Reduction of Sodium Intake from Papaya Salad with the Use of Sodium-Reduced Fermented Fish in Producing Traditional Seasoning Sauce

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Summary Fermented fish is a common seasoning used in Northeastern Thailand and Laos to give food a salty taste. It is also used as a basic ingredient for preparing various seasoning sauces for many local dishes. This study examined the effect of sodium reduced fermented fish (SRFF) on reducing the sodium content in prepared traditional papaya salad. Three local producers provide fermented fresh water fish produced with either normal salt (FF) or 60% sodium-reduced salt (SRFF) that were then used by 3 local sauce producers to make papaya salad seasoning sauces. Three local street food vendors then were used these sauces as the main ingredients for preparing their papaya salads. Sodium contents of the FFs, SRFFs, and papaya salads were analyzed using Inductively Coupled Plasma-Optical Emission Spectrometer. Significant differences between sodium contents in sauces and papaya salads were evaluated using the $t$-test. Results showed that the SRFF contained 54% less sodium than the FF, while sodium in the SRFF sauces was approximately 42% less than from FF sauces. The papaya salads prepared from SRFF sauces contained on average 492±27 mg sodium per 100 g, which was 33% lower than those prepared from FF sauces. The use of SRFF could significantly reduce sodium content in traditional papaya salad by up to one-third, which could be beneficial in lowering the risk of hypertension among Northeastern Thai and Laotian people with minimal change in eating behaviors.

Key Words Thailand, Laos, condiment, sodium reduction, potassium chloride

Hypertension is a major risk factor for heart disease and hemorrhagic stroke, which each year causes at least 9.4 million deaths worldwide (1). In 2015, the prevalence of hypertension among adults (>18 y) in Southeast Asian countries was estimated to be 23% (2). Excessive consumption of salt greater than the World Health Organization (WHO) recommendation (5 g/d or 2 g/d of sodium) can be a major risk factor for hypertension and cardiovascular disease (3). The Population Urban Rural Epidemiology study found that each 1 g of sodium intake can increase systolic blood pressure by 2.6, 1.7, and 0.7 mmHg in high (>5 g/d), moderate (3–5 g/d), and low (<3 g/d) sodium intake groups, respectively. Moreover, the restriction of sodium intake at less than 2 g/d for 30 d can reduce systolic blood pressure by 2 mmHg (4). On average, the world’s daily salt consumption is 10 g/person (4 g sodium). The main source of dietary sodium is based on the cultural context and dietary habits of a population (5, 6). In 2014, daily sodium intake of Thai people was on average 2.973 mg/person, which the highest intake was found in the Northern region at 3,730 mg/person followed by the Northeast region at 3,400 mg/person. The sodium sources for both regions come mainly from condiments. Salt, fish sauce, and the salt in curry paste contribute up to 45% of sodium intake in the Northern region whereas fish sauce, salt, and fermented fish contribute up to 60% of sodium intake in the Northeast region (7–9).

Fermented fish is the traditional seasoning condiment commonly used for increasing the salty taste in most Northeastern Thai and Laotian popular dishes, such as papaya salad (Som Tam), chili paste, bamboo soup, and spicy minced fermented fish. Fermented fish normally contains a sodium level of 5,000–6,000 mg/100 g. In the production process, freshwater fish is mixed with salt and rice bran or roasted broken rice. The mixture is then fermented at ambient temperature for at least 6 mo. The fermentation process mainly depends on enzymes from the fish gut as well as natural lactic acid bacteria. For convenience, fermented fish is the primary ingredient in preparing commercial seasoning sauces for several traditional dishes. For example, fermented fish is mixed with pickled garlic brine, shrimp paste, and monosodium glutamate (MSG) to prepare papaya salad seasoning sauce (9, 10).

WHO’s technical package for reducing salt consumption describes five key areas for action, namely: (i) measure and monitor population salt consumption patterns, (ii) promote the reformulation of foods and meals to contain less salt, (iii) implement standards for effective and accurate labeling and marketing of food, (iv)
educate and communicate to empower individuals to eat less salt, and (v) support settings to promote healthy eating (11). Product reformulation is thus one strategy for reducing a population’s salt intake.

To reduce the sodium content in foods, potassium chloride (KCl) is widely used as a sodium chloride (NaCl) replacement, since it can provide similar sensory quality and safety to food products such as cheese, bread, and other condiments (12–16). In terms of regulations, KCl is accepted for use as a food ingredient by the United States Food and Drug Administration (USFDA). It is also generally recognized as safe (GRAS) by the Codex Alimentarius when used as a flavor enhancer, flavoring agent, nutrient supplement, pH control agent, stabilizer, or thickener (17, 18). Moreover, the use of KCl can potentially increase dietary potassium among populations that normally under-consume it (WHO recommendation is at least 3,500 mg/d) (19, 20). While providing a salty taste flavor, unfortunately KCl can also has undesirable aftertastes (i.e., bitter, acrid, metallic). The Umami flavor is usually needed to overcome such a problem. Ingredients such as meat, cheese, mushrooms, seafood, and MSG, therefore, are added in product formulation (12, 15). KCl has been commercially used in Thailand as a salt substitute for condiments like fish and soy sauces since 1996 (21). According to US and Thai FDAs, a reformulated food product containing 25% less sodium than its original version can be claimed as a “reduced-sodium product”. Varieties of sodium-reduced sauces especially fish and soy are now available in the market. However, sodium-reduced traditional condiments, such as fermented fish that is normally produced based on local folk knowledge, are not available in the market.

In this study, sodium-reduced fermented fish (SRFF) was developed using traditional processes. The product passed the safety standard of fermented fish and was also accepted by the producers representing expert panels (22, 23). Following current local practices, this fermented fish was used to prepare papaya salad seasoning sauces, which were then used for preparing papaya salads. The aim was to evaluate how much the sodium content could be reduced in the papaya salads that were prepared using SRFF seasoning sauces.

**MATERIALS AND METHODS**

**Study area.** The study area was Ubon Ratchathani province, Northeast Thailand which is approximately 800 km from Bangkok and on the Lao People’s Democratic Republic.

**Salty condiments.** Normal salt (Eagle™ brand, Jew Heng Ltd., Bangkok, Thailand), 60% sodium-reduced salt (Les So™ brand, refined salt partially replaced with KCl. Ampol Food Processing Co., Ltd, Nakhon Pathom, Thailand), fish sauce (Tiparos™ brand, Tang Sang Hah Co., Ltd, Samutprakarn, Thailand), shrimp paste (Saltboat™ brand, Rimitalay-Bangkok Co., Ltd, Samutprakarn, Thailand), pickled garlic brine (Savepack™ brand, Siam Makro PCL, Bangkok, Thailand), and monosodium glutamate, MSG (AJI-NO-MOTO® brand, Ajinomoto Co., Ltd, Phra Nakhon Si Ayutthaya, Thailand) were used in the study.

**Participants.** Local participants were 3 fermented fish producers, 3 papaya salad seasoning sauce producers and 3 local street food vendors. Written consent forms were obtained from all participants at the times of fermented fish, seasoning sauce, and papaya salad production/preparation. The research protocol was approved by the Institutional Review Board, Mahidol University (COA. No. 2017/137.0407 and 2019/134.0406).

**Fermented fish production.** Normal fermented fish (FF) and sodium-reduced fermented fish (SRFF) were produced using normal salt and 60% sodium-reduced salt, respectively. Three producers used their own recipes to produce the FF and SRFF. The amount of sodium-reduced salt was added into SRFF at 93% of the amount of the normal salt added into FF. The amount of sodium-reduced salt added into SRFF was adjusted to be lower and replaced with water due to lower moisture content (0.1% for sodium-reduced salt versus 7% for normal salt).

Local freshwater fish, the namely Siamese Mud Carp (Henicorhynchus siamensis), sized 6–9 cm long, were scaled, gutted, washed with tap water, then mixed and softly kneaded with salt. The mixture was packed tightly in a high density polyethylene (HDPE) plastic bag, closed with rubber bands, and left overnight. On the following day, water and roasted rice bran or ground roasted broken rice were mixed into the mixture, which was then kept in a tightly closed container, protected from light, and at room temperature for 10 mo. After 10 mo, the producers tested their products based on their expertise and their products’ sensory profiles. The producer-accepted and most sodium-reduced SRFF was used for further study with the FF from the same producer.

**Production of seasoning sauces for papaya salad.** The selected FF and SRFF were blindly given to 3 local seasoning-sauce producers to make papaya salad sauces (FFS and SRFFS, respectively) using their own recipes. Water, herbs and other ingredients (e.g., pickled garlic brine, shrimp paste, normal salt, MSG, and sugar) were mixed into the fermented fish, and the mixtures were simmered for 20–30 min and filtered through cheesecloth. The producers then tested the filtrates and seasoned them until they were acceptable in terms of sensory standards before being packed in closed glass bottles until use.

**Papaya salad preparation.** FFS and SRFFS were then blindly given to 3 local street food vendors in random order as the main ingredient for preparing their papaya salads using their own recipes (Fig. 1). Once the salads were prepared, the chef at each street food location approved them based on their own sensory standards before being sent for chemical analysis.

**Sodium and potassium content determinations.** Samples were heated in a microwave digestion system and sodium was analyzed in Inductively Coupled Plasma-Optical Emission Spectrometer according to AOAC.
Reduction of Sodium Intake from Papaya Salad


Statistical analysis. Statistical analysis was performed using the SPSS for Windows version 18.0 (SPSS Inc, Chicago, U.S.A.). Significant differences ($p < 0.05$) between the sodium and potassium contents of the normal and sodium-reduced products were evaluated using the $t$-test (25).

RESULTS

Fermented fish

The general recipes for traditional fermented fish production are based on the ratio of fish to salt at approximately 4–5:1. In this study, the recipes and fermentation methods followed the procedures of 3 local producers. Sodium-reduced salt was added into SRFF at 14–17% for total weight of all ingredients. Adding sodium-reduced salt into the SRFF at a high amount without causing an undesirable aftertaste may due to the Umami taste components naturally found in fermented fish (26). After fermentation, all producers tested and approved their FF and SRFF products based on their own standards.

Table 1 shows that by replacing normal salt with the sodium-reduced salt, the sodium contents in the SRFF from all producers could be reduced by over 50%, while, the potassium content could be increased up to 20 times. SRFF producer 1 could reduce sodium content at the highest percentage, since this producer used the highest amount of salt in the fermented fish production. Consequently, both FF and SRFF of this producer were used for further study.

Seasoning sauces for papaya salad

For convenience and value-adding, specific seasoning sauce products have been formulated and are used to prepare papaya salad, instead of directly using fermented fish and various ingredients as in the past. However, fermented fish is still the main ingredient in such seasoning sauces (88–95% w/w), which can contribute about 70% of sodium in the FF sauce. Each seasoning sauce producer had his/her own recipe that contained different additional ingredients. Many of them also added sodium into the products such as pickled garlic brine, salt, MSG, and shrimp paste. Even so, the seasoning sauces that used SRFF as the base were able to reduce sodium content by approximately 40%. Variations in sodium content and reductions are shown in Table 2 with regard to the unique recipes of each seasoning sauce producer. The use of SRFF also affected...
the increases in potassium content in the seasoning sauces. All producers found that the sauces prepared from SRFF were similar to their normally produced products. Since the flavor profile of the seasoning sauce was quite unique to each producer, the products from all 3 producers were used for further study among the street food vendors.

**Papaya salads**

Street food vendors, restaurants, and households now widely use seasoning sauces to prepare papaya salad. Even though a seasoning sauce is used, chefs normally taste and season prepared papaya salads using other ingredients (e.g., fish sauce, MSG, lime, sugar, tamarind sauce) depending upon flavor preferences. Seasoning sauce was used at 5–16 g for 100 g of papaya salad. Table 3 indicates the sodium content that would be consumed by consumers. After the seasoning sauces from the 3 producers were used to prepare papaya salad by the chef of each street vending location, it was discovered that both the seasoning sauce and the chef could affect the amount of reduced sodium. For example, SRFFS no. 1 resulted in papaya salad with the least sodium content and greater reduced sodium as compared to its original FFS. On average, the use of SRFF as the primary ingredient could reduce sodium content in the papaya salad by approximately 30% regardless of the type of seasoning sauce and the chef. For one serving of papaya salad at 160 g (9), a consumer’s sodium consumption would be 787 mg from SRFFS instead of 1,182 mg from FFS. The use of SRFFS also increased potassium intake, which was found to be up to 782 per serving instead of 270 mg (Table 4). In addition, moles of sodium/potassium ratio of the papaya salad prepared from SRFFS was 1.71 which was much lower than the one from FFS that was 7.42.

**DISCUSSION**

Since fermented fish is a major source of sodium in the Northeastern Thai and Laotian diets, it is suspected to be one of the main causes for the growing hypertension problem in these regions (7, 9). The use of sodium-reduced salt, which is already commercially available, is one convenient and natural way to reduce the

<table>
<thead>
<tr>
<th>Street food vendor</th>
<th>Seasoning sauce 1</th>
<th>Seasoning sauce 2</th>
<th>Seasoning sauce 3</th>
<th>Average a,b</th>
<th>Na reduction re. sauce c (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FFS</td>
<td>SRFFS</td>
<td>FFS</td>
<td>SRFFS</td>
<td>FFS</td>
</tr>
<tr>
<td>Vendor 1</td>
<td>776</td>
<td>456</td>
<td>645</td>
<td>498</td>
<td>623</td>
</tr>
<tr>
<td>Vendor 2</td>
<td>768</td>
<td>482</td>
<td>820</td>
<td>488</td>
<td>771</td>
</tr>
<tr>
<td>Vendor 3</td>
<td>726</td>
<td>504</td>
<td>822</td>
<td>474</td>
<td>700</td>
</tr>
<tr>
<td>Average</td>
<td>757</td>
<td>481</td>
<td>762</td>
<td>487</td>
<td>689</td>
</tr>
<tr>
<td>Na reduction re. sauce (%)</td>
<td>36.35±5.38</td>
<td>35.20±10.79</td>
<td>26.34±10.24</td>
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</tr>
</tbody>
</table>

Overall average Na reduction (%) 32.63±9.22

1 Mean±SD from 3 preparations; 2 Means of sodium (Na) in papaya salad prepared by each sauce with different superscripts (small alphabet) are significantly different (p<0.02); 3 Means of sodium in papaya salad prepared by each vendor with different superscripts (capital alphabet) are significantly different (p<0.05); 4 The difference between sodium content in papaya salad prepared by FFS and SRFFS as the percentage of content in papaya prepared by FFS.

### Table 2. Sodium and potassium contents in papaya salad seasoning sauces (FFS and SRFFS) produced by 3 local sauce producers using normal fermented fish (FF) and sodium-reduced fermented fish (SRFF).

<table>
<thead>
<tr>
<th>Source</th>
<th>Sodium content (mg/100 g)</th>
<th>Sodium reduction (%)</th>
<th>Potassium content (mg/100 g)</th>
<th>Potassium increase (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FFS</td>
<td>SRFFS</td>
<td>FFS</td>
<td>SRFFS</td>
</tr>
<tr>
<td>Sauce producer 1</td>
<td>4,425</td>
<td>2,243</td>
<td>49.31</td>
<td>163</td>
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<tr>
<td>Sauce producer 2</td>
<td>5,841</td>
<td>3,501</td>
<td>49.31</td>
<td>217</td>
</tr>
<tr>
<td>Sauce producer 3</td>
<td>5,547</td>
<td>3,352</td>
<td>36.33</td>
<td>208</td>
</tr>
<tr>
<td>Average^1,2</td>
<td>5,271±747</td>
<td>3,092±735</td>
<td>41.90±6.68</td>
<td>196±29</td>
</tr>
</tbody>
</table>

^1 Mean±SD; ^2 Means of sodium in FFS and SRFFS are significantly different (p=0.02); ^3 Means of sodium in FFS and SRFFS are significantly different (p=0.002); ^4 The difference between sodium or potassium content in FFS and SRFFS as the percentage of content in FFS.

### Table 3. Sodium contents in papaya salads prepared by 3 local street food vendors using papaya salad seasoning sauces of 3 sauce producers that were produced from normal fermented fish (FFS) and sodium-reduced fermented fish (SRFFS) (3 preparations for each seasoning sauce).

<table>
<thead>
<tr>
<th>Street food vendor</th>
<th>Seasoning sauce 1</th>
<th>Seasoning sauce 2</th>
<th>Seasoning sauce 3</th>
<th>Average</th>
<th>Na reduction re. vendor^3 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FFS</td>
<td>SRFFS</td>
<td>FFS</td>
<td>SRFFS</td>
<td>FFS</td>
</tr>
<tr>
<td>Vendor 1</td>
<td>776</td>
<td>456</td>
<td>645</td>
<td>498</td>
<td>623</td>
</tr>
<tr>
<td>Vendor 2</td>
<td>768</td>
<td>482</td>
<td>820</td>
<td>488</td>
<td>771</td>
</tr>
<tr>
<td>Vendor 3</td>
<td>726</td>
<td>504</td>
<td>822</td>
<td>474</td>
<td>700</td>
</tr>
<tr>
<td>Average</td>
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<td>481</td>
<td>762</td>
<td>487</td>
<td>689</td>
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<tr>
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<td></td>
<td></td>
</tr>
</tbody>
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1 Mean±SD from 3 preparations; 2 Means of sodium (Na) in papaya salad prepared by each sauce with different superscripts (small alphabet) are significantly different (p<0.02); 3 Means of sodium in papaya salad prepared by each vendor with different superscripts (capital alphabet) are significantly different (p<0.05); 4 The difference between sodium content in papaya salad prepared by FFS and SRFFS as the percentage of content in papaya prepared by FFS.
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Table 4. Potassium contents in papaya salads prepared by 3 local street food vendors using papaya salad seasoning sauces of 3 sauce producers that were produced from normal fermented fish (FFS) and sodium-reduced fermented fish (SRFFS) (3 preparations for each seasoning sauce).

<table>
<thead>
<tr>
<th>Street food vendor</th>
<th>Seasoning sauce 1</th>
<th>Seasoning sauce 2</th>
<th>Seasoning sauce 3</th>
<th>Average (^1,^2)</th>
<th>K increase re. vendor (^3,^4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vendor 1</td>
<td>FFS 195</td>
<td>SRFFS 699</td>
<td>FFS 204</td>
<td>SRFFS 417</td>
<td>FFS 188</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>373</td>
</tr>
<tr>
<td>Vendor 2</td>
<td>FFS 129</td>
<td>SRFFS 349</td>
<td>FFS 128</td>
<td>SRFFS 428</td>
<td>FFS 134</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>424</td>
</tr>
<tr>
<td>Vendor 3</td>
<td>FFS 175</td>
<td>SRFFS 677</td>
<td>FFS 188</td>
<td>SRFFS 401</td>
<td>FFS 176</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>577</td>
</tr>
<tr>
<td>Average (^1,^2)</td>
<td>166±34</td>
<td>575±196</td>
<td>173±40</td>
<td>435±46</td>
<td>166±28</td>
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<td></td>
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<td>458±106</td>
</tr>
</tbody>
</table>

K increase re. sauce \(^4\) (%)

|                | 239±60          | 166±99          | 181±72          |

Overall average K increase (%) 195±76

\(^1\) Mean±SD from 3 preparations; \(^2\) Means of potassium (K) in papaya salad prepared by each sauce with different superscripts (small alphabet) are significantly different (\(p<0.05\)); \(^3\) Means of potassium in papaya salad prepared by each vendor with different superscripts (capital alphabet) are significantly different (\(p<0.03\)); \(^4\) The difference between potassium content in papaya salad prepared by FFS and SRFFS as the percentage of content in papaya salad prepared by FFS.

risk of hypertension from fermented fish by reducing sodium and increasing potassium consumptions. This study showed that sodium-reduced salt could be easily merged into the normal supply chain of fermented fish down to a popular consumer dish with no difficulties in terms production and preparation processes and sensory acceptability. The normal processes within the papaya salad value-chain from the production of fermented fish until the preparation of the dish were minimally altered or not-at-all. Sodium consumption for one serving could be approximately 39% of RDI instead of usually at 59%. Moreover, the sodium/potassium ratio of the SRFFS papaya salad was closer to 1 which is recommended intake ratio of WHO (27).

Regarding the global target on non-communicable diseases (NCD) that requires sodium consumption to be reduced by 30%, this approach could be quite feasible and practical (28). In addition, the cost of SRFF was only slightly higher than the FF by US$ 0.26 per kg or 8%. Since fermented fish is at the beginning of the supply chain for many dishes in these regions, it would be feasible to reduce sodium consumption in this region by applying this strategy.

Disclosure of state of COI

No conflicts of interest were disclosed.

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