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RESEARCH ARTICLE

Sensory Characteristics of Dried and Rehydrated Sea Urchin *Tripneustes gratilla* Roe with Different Steaming Times as Pre-Treatment

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ABSTRACT

Sea urchin roe, as raw material, is highly perishable and is usually served raw or fresh. Therefore, preserving the freshness of the raw products by maintaining good sensory characteristics, such as appearance/color, odor, flavor, texture, and general acceptability, during distribution has been a concern of local producers. Here, we evaluated the sensory characteristics of dried, rehydrated, and fresh (control) sea urchin *Tripneustes gratilla* roe under different steaming times: 1 min, 2 min, and 3 min. Roe samples were evaluated for sensory characteristics, *i.e.*, color, odor, texture, flavor, and general acceptability, by the panelists using a 3-point hedonic scale. Findings revealed that there were no significant differences ($p<0.05$) among general acceptability, texture, and flavor scores between sea urchin roes' processed forms (dried, rehydrated, and fresh) and steaming time (1, 2, and 3 min). However, in terms of color, the dried roe was significantly different ($p<0.05$) from the fresh roe but not from the rehydrated roe, while no significant change ($p<0.05$) in color was noted between different steaming times. For odor attribute, there was a significant difference ($p<0.05$) between the processed forms, where fresh roe was significantly different ($p<0.05$) from dried and rehydrated roes, but steaming time did not significantly affect ($p>0.05$) the roes' odor. This study suggests that steaming for 1-3 min as pre-treatment for dried, rehydrated, and fresh sea urchin *T. gratilla* roe generally renders good sensory attributes. It also indicates that drying and rehydration of steamed sea urchin roe could be used as preservation techniques for a fragile and perishable sea urchin *T. gratilla* roe. However, further analyses are needed, particularly on the shelf-life and proximate and microbial analyses.

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Introduction

Any techniques or processes employed for aquatic products' post-harvest handling, processing, and marketing from harvest time to final utilization refer to fish processing technology. The ultimate objective of applying processing technology to fishery products is to prevent or delay spoilage caused by enzymes, microorganisms, and physical or mechanical means (Espejo-Hermes, 1998). Among the fish processing technologies traditionally practiced worldwide is drying, which simply refers to the removal of any water or moisture content from the fishery products (Tahiluddin & Kadak, 2022). Drying can be efficient through evaporation or other methods like using absorbent pads or pressure and by adding salt (Wheaton & Lawson, 1985). Dehydrated products readily take up moisture when immersed in a liquid medium,

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causing a huge in their thermophysical properties. Rehydration kinetics as well as the equilibrium moisture content of significant alterations in rehydrated products mainly influenced by the water temperature (Krokida & Philippopoulos, 2005).

Sea urchin roe is a highly valued culinary delicacy worldwide, especially in Asia, North America, Chile, and European countries, accounting for nearly 90% of the global demand (Sun & Chiang, 2015). In Japan, the consumption of sea urchin roe was only confined among the coastal villagers; however, with the introduction of technologies like refrigerated transportation, it is now predominantly available to many populace (Unuma et al., 2015). In the Philippines, the diversity of sea urchins is high, with 210 species recorded (Mooi & Munguia, 2011). There are three species commonly harvested from the wild for consumption; these are *T. gratilla, Diadema* spp., and *Salmacis* spp., and sea urchin fishery provides livelihood to many Filipinos living in the coastal areas (Nievales et al., 2006). Due to its increasing demand, the cultivation of sea urchin *T. gratilla* has been successfully tested in cages (Manuel et al., 2013).

Sea urchin roe is highly perishable and is usually served raw or fresh (Baião et al., 2021; Verachia et al., 2022). Preserving the freshness of the raw product during distribution has been a concern of local producers. This problem does not only have impacts on the availability of the product in the market. It also limits the reach of the distribution. What is more damaging to the industry is the product's highly perishable in nature, which may lead to post-harvest losses despite the high demand for the product. Processing of sea urchin roe is not widely practiced in the Philippines. The use of traditional fish processing techniques, such as salting, is the only common method of preserving sea urchins (Tahiluddin & Kadak, 2022), and the procedure of making salted sea urchins has been elaborated by Espejo-Hermes (1998). Since the early 1980s, there has been a great international demand for brined sea urchin roe (McManus et al., 1991), indicating that brining was also a predominant method of preservation in exporting the sea urchin roe. Due to the limited processing techniques of sea urchin roe, the authors were inspired to investigate the potentials of drying and rehydration processes with different steaming times (1, 2, and 3 min) as pre-treatment to sea urchin *T. gratilla* roe, and evaluated their sensory characteristics, *i.e.*, color, odor, texture, flavor, and general acceptability.

Materials and Methods

Raw Materials

The sea urchins (*T. gratilla*) were procured from an identified supplier. The raw materials were transported immediately to the Post-Harvest Laboratory of the College of Fisheries, Mindanao State University-Tawi-Tawi College of Technology and Oceanography, Sanga-Sanga, Bongao, Tawi-Tawi, Philippines. Upon arrival, the raw materials were cleansed with sea water, stripped off foreign materials, and damaged and small sea urchins were removed.

Roe (Gonad) Collection

The sea urchins were washed, and the shell (test) was opened into halves by cracking along the ambulacral area using a knife. Next, the digestive system and gut content were dislodged by making an abrupt downward swing of the arm holding the sea urchin. Afterward, the entrails were removed using forceps.

Steaming of Roes

The cleaned sea urchins with attached roes were steamed in batches (Table 1). After steaming, the roes were scraped off from their test with a rubber spatula.

Table 1. Pre-treatments according to the batch of roe samples.

Batch	Pre-treatment
A	Steaming for 1 min before scraping off the roe.
B	Steaming for 2 min before scraping off the roe.
C	Steaming for 3 min before scraping off the roe.

Drying of the Roe Samples

After steaming, roe samples were weighed, placed into drying trays, and dried using the solar dryer at a temperature of around 40 °C for three days.

Rehydration of Roe Samples

The dried roes were rehydrated by soaking them in water. Rehydration was done until the gonad was within 80% of its original/initial wet weight. The observation was done at 30 min intervals. To monitor rehydration rate, the samples were placed in a weighed and cleaned muslin cloth before soaking in water. Before every weighing, the cloth and the roe were drained for 5 min. Rehydration time was recorded.

Sensory Evaluation of Roe Samples

All dried, rehydrated, and fresh roe samples were evaluated by ten panelists. Sensory characteristics, *i.e.*, color, odor, texture, flavor, and general acceptability of the products, were observed properly and evaluated using the 3-point hedonic scale, ranging from orange (score: 1) to greenish brown (score: 3) for color, fishy (score: 1) to aromatic (score: 3) for odor, soft (score: 1) to firm (score: 3) for texture, salty (score: 1) to sweet (score: 3) for flavor, and not acceptable (score: 1) to highly acceptable (score: 3) for general acceptability.

Statistical Analysis

The data on the sensory characteristics were analyzed using IBM SPSS version 20. Significant differences and possible interactions among the processing methods (drying, rehydrating, and unprocessed or fresh samples) and steaming time (1, 2, and 3 min) were determined using a two-way

analysis of variance (ANOVA). The data are presented here as mean±SE. Significant differences in the mean were set to $p<0.05$.

Results

The sensory attributes of sea urchin roes in different forms, such as fresh, dried, and rehydrated, are shown in Figures 1, 2, 3, 4, and 5. In terms of their general acceptability, fresh roes steamed for 3 min gave the high mean (2.25±0.49), followed by the roes steamed for 2 min (2.2±0.42) and 1 min (2.05±0.37). The same order for the general acceptability was also observed for the dried and rehydrated roes, in which steamed roes for 3 min gave a high mean (2.15±0.24, 2.25±0.39), followed by the roes steamed for 2 min (2.0±0.28, 2.1±0.21) and 1min (2.0±0.28, 2.1±0.46), respectively (Figure 1). However, two-way ANOVA revealed that there was no significant difference in sea urchin roes between different forms (dried, rehydrated, and fresh) and steaming time (1, 2, and 3 min).

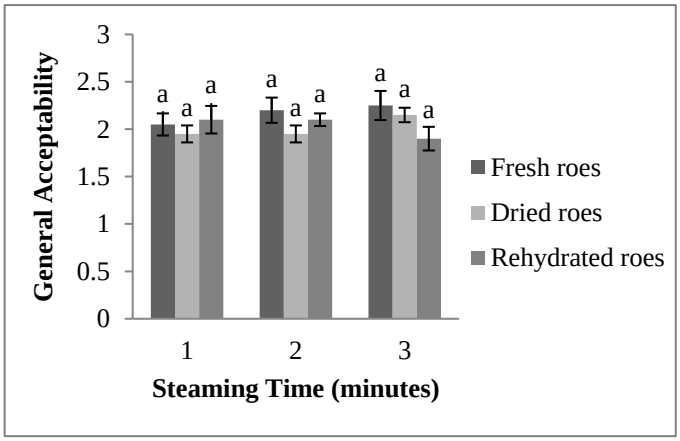

Figure 1. General acceptability of fresh, dried, and rehydrated sea urchin roes at three different steaming times. Scale: 3=Highly acceptable, 2=Acceptable, and 1=Not acceptable.

The color attributes of the sea urchin roes steamed for 1, 2, and 3 min in the fresh form showed that the roes steamed for 2 min obtained the highest score (1.9±0.88), followed by 3 min (1.7±0.48) and 1 min (1.55±0.44) with only slight difference. The value represents the yellow color of the roes. However, for the dried form, roes steamed for 3 min gave a high mean (1±0.62), followed by the roes steamed in 2 min (0.95±0.83) and 1 min (0.95±0.64), indicating that the color of roes in dried form was much darker than the fresh one and the value represents the orange color. The same order was also observed in the rehydrated form, where the roes steamed for 3 min gave a high mean (1.45±0.99), followed by the roes steamed for 2 min (1.15±0.78) and 1 min (1.05±0.80), the values represent the orange to yellowish color of the rehydrated roes (Figure 2). Statistical analysis using two-way ANOVA revealed that there was no significant difference between the different steaming times (1, 2, and 3 min). However, a significant difference was detected in terms of processed form, where fresh roe was significantly different ($p<0.05$) from dried and rehydrated roes.

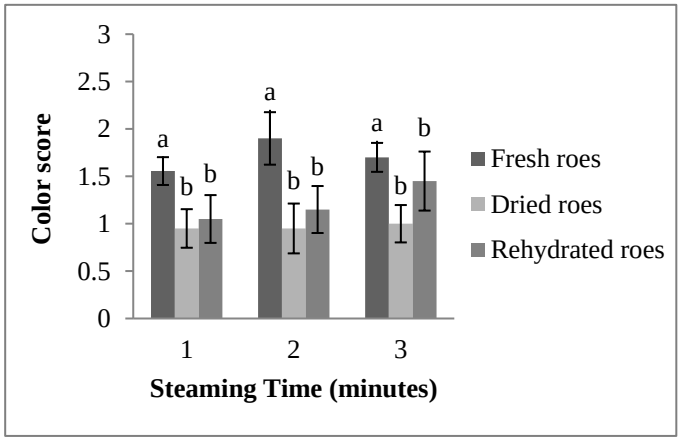

Figure 2. Color score of fresh, dried, and rehydrated sea urchin roes at three different steaming time. Scale: 3=Greenish brown, 2=Yellow, 1=Orange.

The odor/aroma of the sea urchin roes was also evaluated, and the results showed that fresh roe steamed for 3 min obtained the highest score (1.6±0.84), followed by the roe steamed in 1 min (1.4±0.568) and 2 min (1.35±0.67). However, for the roes in dried form, it gave the highest mean at roes steamed for 3 min (2±0.527), indicating a rancid odor, followed by the roes steamed for 2 min (1.95±0.55) and 1 min (1.8±0.59) indicates the fishy to rancid odor. Whereas, for the rehydrated form, roes steamed for 3 min gave a high mean (1.75±0.68), followed by the roes steamed for 1 min (1.65±0.54) and 2 min (1.6±0.74), which indicates a fishy to slight rancid odor (Figure 3). When analyzed statistically using two-way ANOVA between the processed forms and steaming, the results revealed that the odor of dried roes was significantly different ($p<0.05$) from the fresh roes but not from the rehydrated roes. However, there were no significant changes of color ($p<0.05$) using different steaming times.

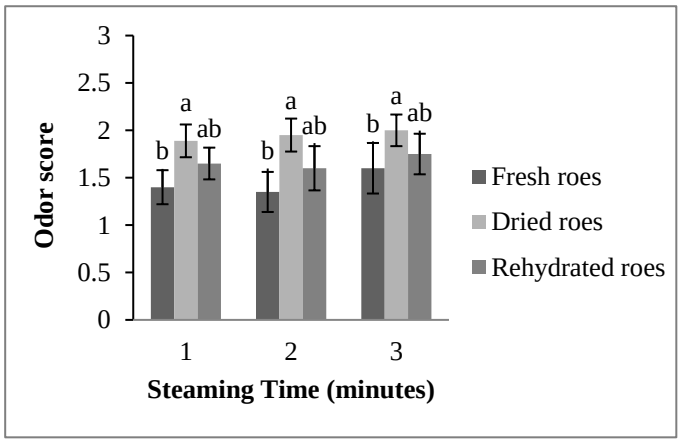

Figure 3. Odor score of fresh, dried, and rehydrated sea urchin roes at three different steaming times. Scale: 3=Aromatic, 2=Rancid, 1=Fishy.

As for the texture, fresh roes steamed for 3 and 1 min obtained the highest mean (1.85±0.53, 1.85±0.75), respectively, followed by roes steamed for 2 min (1.8±0.79), indicating a smooth and soft texture. In dried form, roes steamed for 1 min gave a high mean for texture (1.6±0.84), followed by the roes steamed in 3 min (1.55±0.60) and 2 min (1.5±0.78), the results are slightly varied, and the score indicates a firm to crisp texture. As for rehydrated roes steamed for 3 min, it gave a high mean for texture (1.9±0.394), followed by the roes steamed for 2 min (1.95±0.55) and 1 min (1.6±0.843), that indicates a clammy texture (Figure 4). However, there was no statistical difference ($p>0.05$) between the processed forms and the steaming time.

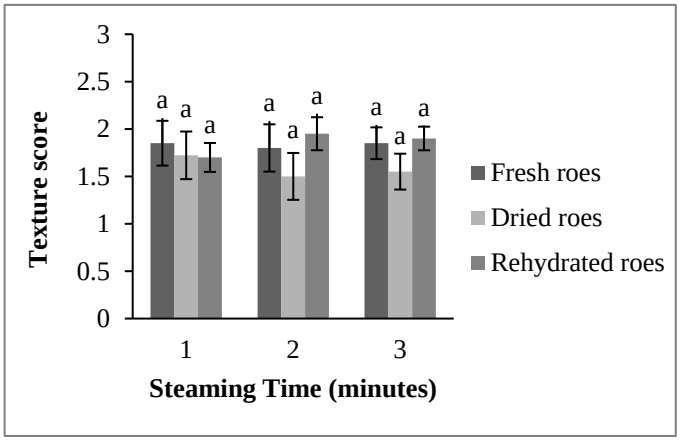

Figure 4. Texture score of fresh, dried, and rehydrated sea urchin roes at three different steaming times. Scale: 3=Firm, 2=Clammy, 1=Soft.

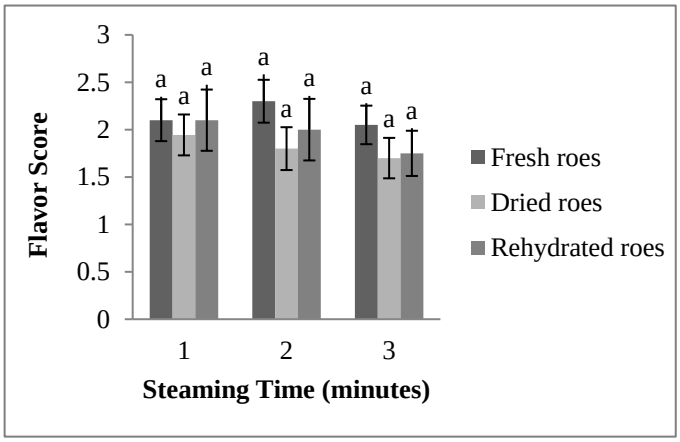

Figure 5. Flavor score of fresh, dried, and rehydrated sea urchin roes at three different steaming times. Scale: 3=Sweet, 2=Bitter, 1=Salty.

Lastly, for the flavor attributes, the fresh roes steamed for 2 min gave a high mean (2.3±0.715), followed by the roes steamed in 1 min (2.1±0.70) and 3 min (2.05±0.64), indicating the bitter-sweet flavor. However, the dried roes steamed for 1 min gave a high mean (1.85±0.71), followed by the roes steamed in 2mins (1.8±0.72) and 3mins (1.7±0.68), representing a salty-bitter taste. Whereas rehydrated roes steamed for 1 min gave a high mean (2.1±1.02), followed by the roes steamed in 2 min (2±1.03) and 3 min (1.75±0.76), which gave a bit of salty-bitter flavor (Figure 5). Analysis using two-way ANOVA revealed no significant differences ($p>0.05$) between the steaming time and the different processed forms.

Discussion

Sea urchins, such as *T. gratilla,* are abundant and widely consumed in the Philippines (Regalado et al., 2010). Sea urchin roes are a highly demanded food product and are considered a delicacy by consumers in several parts of the world (Kalogeropoulos et al., 2012), especially in the place of Tawi-Tawi. They are widely available and consumed mostly every day but are generally available during the Ramadan season (Mawallil, 2022). Locals have been consuming the sea urchin roes directly as an appetizer, part of their meal, and even during beach picnics. Sea urchins can be easily collected and can be directly eaten as raw or cooked with rice inside their shells (Lawrence, 2001). However, because the roes of the sea urchin are sensitive and perishable in nature caused by the effects of different factors such as time, temperature, and others, thus maintaining the quality of the roes is one of the most challenging tasks to perform (Chinprahast et al., 2013). Hence, this study was realized to add the time factor for the overall keeping quality of the roes by evaluating the different steaming times as well as the drying and rehydration processes.

Sensory evaluation is a common and widely used method for the evaluation of different food products in terms of their sensory attributes, which are perceived by human. The results of the sensory evaluation represent the consumer's interpretation of the products to better understand the human's perceptions of the product itself (Stone et al., 2020). The quality of the sea urchin roe greatly depends on sensory characteristics, such as color, texture, appearance, size, and taste, that are affected by seasonal harvesting and vary according to species exhibiting various attributes (Verachia et al., 2022). The sensory evaluation for all forms of sea urchin roes assessed in this study revealed that the aforementioned sensory attributes, particularly the appearance/color and odor, had a significant impact on the overall acceptance of the sea urchin roes. Prior to consumption, customers' expectations are formed and primed by the product's general appearance and color and when the product's taste, odor, and flavor are not accurately represented by the visual representation, the perception of "like" is lower than what was anticipated, which is known as a disconfirmation of expectations (Fiorentini et al., 2020). Thus, in order to influence how consumers perceive food products, overall appearance and other sensory attributes must be taken into account.

Furthermore, the sensory attributes of sea urchin roes might also be affected by the pre-treatment used and different methods of processing employed, whether positive or negative

effects, such as what happened to some food products (Speranza et al., 2021). In the study of Shimada et al. (1993), they steamed the roes to inactive the enzymes to which the microbial growth may be lessened. Also, in fish preservation, heat is among the important methods to lengthen the product's shelf-life (Skipnes, 2014). In this study, the pre-treatment employed, such as the steaming time for the sea urchin roes, is proven to have a general positive impact on the sensory characteristics of the sea urchin roes as well as the different processing methods, such as fresh, dried, and rehydrated roes. Although, the pre-treatment used in this study, such as the different steaming times, showed no significant difference between the 1, 2, and 3 min of steaming. However, it still showed the positive effects of the pre-treatment because the steaming time for 3 min obtained the highest acceptability for all the forms (such as fresh, dried, and rehydrated) of roes evaluated. In addition, it was also observed that by employing the pre-treatment, the roes of the sea urchins became slightly firm in fresh form after steaming as compared to the fresh roes without steaming, which can easily be melted or liquefies which was observed by scooping the roe from its shells. The steamed roes were easily scooped, and roes remained intact as one compared to not steamed roes indicating that steaming could provide a good roe product for the fisheries food industry. When sea urchin roes were dried and/or rehydrated after steaming, the general acceptability was similar to those fresh steamed roes. This suggests that after drying the roes of the sea urchin, it can be rehydrated again and can be served without further cooking.

Conclusion

In conclusion, sensory characteristics, *i.e.*, general acceptability, texture, and flavor, of sea urchin roes did not affect by steaming time and type of processing. However, color and odor attributes were influenced by drying and rehydration processes, but did not influence by steaming time. This study highlights the application of steaming for 1-3 min as pre-treatment to obtain general good sensory attributes of fresh, dried, and rehydrated sea urchin roes. It likewise indicates that drying and rehydration processes could provide preservation of sea urchin roe, a perishable and fragile fishery product. However, the shelf-life and proximate and microbial analyses of sea urchin roes subjected to these processes need further evaluation.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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