sour sauce (2)	G-Hws
	Sour sauce (3)	G-WS
Thailand	Condiment sauce (1)	T-M
	Condiment sauce (2)	T-GMo
	Condiment sauce (3)	T-GMn
	Tomato Ketchup	T-Htk
	Chili Ketchup	T-Rck
	Pure MSG	T-AJ
	Pork flavor powder	T-RDp
	Pork bouillon cube	T-KN
	Thin soy sauce (1)	T-KW
	Thin soy sauce (2)	T-HB
	Sweet black soy sauce	T-HBbss
	Fish sauce (1)	T-Tfs
	Fish sauce (2)	T-Sfs
	Sour sauce	T-HBss

All products were collected between January and May in 2019 by a simple random sampling method from three different shops for each product and brand (**Figure 1**).

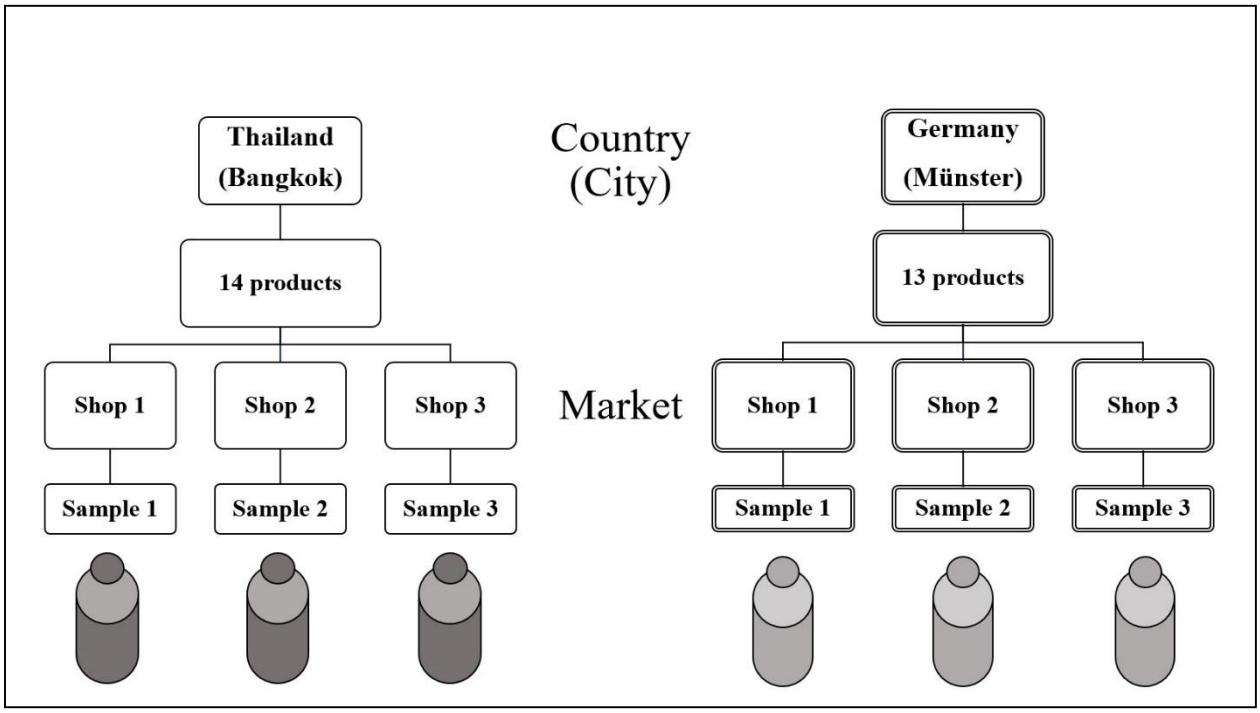

Figure 1. Products collected in Thailand and Germany

Product preparation and L-glutamic acid determination

The L-glutamic acid content was analyzed using the Enzymatic Bio Analysis/Food Analysis kit (Roche Diagnostics, Darmstadt, Germany). Before testing, the liquid samples were diluted with deionized water and the solid samples were homogenized and the glutamate extracted with deionized water. If necessary, the samples were deproteinated with perchloric acid and the L-ascorbic acid was eliminated using H_2O_2, according to the kit manufacturer's instructions. A spectrophotometer (Fisher Scientific UK Ltd., Loughborough, UK) was used to determine the L-glutamic acid in triplicate. The final L-glutamic acid contents were calculated in g/100 g as the L-glutamic acid concentration of the sample solution (g/L) divided by the weight of the sample (g/L sample solution) × 100.

The measurement of condiment and seasoning product in household unit

The weight of condiments and seasonings measured out using normal household equipment (teaspoon, tablespoon and also liquid drop were weighed accurately using an analytical balance weighing up to 220 g with a resolution of 0.0001 g (Sartorius, Goettingen, Germany). The amounts of glutamate in the samples of condiment and seasoning were thus calculated to a resolution of one milligram for each household measurement unit.

RESULTS

Comparison of free glutamate content between German and Thai products

The measured glutamate content of all the Thai and German condiment samples are shown in **Figure 2**. The results showed that the highest glutamate contents were in the condiment sauces. The average amount in the condiment sauces was 3,491.67 mg/100 g in the German products (G-MW, G-WRP, G-KAp and G-Kss) and 1,872.22 mg/100 g in the Thai products (T-M, T-GMo and T-GMn) so German condiments contained almost twice the amount of glutamate as the Thai products. The condiment sauce products from Germany (G-MW) were different from the Thai products (T-M) with some claiming that they taste better, possibly because of the higher amount of glutamate (8,416.67 mg/100 g) in the German product (G-MW) than in the highest product from Thailand (T-GMo) containing only 2,533.33 mg/100 g, a difference of 4-5 times (**Figure 2(A)**). Two condiment sauces under the same brand name and type were available in both Thailand (T-M) and Germany (G-MW) with T-M containing a glutamate content of 1,550.00 mg/100 g and that of G-MW being much higher at 8,416.67 mg/100 g. Therefore, these results illustrate differences in glutamate levels based on the ingredients used during product processing and testing for consumption by the local people in the two different countries. The most popular condiment sauces in Germany were G-KAp and GKss whereas T-GMo and T-M were widely available in Thailand. Ketchup is a favorite condiment in both Germany and Thailand. **Figure 2(B)** shows that the glutamate contents in the German ketchup products were higher than those in the Thai ketchup products. The German tomato and chili ketchups had a glutamate content of approximately 226.00 and 250.00 mg/100 g, respectively.

In contrast, the glutamate level in flavor enhancers from Thailand was higher than in those from Germany (**Figure 2(C)**). In Thai products, the highest glutamate concentration was in pure MSG (T-AJ) at about 750 mg/100 g, which was the most popular brand and normally used in Thai recipes. The other flavor enhancers, T-RDp (pork flavor powder) and T-KN (pork bouillon cube), contained glutamate levels of 241.67 and 156.67 mg/100 g, respectively. In Germany, lovage, known as the Maggi herb, is claimed to offer an aroma similar to that of condiment sauce and is popular in German recipes. The glutamate content of this plant, including the leaves, leaves with stalks and stalks were also determined with the highest level of 187.50 mg/100 mL found in the lovage stalks, with levels in the leaves and the mixed leaves and stalks of 137.50 mg/100 ml **Figure 2(D)**).

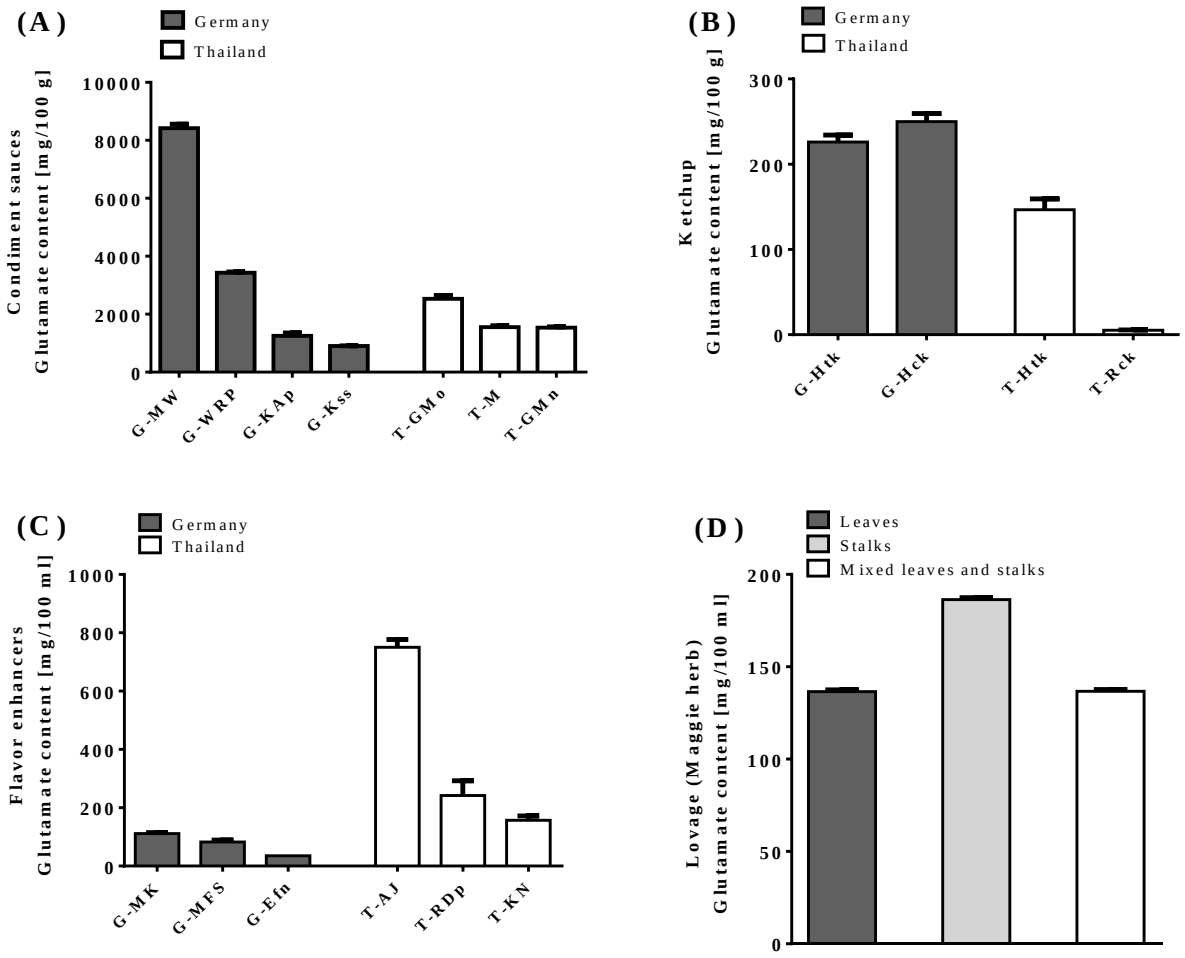

Figure 2. Comparison of the glutamate content of condiment products from Germany and Thailand: (A) condiment sauces; (B) tomato and chili ketchups; (C) flavor enhancers; and (D) lovage (Maggi herb). The results are expressed as mean ± SD (n = 3).

Free glutamate content in German and Thai condiments

Because of the different cultures of eating in Germany and Thailand, it is difficult to compare the glutamate content in the many different kinds of local product (**Table 2**), which depends on the different ingredients. The lowest glutamate content, at between 0.00 and 55.00 mg/100 g, was found in sour sauce from three different local brands in Germany (G-WS, G-Hws and G-Hws). However, sweet black soy sauce, containing a glutamate level of 270.00 mg/100 g, is unpopular in Germany. In Thailand, the most popular condiments added to Thai main dishes are fish sauce and thin soy sauce. These products are prepared from fermented fish and soybeans. The glutamate content of the fish sauce and thin soy sauce were 741.67 to 816.67 mg/100 g and 558.33 to 591.67 mg/100 g, respectively. Other condiments such as sour sauce and sweet black soy sauce contained the lowest glutamate contents of 0.00 to 10.00 mg/100 g.

Table 2. The glutamate content of condiments from Germany and Thailand.

Country	Products	Product Abbreviation	Glutamate content (mg/100 g)
Germany	Sweet black soy sauce	G-DSS	270.00
	Sour sauce (1)	G-AWs	55.00
	Sour sauce (2)	G-Hws	12.50
	Sour sauce (3)	G-WS	0.00
Thailand	Thin soy sauce (1)	T-KW	591.67
	Thin soy sauce (2)	T-HB	558.33
	Sweet black soy sauce	T-HBbss	10.00
	Fish sauce (1)	T-Tfs	741.67
	Fish sauce (2)	T-Sfs	816.67
	Sour sauce	T-HBss	0.00

Free glutamate content of German and Thai recipe dishes

Table 3 shows the free glutamate content of German and Thai recipe dishes. Because of the eating culture, condiments and seasoning products, such as tomato/chili ketchups, seasoning powder and condiment sauce, are usually added in German cooking. Parmesan cheese (Parmigiano-Reggiano), a granular cheese, is a favorite ingredient in German dishes. Parmesan cheese also acts as a flavor enhancer because it contains a high amount of free glutamate, approximately 6,500 to 6,850 mg/100 g, with tomato concentrate containing between 1,350 and 1,700 mg/100 g[3]. The results show the amounts of glutamate in the German recipe dishes, such as old-fashioned tomato soup, spaghetti Bolognese and German tomato salad, as 72.24, 186.06 and 443.81 mg per serving, respectively. However, the glutamate content of almost all of the Thai recipe dishes was significantly different from those of the German dishes. Fish sauce and soy sauce are usually used as the main condiment in Thai cuisine. Thai recipe dishes, such as curry, clear soup and fried chicken, exhibited glutamate contents of 113.33, 93.33 and 73.33 mg per serving, respectively. Traditionally, Thai consumers do not eat a main dish alone but usually add condiments and seasonings such as tomato or chili ketchups, condiment sauce and fish sauce to the meal, with glutamate contents of 15.62, 80.24 and 226.66 mg per tablespoon (10-12 g), respectively.

Table 3. The glutamate content of German and Thai recipe dishes per serving.

Germany					Thailand				
Recipes	**Condiment**	**Household measure**	**Glutamate (mg/ household measure)**	**Glutamate (mg/serving size)**	**Recipes**	**Condiment**	**Household measure**	**Glutamate (mg household measure)**	**Glutamate (mg/serving size)**
Spaghetti bolognese	Tomato concentrate	¾ Tbsp.	135.79	820.79	Clear soup	Pork bouillon cube	1 Cup (250 ml)	391.68	544.1
	Sprinkle parmesan cheese	1-2 Tbsp. (5-10 g)	685.00			Fish sauce	1 Tbsp.	86.96	
						Thin soy sauce	1 Tbsp.	65.46	
German spaghetti dinner	Liebstöckel (lovage)	2 Tbsp. (1 g)	137.50	822.5	Curry	Fish sauce	1 Tbsp.	86.96	1,211.96
	Sprinkle parmesan cheese	1-2 Tbsp. (5-10 g)	685.00			Pure MSG	½ Cup (125 ml)	1,125	
German Tomato Salad	Liebstöckel (lovage)	1 tsp. (1 g)	137.5	443.81	Fried chicken	Sweet black soy sauce	1 Tbsp.	1.15	146.85
	Condiment sauce	1 tsp.	306.31			Thin soy sauce	1 Tbsp.	65.46	
Old Fashioned Tomato Soup	Tomato paste	3 Tbsp.	72.24	72.24		Dipping thick soy sauce	1 tsp.	80.24	

Table 3. The glutamate content of German and Thai recipe dishes per serving (continued)

Germany					Thailand				
Recipes	**Condiment**	**Household measure**	**Glutamate (mg household measure)**	**Glutamate (mg/serving size)**	**Recipes**	**Condiment**	**Household measure**	**Glutamate (mg household measure)**	**Glutamate (mg/serving size)**
German Fried Meat Patties	Seasoning powder	1 Tbsp.	6.41	6.41	Fried vegetable	Fish sauce	1 tsp.	24.69	164.12
						Pork flavor powder	½ Cup (125 ml)	120.84	
Rindergulasch	Tomato paste	¼ Tbsp.	6.02	6.02		Thin soy sauce	1 tsp.	18.59	
Fried Potato	Dipping tomato ketchup	2 Tbsp.	48.16	54.57	Omelette	Fish sauce	2 tsp	49.38	65.00
	Seasoning powder	1 Tbsp.	6.41			Dipping tomato ketchup	1 Tbsp.	15.62	
Pizza	Dipping tomato ketchup	2 Tbsp.	48.16	733.16	Fried noodle	Sweet black soy sauce	1 tsp.	0.35	43.63
	Sprinkle parmesan cheese	1-2 Tbsp. (5-10 g)	685.00			Thin soy sauce	1 tsp.	18.59	
						Fish sauce	1 tsp.	24.69	
					Seasoning	Fish sauce with fresh chili	½ Tbsp.	113.33	113.33

The glutamate content per serving of recipe dishes. Tbsp. = tablespoon, tsp. = teaspoon

DISCUSSION

This survey study has compared the amount of glutamate in condiments and seasonings available in Germany and Thailand. Remarkably, versions of the same brand of condiment obtained in Germany and Thailand had different glutamate contents. Another noticeable difference was the higher glutamate level in German products such as condiment sauce and tomato ketchup than those in the Thai condiments. In contrast, the flavor enhancers such as pure MSG, flavor powder and bouillon cubes from Thailand had a higher glutamate content than those from Germany. The sour sauce from both countries had the lowest glutamate contents according to the ingredient types. The prevailing cultural consumption behavior thus seems to affect the level of glutamate intake. Our findings have also evaluated the glutamate content in condiments and the daily intake levels calculated from the recipes.

Natural glutamate is chemically indistinguishable from an artificially-prepared glutamate such as MSG and both are metabolized in the same way in the human body. This might be the reason why several studies by organizations such as the Joint FAO/WHO Expert Committee on Food Additives (JECFA), the US Food and Drug Administration (FDA) and the European Food Safety Association (EFSA) consider MSG to be a food additive generally recognized as safe ingredient[3,12,17-18]. The FDA have reported that an average adult consumes approximately 13 g/d of glutamate from the protein in food, while the intake of added MSG is estimated to be only 0.55 g/d so is not toxic to humans. However, glutamate sensitivity has been suggested as one possible cause of the group of CRS/MSC symptoms that affect some people. Woods et al.[19] studied the effect of MSG on asthmatic adults who perceived themselves to be hypersensitive to MSG. The study found no significant MSG level, which could be responsible for changes in the soluble inflammatory markers or triggers of bronchoconstriction. Cynober[2] also reported that the excessive consumption of glutamate can be limited by its bioavailability, which therefore cannot cause neurotoxicity or any adverse effects in adult humans. Zanfirescu et al.[12] also investigated the alleged adverse effects of MSG despite food safety regulatory agencies claiming that it was safe. They reviewed the consequences of prolonged exposure to MSG in several preclinical studies related to various physiological systems, such as the cardiovascular, hepatic, neurological, systemic inflammatory and metabolic systems and changes in habit. An analysis of previous research has also revealed several studies that showed no negative health effects of MSG from chronic human exposure[12].

Regarding the glutamate intake in different regions, Beyreuther et al.[20] reported that the total intake of glutamate from food in European countries ranged from 5 to 12 g/day, whereas the mean intake of artificial glutamate was also used at about 0.3 to 0.5 g/day. In the USA, Beyreuther et al.[20] also reported the average consumption of food-additive sources of glutamate level approximately 0.3 to 1 g/day in Williams and

Woessner[21]. The European Directive has recommended a limit for glutamate content of about 10 g/kg of food product[22-23]. WHO recommends that foods containing MSG should not exceed the safe limit of 120 mg/kg body weight/day[24]. In Germany, the average intake of free glutamate in foods was estimated at about 10 g/d (range: 4.6-12 g/d)[20]. In Asian countries (excluding Thailand), especially in Japan and Korea, the average amount of glutamate added in the form of MSG may reach 4 g/d (range: 1.2-1.7 g/d). This study also demonstrated that MSG and other glutamate salts could be used as a food additive with no harm or toxicity to people up to a maximum dose of 16 g/kg body weight[20]. Walker and Lupien[25] also reported that MSG was not toxic with no negative effects on the human fetal, cardiovascular and neurological systems.

Glutamate levels in natural foods and food products have been reported in several studies. Jinap and Hajeb[3] determined the range of glutamate levels in various foodstuffs from many countries, such as vegetables (10 to 246 mg/100 g), soy sauce (412 to 1,264 mg/100 g) and fish sauce (621 to 1,383 mg/100 g). The present study has compared the glutamate content of condiment products from Thailand and Germany and found that the amount of glutamate in German products, such as lovage stalks was 187.50 mg/100 mL, in condiment sauce about 900.00 to 8,416.67 mg/100 mL, in tomato ketchup 226 mg/100 g and in flavor enhancers from 35.00 to 111.67 mg/100 g. The glutamate content in Thai products, such as condiment sauce was between 1,550.00 and 2,533.33 mg/100 g, in tomato ketchup 146.67 mg/100 g, in flavor enhancers from 156.67 to 750.00 mg/100 g, and in fish sauce from 741.67 to 816.67 mg/100 g. The present study has revealed that the glutamate content of German condiments was higher than those of Thai condiments. In contrast, the flavor enhancers from Thailand contained a higher amount of glutamate than those from Germany. According to the differences in dietary cultures, as a result, there are differences in ingredients and the amount of glutamate levels in each type of recipes. For example, Thailand have several recipes that contain glutamate content such as Thai style papaya salad, Northeastern style spicy papaya salad, Tom Yum Goong (Spicy prawn soup) and Pad Priao Wan (Sour and Sweet Stir-Fry) that contain glutamate levels about 289.48 mg, 647.29 mg, 583.09 mg, and 1,495 mg, respectively[3,26]. For Korea, the traditional recipe is Miyeok-guk (Seaweed soup) that contains glutamate levels about 437.65 mg per serving. Meanwhile, Miso soup and natto, the traditional recipe of Japan contains glutamate levels about 21.64 mg per serving and 136 mg, respectively. In Europe, the favorite food including spaghetti and pizza contain glutamate levels about 2,107.3 and 369 mg per serving, respectively[3,26]. It can be seen that differences in cultural consumption will lead to different amounts of glutamate level. However, the amount of glutamate in food in each country is not in an amount that is toxic to consumers.

CONCLUSIONS

These results suggest that the differences in glutamate content depends on the product processing, local ingredients and the food consumption behaviors of the consumer, implying

that the food processing, ingredients and eating culture is the factors affecting the glutamate content of a normal meal. The findings on the glutamate content of Thai and German condiments can be used to estimate the amount of glutamate consumed in Thai and German recipe dishes so can also be used to calculate the daily intake of glutamate. These findings can be used as a database of glutamate intake for consumers in both countries. Our findings suggest that the glutamate intake of consumers from both countries is at an average level so does not have a negative effect on human health in the form of CRS or MSC.

Conflict of interest: We declare that there is no conflict of interest.

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