JOURNAL OF UNDERGRADUATE RESEARCH

Sensory Evaluation of Local Versus Imported Shrimp to Develop Marketing Strategies for United States Shrimp Producers

Gina Fimiano, Katlyn Nau, Charles Sims, and Razieh Farzad

College of Agriculture, University of Florida

Dr. Razieh Farzad, Department of Food Science and Human Nutrition

Abstract

Shrimp is considered a high-value seafood product and the most consumed seafood in the United States. However, it is characterized by a short shelf-life. The United States is heavily dependent on seafood imports, including shrimp, with more than 80% of seafood consumed in the U.S. being imported. Imported shrimp products are usually treated with preservatives such as phosphate to maintain quality, and possibly subjected to multiple rounds of freezing and thawing that can affect quality as well. Therefore, this study aimed to understand and compare the sensory/organoleptic characteristics of imported to U.S.-based shrimp products. Additionally, nutritional values of the shrimp products were evaluated by analyzing their proximate composition. These results of the sensory panel showed a discrepancy between consumer stated preferences and actual behavior regarding shrimp products. While participants expressed a preference for preservative-free shrimp, as demonstrated acceptability was higher for imported shrimp containing preservatives. Proximate analysis showed farm-raised shrimp to have significantly higher ($p<0.05$) protein content in comparison to wild-caught and imported shrimp. This can be a leverage to develop marketing strategies for locally produced shrimps that are not treated with preservatives.

Keywords: proximate analysis, preservatives, consumer acceptability, protein, hedonic ranking

Introduction

Shrimp is considered a high-value seafood product and the most consumed seafood in the United States (U.S.) (Ropicki et al., 2024). To satisfy the high demand for shrimp, imports of primarily farm-raised shrimp have grown to the point of representing more than 80% of the U.S. supply (Love et al., 2020). Principal importers include countries such as Thailand (27%), China (16%), Vietnam (11%), India (9%), Ecuador (7%), and Mexico (7%) (USITC, 2023). Currently, farm-raised shrimp make up 55% of global shrimp production (Liu et al., 2021). However, this trend can affect the quality of shrimp products available in the U.S. marketplace because shrimp has a very short shelf life, and refrigeration alone is not sufficient to preserve its organoleptic

characteristics for an extended period. Shrimp are highly perishable due to their chemical-physical properties (i.e., poor collagen, high pH and moisture content, and non-protein nitrogen). Immediately after harvest, microbial and endogenous enzymes begin degradation processes, quickly leading to a loss of quality and product unacceptability, such as the development of off-flavors and loss of water-holding capacity, resulting in toughening of the shrimp (Sae-leaw et al. 2021, & Miraglia et al., 2018). To prevent quality loss, most shrimp products are frozen at least once before reaching the market. However, freezing can lead to dehydration and further loss of quality. Therefore, phosphate, a Generally Recognized as Safe (GRAS) mineral permitted by the US Food and Drug Administration (FDA), is often added to shrimp products to improve their water-holding capacity (Campton., 2012). Therefore, the goal of this project was to support the U.S. shrimp industry by providing consumers with information on the sensory and quality characteristics of shrimp raised in an aquaculture facility in the U.S., compared to imported shrimp products and wild-caught shrimp in the U.S. Additionally, the nutritional value of the shrimp products was evaluated. The U.S.-based shrimp aquaculture facility is close to the market and to end users, and its products are fresh, never frozen. In this facility, the shrimp is produced for the whole life cycle without the use of any aquaculture drug such as antibiotics (Ropicki et al., 2024). Additionally, no phosphate is added to the final shrimp products.

To achieve this goal, the supportive objectives included understanding consumers's sensory perception of these shrimp products through a sensory panel and proximate analysis of shrimp products's composition. The results revealed distinct opinions on farm-raised shrimp in the U.S., with some adoring it while others were less enthusiastic. Interestingly, consumers showed a preference for imported products that included phosphate salt as a preservative. This divergence in preferences presents an opportunity and can be leveraged to strengthen the shrimp aquaculture industry through a more comprehensive educational approach. Moreover, the proximate analysis showed that domestically farmed shrimp exhibit notably higher protein content. This finding suggests a potential marketing strategy wherein the high protein content could be promoted to appeal to individuals who prioritize protein intake in their dietary choices.

Materials and Methods

Sample Information

Four shrimp samples were used in this study including two imported farm-raised samples from India and Indonesia, one U.S. wild-caught sample, and one U.S. farm-raised sample. The imported and wild-caught samples were purchased from grocery stores whereas the U.S.-based farm-raised sample was donated by the shrimp farm. The imported and U.S. wild-caught shrimp were received frozen, while U.S. farm-raised shrimp were received fresh.

Sample Preparation

All samples were received 24 hours prior to testing. Upon receipt, samples were peeled, deveined, and stored in a commercial food-grade refrigerator at 4°C. Before sensory panel testing, shrimp were boiled in 1.5 liters of water for 2 minutes, drained, and immediately placed in an ice-bath for an additional 2 minutes. Once removed, the shrimp were placed in labeled plastic cups on ice until received by panelists for testing, as shown in Figure 1. This combination of time and temperature was critical to ensure the safety of sensory panel participants.

Figure 1. Example of sensory tray provided to the sensory panel participants.

Sensory Evaluation

The sensory study was done in the sensory kitchen of Food Science and Human Nutrition department at University of Florida (UF) following UF's Institutional Review Board approval for conducting research including human subjects. Panelists (n=103) were recruited and screened for eligibility to attend the sensory study through UF's sensory laboratory listserv. Only panelists

over 18 with no allergy to shrimp could participate. One hundred and three panelists attended the sensory panel. Although the panel was open to the public, the location and accessibility of an on-campus facility attracted a large percentage of college-age students; 49% of panelists were 18-24 years of age and 31% were 25-34 years of age.

Participants were also screened for the frequency of their seafood consumption, and only those who had consumed shrimp at least once in two months preceding the study day could participate. Additionally, information on seafood purchasing patterns, cooking methods, preferences for US-based versus imported and products with and without preservative was collected from each panelist. A draft of the ballot for the sensory study has been provided as a supplementary document. Panelists were presented with four shrimp samples in a container labeled with a unique three-digit numerical code. They were asked to indicate which sample they preferred and to rate the samples on a 1-9 hedonic scale for flavor, texture, aroma, and overall liking. Additionally, they were asked to rank the samples based on chewiness, sweetness, and firmness. The presence of off-flavors was to be identified as present or absent and panelists were asked to describe off-flavors with open-ended response. All samples were ranked in comparison to one another at the end of individual evaluation. Participants were instructed to use water and crackers as palate cleansers between shrimp samples.

Proximate Composition Analysis of Shrimp Samples

Proximate analysis including total moisture, crude protein, total fat, and ash were conducted in 6 samples using the service lab (Midwest Laboratories, Omaha, NE). Table 1 shows the methods that were used for proximate analysis.

Table 1. Methods used for the proximate and analysis of the shrimp samples.

Component	Method
Protein (Curd) (%)	AOAC 990.3
Fat (Crude) (%)	AOAC 945.02
Moisture (%)	AOAC 930.15
Ash (%)	AOAC 2003.05

Statistical Analysis

overall, appearance, aroma, texture, and flavor ratings.

Panelists were asked to rate each sample separately on a hedonic scale from 1-9 (1 = dislike extremely, 9= like extremely) based on overall liking, overall appearance liking, overall aroma liking, overall texture liking, and overall flavor liking. Two-way Analysis of Variance (ANOVA) was used as a statistical tool to analyze variance across mean values for each attribute. Tukey's HSD control was used for pairwise comparison for maximum experiment wise error rate.

scale tests: firmness JAR, chewiness, sweetness.

Samples were individually ranked on a scale from 1-5, one being much too soft, 5 being much too firm. For chewiness and sweetness, a 1-9 scale was used to rank intensity of attributes. Two-way ANOVA and Tukey's HSD were used as statistical tools to analyze data.

off-flavors.

Panelists were asked to identify if any off-flavors were present in samples with two choices of 'yes' or 'no'. 'Yes' was assigned a scale parameter value of 1.00 and 'no' was assigned a value of 2.00 for data analysis. Two-way ANOVA was used as a statistical tool to analyze variance across mean values. Tukey's HSD was used for pairwise comparison. Panelists were asked to describe off-flavors present in each sample through open-ended free response.

overall ranking.

Panelists ranked the samples in order of preference (1=most preferred, 4=least preferred) in comparison with one another. All samples were present at the time of ranking. Friedman analysis was used to analyze statistical data. Samples with higher values correlate to lower panelist ranking.

statistical analysis of proximate data.

Statistical analysis for the proximate analysis date was conducted using GraphPad prism software (La Jolla, CA, USA). One-way ANOVA was utilized to compare the proximate composition. Tukey's post-hoc test was applied to determine where the significant ($p < 0.05$) differences occurred amongst the means.

Results

Figure 2 shows the participants' (n=103) eating habits and their reasoning for consumption of shrimp. The majority of the panel participants (figure 2)indicated that they eat shrimp because they like the taste. Nutritional value and health benefits were ranked after the taste. 69% indicated that they prefer shrimp with no preservatives and 81% indicated the preference for fresh never frozen samples.

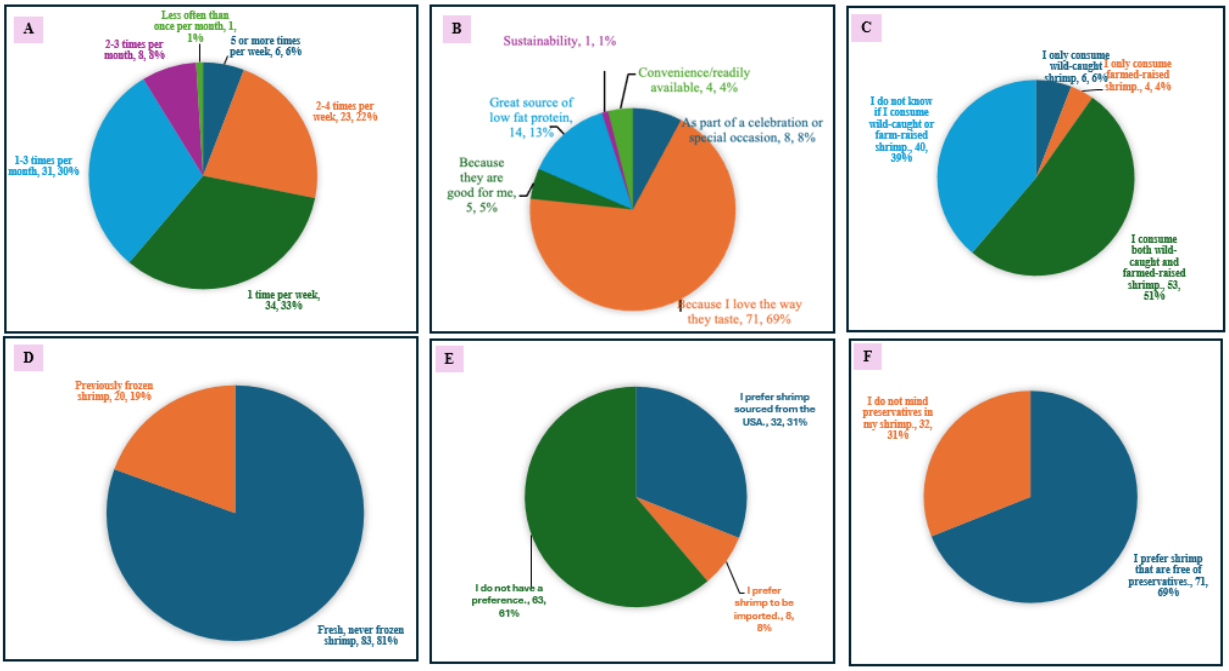

Figure 2. Sensory panelists's A) shrimp eating habits, B) reasoning for consumption of shrimp, C) preference for wild-caught versus farm-raised shrimp, D) preference for fresh versus shrimp, E) preference for local versus shrimp products, and F) preference for presence or absence of the preservatives.

Appearance, Aroma, Texture, Flavor, and Overall Favorability

Figure 3 shows the overall appearance, flavor, and texture rankings for the four shrimp samples analyzed in this study.

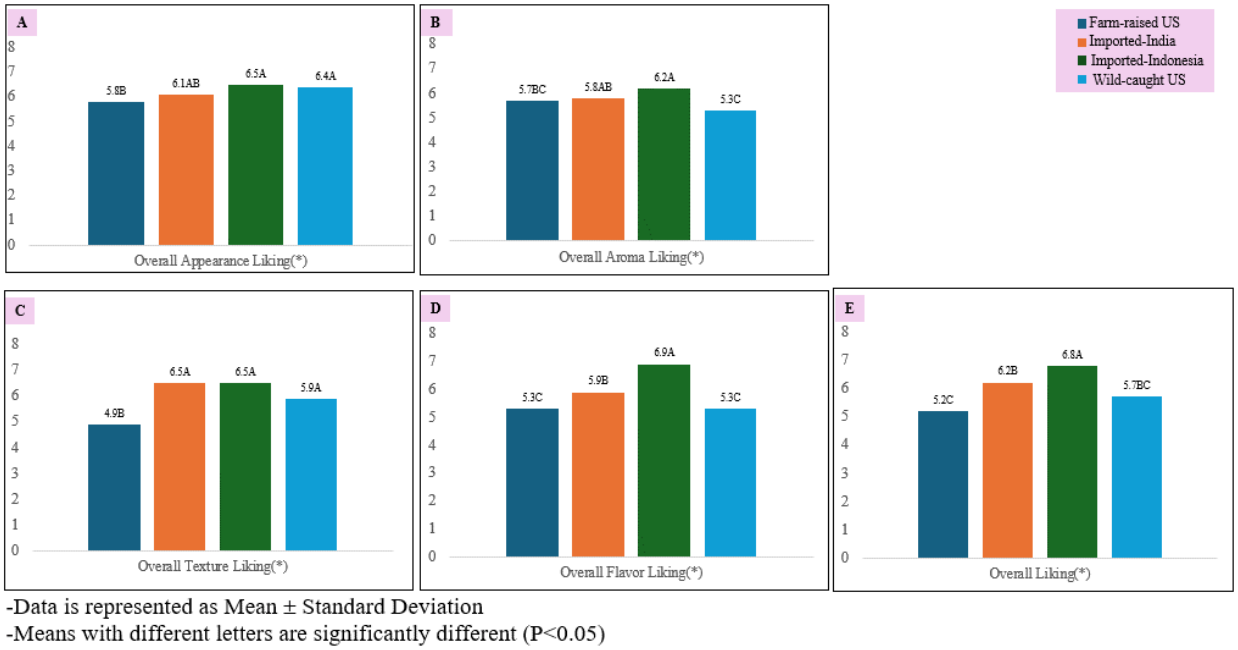

Figure 3. A) overall appearance, B) overall aroma, C) overall texture, D) overall flavor, and E) overall preference

Overall Preference

Figure 4 shows the overall ranking of the shrimp sample by sensory panelists. A higher number indicates lower ranking by the panelists, which shows both domestic farm-raised and wild-caught samples ranked significantly lower than the imported products.

Figure 4. Overall ranking of shrimp samples.

Scale tests: Sweetness, Chewiness and Firmness JAR

Figure 5 shows the sweetness and chewiness rankings of shrimp samples. The firmness JAR crosstabulation has been also provided in the same figure.

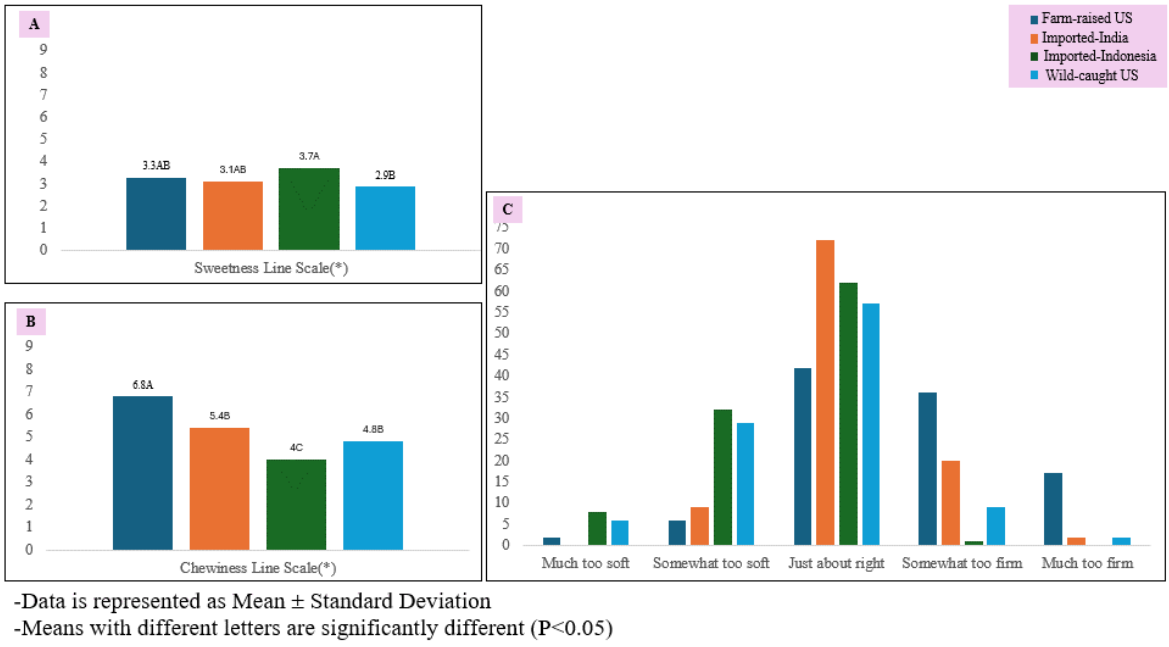

Figure 5. Shows A) sweetness, B) chewiness, and C) firmness JAR Crosstabulations

Off flavors:

The panelists described the presence of any off-flavors in an open-ended question. The responses have been provided in Table 2.

Table 2. Off flavor descriptions by sensory panel participants.

Sample	Panelists description of off-flavor
Farm-raised	Fishy, sweet, bland and dry
Imported India	Fishy, clam/crab salty, raw shrimp, and overpowering
Imported Indonesia	Acidic, metallic, and artificial
Wild-caught U.S.	Strong fishy, dirty, raw and unpleasant

Proximate analysis:

The results of proximate analysis showed that U.S. farm-raised shrimp have a significantly higher protein content than the imported and U.S. wild-caught shrimp. Additionally, imported shrimp had significantly higher moisture content than farm-raised and wild-caught shrimp. Table 3 shows the data for proximate analysis.

Table 3. Proximate Composition (%), Wet Weight Basis.

Sample	Protein	Fat	Ash	Moisture
Farm-raised	20.2 ±2.5***	0.7±0.11	1.9±0.2	76.1±0.7*

Imported	12.7± 0.7**	0.59±0.11	1.9±0.2	84.9±1.0***
Wild-caught U.S.	17.9± 0.6*	0.58±0.6	1.8±0.2	80.0±0.9**

Data is represented as Mean ± Standard Deviation, n=6
Means labelled with different numbers of asterics were significantly different ($p < 0.05$).

Discussion and Conclusion

A sensory panel and proximate analysis were conducted to better understand consumer preferences for various shrimp products in the U.S. market, aiming to refine marketing strategies and support the U.S.-based shrimp production industry. Although most sensory panel participants indicated they prefer locally-produced shrimp and shrimp products with no preservatives, the panel results indicated preference for imported shrimp products over both farmed and wild-caught U.S. shrimp. The imported products were rated higher in appearance, texture, and aroma, and were preferred to U.S. shrimp products overall. This finding is consistent with previous studies (Condrasky et al., 2005) and highlights that U.S. shrimp consumers have a preference and have developed a taste for imported shrimp containing phosphate, which is commonly used as a preservative in imported products available in the U.S. market. This can stem from the fact that imported products are the major seafood products available on the U.S. marketplace (Ropicki et al., 2024). Additionally, although the imported products were preferred by the shrimp sensory panel, there was a divide in their preference for farm-raised shrimp, with some ranking it highly while others did not like it at all. This further confirms that the sensory panel responses reflect not being as familiar with the domestic product as with the imported offerings (Condrasky et al., 2005 & Love et al., 2020).

Based on proximate analysis, U.S. farm-raised shrimp had significantly higher protein than imported and U.S. wild-caught. Protein claims can be utilized as a marketing strategy, targeting individuals mindful of protein intake. The imported samples had higher moisture content than the others, likely due to added phosphates to retain moisture for a more desirable texture.

This study shows that consumer acceptance of domestic shrimp requires significant effort, potentially achievable through robust marketing and information campaigns. These initiatives could successfully reintroduce domestic shrimp to consumers, paving the way for its positioning as a premium brand commanding higher prices. Additionally, opportunities exist in alternative marketing channels, such as restaurants, where experts recognize and appreciate the qualities of domestic shrimp. Finally, local shrimp companies should utilize marketing strategies that

highlight unique selling points such as free of chemicals, additives, or pesticides to attract consumers with a "clean label" mindset.

Future Research

Additional sensory panels should be conducted using an expert panel to develop better insight into sensory characteristics of locally-produced shrimp. Although the cooking method used in this study was validated to ensure safety of all products that were served during the panel, validating a cooking method that preserves the sensory characteristics of farm-raised shrimp while ensuring safety would be instrumental for future sensory panels to understand the organoleptic characteristics of the shrimp.

Acknowledgment

The funding for conducting the sensory panel was provided by the Florida Sea Grant Helping Aquaculture Reap Value and Enhance Student Training and University of Florida IFAS undergraduate research program.

References

Campden, B. R. I. (2012). *Review of polyphosphates as additives and testing methods for them in scallops and prawns*. *Report No. SR654*.

Condrasky, M., Vinyua, F., & Howell, D. (2005). Measuring product differences by sensory analysis: The case of imported and US domestic shrimp. *Foodservice research international, 16*(3-4), 69-85.

Erickson, M. C., Bulgarelli, M. A., Resurreccion, A. V. A., Vendetti, R. A., & Gates, K. A. (2007). Sensory differentiation of shrimp using a trained descriptive analysis panel. *LWT-Food Science and Technology, 40*(10), 1774-1783.

Liu, Z., et al. (2021). Comparison of the proximate composition and nutritional profile of byproducts and edible parts of five species of shrimp. *Foods,10*(11), 2603. https://doi.org/10.3390%2Ffoods10112603

Love, D. C., Asche, F., Conrad, Z., Young, R., Harding, J., Nussbaumer, E. M., Thorne-Lyman, A.L., & Neff, R. (2020). Food sources and expenditures for seafood in the United States. *Nutrients, 12*(6), 1810.

Miraglia, Dino, et al. (2021) Quality evaluation of shrimp (Parapenaeus longirostris) treated with phenolic extract from olive vegetation water during shelf-Life, before and after cooking. *Foods, 10*(9), 2116.

Ropicki, A., Garlock, T., Farzad, R., & Hazell, J. E. (2024). Recirculating aquaculture system-based production as a pathway to increase aquaculture in developed countries: The case of United States aquaculture. *Aquaculture Economics & Management*, 1-22.

United States International Trade Commission. (2023). *USITC Votes to Continue Investigations on Frozen Warmwater Shrimp from Ecuador, India, Indonesia, and Vietnam*. Inv. No(s). 701-TA-699-702 and 731-TA-1659-1660.

Sae-leaw, T., Benjakul, S., & Vongkamjan, K. (2018). Retardation of melanosis and quality loss of pre-cooked Pacific white shrimp using epigallocatechin gallate with the aid of ultrasound. *Food Control, 84*, 75-82.