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Fermented Shrimp Products as Source of Umami in Southeast Asia

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Abstract

Fermented shrimp products are widely consumed in Southeast Asian countries. They are mainly categorized into shrimp sauces, shrimp pastes, and lacto-fermented products. Fermented shrimp products of each group in each region are processed with almost the same technologies but the fermentation time and salt contents of the products are somewhat different. These products which are known with different names in each country are usually used as side dishes, condiments or main dishes. The main function of the products is to provide a salty and umami taste to the food. To produce fermented shrimp products, salt is mixed with cleaned fresh or dried shrimp and allowed to be fermented for several months to enable the indigenous enzymes to auto-digest the meat and create products with high amino acids content. The enzymatic fermentation of shrimp mediated by indigenous proteases yields short chain peptides and free amino acids which render the typical flavour and taste of umami. Salt is added to prevent deterioration and food poisoning as well as to produce meaty-savoury flavour. Fermentation process also produces high glutamic content, other amino acids and nucleotides which contribute to the umami taste of the products.

Keywords: Umami; Glutamate; Fermented shrimp; Shrimp sauce; Shrimp paste; Southeast Asia

Introduction

Fermentation is a common practice in food preservation; it plays an important role in improvement of nutritional and functional properties of foods [1]. Fermented food products are good source of peptides and amino acids [2,3]. During fermentation process, a specific amino acid is synthesized in large quantities. The selected microorganism is cultured with nitrogen and carbohydrate sources; during the process of fermentation L-form of the amino acid is produced. One of umami taste compounds glutamate is produced from 2-oxo-glutarate (2-oxo-pentanedioic acid) by reductive ammonia fixation that uses the enzyme glutamate dehydrogenase during fermentation process. The umami taste of fermented products mainly depends on their glutamate concentration [4]. Fermented products are usually consumed as seasonings to add umami taste to dishes.

Fermented products, especially fermented fishery products are extensively consumed in Southeast Asian countries since the 15th century; they are consumed as staples, side dishes or condiments/seasonings in daily foods; the product imparts delicacy and high nutritional properties [5], and also umami taste and rich flavour [6].

According to Yoshida [6], the widespread consumption of fishery fermented products over a wide geographical area throughout Southeast Asia is due to the simplicity of the processing techniques and uniformity of the final fermented products. Although these products are known with different names in each region, their main function is the same, to provide a salty and umami taste to the food [7]. Fermented shrimp products are among the fishery fermented products with widespread consumption in Southeast Asian countries. This article briefly describes fermented shrimp products from different countries of Southeast Asia including methods of their preparation and the umami taste properties of each product.

Fermented Shrimp Products

Fermented shrimp products are mainly categorized into sauces, pastes, and lacto-fermented products. Those products are known with diverse names by local population of each nation. Table 1 shows various fermented shrimp products being produced in Southeast Asia region.

Country	Shrimp sauce	Shrimp paste	Fermented shrimp
Burma	*Ngan pya ye*	*Seinsanga-pi* *Hmyinnga-pi*	
Cambodia	*Nam tom*	*Kapi* *Pra hoc* *Mam ruoc*	
Indonesia		*Terasiudang*	
Malaysia		*Belacan*	*Cencalok*
Myanmar	*Pazunggampya ye*	*Nga-pi* *Seinza* *Hmyannga pi*	
Philippines	*Alamang-patis*	*Bagoong-alamang* *Buronghipon* *Dinailan* *Lamayo*	*Balao-balao*
Thailand	*Nam kapi* *Nam khoei*	*Kapi*	*Jaloo* *Koongsom*
Vietnam	*Nam tom* *Nuoc mam torn chat*	*Mam ruoc* *Mam tom* *Mam tep*	

Table 1: Fermented shrimp products in Southeast Asian countries.

While, most of the people in the countries in this region regularly use shrimp sauce and paste in their daily cooking, fermented shrimp products is only produced and consumed by the people of Malaysia, Thailand and Philippines. Depending on the species of shrimp, the quantity of salt used, and the treatment of raw materials prior to fermentation, different types of products are produced [7]. In order to produce fermented shrimp products, salt is mixed with cleaned fresh or dried shrimp and allowed to be fermented for several months in order

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Country	Species
Burma	*A. indicus* *A. intermediuc* *A. vulgaris*
Indonesia	*A. japonicus* *A. sibogaesibogae*
Malaysia	*A. japonicus* *A. erythraeus* *A. sibogaesibogae*
Philippine	*A. erythraeus* *A. intermedius* *A. vulgaris*
Singapore	*A. erythraeus* *A. indicus* *A. vulgaris*
Thailand	*A. japonicus*

Source: Ruddle (1993)

Table 2: Shrimp of *Acetes* species used for fermentation in Southeast Asian countries.

to enable the indigenous enzymes to auto-digest the meat and create products with high amino acids content. The enzymatic fermentation of shrimp mediated by indigenous proteases yields short chain peptides and free amino acids which render the typical flavour and taste. Salt is added to prevent deterioration and food poisoning as well as to yield meaty-savoury flavour [1]. Fermented shrimp products develop umami taste formed by the degraded products, amino acids, nucleotides and salt [8]. Therefore, such fermented products are also a good source of peptides and amino acids [2,3].

Shrimps of the genera *Acetes*, *Mesopodopsis, Lucifer*, and *Mysids* are usually used to produce fermented shrimp products. The genus *Acetes* is the most common raw materials to produce shrimp sauce, paste and other fermented products. However, shrimp species used are depending on the types of shrimp available in each country. Table 2 shows that *Acetes* species are mostly used shrimp to produce fermented shrimp products in Southeast Asian countries, in which *A. indicus, A. erythraeus, A. vulgaris* and *A. japonicus* are the most commonly used species. Fermented shrimp products are usually high in umami taste components (Figure 1). For instance, fermented shrimp paste from Malaysia (*belacan*) contains more than 4,200 mg/100 g of free glutamic acid. Shrimp sauces of Thailand and Indonesia (*terasi* and *kapi,* respectively) are also rich in free glutamic acid.

Shrimp sauce

Shrimp sauces produced in Southeast Asian countries are called *Ngan pya ye* (Burma), *nam tom* (Cambodia), *pazunggampyaye* (Myanmar), *alamang-patis* (Philippines), *namkapi* and *nam khoei* (Thailand), and *nam tom* and *nuoc mam torn chat* (Vietnam) (Table 1). Marine shrimp species are used as the raw materials to produce shrimp sauces. Differences in composition of the products depended on the raw materials used and also the fermentation period [7].

Krill is shrimp-like zooplankton, usually found in large amounts in Southeast Asia seas. Fermented krill sauce is one of the popular umami-rich condiments produced in Thailand. Krill is preferred to be used for making shrimp sauce as compared to other types of shrimp since it is spoilt very fast. To produce the shrimp sauce, frozen krill is added with 30% salt. After storing the mixed krill at 5°C for three months without stirring, it is squeezed, filtered and boiled to make into sauce [8].The fermented krill sauce is rich in free amino acid which is more profound in its taste as compared with soy sauce. This fermented sauce has a characteristic flavour of krill and strong umami taste [9].Krill sauce is used for improving the flavour of food and it can be well preserved at low pH. Halophilic lactic acid bacteria grow well in the sauce and help to improve in the preservation of the product [10].

In some part of Southeast Asian countries, shrimp head is used to process shrimp sauce; this product contain different level of amino acid as compared to common shrimp sauce. Shrimp head sauce has stronger umami taste. Chen [11] showed that free glutamic acid contents in shrimp sauce and shrimp head sauce were 16.1 and 59.7 mg/100 ml, respectively. The differences can be due to the different bacterial strains presence in the inoculum used for the fermentation process. The protein in shrimp sauce is hydrolysed by *Enterobacter sp*., while that of shrimp head sauce is by *Bacillus sp*. A basic procedure to produce shrimp head sauce is described by Chen et al. [12]. Shrimp heads and phosphate buffered saline are homogenized into paste, and autoclaved to inhibit all of the enzymes and microorganisms. After cooling, a 10% bacterial inoculum is added to the paste and liquefaction is carried out by the bacteria for about 5 days. The aqueous portion (hydrolysate) is then separated from the undigested solids through filtration before 10-15% salt is added to the hydrolysate. The sauce is produced after boiling and filtration of the hydrolysate. Later, Chen [13] developed a procedure to improve the flavour of shrimp head sauce. He proposed an addition of soy sauce to the original shrimp head hydrolysate. The modified shrimp head paste was fermented by *Aspergillus oryzae* and *Saccharomyces rouxii* or liquefied using hydrochloric acid.

Ngan pya ye is a dark brown colour extractor sauce obtained as a by-product of *nga-pi* (fermented shrimp) manufacture in Myanmar. *Ngan pya ye* is usually aged in concrete storage tanks for one year before being consumed. During this period partial hydrolysis will occur which result in the development of unique flavour. After aging, the sauce is boiled for 4-6 hours to reduce the moisture content; at the same time the boiling also contributes to partial sterilization of the sauce. Solar dryer or steam boiling is used to concentrate *ngan pya ye*. To improve the dark colour and strong smell of *ngan pya ye,* the production of bleached *ngan pya ye*

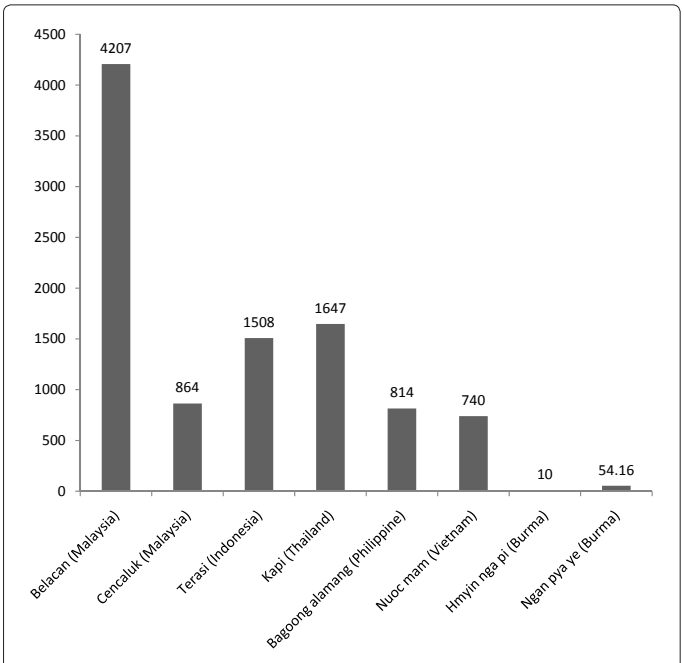

Figure 1: Levels of free glutamic acid (mg/100 g) in fermented shrimp products from different countries.

was proposed. Activated carbon together with heating and continuous stirring is used for bleaching *ngan pya ye*. Using this method, the colour of the bleached *ngan pya ye* turns from dark brown to golden yellow and part of the odour can also be removed simultaneously[14]. The study by Sanda [15] on amino acid content of different types of *ngan pya ye* in Myanmar showed that boiled shrimp sauce contains higher glutamic acid as compared to the raw or bleached typed. Boiled *ngan pya ye* contain 54.16 mg/100 ml free glutamic acid, which is responsible for the umami taste in the product (Figure 1).

Shrimp Paste

It is believed that shrimp paste was originated in continental Southeast Asia, probably among the Cham and Mon peoples of Indochina [16]. Fermented shrimp paste is known by several names in different regions of Southeast Asia (Table 1). It is called *belacan* in Malaysia, *kapi* in Thailand and Cambodia, *nga-pi* in Myanmar, *bagoong-alamang, burong, dinailan* and *lamayo* in Philippines, *terasi* in Indonesia, and *mam* in Vietnam [17]. As compared to fermented fish products, shrimp pastes have lower salt content; this may be due to the different composition of fish and shrimp (shrimp has higher water content).

Fermented shrimp paste is produced using different protocols in different parts of the countries in Southeast Asia. For instance, in some parts of Myanmar, Indonesia, and Philippines shrimp paste is produced without the use of salt. The final product of *Bagoong alamang* produced in some parts of the Philippines, contain the shell of shrimp. If the shell shrimp paste is fermented for a long period of time, the shell eventually decomposes and the product becomes a semi-liquid paste, as in the *Zhejiang* of China [16]. At the end of the manufacturing process, shrimp paste is usually dried to reduce the moisture content and to produce a semi-solid product. The semi-solid nature of the product means it needs only a little amount of salt and it has a strong umami taste [18]. The drying process and reduction of moisture also increase the shelf life and flavour intensity of the product; complete drying would prevent rancidity of the product. The addition of salt would enhance both the flavour and the shelf-life of the shrimp paste [18]. Comminuting the sun dried shrimp without the addition of salt is also practiced in some parts of Thailand; this technique which uses epipelagic shrimp produces an unsalted shrimp paste [16].

Belacan is a traditional salted and fermented shrimp paste of Malaysia. It is a thick paste with a greyish pink to greyish purple colour and it has a strong pungent shrimp taste i.e., buttery, sting taste with a touch of sweetness. *Belacan* is one of the main condiments in Malaysian cuisine and it is usually added as a flavouring ingredient in most local dishes. Shrimp of *Acetes* species and high amount of salt are the main raw materials to produce *belacan*. Shrimp tissues undergo enzymatic breakdown during the fermentation and bacterial action assist in proteolysis and flavour development. Various techniques used to produce *belacan* results in composition and quality differences among products. In Malaysia, considerable amount of shrimp paste are produced in fishing villages using traditional method using starter culture and microbial fermentation. Dried shrimp is usually used for paste production. Salt is added with different individual's favourite ratio (5-20%) and mixed thoroughly. The darker coloured shrimp paste is produced after it is being fermented for one week [19]. The perfect *belacan* with a pleasant flavour and aroma is produced after one or two weeks of fermentation. A high quality *belacan* should consist of about 50% moisture content and between 13 to 17% of salt [20]. *Belacan* with low moisture content is very dry and hard.

Traditionally, *belacan* is used as a flavour enhancer in several Malaysian dishes. It is also mixed with chillies and lime as a dipping condiment known as *sambal-belacan* which is much favoured by Malaysians [21]. Other than that, it is used in a variety of Malaysian dishes such *laksa* (a coconut curry broth based noodle dish containing ground fish fillet), *nasi goring belacan* (fried rice containing shrimp paste), *sambal-tumis* (spicy sautéed chilli paste), as amped as (sweet and sour fish stew), and *kangkung goring belacan* (fried water convolvulus containing shrimp paste) [21-23]. *Belacan* has strong umami taste and contain considerable amounts of glutamate and 5'-nucleotides glutamate content [24,25]. The concentration of free glutamic acid found in different brands of Malaysian *belacan* was reported to be 180–530 mg/100 g. The total concentration of 5'-nucleotides of *belacan* ranges from 0.85 to 42.25 mg/g [25]. Jinap et al. [25] reported up to 32 folds of significant increase in umami attributes when *belacan* was added to Malaysian dishes. *Belacan* has been identified as one of the major umami contributors in Malaysian cuisines. Dishes containing *belacan* has been shown to have high intensity of meaty flavour which best represent umami taste [25].

Kapi is a typical traditional fermented shrimp paste of Thailand. It is mainly produced from the marine shrimp or krill (*Acetes* or *Mesopodopsis* species), that was mixed with salt at a ratio of 3–5:1. The moisture content is decreased by sun drying, and then it is thoroughly blended or homogenised to produce semi-solid paste. The paste is fermented for two months until the desired flavour has developed [26]. *Kapi* is usually used as condiment to enhance the palatability of foods. When *kapi* is mixed with chilli, it is called *belacan-kapi* or *pherik-kapi,* which is also regarded as a favourite spicy condiment in Thailand. *Belacan-kapi* is typically made of raw chilli which is pounded with toasted fermented shrimp paste (*kapi*) that has been added with salt, sugar and organic acids [6]. *Kapi* is very rich in umami taste and contain high amounts of free glutamic acid (647 mg/100 g) [27].

Terasi, a fermented shrimp paste, is a traditional condiment used commonly in Indonesia. It is produced from the planktonous shrimp *Schizopodes* or *Mytis* sp. Shrimp paste (*terasi-udang*) is much more favoured than fish paste (*terasi-ikan*) for most Indonesians. *Terasi-udang* is usually mixed with chilli, garlic and salt which they call it *sambal-terasi. Terasi-udang* is made from shrimp which has been mixed with about 15% salt. The mixture is fermented (usually takes 6-9 months) until the desired *terasi* aroma has been developed. In Java Island, shrimp paste is often prepared from pre-cooked shrimps called *brabon* (literally means mother paste). *Terasi* is used as a flavour enhancer in various Indonesian dishes. *Terasi-udang* is dark brown, grey or red paste in colour with a distinct taste and strong aroma [28]. It has considerable level of free glutamic acid (1508.56 mg/100 g) [27] and is rich in umami taste [27].

Petis-udang is also another local shrimp paste widely consumed in Indonesia. The shrimp wastes (heads and shells) are boiled to produce *petis-udan;* the waste is by-product of Indonesian shrimp crackers (*krupuk-udang)* processing, in which the shrimp meat is used. *Petis-udang* is used as a seasoning in various Indonesian-style salad dressings and other dishes [29]. The nucleotide content in *petis-udang* is not very high, but it contains a variety of free amino acids, such as glycine, alanine, and glutamic acid [6].

In Myanmar, shrimp paste is called *seinsanga-pi* or *hmyinnga-pi.* It is a pink to reddish colour paste made from very small *Mysis* or planktonic shrimps. The paste made from quality shrimp is called *seinsanga-pi* and the rest are basically called *hmyinnga-pi.* To produce this type of shrimp paste, shrimp is mixed with salt and dried under

the sun for 3 to 4 days. The mass is later pounded with the addition of extra salt and water to obtain paste. The paste is sun dried again for a day and pounded for 3-4 times to get a homogeneous and smooth paste. The paste is then fermented for 4 to 6 month. This shrimp paste is rich in umami taste. *Hmyinnga-pi* contains considerable amounts of free glutamic acid (10.08 mg/100 g) [14].

Salty fermented shrimp paste is called *bagoong-alamang* in the Philippine. *Bagoong-alamang* is consumed raw or cooked and is generally used as flavouring or condiment in many traditional Filipino dishes. The characteristics of this product vary among different parts of the Philippines. In the Tagalog provinces, the paste is completely fermented and ground, with or without the addition of colouring matter. In the Ilocos and Pangasinan provinces, it is either partially or completely fermented. In the Visayas and Mindanao provinces, the product is slightly fermented without any liquid [30]. *Bagoong-alamang* is normally fermented for 10 days. According to Peralta et al. [31], the content of L-glutamic acid in *bagoong-alamang* increased from 25.8 to 38.2 mg/100 g during the 10 days of fermentation. The increase in free glutamic acid during fermentation enhances the desirable umami taste in the product. Prolonged fermentation of shrimp paste for more than one year brings about a decrease in free amino acids, especially free glutamic acid. The shrimp paste made in the Philippines was reported to contain higher free glutamic acid (814.15 mg/100 g) as compared to those made in other Southeast Asia countries [27].

Other Fermented Shrimp Products

In Southeast Asia region, only two techniques are used to preserve small shrimp: fermentation and sun-drying. Fermentation is the simplest method, but it does not overcome the problem of texture due to the presence of shrimp shell. This issue is usually resolved by comminuting the shrimp, either by grinding or pounding. Comminution of sun-dried shrimp is carried out either with or without the addition of salt [18]. Other than sauce and pasty products, shrimps are sometimes made into other fermented products which are rich in umami taste. For instance *balao-balao* in the Philippine is a lactic acid fermented rice/shrimp mixture, which is prepared by mixing boiled rice, raw shrimp and 3% of salt. *Penaeusindicus* or *Macrobrachium* shrimp species are usually used to produce *balao-balao.* The mixture is usually packed in an anaerobic container and allowed to be fermented for few days or weeks [32-35]. During fermentation the mixture becomes acidic, and the shrimp shell reddens and softens. *Balao-balao* is well-preserved because it has low pH and is kept in the anaerobiosis environment; however, the product must be cooked before consumption [1]. It is commonly prepared for the table in sautéed form and is consumed as an appetizer or main dish.

Cencalok or pickled shrimp is a popular Malaysian product made from *Acetes* shrimp. To make *cencalok*, shrimp is usually washed and added with 10-20% salt and some amounts of rice powder. The mixture is then fermented for more than one month [36]. After fermentation, it turns into a suspension of tiny pink shrimp in a sauce having a salty taste. The product has a very strong shrimp, briny smell which stings to the nose [36]. This product has rich umami taste and contains about 864 mg/100 g free glutamic acid [24].

Jaloo is an indigenous salt fermented krill shrimp (*Macrobrachium orientalis*) produced by the residents of the coastal areas in the south of Thailand. Jaloo is produced from fresh (un-dried) krill shrimp that has undergone anaerobic fermentation for 2–3 days. *Koongsom* is another fermented shrimp product of Thailand produced by mixing small shrimp (*Acetes* sp.) with salt and palm-sap-sugar concentrate as a source of carbohydrate. The mixture is usually fermented by lactic acid bacteria for the development of a sour taste and the typical flavour of fermented shrimp [37].

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