Instrumental textural properties and sensory acceptability of rehydrated Thai fermented fish dip as affected by addition of Xanthan Gum and modified Tapioca starch

Pongdanai Duangsai and Somsamorn Gawborisut

Fish Processing Laboratory, Department of Fisheries, Khon Kaen University, Khon Kaen, Thailand

ABSTRACT
Instant powder of Thai-fermented fish dip (TFFD), a conveniently used dipping product, fails to form a homogenous viscous paste after being rehydrated. The addition of thickening agents, xanthan gum and hydroxypropyl distarch phosphate from tapioca (HDPT), may resolve this problem. Two sets of instant TFFD samples (5 samples/set) were mixed with five concentrations of xanthan gum (0%, 0.05%, 0.1%, 0.15%, and 0.2%) and five concentrations of HDPT (0%, 0.1%, 0.2%, 0.3%, and 0.4%), respectively. The samples were analyzed for CIE color values (L*, a*, and b*), aw, yeast and mold count (YM), and total plate count (TPC). They were also rehydrated and evaluated for CIE color values, texture profile analysis (TPA) (firmness, consistency, cohesiveness, and viscosity), and sensory scores (homogeneity, color, odor, flavor, mouth-feel texture, and overall acceptability). It was found that the concentrations of both thickening agents did not influence the CIE color values, aw, YM, or TPC of TFFD powder. They also did not affect the CIE color values of rehydrated product. Xanthan gum at 0.1–0.4% improved TPA values (firmness and cohesiveness) and sensory scores (homogeneity, flavor, and overall acceptability) of rehydrated product. HDPT at 0.2% produced no adverse effect on flavor and improved the homogeneity of the product. However, it failed to improve TPA values.

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Introduction
Fermented fish dip, a savory condiment common to Southeast Asian countries, is composed of simple components including fermented fish and taste/flavor-enhancing ingredients. Fermented fish provides a good amount of protein, and gives richness, saltiness, robust aroma, and umami flavor to the dip. Taste/flavor-enhancing ingredients, variable depending on the food resources in each country, contribute to the saltiness, sourness, sweetness, and aromatic herbal flavors in the dip. Thai fermented fish dip (TFFD), known in the Thai language as Jaew Bong, Plara Bong, or Nam Prik Plara, is the second most popular chili dip in Thailand.[1,2] Fermented fish blended into TFFD is a mixture of fish, salt, and a source of carbohydrate (unroasted or roasted rice or rice bran), which is allowed to ferment for at least 6 months in the shade.[3] Taste/flavor-enhancing ingredients such as fermented fish sauce, tamarind paste, sugar, and herbs are combined in TFFD to provide saltiness and umami, sourness, sweetness, and a unique herbal flavor, respectively. Fresh herbs such as garlic, red shallot, lemon grass, galangal, and kaffir lime leaf are used to produce fresh herbal flavors in TFFD.[4,5] Dried herbs such as chili powder are also added to produce a red color and heat sensation in the product.[4] In the past, TFFD was homemade and served uncooked with rice and roasted or fried meat. However, at present, it is mostly manufactured by small-scale producers and completely cooked to eliminate foodborne pathogens.[4]
Despite its popularity, the shelf life of TFFD is as short as 5 days at ambient temperature because the product has low or medium acidity and a high moisture content.\textsuperscript{[6]} The drying process, capable of lowering $a_w$ in TFFD to $< 0.6$, can increase keepability and ease transportation of the product.\textsuperscript{[6]} Dried TFFD can be ground or pulverized and used in powder form as an instant product. To use this instant powder, a proper amount of hot water is added to rehydrate the product. After a quick stir, the product must regain its original viscous paste and meet the appearance requirement of Thai Industrial Standards Institute.\textsuperscript{[5]} in which all ingredients in the product must be homogenously mixed and evenly distributed throughout the paste. However, our preliminary study revealed that TFFD powder has poor water absorption, thus requiring at least 30 min to be rehydrated. Insufficient rehydration time of $< 30$ min causes solid particle deposition, thus separating solid particles from the liquid portion. The separation of these two portions causes the product to fail in appearance quality according to the Thai Industrial Standards Institute.\textsuperscript{[5]} Moreover, insufficient rehydration time makes the dip form a low-viscosity mixture, thus creating an undesirable runny product. Supplementation of the instant dried TFFD with food-thickening agents such as xanthan gum and modified tapioca starch may allow the product to instantly form a viscous paste, and the solid and liquid portions to be promptly and homogeneously mixed.

Xanthan gum is a polysaccharide hydrocolloid produced by the bacterium \textit{Xanthomonas campes\-tris}. The gum is an ideal thickening agent and stabilizer for culinary products because of its stability at low pH, high viscosity at low shear, and pseudoplastic rheology.\textsuperscript{[7]} It is also salt-tolerant.\textsuperscript{[8]} So, the high salt concentrations in rehydrated TFFD may have little influence on the gum’s viscosity. The fine particle size of xanthan gum provides rapid and strong development of viscosity in cold or hot water at a wide range of temperature between 0 and 100°C, so it is widely used in several dry mixed products such as dips, gravies, salad dressings, soups, and sauces.\textsuperscript{[7,9–11]} The gum also yields excellent texture and flavor release.\textsuperscript{[7]} Due to these properties, xanthan gum could be an ideal thickening agent for instant TFFD. Morris\textsuperscript{[12]} reported that the levels of xanthan gum used in food are between 0.05% and 1.0%. In sauces and gravies, levels of 0.1–0.4% are recommended.\textsuperscript{[7]} No studies on the supplementation of instant TFFD powder with xanthan gum have been published. However, the use of xanthan gum in some Thai dishes such as frozen green curry and Cantonese sukiyaki sauce has been reported by Yansupap\textsuperscript{[13]} and Siangprohde,\textsuperscript{[14]} respectively. Studies on the effects of xanthan gum on the properties or quality of international food items such as cream cheese, barberry pulp syrup, and corn flour tarhana have been published by Salari et al.,\textsuperscript{[15]} Maleki et al.,\textsuperscript{[16]} and Anil et al.,\textsuperscript{[17]} respectively.

Modified starch is natural starch that has been modified chemically.\textsuperscript{[18]} Such modifications produce physical changes contributing to shelf stability, appearance, convenience, and performance in food preparation. Crosslinked starch is a type of modified starch in which natural starch is crosslinked at selected hydroxyl (–OH) groups of two adjoining, intact, starch molecules. The crosslinking enables the starch to withstand such conditions as low pH, high shear, or high temperature. Tapioca starch and its modified starches are commonly used in Thailand because the country is among the major tapioca-producing countries in the world. Modified tapioca starches are relatively cheap compared to other imported thickening agents, and the starches are widely used in frozen dishes and sauce industries. Tapioca starch is used for manufacturing hydroxypropyl distarch phosphate, a type of modified starch. The hydroxypropyl distarch phosphate from tapioca (HDPT) is used as a thickening agent in sauces containing a high sugar, acid, and salt content such as Thai sweet chili sauce. Moreover, it has been used for replacing regular tapioca starch to prevent retrogradation in salad dressings, gravies, canned foods, chilled and frozen dishes, and puddings.\textsuperscript{[19]} HDPT may be effective in increasing the viscosity of rehydrated TFFD and prevent separation of the liquid and the solid parts in the product. However, no studies on the use of HDPT in TFFD have been published. Duangsai et al.\textsuperscript{[11]} reported that adding guar gum at 0.2% to TFFD powder is the most suitable because the gum at this concentration could improve cohesiveness of rehydrated TFFD. However, the concentration failed to improve other TPA values (firmness, consistency and viscosity) and sensory acceptability. We therefore propose to prove that either xanthan gum or HDPT benefits the quality of instant dried TFFD powder and its rehydrated paste.
Materials and Method

Preparation of TFFD and dried TFFD powder

TFFD was prepared using a recipe modified from that of Duangsai et al.\textsuperscript{[1]} by blending 1,000 g minced fermented fish, 80 g finely chopped galangal, 60 g sliced lemongrass, 150 g peeled roasted shallots, 150 g peeled roasted garlic, and 44 g dried chili powder for 5 min using a food processor (MCM 640660, Bosch, Bratislava, Slovakia). After that, the mixture was placed in a nonstick pan, and combined with 40 g concentrated tamarind juice, 34 g sugar, and 12 g julienned kaffir lime leaves. The TFFD was then cooked on a stovetop. The pan was stirred continuously to produce an even temperature in the dip. When the internal temperature of the dip reached 75–85°C, the flame was dimmed, and the temperature was maintained at these levels for 15 min.\textsuperscript{[20]}

The precooked TFFD was spread on silicone baking sheets at a thickness of about 2 mm and dried at 60°C for 18 h in a hot air oven (SOV 70B, Daehan Labtech, South Korea) until the \( a_w \) of the product was equivalent to 0.6 or lower according to Duangsai and Gawborisut.\textsuperscript{[4]} The dried TFFD was aseptically removed from the sheets and ground using a Philips HR2115/02 blender (Philips, Eindhoven, Netherlands). The powder was then kept in sterilized plastic bags and further used for the experiment. Before being used, TFFD powder was thoroughly stirred using a sterilized spatula.

Combination of xanthan gum and HDPT in TFFD powder

The xanthan gum used in the experiment was purchased from a local supplier (Union Science Trading Co., Ltd., Khon Kaen, Thailand). To add xanthan gum to dried TFFD powder, the powder was aseptically weighed and placed in five sterilized plastic bags (150 g/bag). Then, five concentrations of the gum (0%, 0.05%, 0.10%, 0.15%, and 0.2%) were randomly assigned to these bags. The gum was thoroughly mixed with TFFD in each bag. The experiments were repeated in triplicate using TFFD powder prepared from three batches of fermented fish. Five concentrations of HDPT (0%, 0.1%, 0.2%, 0.3%, and 0.4%) were also mixed with TFFD powder in the same manner. The HDPT (Superthick 3\textsuperscript{TM}, INS 1442) with a gelatinization temperature of between 58 and 64°C was obtained from a local producer (Eiamheng Modified Starch Co., Ltd., Nakhornratchsima, Thailand). All samples were kept at ambient temperature and analyzed within 36 h.

Analysis of quality parameters of instant dried TFFD powder

Samples of instant dried TFFD containing xanthan gum and HDPT were analyzed to determine their International Commission on Illumination (CIE) color values (\( L^* \), \( a^* \), and \( b^* \)), \( a_w \), yeast and mold count (YM), and total plate count (TPC). The CIE color values (\( L^* \), \( a^* \), and \( b^* \)) of each sample were observed under a D65 artificial daylight bulb at a 10° standard angle using a Minolta CM-2600d spectrophotometer (Konica Minolta, Inc., Tokyo, Japan). The \( L^* \) value (0–100) represents the lightness. The \( -a^* \) to \( +a^* \) and \( -b^* \) to \( +b^* \) values represent green–red and blue–yellow, respectively. The \( a_w \) values of the samples were determined using an Aqua Lab Series 4TEV water activity meter (Aqua Lab, Pullman, WA, USA).

The YM was enumerated using a method published by Özpolat and Patir\textsuperscript{[21]} employing acidified potato agar with a pH of 3.5 ± 0.1. Twenty-five grams of sample was weighed into 225 ml of 0.1% peptone water and mixed well using a 3500 Jumbo Stomacher (Seward Laboratory Systems, Inc., Bohemia, NY, USA) for 60 s. Decimal dilutions were then performed and appropriate dilutions (\( 10^{-1} \)– \( 10^{-6} \)) were spread onto the agar. The agar plates were incubated at 23 ± 1°C for 5 days in an incubator. The enumerated YM colonies were counted, converted into logarithmic values, and expressed in log CFU/g.
The TPC was determined according to Al-Harbi and Uddin\textsuperscript{[22]} using standard plate count agar (BBL, Spark, MD, USA). Appropriate dilutions ($10^{-1}$–$10^{-8}$) were enumerated in the agar by the pour plate technique. The agar plates were incubated in an incubator at $30 \pm 1^\circ$C for 48 h. The enumerated TPC colonies were counted and expressed in log CFU/g.

**Analysis of quality parameters of rehydrated TFFD**

Samples of instant dried TFFD were rehydrated prior to analysis by adding a proper amount of hot water ($> 90^\circ$C). The amount of hot water was calculated as shown in Eq. 1.

$$\text{WT}_{\text{reh}} = \text{W}_{\text{uncook}} - \text{W}_{\text{dried}}$$

where $\text{WT}_{\text{reh}}$ is the amount of hot water used for rehydrating the sample (g), $\text{W}_{\text{uncook}}$ is the weight of uncooked TFFD (g), and $\text{W}_{\text{dried}}$ is the weight of dried TFFD (g). The rehydrated samples were evaluated for CIE color values, texture profile analysis (TPA), and sensory acceptability scores. The CIE color values of rehydrated TFFD were determined as previously described. The TPA values (firmness, consistency, cohesiveness, and viscosity) were analyzed within 30 min after being rehydrated according to Duangsai et al.\textsuperscript{[1]} using a TAXT2 texture analyzer (Stable Micro Systems Ltd., Vienna, Austria). Ninety grams rehydrated sample placed in a cylindrical aluminum container (50 mm diameter $\times$ 65 mm height) was analyzed using a P/35 cylindrical probe at a speed of 1.0 mm/s and a distance of 30 mm.

Sensory acceptability (homogeneity, color, odor, mouth-feel texture, flavor, and overall acceptability) of the samples was scored within 30 min after being rehydrated using a 9-point hedonic scale ($1$ = dislike extremely, $5$ = neither like nor dislike, $9$ = like extremely) as described by Meilgaard et al.\textsuperscript{[23]} A score of 5 was the cutoff-point for all sensory parameters. Each sample was assigned a three-digit number and evaluated in a room at $25^\circ$C by 18 female and 17 male panelists aged between 20 and 50 years. All panelists were acquainted with TFFD.

**Statistical analysis and experimental design**

The experimental design was a randomized complete block design (RCBD). Statistical analysis was conducted using the IBM SPSS Statistics 21 program (IBM, Armonk, NY, USA) at a 95% confidence level. Mean values were compared using the least significant difference (LSD) test.

**Results and discussion**

**Quality parameters of instant dried TFFD powder**

The statistical analyses reveal that the concentration of xanthan gum did not affect the CIE color values of TFFD samples ($P > .05$) (Table 1). The $L^*$, $a^*$, and $b^*$ of the samples were in the ranges of 41.28–42.63, 10.79–11.12, and 24.76–25.79, respectively. Posri\textsuperscript{[20]} stated that the redness, indicated by the $a^*$ value, plays an important role in the quality of TFFD because it reflects the freshness and heat of the product. Xanthan gum used in the experiment exhibited an off-white color with $L^*$, $a^*$, and $b^*$ values of 85.23, 1.82, and 14.89, respectively. The results show that using xanthan gum at low concentrations of up to 0.2% produces no effect on color components, especially $a^*$ value reflecting quality of the product. The results for $L^*$ and $a^*$ values agree with those of Duangsai et al.\textsuperscript{[1]} who found that adding guar gum at low concentrations of between 0.1% and 0.4% did not change the $L^*$ and $a^*$ values of instant TFFD powder. However, using the gum at a concentration $> 0.2$% altered the $b^*$ values of the product.

Similar results were also found for TFFD supplemented with HDPT (Table 1). The results show that the concentration of HDPT did not significantly affect the CIE color values ($P > .05$). The $L^*$, $a^*$, and $b^*$ values of the product were in the ranges of 37.80–38.84, 11.44–11.82, and 22.37–23.34,
respectively. The HDPT used in the experiment had a white color, exhibiting L*, a*, and b* values of 93.81, 0.21, and 2.13, respectively. The result indicates that the use of HDPT at low concentrations of up to 0.4% produced no effect on the color composition of the product.

The a_w values of instant TFFD powder containing different concentrations of xanthan gum are shown in Table 1. The results reveal that using xanthan gum at concentrations of up to 0.2% produced no effect on the a_w of the product. The gum used in the experiment contains a low a_w of 0.54. This low a_w and the use of low concentrations showed no influence on the a_w of instant TFFD. It is obvious that a_w values in all samples remained lower than 0.6, meeting the requirements of the Thai Industrial Standards Institute.[5] The results are in agreement with those of Duangsai et al.[1] who reported that adding guar gum to TFFD powder at low concentrations of between 0.1% and 0.4% did not change the a_w of the product. The effects of HDPT concentration on the a_w values of TFFD powder are also shown in Table 1. The concentration of HDPT did not significantly affect the a_w of the TFFD powder (P > .05). Analysis of the HDPT reveals that the starch contained a low a_w value of 0.56. The low concentrations of HDPT used in the experiment may have contributed to the unchanged a_w in the product.

The YM and TPC of instant TFFD powder containing xanthan gum are exhibited in Table 1. The microbial parameters were not significantly affected by the concentration of xanthan gum (P > .05). The xanthan gum used in the experiment contained low microbial loads, with YM and TPC of <15 and <25 CFU/g, respectively. The use of xanthan gum at low concentrations may produce no effect on the microbial constituents of the samples. The experiment also shows that the HDPT concentration did not significantly affect the YM and TPC of the product (P > .05). The YM and TPC of TFFD containing HDPT were in the ranges of 3.64–4.25 and 3.62–3.71 log CFU/g, respectively. The analyzed microbial loads of HDPT show that the starch contained low YM and TPC of <15 and <25 CFU/g, respectively. It is obvious that using HDPT at a low concentration of up to 0.4% may have no effect on the microbial components of TFFD powder. Our experiment leads to the conclusion that using xanthan gum at a concentration of up to 0.2% and HDPT at a concentration of up to 0.4% neither altered the physical properties (CIE color values and a_w) nor changed the microbial compositions (YM and TPC) of the product.

Quality parameters of rehydrated TFFD

Rehydrated samples were analyzed for CIE color value, TPA, and sensory scores. The CIE color values of samples containing xanthan gum and HDPT are exhibited in Table 2. The results show that the concentration of both thickening agents did not significantly affect the color values of the rehydrated TFFD (P > .05). The low concentrations of the thickening agents used in the experiment, as previously described, may have no effect on the color parameters of rehydrated TFFD.

Table 1. Quality parameters of instant dried fermented fish dip as affected by concentrations of xanthan gum and hydroxypropyl distarch phosphate from tapioca.

| Thickener agent | Concentration (%) | CIE color values | Yeast and Mold count (log CFU/g) | Total plate count (log CFU/g) |
|-----------------|-------------------|-----------------|-------------------------------|-----------------------------|
| Xanthan gum     | 0                 | 41.28 ± 0.59a   | 11.11 ± 0.57a                 | 0.46 ± 0.03a                | 4.01 ± 0.56a                 | 3.69 ± 0.11a                 |
|                 | 0.05              | 41.87 ± 0.65a   | 11.14 ± 0.45a                 | 0.46 ± 0.03a                | 3.64 ± 0.21a                 | 3.70 ± 0.08a                 |
|                 | 0.1               | 41.96 ± 0.98a   | 11.28 ± 0.23a                 | 0.46 ± 0.03a                | 3.68 ± 0.16a                 | 3.59 ± 0.15a                 |
|                 | 0.15              | 42.03 ± 0.80a   | 11.12 ± 0.35a                 | 0.46 ± 0.03a                | 4.25 ± 0.61a                 | 3.62 ± 0.09a                 |
|                 | 0.2               | 42.63 ± 1.09a   | 10.79 ± 0.39a                 | 0.46 ± 0.03a                | 3.66 ± 0.20a                 | 3.65 ± 0.09a                 |
| HDPT            | 0                 | 37.80 ± 0.83a   | 11.82 ± 0.29a                 | 0.46 ± 0.03a                | 3.65 ± 0.11a                 | 3.82 ± 0.02a                 |
|                 | 0.1               | 38.65 ± 2.23a   | 11.45 ± 0.75a                 | 0.46 ± 0.04a                | 3.65 ± 0.11a                 | 3.79 ± 0.04a                 |
|                 | 0.2               | 38.06 ± 2.05a   | 11.75 ± 0.53a                 | 0.47 ± 0.02a                | 3.71 ± 0.15a                 | 4.06 ± 0.47a                 |
|                 | 0.3               | 38.54 ± 2.54a   | 11.64 ± 0.53a                 | 0.46 ± 0.03a                | 3.62 ± 0.21a                 | 4.03 ± 0.47a                 |
|                 | 0.4               | 38.84 ± 0.96a   | 11.44 ± 0.45a                 | 0.46 ± 0.03a                | 3.74 ± 0.07a                 | 4.61 ± 0.01a                 |

Expressed as mean ± standard deviation (n = 3)
HDPT: hydroxypropyl distarch phosphate from tapioca.
Values with the same letter (a–a) in a column for each quality parameter in one of the gums were not statistically different (P > .05) according to the least significant difference.
Table 2. CIE color values of rehydrated fermented fish dip as affected by concentrations of xanthan gum and hydroxypropyl distarch phosphate from tapioca.

| Thickening agent | Concentration (%) | L*       | a*       | b*       |
|------------------|-------------------|----------|----------|----------|
| Xanthan gum      | 0                 | 44.31 ± 1.15a | 10.70 ± 0.26a | 25.00 ± 1.37a |
|                  | 0.05              | 45.44 ± 1.88a | 10.77 ± 0.01a | 24.94 ± 1.27a |
|                  | 0.1               | 44.21 ± 1.93a | 10.75 ± 0.11a | 24.87 ± 1.36a |
|                  | 0.15              | 45.11 ± 1.14a | 10.93 ± 0.06a | 24.29 ± 0.98a |
|                  | 0.2               | 45.35 ± 1.79a | 11.02 ± 0.24a | 25.06 ± 1.58a |
| HDPT             | 0                 | 39.01 ± 1.13a | 10.63 ± 0.15a | 24.94 ± 1.66a |
|                  | 0.1               | 39.80 ± 1.87a | 10.91 ± 0.18a | 24.97 ± 1.77a |
|                  | 0.2               | 40.48 ± 1.97a | 10.73 ± 0.23a | 24.91 ± 1.42a |
|                  | 0.3               | 40.74 ± 1.02a | 10.88 ± 0.07a | 25.03 ± 1.40a |
|                  | 0.4               | 40.37 ± 1.20a | 10.97 ± 0.01a | 25.31 ± 1.87a |

Expressed as mean ± standard deviation (n = 3).
HDPT: hydroxypropyl distarch phosphate from tapioca
Values with the same letter (a-a) in a column for each quality parameter in one of the gums were not statistically different (P > .05) according to the least significant difference.

Figure 1. Firmness (a), consistency (b), cohesiveness (c), and viscosity (d) of rehydrated Thai fermented fish dip as affected by concentration of xanthan gum. Identical letters above the line within each parameter indicate values that are not significantly different at a confidence level of 95% (n = 15)
Values determined from instrumental TPA (firmness, consistency, cohesiveness, and viscosity) of the rehydrated TFFD containing xanthan gum are shown in Figure 1. The firmness (Figure 1a) and cohesiveness (Figure 1c) of rehydrated TFFD were significantly affected by the concentration of xanthan gum ($P < .05$). However, consistency (Figure 1b) and viscosity (Figure 1d) were not significantly affected by the concentration ($P > .05$). The firmness and cohesiveness when using xanthan gum at 0.5% were not significantly different from those for the control containing 0% xanthan gum ($P > .05$). It is noticeable that firmness and cohesiveness increased significantly when xanthan gum was used at 0.1–0.2%. However, they were not significantly different when using xanthan gum at 0.1% than at 0.15% and 0.2% ($P > .05$). Kuppuswami[11] reported that xanthan gum is a long-chain carbohydrate molecule. Solutions of xanthan gum show high levels of pseudoplasticity. At low shearing force, the gum can produce high viscosity because the immobile molecule of xanthan gum becomes entangled in high-order networks. These entangled networks may cause an increase in the firmness and cohesiveness of rehydrated TFFD. It is predicted that xanthan gum at 0.05% may be a too low concentration to produce a substantial entangled structure, so it failed to improve the firmness and consistency of the product. The results indicate that using xanthan gum at 0.1–0.2% improves the texture of the rehydrated TFFD. However, 0.1% xanthan gum, offering a lower investment cost compared to 0.15% and 0.2%, is the most suitable concentration.

![Figure 2](image-url)

*Figure 2.* Firmness (a), consistency (b), cohesiveness (c), and viscosity (d) of rehydrated Thai fermented fish dip as affected by concentration of hydroxypropyl distarch phosphate from tapioca. Identical letters above the line within each parameter indicate values that are not significantly different at a confidence level of 95% ($n = 15$)
The TPA parameters of rehydrated samples containing HDPT are exhibited in Figure 2. The results show that increasing the concentration of HDPT did not significantly elevate the firmness, consistency, cohesiveness, or viscosity of the rehydrated product (P > .05). Although hot water at a temperature of > 90°C was added to TFFD powder, we found that during the mixing process, the temperature of TFFD mixture rapidly dropped to around 66°C which is close to the gelatinization temperature of HDPT (64°C). Ai and Jane[24] stated that after heating to above the gelatinization temperature, starch granules lose their crystalline structure, absorb water, swell, disperse to some extent, and develop significant viscosity. We presume that HDPT may have been poorly gelatinized and that dispersion of long-chain starch molecules was not achieved, so the viscosity was not developed and consequently caused unimproved TPA. The results lead to the conclusion that HDPT may not be a suitable thickening agent for instant TFFD because the temperature of the product may fall below the

Figure 3. Figure 3 Sensory scores of rehydrated Thai fermented fish dip as affected by different concentrations of xanthan gum (a) and hydroxypropyl distarch phosphate from tapioca (b) Identical letters above the bars within each attribute indicate values that are not significantly different at a confidence level of 95%
gelatinization temperature of the starch during the rehydration process. A reduction of temperature to below the gelatinization temperature may also occur when consumers use the product, leading to an unacceptable runny texture. In addition to that, poorly gelatinized or uncooked starch is slowly broken down by digestive enzymes. After that, the starch can produce gas in the lower bowel and cecum that results in hypertrophy of the cecum. It is obvious that a minor problem during the rehydration process can lead to several adverse effects. HDPT is therefore not a suitable thickening agent for instant TFFD powder. Xanthan gum capable of thickening the product at low temperatures is a better choice for instant TFFD powder.

The sensory scores of rehydrated samples containing xanthan gum are exhibited in Figure 3a. The results show that the concentration of xanthan gum did not significantly influence the color, odor, or mouth-feel texture of the product (P > .05). However, it significantly affected homogeneity, flavor, and overall acceptability (P < .05). The homogeneity of the rehydrated TFFD was significantly improved when xanthan gum was used at 0.05% or higher (Figure 3a). The panelists' records show that addition of xanthan gum at these concentrations made the liquid and solid portions well mixed, allowing the product to become more homogenous (Figure 4a). The results lead to the conclusion that addition of xanthan gum at a concentration as low as 0.05% benefits the appearance quality of the rehydrated TFFD. Using xanthan gum at a concentration of 0.1% or higher significantly increased the flavor scores of rehydrated TFFD (P > .05). According to Sworn, xanthan gum can increase flavor release in food products. Used at a concentration of 0.1% or more, the gum may improve flavor release from rehydrated TFFD, thus allowing panelists to perceive more flavor and consequently award higher flavor scores. The results also show that using xanthan gum at 0.1% or more yielded significantly higher overall acceptability scores than at 0% (P < .05) (Figure 3a). Concerning the ability to improve the flavor score and the cost investment, we conclude that adding 0.1% xanthan gum to instant TFFD is the most suitable. This conclusion is in agreement with Sworn who stated that typical concentrations of xanthan gum used in food products are in the range of 0.1–0.3%.

The sensory scores of rehydrated samples containing HDPT are shown in Figure 3b. The concentration of HDPT did not significantly affect the color, odor, mouth-feel texture, or overall acceptability of the product (P > .05). However, they significantly affected homogeneity and flavor scores (P < .05). The homogeneity scores increased as the concentration of HDPT increased (Figures 3b and 4b). The results show that a concentration of 0.2–0.4% yielded a significantly higher homogeneity score than 0% (P < .05). Although the concentrations of 0.3–0.4% improved the homogeneity of the product, they caused lower flavor scores compared with 0.2% (Figure 3b). The panelists' records reveal that the rehydrated samples containing 0.3–0.4% HDPT exhibited an unnatural flavor. Based on this
information, we concluded that the concentration of 0.2% HDPT is more suitable than the other concentrations. Although HDPT at 0.2% could improve the homogeneity of the product, it may be uncooked if the temperature falls to below its gelatinization temperature during the rehydration process. Uncooked starch may be unable to improve TPA parameters and may further cause undesirable health effects. We therefore conclude that adding HDPT to instant TFFD powder is not appropriate.

CONCLUSION

The most suitable thickening agent for instant TFFD is xanthan gum at 0.1%. At this concentration, the gum improved the TPA parameters (firmness and cohesiveness) and sensory scores (homogeneity, flavor, and overall acceptability) of the product. HDPT is not a suitable thickening agent because the starch may not be gelatinized during the rehydration process. We suggest the use of xanthan gum at 0.1% in instant TFFD powder or other types of instant chili dips in Thailand. Study on shelf-life of TFFD powder supplemented with 0.1% xanthan gum should be further investigated. In addition to that, investigation of the benefits of xanthan gum on the quality of other international instant dips should be further carried out.

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ORCID

Somsamorn Gawborisut http://orcid.org/0000-0003-3111-8266

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