

Review Article

“Nuoc Mam” Fish Sauce in Vietnam: A Long History from Popular Seasoning to Health Benefit Bioactive Peptides

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Abstract

“Nuoc mam” is a kind of fish sauce, a popular salt-fermented fish product in Vietnam and similar to other fish sauces in the South-East Asian. In a long time, this sauce is used as a condiment just for enhancing the taste of food based on the salted and umami features. Under the light of science, the traditional fish sauce reveals its properties as a mixture of peptides and amino acids, the group now gained much more interest by their properties to health benefits in preventing the human from chronic diseases in ageing process. The quality of nuoc mam depends on many factors and requires high experience. This review covers the technology aspect of this product to get high quality in related to health benefit effects.

INTRODUCTION

Vietnam as well as the others Southeast countries locates near the ocean with the long coastal areas. The geographical properties cause the good conditions for livelihood based on the marine resources. Since the very early time, the antique technology for preservation of the fish by salt was known and spread out to fishery communities. Fish and salt are both come from the sea and then blended together in the fish sauce, a harmonious integration of the seafood. Although existing with the differences in fish species (anchovy, sardine, mackerel), technologies and the names (nuoc mam in Vietnam, nampla in Thailand, patis in Philippines, shottsuru in Japan and yeessui in China) [1] fish sauces from different countries have the same principle that is the fermentation of fish by autolysis in high salt concentration. In Vietnam, the notion of “Nuoc mam” was first defined legally in the Order of Indochina Government (in French) on 21 December 1916: “*Nuoc mam is the result of the maceration of fish in a concentrated marine salt solution, that is basically a saline solution of albuminoids in a certain degree of disintegration*” [2].

Apparently, the technologies of fish sauce seem very simple but when going further, this is the state of art in controlling the complex hydrolysis by bacterial communities and intestinal enzymes. The main factors influences to the fermentation are the species of fish, the salt: fish ratio, the time of salting, the temperature (using the sun light), the circulation of fish liquid (fermented liquid) through the fish residue. Even the addition of salt in the process of fermentation is also required more

experience. There are the two conflict targets in the processing of fish sauce, the yield and the quality. The high yield and short time will make the reduction of the quality [3].

In Vietnam, the nuoc mam are produced along the coastal areas, from the North to the South as Cat Ba, Thanh Hoa, Nghe An, Khanh Hoa, Phan Thiet, and Phu Quoc, with differences in fish species as well as technology. Among them, nuoc mam Phu Quoc may be the best in quality. Phu Quoc is the island located in the west-south of Vietnam, near the Kien Giang province (Figure 1). The traditional nuoc mam processing in this island has the long history of about 200 years. At first, this product was not interest to the European people by the strong flavor, but later, the Pasteur Institute in Saigon carried out the first research in chemical compositions of nuoc mam and published in Vietnam in 1918 [4]. In this Bulletin, Dr. Rosé presented the results of the survey about the nuoc mam processing in Vietnam in different aspects, from raw materials, technology, chemical compositions, manufacture until suggestion in controlling the quality and industrial development of this product. This study confirmed the value of nuoc mam as the source of amino acids and peptone. Since that day, nuoc mam in Vietnam has gained more and more interest from the world and the Phu Quoc brand name become famous. In the trade embargo time after 1975, this brand name were used illegally by the foreign companies and Vietnam has to struggle for getting the EU Certificate of Protected Designation of Origin of Phu Quoc in 2013 [5].

Nuoc mam fish sauce has been going along with all the dishes in Vietnam. Besides being the condiment in different meals,

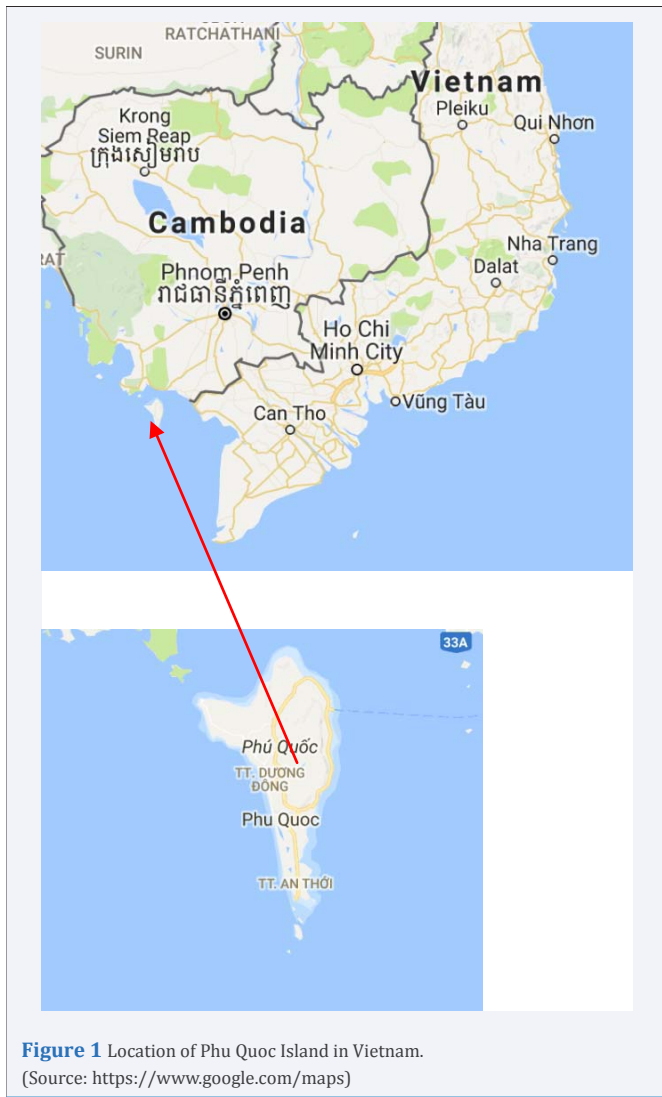


Figure 1 Location of Phu Quoc Island in Vietnam.
 (Source: <https://www.google.com/maps>)

nuoc mam in some cases is the main sauce in the poor family. Now a days, with more discoveries about the health benefits of fish protein hydrolysate [6], fish sauce become the value food in terms of the source of bioactive peptides and essential amino acids (Figure 1).

NUOC MAM FISH SAUCE PROCESSING

In principle, the technology of fish sauce includes the main step (Figure 2) [1], salting fish with appropriate fish: salt ratio [2], fermenting in 9-12 months or more in the vats with recirculation of the liquid through the fish until it is mature and taken out as the highest amino acid concentration liquid, then [3] adding the brine to the fish residue and repeat the circulation for dissolving more amino acids, finally [4], mixing the extracts for getting the final product with different grades based on the nitrogen concentration [3]. In the North of Vietnam, for reduction of the time, the liquid is heated by the sun then return to the barrels and the fish in the vats is blended. This technology requires hard labor. In some areas, the fish after capture is let for somewhat spoilage before salting, that causes the conditions for enhancing the autolysis by enzyme and bacteria in fish hydrolyze the muscle. People also use the enzyme from plant as papain or bromelain for

hydrolysis faster. However, when accelerating the fermentation, the quality of fish sauce is reduced in organoleptic properties [7] (Figure 2).

The quality of nuoc mam Phu Quoc is highest in Vietnam and its processing is based mainly on natural materials and process. The first factor influenced to the quality is the fish species selected for nuoc mam processing, that is the anchovy *Stolephorus commersonii* captured from the sea in the south of Vietnam [8]. The capture season of anchovy last from July to December annually. The purity of anchovy, in terms of less by-catch, is important. The less the by-catch fish, the more the specific quality of nuoc mam. Comparing to many other coastal areas in Vietnam where many different fish species are used, the nuoc mam manufacturers in Phu Quoc island take care the purity of anchovy and the fishermen have to select the fish onboard and take out other species from every catch.

The second feature of the Phu Quoc processing is the early salting when the fish is fresh. This inhibits the operation of spoilage bacteria although the fermentation later requires more time since the high robust muscle. Because of that, the processing time of nuoc mam Phu Quoc is during from 12 to 15 months, longest among other technologies.

The materials for making the vats and the tools are also important. In the early time, the vats are made of the indigenous trees in the Phu Quoc Island, even the material for sealing the small gaps between the wood bars is made from the sap of tree. The vats are reinforced by the strong cords made by bamboo [4].

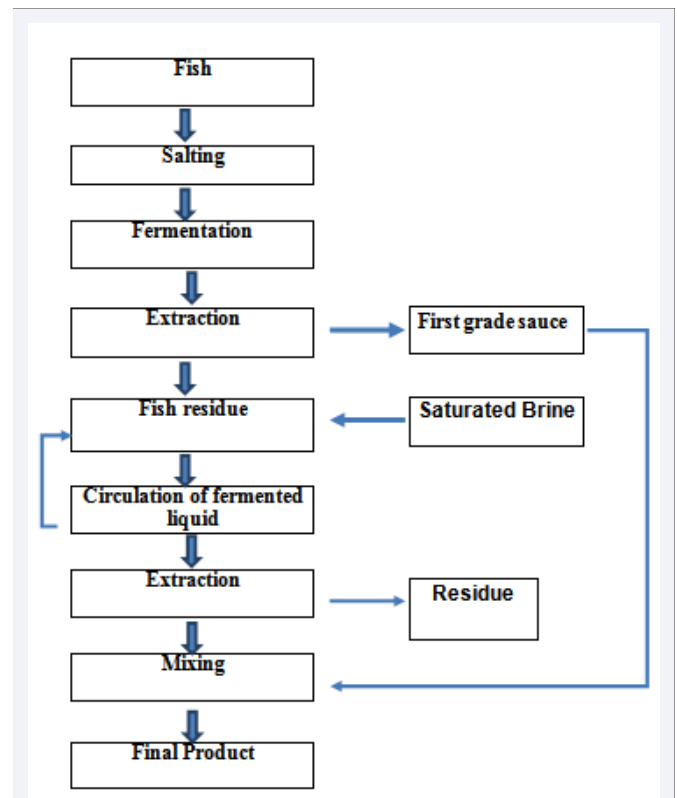


Figure 2 Flow chart of the nuoc mam fish sauce processing. This flow chart is subject to change according to the areas and local technologies in Vietnam.

There is a valve connected to the out hole near the bottom of the vat for taking out the liquid. In order to avoid the solid going with the liquid, the filter is set in the out hole. This filter is made with high skill from a kind of tree, coral, and small stone (Figure 3).

After the time of fermentation, the extraction starts through the small valve near the bottom of the vats. By adjusting the flow rate, we can obtain the transparent liquid. The first extract is high value and called "nuoc mam nhi", which often does not sale but using in mixture with the next extracts with lower quality. After that, the brine is added to the vats and the extract is circulated many times to get more and more protein hydrolysate from fish residues. People check the maturation of nuoc mam through the color, flavor and the thickness of the liquid. The mature nuoc mam has the amber color, umami flavor and high viscosity. For enhancing the fermentation, the circulation of fish liquid may be sooner and happen in the progress of fermentation.

Besides the autolysis of enzymes in the fish, there are many bacterial communities exist in the fish sauce that their dynamic variation and their role seem unclear. In along time, based on the culture-dependent methods, many bacteria were found in the fish sauce such as *Achro mobacter*, *Bacillus*, *Micrococcus*, *Staphylococcus*, *Streptococcus*, *Tetragenococcus* and *Vibrio* [9,10]. For overcoming the limit of culture-dependent method in research of the sequential changes of the bacteria communities in the process of fermentation, Fukui *et al.*, have used both traditional method and the 16S rRNA gene clone library analysis for identification of bacteria. The results showed that the *Staphylococcus* species dominated in the first 4 weeks then the halophilic and high halophilic bacteria increased significant

from 4 and 6 weeks and the dominant species changed to *Tetragenococcus halophilus* [1].

CHEMICAL COMPOSITIONS AND TASTE OF NUOC MAM

Besides the main constituents being amino acids and peptides, fish sauce contains vitamins C and B such as folic acid, niacin, riboflavin, pantothenic acid, thiamine, vitamin B6 and vitamin B12, minerals such as calcium, phosphor, iodine and iron [11]. The chemical compositions of fish sauces from Thailand, Vietnam and Japan are different in pH, NaCl, amino acid, amino nitrogen, total nitrogen and peptide nitrogen concentrations. Comparing to Japan and Thailand, the nuoc mam in Viet Nam has the highest concentration in all kinds of nitrogen concentrations [12] (Table 1).

Under the hydrolysis of proteolytic enzymes, the peptide bonds in the protein molecules are broken into smaller fragments in the progress of the fermentation, resulting the mixture of polypeptides, peptides and amino acids. The further the hydrolysis, the smaller the fragments are, meaning that the peptides and amino acids produced increasingly. The characteristics of nuoc mam therefore are expressed by nitrogen contents, namely total nitrogen, amino acid nitrogen, and in the other hand, the ammoniacal nitrogen which indicates the over degradation of amino acids. According to CODEX STAN 302-2011 [13], for being approved as fish sauce, the total nitrogen content is not less than 10g/L in which the amino acid content is not less than 40% of the total nitrogen, and the salt content is not less than 200g/L. In the first grade nuoc mam in Vietnam, the total nitrogen content varies from 30-39 g/L, in which the free amino acid content can account for 60-79% of the total nitrogen [7]. For adjusting the flavors, tastes, colours, stabilisation and preservation, many additives are used in the final products and therefore their maximum contents are introduced in the CODEX STAN 302-2011. Depending on different areas in Vietnam, the chemical compositions of nuoc mam are different, in which, nuoc mam produced in Phu Quoc possesses the highest quality (Table 2).

When talking about nuoc mam, people think about its strong flavor that is hard to be approved at the first experience. However, after adding to the soup or many meals, nuoc mam enhances the taste significant. Through the series of omission and addition tests, Park *et al.* [14], have found 11 compounds that were identified to be the taste-active components in nuoc mam in Vietnam, namely glutamic and aspartic acid, threonine, alanine, valine, histidine, proline, tyrosine, cysteine, methionine, and pyroglutamic acid. Among them, the glutamic acid, followed by pyroglutamic and alanine the most effective compounds in being responsible for the characteristic flavor and taste of nuoc mam, including umami, sweetness, and overall taste.

NEW ROLE OF NUOC MAM IN HEALTH BENEFITS

As the definition, nuoc mam is the liquid that contains mainly a mixture of peptides, amino acids as well as minerals dissolved from the fish, which makes nuoc mam being the resource of essential amino acids. Comparing to fish sauce from Asian countries, the nuoc mam in Vietnam is rich of aspartic acid, threonine, glutamic acid, leucine and lysine [15,16]. Due to the high salt concentration, nuoc mam is only used as condiment with



Figure 3 a) The salted anchovy in landing, b) Recirculation of liquid from salted fish, c) Set up the wooden frame in the surface of the salted fish, d) The line of wooden vats in a traditional nuoc mam processing factory in Phu Quoc.

Table 1: Chemical properties of fish sauces from Thailand, Vietnam and Japan.

| Source of fish sauce | NaCl % | pH | Formol nitrogen (g/100mL) | Amino acid (g/100mL) | Amino nitrogen (g/100mL) | Total nitrogen (g/100mL) | Peptide nitrogen (g/100mL) |
|----------------------|--------|------|---------------------------|----------------------|--------------------------|--------------------------|----------------------------|
| Thailand (n=8) | 25.9 | 5.55 | 1.33 | 8.28 | 1.32 | 1.83 | 0.50 |
| Vietnam (n=29) | 22.0 | 6.31 | 2.10 | 9.58 | 1.53 | 2.58 | 1.05 |
| Japan (n=29) | 23.5 | 5.97 | 1.31 | 7.97 | 1.27 | 1.71 | 0.44 |

n: sample size
Adapted from [12]

Table 2: Total nitrogen, percentage of amino acids/ total nitrogen of first grade nuoc mam from different areas in Vietnam.

| Locations | Fish | Total nitrogen g/L | Percentage of amino acid nitrogen/total nitrogen, % |
|---------------------------------|----------|--------------------|---|
| Cat Hai (North) (n=6) | By-catch | 14.50 - 26.60 | 48.21 - 66.40 |
| Thanh Hoa (North Center) (n=2) | Anchovy | 30.31 - 30.45 | 69.65 - 76.9 |
| Nghe An (North Center) (n=2) | Anchovy | 28.0 - 31.36 | 72.76 - 79.96 |
| Da Nang (Center) (n=3) | Anchovy | 19.18 - 28.70 | 68.09 - 73.86 |
| Nha Trang (South Center) (n=4) | Anchovy | 24.01 - 27.44 | 52.24 - 73.05 |
| Phan Thiet (South Center) (n=3) | Anchovy | 16.91 - 30.24 | 60.36 - 71.62 |
| Phu Quoc (South) (n=4) | Anchovy | 32.97 - 39.62 | 65.50 - 76.76 |

Adapted from (7), n: number of samples

a small quantity rather than a nutrient. However, with the daily consumption, nuoc mam can be the supplement for people that have the meal lacked some of essential amino acids. In Vietnam, the fishermen and divers often drink a cup of first grade nuoc mam before working to keep warm and enhance the performance. Based on rich of free amino acids, nuoc mam can be absorbed quickly to the body and take part physiological processes [17].

With many studies in fish protein hydrolysate, fish bioactive peptides related the health benefits such as antioxidants [18], antihypertensive and so protecting human from chronic diseases, the fish sauce should have the same activities and need more further researches. Different from parent protein, after hydrolysis, the peptides expose the side groups with bioactivities. These activities depend on the molecular weight and the amino acid sequences. They can scavenge the free radicals that are believed to cause many disorders and stimulate the ageing process [19-22]. Comparing to fish protein hydrolysate, the degree of hydrolysis of fish sauce is higher and therefore it contains much more short peptides which may reveal more active groups to the environment.

Besides being the nutrient and bioactive functions, the nuoc mam fish sauce was used as the vehicle to bring the iron to the body.

The two groups of women were administrated daily 10 mL fish sauce with 10 mg iron as NaFeEDTA (iron-fortified group) and 10 ml fish sauce without iron (control group). The results after 6 months showed that the hemoglobin and serum ferritin (SF) concentrations in iron-fortified group are 116.3 and 30.9, respectively, comparing to 107.6 and 14.6 in the control group. The data proved that when consuming the iron-fortified fish sauce, the absorption of iron into the body was more efficient. This method is very promising in case of about 4-5 billion people are now in iron deficiency anemia [23,24].

CONCLUSION

From the beginning of the traditional condiment originated from preservation of fish, nuoc mam fish sauce in Vietnam, based mainly on peptides and free amino acids, has become the value food and expressed many unique properties that can be useful not only in food but nutraceuticals and medicine. In order to extent the applications of nuoc mam, it is necessary to increase the further researches in processing technology in the direction to reveal more functional properties in human body.

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