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The use of imported pangasius fish in local restaurants

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Abstract

Pangasius fish, primarily *Pangasius hypophthalmus* (tra/swai) and *Pangasius bocourti* (basa) belonging to the Pangasiidae family of catfish, are an imported farm-raised freshwater fish. The labels “tra/swai” and “basa” seldom appear on restaurant menus, so it is unclear how and to what extent pangasius is used in restaurants. In this study, we investigated 47 different fish products served at 37 restaurants in a city in the southeastern United States. A commercial rapid lateral flow (LF) assay (EZ Pangasius™ kit) was used to identify pangasius fish and the results were verified by enzyme-linked immunosorbent assay (ELISA) using a pangasius-specific monoclonal antibody (mAb) T7E10. Isoelectric focusing (IEF) was then employed to examine the protein patterns in the ready-to-eat fish samples. The results showed that 26.7% of the domestic catfish (Ictaluridae family) and 22.2% of the grouper dishes served were actually pangasius. A high percentage (66.7%) of dishes displayed under the general name of “fish” on the menu were also identified as pangasius, revealing the widespread but economically favorable and/or fraudulent use of this fish in the restaurant industry. The IEF results revealed that the pangasius positive samples were exclusively tra/swai. There was no significant difference in the prices charged to restaurant customers between pangasius negative and positive samples, indicating that price is not a good indicator of fish authenticity. These findings highlight the need for stringent enforcement of the existing regulations to discourage the fraudulent use of pangasius fish, either tra/swai or basa.

Keywords: Pangasius fish; Tra/swai; Basa; Fish fraud

1 Introduction

Asian farm-raised pangasius fish, mainly *Pangasius hypophthalmus* (tra/swai) and *Pangasius bocourti* (basa), belongs to the Pangasiidae family in Siluriformes order of catfish. They have been cage-raised by Vietnamese and Cambodian farmers along the Mekong basin for decades; nowadays they are cultured predominately in intensive farming ponds (Binh, D'Haese, Speelman, & D'Haese, 2010). Basa has a better texture and flavor than tra/swai, but is much slower growing, requiring twice as long to become commercially available compared with tra/swai (U.S. ITC, 2009, VASEP, 2014a,b). Basa is also less readily adaptive to intensive farming practices for it cannot tolerate compromised aquatic environments as well as tra/swai. The import of pangasius into the United States (U.S.), mainly in the form of frozen fillet, boomed around 2005 (Hanson & Sites, 2014), making it the fastest growing fish commodity in the U.S. market. In 2014, the U.S. imported $336.99 million worth of frozen pangasius fillets from the major supplier in Vietnam, making it the largest single importer worldwide (VASEP, 2014a,b). This rapid expansion in the market for pangasius arises due to its relatively low price and desirable quality attributes, including its white flesh, delicate texture, clean taste and lack of horizontal bones. Its low fat content, high protein level and abundant essential amino acids also make pangasius a favorable choice as a fish food source (Orban et al., 2008). Pangasius entered the list of the top 10 seafoods consumed by Americans in 2009 and had risen to 6th place by 2013 based on consumption per capita (NFI, 2016).

When it was first imported into the U.S., pangasius was marketed as “catfish” by fish distributors, but in 2002 the U.S. Food and Drug Administration (U.S. FDA) ruled that only the North America native catfish (Ictaluridae family) can be labeled and sold as true catfish in the U.S (U.S. FDA, 2002). However, numerous media investigations have reported the fraudulent labeling of pangasius as domestic catfish in the years since (Consumer Reports Magazine, 2011), and traits such as fast growth, high yield and low price have also led to imported pangasius becoming a frequent substitute for wild caught high-value fish species such as grouper, snapper, cod and sole (Warner, Timme, Lowell, & Hirshfield, 2013), all of which have been suffering from limited oceanic resources, long growing periods and seasonal harvests. These deceitful practices have led to fraudsters being subjected to imprisonment and fines, especially those responsible for fraudulently labeling and selling pangasius as other species in bulk volume, either to avoid paying antidumping duties or for premium economic gain (U.S. Department of Justice, 2009).

In addition to violation of the food labeling laws, a major concern related to the hidden use of Asian aquaculture products such as pangasius fish is the abuse or misapplication of various chemicals and antimicrobial agents including parasiticides, fertilizers, disinfectants and antibiotics, either to prevent or treat outbreaks of infectious disease. Rico et al. (2013) reported that antibiotics contribute significantly to the chemical mass inputs of pangasius, containing up to 93 g per

tonne of harvested products. In the U.S., the use of those antibiotics in aquaculture products is illegal under Section 512 of the Federal Food, Drug, and Cosmetic Act (U.S. FD&C Act, 1938a).

As the quantities of pangasius fish being imported every year continue to grow, the names used for pangasius, especially “tra/swai” and “basa”, seldom appear on restaurant menus. A thorough search of the literature revealed no studies investigating how pangasius fish is used in restaurants. Given the lack of legislation related to standardized seafood labeling and systems for applying it to restaurants/grocery stores nationwide, these fraudulent practices are especially likely to occur in restaurants, where around 70% of seafood consumption in the U.S. is believed to take place (Stier, 2007). The overall goal of this research was thus to investigate whether pangasius was indeed rarely used at the restaurant level, as reflected by their menus, with the following specific aims: 1) investigate if pangasius is served as a substitute for domestic catfish or other types of fish species in restaurants; and 2) determine the frequency of using pangasius in restaurant fish dishes without specifying the species on the menu. A commercial lateral flow (LF) assay (EZ Pangasius™ kit) was employed to rapidly identify the presence of pangasius fish. Indirect non-competitive enzyme linked immunosorbent assay (iELISA) using a pangasius-specific monoclonal antibody (mAb) T7E10 was further utilized to confirm the results obtained from the rapid LF assay. Isoelectric focusing (IEF), a commonly used technique for fish species identification, was employed to examine the species-specific protein banding patterns and, where possible, to distinguish basa from tra in pangasius positive restaurant samples. The relationship between product price and product authenticity was also analyzed.

2 Materials and methods

2.1 Restaurant fish samples

A total of 47 samples of fish dishes were collected from 37 restaurants in a medium sized city in the souneastern United States from October 2013 to March 2014. These restaurant samples were grouped into three types. Group A was composed of 15 samples labeled “catfish” on the restaurant menus; Group B consisted of fish dishes claiming to contain species with relatively high prices, including 18 grouper samples, 3 snapper, 1 sea bass and 1 sole; and Group C contained fish products without specifying the species, generally referred to as “fish of the day” or “fish platter”. All samples were purchased as take-out orders and immediately processed for analysis upon receipt. Restaurant samples that were cooked with various sauces and gravies were promptly rinsed with deionized water and patted dry with clean paper towels. A portion of fish meat (~5 g) was cut from the interior part of each sample for subsequent analyses. All utensils were cleaned thoroughly after handling each sample to avoid cross-contamination, and all the samples were carefully labeled, placed in individual sterile sampling bags and stored at −20 °C until use.

Authentic tra/swai (*Pangasius hypophthalmus*) and basa (*Pangasius bocourti*) were provided by the Bureau of Food Laboratories, Florida Department of Agriculture and Consumer Services. Channel catfish (*Ictalurus punctatus*), black grouper (*Mycteroperca bonaci*), and red grouper (*Epinephelus morio*) were purchased from a reliable fish market and used as fish standards.

2.2 Lateral flow (LF) strip assays

The assay was performed according to the manufacturer's instructions. Briefly, after thawing, a portion of 0.5 g fish meat from each sample was placed into a tube containing the extraction solution provided in the test kit (EZ Pangasius™ Kit, ELISA Technologies Inc., Gainesville, FL, USA). After mixing thoroughly, a test strip was removed from the pouch and placed in the tube of sample extract. After 10 min, the result was read through visible color changes at the “control line” and “test line” on the strip. The appearance of two red lines at both the control and test lines indicated the sample was positive for pangasius fish, while a single red control line represented a negative result. The commercial LF assay kit used was a one-step rapid immunochromatographical assay that employs a pair of mAbs previously developed in our laboratory. Pangasius-specific T7E10 was used as the detection mAb and an all-fish specific mAb F7B8 was used as the capture mAb (Hsieh, Chen, & Gajewski, 2009).

2.3 Indirect non-competitive enzyme-linked immunosorbent assay (iELISA)

Approximately 5 g of the restaurant fish sample was weighed into a beaker and mashed into particles using a glass rod. An extraction buffer of 0.15 M sodium chloride (NaCl) was added to the mashed sample (1:5 w/v) and the mixture homogenized at 11,000 rpm for 1 min. The homogenized sample was then rested at 4 °C for 2 h, followed by centrifugation at 5000 g for 30 min at 4 °C. The supernatant was filtered through a Whatman # 1 filter paper and aliquots of the filtrate placed in 2 ml micro-tubes and stored at −20 °C until used. After heating in a boiling water bath for 10 min, the tra/swai and basa standards were extracted with 0.15 NaCl and prepared in the same way as the restaurant samples. The soluble protein concentration was determined using a Protein Assay kit II (Bio-Rad, Hercules, CA, USA), with bovine serum albumin (BSA) as the standard. The clear filtrates were used for the following analyses.

Each protein extract was diluted in 0.06 M carbonate buffer (pH 9.6) to a final concentration of 2 μg protein/100 μl. The 96-well polystyrene microplate was coated with 100 μl diluted extract per well and then incubated at 37 °C for 60 min. The plate was washed three times with 250 μl/well of PBST (10 mM phosphate buffered saline (PBS), pH 7.2 with 0.05% v/v Tween-20), followed by incubation with 200 μl/well of blocking buffer (1% w/v BSA in 10 mM PBS) at 37 °C for 60 min. The same washing step was performed twice and then 100 μl primary antibody supernatant T7E10 diluted 1:8 (v/v) in the antibody buffer (1% BSA in 10 mM PBS containing 0.05% Tween-20) was added to each well and incubated at 37 °C for 60 min. After washing three times, 100 μl/well of horseradish peroxidase-conjugated goat antimouse IgG-Fc specific solution (diluted 1:3000 in antibody buffer) (Sigma–Aldrich Co., St. Louis, MO, USA.) was added and the plate was incubated at 37 °C for 60 min. Afterwards, the plate was washed five times and 100 μl/well of the substrate ABTS (2,2′-azino-bis 3-ethylbenzthiazoline- 6-sulfonic acid) was added to develop the color at room temperature for 20 min. The reaction was stopped by adding 100 μl/well of 0.2 M citric acid and the absorbance measured at 415 nm using a microplate reader (MQX200R, BioTek, Winooski, VT, USA).

2.4 Thin-layer isoelectric focusing (IEF)

Raw fish standards were cut into small pieces (1″ x 1″) and prepared by homogenizing the tissue with distilled deionized (DD) water at a ratio of 1:2 (w/v). A separate piece of fish meat from each standard was placed in a clean beaker, covered with aluminum foil and heated in a boiling water bath for 5 min to create the cooked fish standards. After cooling, the cooked meat was homogenized with DD water at a ratio of 1:1 (w/v). Restaurant fish samples were directly homogenized with DD water in the same manner as the cooked fish standards. Each homogenate was then centrifuged at 16,000 g for 3 min and the clear supernatant collected for IEF analysis. The soluble protein concentration was determined as described above.

IEF was carried out on a commercial ampholine polyacrylamide gel plate (PAGplate) (pH 3.5–9.5, GE Healthcare Bio-Sciences AB, Uppsala, Sweden) according to Hsieh (1998) with modifications. The PAGplate was placed on the cooling platform (10 °C) of the Bio-Phoresis horizontal electrophoresis cell (Bio-Rad), which was connected to a power supply unit (PowerPac 3000, Bio-Rad). In each lane, 100 μg protein was loaded onto a paper applicator and 12 μl of broad PI standard (pH 3–10, GE Healthcare Bio-Sciences AB, Uppsala, Sweden) was loaded as the pI marker. The IEF was initially run at a constant power of 10 W for 40 min, after which the applicators were removed and the IEF continued at 20 W for a further 40 min. After removing it from the platform, the gel was fixed in a fixing solution (29 g trichloroacetic acid (TCA) and 8.5 g 5-sulfosalicylic acid dilydrate ($C_7H_6O_6S•2H_2O$) dissolved in 250 ml DD H_2O) for 30 min, followed by staining for 10 min (0.1% w/v Coomassie Brilliant Blue G-250 in destaining solution), destaining for 3 h (ethanol: acetic acid: DD H_2O = 25: 8: 67% v/v/v) and preserving for 30 min (glycerol: destaining solution = 1:9% v/v). After drying overnight, the gel was covered by a clear plastic film and the banding profiles analyzed by a ChemiDoc TM XRS system with Quantity One® software (Bio-Rad). All experiments were repeated at least once.

2.5 Statistical analysis

An independent sample *t*-test was used to determine whether there was a significant difference in prices between the two populations of pangasius positive and pangasius negative samples. SPSS software (version 21) was used to analyze the data, with the significance level set at $P \leq 0.05$.

3 Results

3.1 Analysis of restaurant samples using rapid LF assay

The samples tested in this study represented a wide variety of fish products, including sandwiches, fingers, baskets, platters, sushi rolls, salads, tacos and wraps. Grilling and deep frying were the predominant cooking methods used for the samples, although a few samples were either pan fried, blackened, crusted, or raw. The LF strip assay revealed 14 samples (29.8%) that were positive for pangasius among the 47 restaurant fish samples tested; none were listed as pangasius fish on the restaurant menus (Fig. 1). The fish samples where no fish species was specified had the highest rate of pangasius (6 out of 9, 66.7%); of the 15 “catfish” samples, 4 were identified as pangasius rather than domestic catfish (26.7%); and among the 18 grouper dishes, 4 were identified as pangasius (22.3%). No pangasius fish was identified as a substitute for the samples of snapper, sea bass, and sole tested in this study. The LF assay showed clear results within 1 min, either positive or negative, suggesting that the assay was both sensitive and rapid and could thus serve as a convenient tool for identifying pangasius fish in the routine analysis of a wide range of raw and cooked products.

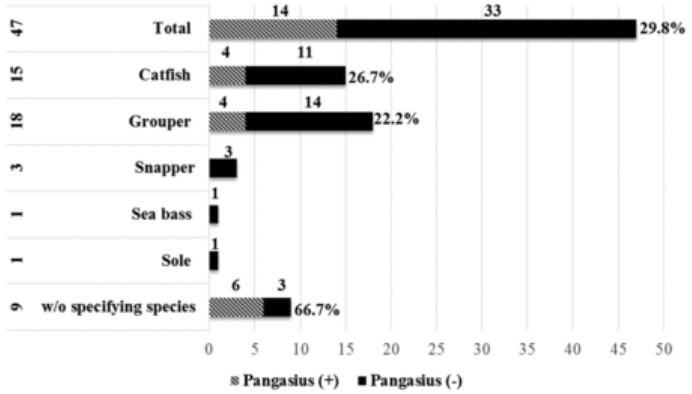

Fig. 1 Types and numbers of the restaurant fish samples collected and the numbers of pangasius positive samples identified by the lateral flow strip assay.

3.2 Confirmation of the LF results using iELISA

To confirm the results of the LF assay, the restaurant samples from each category were then tested using the pangasius-specific mAb T7E10 in the iELISA. The results matched the LF results exactly, with only the restaurant samples that had tested positive for pangasius showing strong reactions with the mAb T7E10. The absorbance readings were very strong, ranging between 2.144 and 2.750, while no signals were detected for any of the pangasius negative restaurant samples (data not shown). In order to investigate whether these fraudulent practices were still occurring, we purchased 7 fish dishes from the 7 restaurants that had been identified as using pangasius fish without listing it as such one year after our initial study. The selected follow-up samples included all four of the

"catfish" pangasius positive dishes and three dishes where the species was not specified. As before, all seven of the samples were verified as being pangasius fish, with absorbance reading between 2.240 and~~to~~ 2.489 (Fig. 2). These results confirmed the continuing use of pangasius fish in restaurants as catfish, highlighting the need for more frequent inspections to halt this persistent dishonest practice.

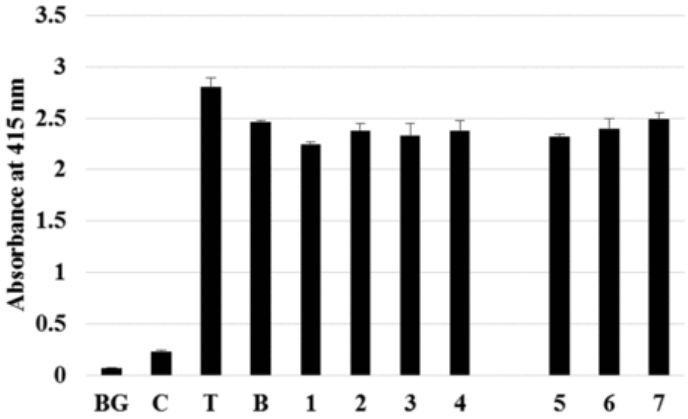

Fig. 2 Follow-up for representative restaurant samples by mAb T7E10-based iELISA. BG: black grouper, C: catfish, T: tra/swai, B: basa, lanes 1–4: catfish pangasius positive samples, lanes 5–7: pangasius positive samples where the species is not specified. n = 2.

3.3 IEF protein profile of restaurant catfish and grouper samples

IEF was used to examine the specific protein banding patterns of the pangasius positive and negative samples. Because the various restaurant fish samples were prepared very differently, both raw and laboratory cooked (100 °C, 15 min) fish standards were included in the analysis for comparison. Fig. 3 shows the IEF banding patterns of authentic pangasius (tra/swai and basa) and catfish standards, together with the restaurant "catfish" samples. The protein profiles reveal that cooking appears to affect the basic proteins more than the acidic ones, with species-specific patterns being manifested in the low pI regions of the gel. Major pI bands for the raw catfish standard (rC) were identified at pH 3.40, 4.26, 4.48, 4.88, 5.78 and 7.20, of which the first three bands remained after cooking, thus potentially serving as a representative band pattern for cooked catfish. Raw basa (rB) and tra/swai (rT) exhibited completely different banding patterns from the domestic catfish but shared similar banding patterns with each other, differing in only one band. Two distinctive acidic bands were retained after cooking, with pIs of 3.80 and 4.01 for basa (cB), and 3.80 and 4.35 for tra/swai (cT). Based on this difference, all four of the pangasius positive "catfish" samples (lanes 1–4) were identified as tra/swai. The other two most prominent bands for both tra/swai and basa were viewed at 5.58 and 7.18. Although the pangasius negative restaurant samples all exhibited the three distinctive bands (3.40, 4.26 and 4.48) typical of authentic catfish, an additional band at pH 3.75 was present in the samples in lanes 10, 11 and 15 and a band at pH 3.85 in lane 13 (Fig. 3). These could be due either to the use of closely related species belonging to the same family of Ictaluridae as channel catfish, or the cooking methods or sauces used might have slightly altered the overall banding patterns. These species were not further identified as this was outside the scope of the present study.

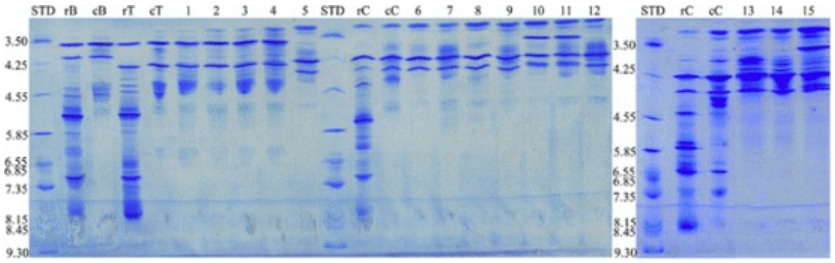

Fig. 3 IEF protein banding pattern of restaurant "catfish" samples in polyacrylamide gel, pH 3.5–9.5. Anode was on top of the gel. STD: pI marker, rB: raw basa, cB: cooked basa, rT: raw tra/swai, cT: cooked tra/swai, rC: raw channel catfish, cC: cooked channel catfish, lanes 1–4: restaurant pangasius positive samples, lanes 5–15: restaurant pangasius negative samples.

Fig. 4 shows the protein banding patterns of all the restaurant "grouper" samples, along with the grouper and pangasius standards. All four of the pangasius positive samples showed the two distinctive bands (pHs 3.80 and 4.35) of the tra/swai standard and were thus positively identified as tra/swai. Only one major and distinctive acidic band (pH ~ 4.25) was seen in the authentic black and red grouper standards after cooking. The banding profiles in the samples in lanes 5–8 differed from the typical grouper patterns, indicating that other species of grouper, cross-bred grouper, or even non-grouper species were being used. All the other restaurant grouper samples showed a banding pattern that matched those of the cooked black or red grouper standards (data not shown). This indicates that an overall higher violative rate could be detected by including a wider range of substituting species than that tested using just the Pangasius kit (22.2%). The authenticity identification of grouper samples is clearly a more complex problem since many

inexpensive fish species, including hake, tilapia, channel catfish, Alaska pollock, mackerel, perch and pangasius, have all been documented as potential substitutes for grouper (Jacquet & Pauly, 2008).

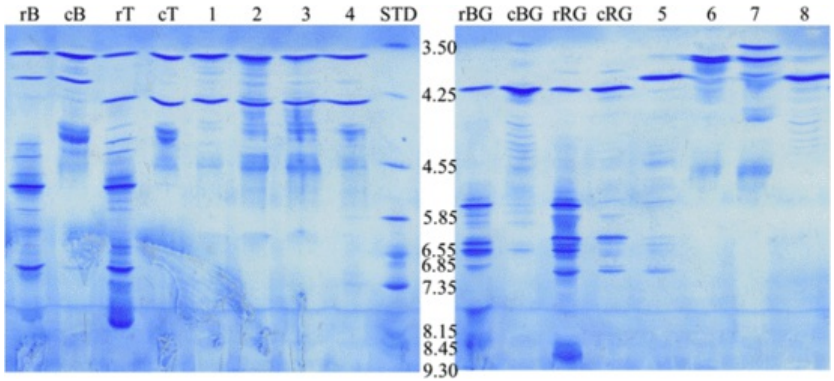

Fig. 4 IEF protein banding pattern of representative restaurant "grouper" samples in polyacrylamide gel, pH 3.5–9.5. Anode was on top of the gel. STD: pI marker, rB: raw basa, cB: cooked basa, rT: raw tra/swai, cT: cooked tra/swai, rBG: raw black grouper, cBG: cooked black grouper, rRG: raw red grouper, cRG: cooked red grouper, lanes 1–4: restaurant pangasius positive samples, lanes 5–8: restaurant pangasius negative samples.

Overall, all the pangasius-positive samples identified by the LF assay were found to be tra/swai. The IEF results not only verified the accuracy of the results obtained from the immunoassays (LF and iELISA), but also provided a means of differentiating between tra/swai and basa in the pangasius positive samples.

3.4 Analysis of the sample prices

The average price of all the restaurant fish samples tested was $10.61, with the lowest and highest priced dishes costing $ 3.19 (for a fish sandwich) and $ 23.00 (for a red snapper dish). Among the three categories, the mean price of the grouper dishes was the highest ($ 11.95) followed by the catfish samples ($ 9.80) and the fish dishes where the species was not specified ($7.19). Based on these results, pangasius fish was used for high-priced fish dishes as well as cheaper ones. The mean prices of the pangasius negative and positive groups were $10.74 and $10.31 respectively. The frequency distributions of these two groups are shown in Fig. 5. The median price of the pangasius negative samples was $10.50, close to the mean price, while 50% of the prices in the pangasius positive group were clustered below $8.99 (median). The interquartile range (IQR) of the negative sample prices (between $8.99 and $12.50) was more narrowly distributed than the positive group (between $6.97 and $14.95), implying the latter group exhibits less consistency in the prices. The results of the independent sample *t*-test revealed no significant differences in price means between the pangasius negative and positive samples, suggesting that price is not a good indicator for fish authenticity.

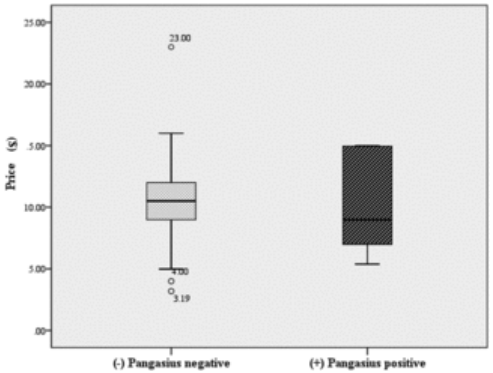

Fig. 5 Results of Box plot for price, with symmetric and positively skewed distributions for the pangasius negative and positive samples, respectively. Outliners indicate the extreme sample prices of $23.00, $4.00 and $3.19.

4 Discussion

A particularly high percentage (66.7%) of pangasius was found in the restaurant-served fish meals (Group C) for which the species was not specified. This indicates the preference for and prevalence use of this inexpensive fish in restaurants. The frequent use of these "anonymous" pangasius fish in restaurants should not be surprising because with an ample supply, pangasius provides price and taste-favorable products, while removing the need for restaurants to disclose fish information to customers who might not be familiar with the name of this imported fish. In a number of cases, these pangasius positive fish dishes were repeatedly claimed to be "grouper" by restaurant servers or managers when the researchers

asked what type of the fish was used in the items they had ordered. This implies that either the servers were misinformed or unaware of the fish species that they were serving. As how the product being marketed and sold to the restaurant or the fish market was unknown, it was often difficult to determine if such behaviors constituted fish fraud since the dishes were given very general names, for example “fish sandwich” or “fish platter”, instead of specifying what they were on the menus as well as on the receipts.

Although the U.S. FDA has ruled that only the Ictaluridae family can be sold and labeled as “catfish” in the U.S., an investigation showed that 14.3% (3 out of 21) of the “catfish” products purchased from retail stores and restaurants in New York, New Jersey and Connecticut were actually pangasius rather than domestic catfish (Consumer Reports Magazine, 2011). This situation has clearly not improved given that our current investigation found a 26.7% substitution rate for domestic catfish using tra/swai in the restaurants surveyed. The past decade has witnessed a significant decline of up to 60% in U.S. farm-raised catfish, while the market share of the imported catfish-like frozen fillets, primarily pangasius, rose from 20% in 2005 ~~to~~ 80% in 2013 (FAO, 2014; Hanson & Sites, 2014). The expansion of the pangasius market is largely due to its low price as it is usually $ 1.50 to $ 2.00 cheaper per pound than U.S. domestic catfish (FAO, 2014). Catfish belongs to the same order of Siluriformes as pangasius. They are both low-priced fish species, and share similar product attributes, including their juiciness, flakiness, gelatinousness, low firmness and fibrousness, and so their target consumers are largely the same (Phan & Nguyen, 2012). In our investigation, all of the cooked catfish samples (100%) tested were coated with a mixture of cornmeal/spices and deep fried, so the cooking method concealed many of the morphological features of the fish and thus made it very difficult for customers to identify the specific type of fish used. Cooking methods can often be utilized by restaurants to mask fraudulent practices such as fish substitution or adulteration.

The premium charged for high value fish such as grouper creates an economic incentive that drives fraudulent practices such as its substitution with other inexpensive fish species. In a local supermarket, the frozen grouper fillet costs $ 15.00 for a 12 ounce portion, while the same size tra/swai fillet is priced at $ 4.00, suggesting that sellers can profit considerably by marketing pangasius as grouper. The OCEANA study in 2013 reported 31% (5 out of 16) of the restaurant grouper dishes tested were mislabeled (Warner et al., 2013) and this may have risen: our study revealed a substitution percentage of 22.3% using pangasius to replace grouper in restaurants, but the substitution level could actually be higher given that other fish species were possibly also used. Generally, a cooked grouper fillet is thicker than that of pangasius and separates in large flakes/chunks with a firmer texture. Consumers should thus be suspicious if they are served a thin fish fillet that crumbles easily into small pieces.

Both of the LF and ELISA analyses using pangasius-specific antibody T7E10 approved to be accurate for the selection of pangasius fish without distinguishing between tra/swai and basa. Because IEF method separates protein components of a sample according to their isoelectric points (PIs) to produce a signature protein profile in the gel with high resolution, we have successfully used IEF to distinguish between these two closely related pangasius fish in this study. IEF is an official method for raw fish species identification (AOAC, 1990). The IEF gel pattern images for the most common raw fish species sold in the U.S. market can be found in the FDA online IEF gel library (FDA, 2015). The IEF pattern of raw tra/swai in the present paper was generally similar to the result reported by Rehbein (2008), that two major heat-stable acidic bands immobilized in the lower pI region, several clustered bands around pI 5.5 ± 0.1, and one distinct band around 7.1. Different processing methods affect the degree of protein denaturation and aggregation, thus change the protein banding profiles from that of the raw fish. However, IEF has also been successfully applied for species identification of cooked fish samples when enough thermal-stable muscle proteins were obtained (Etienne et al., 2000; Hsieh, 1998). In this study, the two heat-stable acidic bands were identified as the representative pattern to distinguish cooked pangasius fish samples by comparing them with the authentic standards. Raw and cooked basa (rB) and tra/swai (rT) exhibited completely different banding patterns from other fish but they shared very similar banding patterns with each other, differing in only one of the two heat-stable bands (PI 4.01 for basa vs 4.35 for tra/swai). This small but distinctive difference enables the distinguishing basa from tra/swai without confusion. To our knowledge, this is the first report on the discrimination between tra/swai and basa by IEF.

One particularly interesting finding based on the IEF results was the exclusive use of tra/swai rather than basa as a substitute in restaurant catfish and grouper dishes. Although both are marketed as pangasius fish, the differences between tra/swai and basa are probably not clear to consumers. In many cases “tra/swai”, “basa” and “pangasius” are used interchangeably, and U.S. consumers therefore tend to think they are the same fish. As the main culturing method for pangasius in Vietnam has shifted from floating cages to farming ponds, many farmers have switched from basa production to tra/swai as a more economic and attractive fish species with a shorter growing period, high yields, lower mortality rates and consequently cheaper production costs (Binh et al., 2010; U.S. ITC, 2009). By 2005, basa production had sunk to a mere 1.29% of the total pangasius raised in the Mekong Delta region in Vietnam (Binh et al., 2010). Interestingly, basa were still widely available on the U.S. market until relatively recently, giving rise to the suspicion that the basa was being substituted by the cheaper and more easily available tra/swai, given the high proportion of tra/swai production. The U.S. International Trade Commission has reported that a number of unnamed suppliers have been decertified by U.S. purchasers for mislabeling Vietnamese swai as the more expensive basa (U.S. ITC, 2009). This is not a problem that is unique to the U.S.; in the Egyptian market, 50% (10 out of 20) of the frozen fillet commodities labeled as basa turned out to be tra/swai when tested (Galal-Khallaf, Ardura, Mohammed-Geba, Borrell, & Garcia-Vazquez, 2014). Although few such cases have been reported at the retail and restaurant levels in the U.S., this type of substitution is probably not unusual given the universal unfamiliarity with the differences between basa and tra/swai when they were first imported into the U.S. Nowadays, this information seems to be delivered with improved accuracy and it is hard to find basa products on the market. Our findings are thus consistent with the high imports of tra/swai and demonstrate a high acceptance of the use of tra/swai as a source of whitefish in U.S. restaurants.

As mentioned before, the hidden use of imported panhgasius may imposes a health concern for the possible use of prohibited chemicals during their production. The negative impacts of aquacultural antimicrobial agents on human health include the development of antibiotic-resistant bacteria and the chronic toxic effects of accumulated chemical residues (Sapkota et al., 2008). Another health consideration for those consuming farm-raised pangasius stems from the bio-amplification of potential metal residues from surrounding aquatic systems; the level of mercury present in some pangasius samples has been shown to exceed the maximum residual limit permitted (Ferrantelli et al., 2012). Moreover, there have been clinical

cases of patients exhibiting allergic reactions exclusively to pangasius fish but having no problems consuming other common fish species such as cod, salmon, tuna and pollock (Raith et al., 2014). This could pose a significant risk for consumers who order a grouper dish that turns out to be the pangasius fish to which they are mono-sensitive.

The U.S. Federal Food, Drug, and Cosmetic Act Sec. 403 requires that food not be offered for sale under the name of another food (U.S. FD&C Act, 1938b). As seafood mislabeling at the retail level and in restaurants continues to be reported nationwide, states and local authorities have started to take action to fight seafood fraud by adopting new labeling laws. For example, a bill was signed into law in Washington State in 2013 that requires all fresh, frozen or processed fish and shellfish to be labeled using its common name at the point of sale, both at the wholesale and retail levels (Laws of 2013, ch. 290, 2013). A similar bill has been approved in California, stating that it is unlawful to sell or offer for sale food fish or shellfish without identifying its common name (Senate bill 1138, 2014). These strengthened legislative tools will support the ability of consumers to make informed purchasing decisions and play a powerful role in fighting fish fraud.

5 Conclusions

This study investigated how imported pangasius fish is used in U.S. restaurants. The results revealed not only the frequent use (66.7%) of pangasius in restaurants for those dishes that do not specify the fish species, but also the fraudulent practice of using pangasius as a substitute for domestic catfish (26.7%) and high-value fish species such as grouper (22.2%). The restaurant pangasius positive samples found in this study were exclusively tra/swai rather than basa according to the results of the IEF analysis. Although it is challenging to determine whether numerous kinds of seafood products are accurately labeled, given various health and economical concerns, consumers have the right to be informed what they are paying for. Hence, more rigorous inspections with effective detection tools to enforce the regulations are needed to ensure the safety and quality of the fish products served in restaurants. Information on the country of origin labeling would also be helpful to support an informed purchasing decision by consumers.

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Highlights

- Pangasius fish often substitute for domestic catfish and grouper in restaurants.
- Pangasius was frequently used in restaurant fish dishes without specifying species.
- Pangasius fish samples identified in this study were exclusively tra/swai.

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