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RESEARCH ARTICLE

Quality Assessment of Processed Sandfish (*Holothuria scabra*) Using Papaya Leaves to Remove its Hard Spiculy Layer

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ABSTRACT

The presence of chalky deposits or hard outer covering and extraneous matter are some reasons for product downgrading of dried sandfish, *Holothuria scabra*, locally known as *balat* or *balatan*. Various amounts of fresh papaya leaves, namely, 50, 75, 100, 150, and 200 grams, were used to test its effectiveness in removing the hard spiculy layer on cooked sandfish and assessing its product quality. Results showed that using 75 grams of papaya leaves with 80 minutes of brushing time was found to be effective as 71-85% of the hard spiculy layer was removed. The final products' colors were black to brown, no off-odor or decomposition detected, with a hard texture and completely dried product. The mean water activity (Aw) was 0.787, an amount within the range of 0.80-0.60 for dried foods, and the mean moisture content was 4.31%, which is far below the acceptable limit of 15% for dried sea cucumber. In addition, the dried sandfish had 69.5% protein, 1.42% fat, 1.88% total carbohydrates, and 298 kcal food energy. The study was conducted on a laboratory scale only, and commercialization should be carried out.

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1. INTRODUCTION

Processing of dried sea cucumber, commonly called *beche-de-mer, trepang, balat*, or *balatan* has been practiced in the Philippines for centuries (Schoppe 2000; Akamine 2002; Choo 2004) and exists in more than 60 coastal communities (Labe et al. 2007). At present, there are about 200 species of sea cucumber in the country, of which 40 are documented to have commercial value (Juinio-Meñez and Samonte 2016). Balat or balatan processing was developed as an export-oriented commodity. Since 1983, the country has maintained a 1000-ton export level (Akamine 2002), making it the second major producer and exporter of *balat* or *balatan* in the world (Conand and Byrne 1993; Akamine 2002; Ferdouse 2004).

Sea cucumber of the Family *Holothuriidae* and *Stichopodidae* are among the most commercially exploited aquatic species in Southeast Asia, given the increasing demand for their processed form in the international market (Choo 2008; Alejandro 2019). *Holothuria scabra* is one of the species with the highest commercial value (Conand and Byrne 1993; Schoppe 2000; Akamine 2002). It possesses microscopic ossicles formed within multinucleated syncytial sclerocytes present in the body wall's dermal layer (Stricker 1986), making the outer covering hard and turgid (Imsiecke et al. 1995), thus difficult to remove during the processing of dried sandfish. These chalky deposits or hard outer cover and extraneous matter are some of the reasons for product downgrading of dried sea cucumber (BAFPS 2013). Tiensongrusmee and Pontjoprawiro (1998) discussed the mechanism of traditional burying of sandfish in the sand; however, this issue necessitates processors to use various tools in the brushing step, such as papaya leaves.

Ground papaya leaves are used to remove the 'chalky spicules' of sea cucumbers (Choo 2004; Rasolofonirina et al. 2004) because of the enzyme papain. Papain (EC 3.4.22.2) is an endocytic plant cysteine protease acquired from the latex of the papaya (*Carica papaya*) (Amri and Mamboya 2012). In Malaysia, papaya leaves were added in the boiling process to soften sea cucumber skin (Choo 2004). The use of papaya leaves in processing sea cucumber is not time-consuming, makes the task easier, reduces the necessary workload, and demands delicate care for the long-acting papain may destroy the integument's structure (Lavitra et al. 2008). Utilizing papaya leaves and fruit in sandfish processing has been observed not only in the Philippines (Brown et al. 2010; Gajelan-Samson et al. 2011) but also in countries like Indonesia (Peranginangin et al. 1994), Malaysia (Choo 2004; Choo 2012), and Madagascar (Rasolofonirina et al. 2004; Lavitra 2008), among others. On the other hand, the amount of papaya leaves to be used in processing dried sea cucumber was not yet recorded.

This study was conducted to determine the effectiveness of papaya leaves in removing the hard spiculy layer of *H. scabra*, the amount to be used, and the time needed to remove the hard outer layer or covering effectively. Moreover, the study focused on evaluating the product's quality in terms of its nutritional value, moisture content, and sensory characteristics.

2. MATERIALS AND METHODS

The interrelated steps involved in producing processed sandfish or *balat/balatan* recommended by the South Pacific Commission (1994) were adopted, and some modifications were done. Standard brushing tools by local processors such as knives, bivalve shells, steel and plastic brushes, and wools were used. The commercial scrubbing pad made of synthetic fibers, abrasives, and resin was found to be the most effective tool in removing the hard outer layer of the sea cucumber but using this material will result in added cost on processors. In this study, papaya leaves were used as the brushing material, and the commercial scrubbing pad served as the control.

2.1 Collection of raw materials

Live sandfish (*Holothuria scabra*) (n= 300) ranging from 250–500 g were purchased from a supplier in the Municipality of Anda, Province of Pangasinan in the Philippines. The raw materials were picked up in the Regional Field Office of the Bureau of Fisheries and Aquatic Resources (BFAR) in Alaminos City, Pangasinan. Live samples of sandfish were placed in high-density polyethylene (HDPE) containers with seawater and were transported to a processing laboratory in the National Integrated Fisheries Technology Development Center (NIFTDC) of BFAR in Dagupan City, Pangasinan.

2.2 Processing of the raw materials into *balat/balatan*

2.2.1 Preparation of the samples.

The live animals were laid straight in a single layer on flat aluminum trays for 10–20 minutes to allow them to straighten themselves and expel the seawater and the sand. The animals were weighed and measured individually. (Figure 2)

2.2.2 Slitting and gutting.

The animals were slitted from 1.0 to 1.5 cm in the anus (posterior end) using a sharp knife. They were allowed to self-eviscerate. The guts or viscera and remaining water were removed by pressing the body. However, the animals that self-eviscerated during transport were inspected for damage in the bodies. The injured animals were removed.

2.2.3 First cooking phase.

Clean seawater was placed in a cooking vat just enough to cover the animals to be cooked. The gutted animals were placed and stirred gently when the water just started to simmer (60–70 °C). The sandfish were then cooked for 60 minutes at simmering temperature (90–95 °C) while being stirred gently and regularly. After cooking, they were transferred to a basin with clean tap water to cool the animals to 40 °C. The cooled boiled animals were divided into lots for the brushing step.

2.2.4 Brushing with fresh papaya leaves.

The animals were brushed with various amounts of papaya leaves in order to remove the hard outer layer containing the spicules. A series of experimental trials were conducted, and eliminations were carried out until the optimum amount of papaya leaves and the optimum time to remove the hard outer layer were obtained.

Different amounts of fresh papaya leaves (50 g, 75 g, 100 g, 150 g, and 200 g) were used to brush or remove the hard outer layer of a one kilogram of cooked sandfish (Figure 1). The weight of one piece, mature papaya leaf was 50 g. After sensory evaluation, the elimination of variables and subsequent trials were conducted using 75 g papaya leaves in 60 min, 80 min, 100 min, and 120 min brushing time.

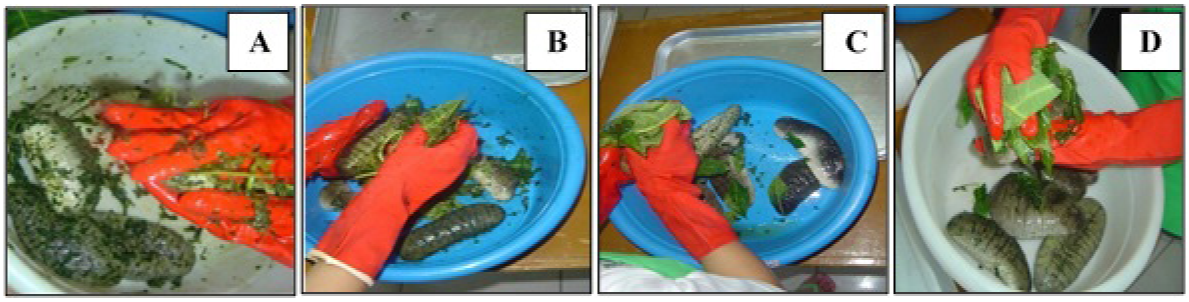

Figure 1. Various amounts of fresh papaya leaves: 50 g (A), 75 g (B), 100 g (C), 150 g (D) and 200 g used in removing the hard outer layer of the uncooked sandfish (*Holothuria scabra*).

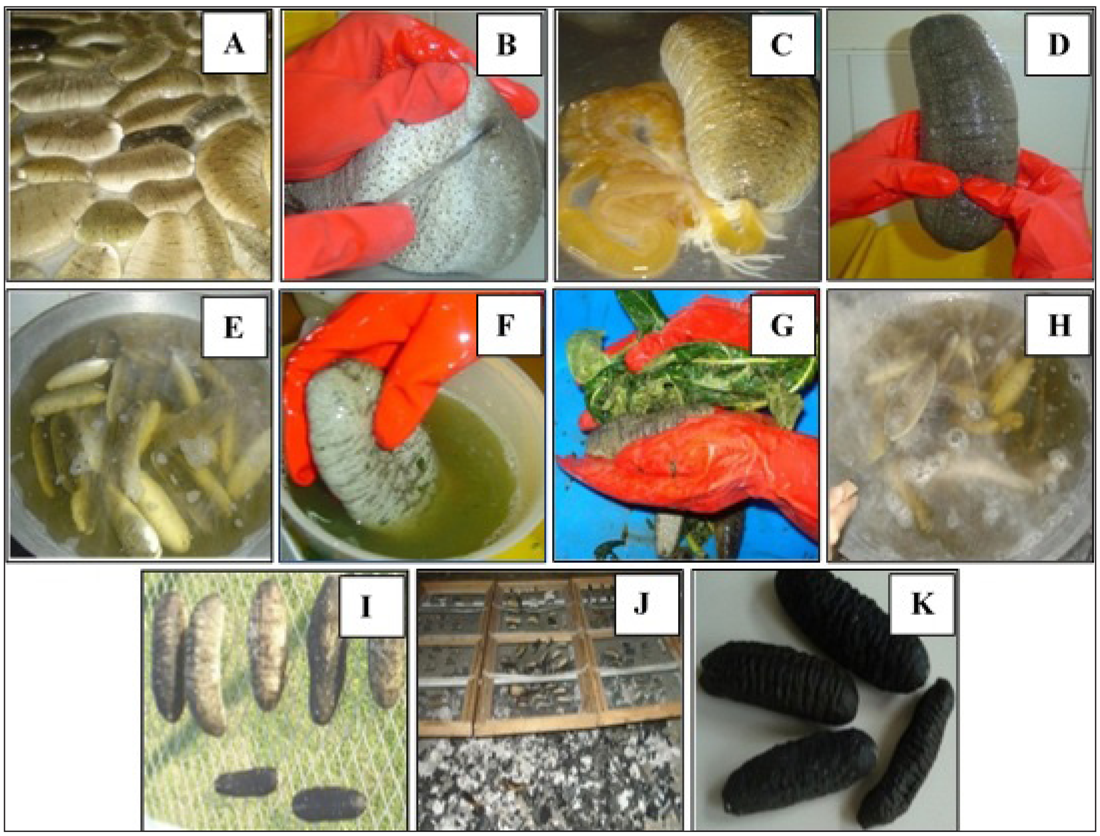

Figure 2. Processing sandfish, *H. scabra* into *balat / balatan* using papaya leaves A) laying on flat surface, B) slitting, C) self-evisceration, D) gutting, E) first cooking, F) brushing with papaya leaves, G) washing, H) second cooking, I) sun drying, J) fire/ smoke drying and K) *balat/ balatan*.

2.2.5 Second cooking phase.

The brushed animals were cooked again, this time in clean tap water at temperatures ranging from 97–99 °C for 60 minutes while being stirred continuously. After cooking, they were transferred to a deep container with clean tap water to cool.

2.2.6 Inspection.

The samples were inspected or checked for the presence of the remaining outer layer and were brushed again for 10 minutes. They were washed and drained ready for drying.

2.2.7 Drying.

The drained cooked animals were laid in a single layer in wire mesh trays. They were sun-dried during daytime and fire or smoke-dried using charcoal during nighttime. The animals were turned over from time to time to speed the drying process. Sun-drying and fire or smoke drying were done within 72 hours, after which the sandfish became hard.

2.2.8 Storage.

The dried products were wrapped in paper and placed inside polyethylene (PE) bags. They were transported to the National Fisheries Research and Development Institute (NFRDI) laboratory and were dried further under the sun until they were completely dried or are "stone-hard." The dried products were stored at ambient temperature for analysis.

2.3 Quality assessment of the processed *balat/balatan*

2.3.1 Proximate/Nutritional composition.

The dried sandfish were analyzed for proximate or nutritional composition, namely fat, protein, total carbohydrate, and food energy, using the procedures of the Official Methods of Analysis of the Association of Official and Analytical Chemists (AOAC 2005).

2.3.2 Chemical analyses: Water activity (Aw) and Moisture content.

The dried products were crushed and analyzed for water activity (Aw), using the water activity meter Novasina® Aw1 Set and moisture content using the moisture analyzer KERN® MLB 50-3N.

2.3.3 Sensory evaluation.

The dried samples were placed in white plates with numerical codes. A panel of evaluators (composed of seven trained panelists) was asked to assess the samples according to the descriptive score sheet parameters. The descriptive score sheet was modified from the South Pacific Commission's (1994) Descriptive Score sheet for *Balat/Balatan*. The panelists assessed the products' quality attributes such as (a) percentage of the hard outer layer that has been removed, (b) shape, (c) odor, (d) color, (e) texture, (f) slit, and (g) presence or absence of sand and filth. The average of the scores was noted for each parameter.

3. RESULTS AND DISCUSSION

3.1 Proximate/nutritional composition

The proximate/nutritional composition of dried sandfish produced during the study on assessment of practices and methods for sea cucumbers is given in Table 1. Dried sandfish processed with papaya leaves has 69.5% protein, 1.42% fat, 1.88% total carbohydrates, and food energy of 298 kcal/100 g.

Proteins make up the bulk of the flesh of sea cucumbers or trepangs (Ram et al. 2017). In this study, a high protein value was found on the dried sandfish sample, which is 69.5%. This result is comparable with and higher than most of the data provided by many scientific papers with respect to protein ratio results. Ibrahim et al. (2015) found processed *H. scabra* to have the highest protein content than *H. atra* and *A. echinites* having a percentage of about 60.40%. Nishanthan et al. (2018), on the other hand, reported a value of 42.7% and 49.84% protein for domestic and industrially processed *H. scabra* in Sri Lanka, while Razafindratovo Andriamanamisata and Telesphore (2019) reported a 46% crude protein on air-dried *H. scabra*. Sroyraya et al. (2017) found a ratio of 22.50%

Table 1. Proximate/nutritional composition of dried sandfish, *H. scabra*

Sample	Ash (%)	Fat (%)	Protein (%)	Total Carbohydrates (%)	Food energy (kcal/100g)
Traditionally processed dried sandfish, *H. scabra*	-	1.42	69.5	1.88	298

protein in the whole body of a freeze-dried *H. scabra* and 55.18% for the body wall. Bordbar et al. (2011) reported that processed sea cucumbers stand out as a rich protein source among most seafood products, to which Chen et al. (2011) claimed that the fully dried sea cucumber may reach up to 83% protein.

Fresh sea cucumbers, including *H. scabra*, have high protein and low fat contents and carbohydrate levels similar to those of protein. The carbohydrate level of processed *H. scabra* was 2.63% in the study conducted by Ram et al. (2017), relatively higher than the carbohydrate content of the product produced from this study. The total fat in processed dried sandfish was found to be 1.26% compared with a range of 0.3–9.9% in other sea cucumber species. Other fat contents noted for processed sea cucumber were 1.03% from Kilo Tammania area (Ibrahim et al. 2015) and 1.96–2.7% in Sri Lanka (Nishanthan et al. 2018). These values agree with Ibrahim et al.'s (2015) report that *H. scabra* has a generally low fat content. The lipids of processed sandfish contain essential fatty acids, including polyunsaturated fatty acids (PUFA), which are considered vital for human well-being. Nishanthan et al. (2018) also reported the fatty acids found in several processed sea cucumbers.

3.2 Chemical analyses: Water activity (Aw) and moisture content

Water activity (Aw) is the amount of water available for microbiological, chemical, and enzymatic reactions (Safefood 360 2014).

The Aw and moisture content of the dried sandfish were analyzed, and the results are shown in Table 2. The dried sandfish brushed using 50 g papaya leaves were found to have the lowest Aw but showed no significant difference with the dried sandfish brushed with other amounts of papaya leaves. Accordingly, the mean Aw was 0.787, an amount within the range of 0.80–0.60 for dried foods. Products with lower Aw are more microbiologically stable and consequently have a longer shelf life. Though all dried sandfish produced with different brushing times were found to be low in Aw, brushing with 75 g of papaya leaves for 100 minutes resulted in having the lowest Aw.

The average moisture content was 4.31%, far lower than the acceptable limit of 15% moisture content requirement for dried sea cucumber (BAFPS 2013).

3.3 Sensory evaluation

There were substantial shrinkage and weight loss in all stages of processing. The dried products' final weight was only recorded when "stone-hard" and was 5.21% of the original weight.

The use of papaya leaves in improving the quality of the dried sandfish has been practiced for years. Because the *H. scabra's* body wall is gritty to the touch (Massin et al. 2009), the sandy wall has to be scrubbed after its initial boiling, and others boiled it with papaya (*Carica papaya*) fruit to soften and smoothen its texture, thereby improving the quality (Gajelan-Samson et al. 2011).

Common grading characteristics used in assessing the quality of *H. scabra* products require that the body must be straight or slightly bent, has a large number of grooves around their body, and no smoky smell. The color of the upper side must be brown-black to black, and the underside is greyish brown (South Pacific Commission 1994).

In this study, sensory evaluation scores for sandfish quality attributes dried for six days are presented in Tables 3 and 4. In terms of color, the samples brushed with 100 g papaya leaves have the highest score; but both samples that used 100 g and 75 g were assessed to be black on the upper side and black to brown-black on the underside. Samples

Table 2. Water activity (A_w) and moisture content of dried sandfish, *H. scabra*

Amount of papaya leaves	**Water Activity (A_w)**	**Moisture content (%)**
50g	0.70	4.857
75g	0.80	4.877
100g	0.75	4.045
Brushing time	**Water Activity (A_w)**	**Moisture content (%)**
75g / 60 min	0.85	4.021
75g / 80 min	0.82	4.089
75g / 100 min	0.74	4.024
75g / 120 min	0.81	4.247

Table 3. Mean sensory scores for the quality attributes of dried sandfish using different amounts of papaya leaves in removing the hard spiculy cover

Quality attribute	Amount of papaya leaves (g)			
	Control	50	75	100
Color	4.44	4.15	4.84	4.99
Odor	4.38	4.82	4.82	4.82
Appearance	4.68	2.37	4.21	4.57
Texture	4.93	5.00	5.00	5.00

Numerical scoring scale modified from the South Pacific Commission (1994) for:

Color: 5 = Upperside: Black; Underside: Black to Brown-black, 4 = Upperside: Black to Brown-black; Underside: Brown, 3 = Upperside: Brown to Grayish-brown; Underside: Grayish-brown, 2 = Upperside: Upperside: Gray to Grayish-white; Underside: Gray to Grayish white, 1 = Upperside: White; Underside: White
Odor: 5 = No smoke odor to slight smoke odor / No off odor (odor of decomposition), 4 = Moderate smoke odor / No off odor (odor of decomposition), 3 = Severe smoke odor / No off odor (odor of decomposition), 2 = Slight off-odor, 1 = Moderate to severe off odor
Appearance: 5 = Outer spiculy layer removed (86-100 %), 4 = Outer spiculy layer moderately removed (71-85 %), 3 = Outer spiculy layer fairly removed (56-70 %), 2 = Outer spiculy layer slightly/poorly removed (41-55 %), 1 = Outer spiculy layer not removed at all (lower than 40 %)
Texture: 5 = Very hard and completely dry (stone dry), 4 = Hard but not completely dry (moist on both ends), 3 = Slightly hard; rubbery and elastic (moist inside), 2 = Elastic, flexible and slightly moist, 1 = Soft and moist

Table 4. Mean sensory scores of dried sandfish washed with 75 g papaya leaves at varying brushing time lengths

Quality attribute	Length of brushing (mins)			
	60	80	100	120
Color	4.3	4.5	4.4	4.4
Odor	3.9	4.0	4.0	4.0
Appearance	2.0	4.5	4.5	4.9
Texture	4.1	4.7	4.7	4.6

Numerical scoring scale modified from the South Pacific Commission (1994) for:

Color: 5 = Upperside: Black; Underside: Black to Brown-black, 4 = Upperside: Black to Brown-black; Underside: Brown, 3 = Upperside: Brown to Grayish-brown; Underside: Grayish-brown, 2 = Upperside: Upperside: Gray to Grayish-white; Underside: Gray to Grayish white, 1 = Upperside: White; Underside: White
Odor: 5 = No smoke odor to slight smoke odor/No off odor (odor of decomposition), 4 = Moderate smoke odor / No off odor (odor of decomposition), 3 = Severe smoke odor / No off odor (odor of decomposition), 2 = Slight off-odor, 1 = Moderate to severe off odor
Appearance: 5 = Outer spiculy layer removed (86-100 %), 4 = Outer spiculy layer moderately removed (71-85 %), 3 = Outer spiculy layer fairly removed (56-70 %), 2 = Outer spiculy layer slightly/poorly removed (41-55 %), 1 = Outer spiculy layer not removed at all (lower than 40 %)
Texture: 5 = Very hard and completely dry (stone dry), 4 = Hard but not completely dry (moist on both ends), 3 = Slightly hard; rubbery and elastic (moist inside), 2 = Elastic, flexible and slightly moist, 1 = Soft and moist

brushed with 50 g had the lowest score, thus brushing with papaya leaves improved the color of the final product.

All samples brushed with papaya leaves were found to have no smoke to slight smoke odor and no off-odor or decomposition, unlike the control samples with moderate smoke odor.

From the Philippine National Standard for Dried Sea Cucumber (PNS/BAFPS 128:2013), defects of the final product appearance include the presence of white chalky deposits. In terms of cleanliness or percentage of the hard outer layer removed, the control samples using the expensive commercial scrubbing pad were near with the values of samples brushed with 100g papaya leaves. The results show that a certain amount of papaya leaves was effective in removing the hard outer layer of sandfish. Both 75g and 100g papaya leaves were able to remove 71-85% of the hard outer layer of the cooked sandfish. In terms of cost efficiency, 75g papaya leaves is recommended (Figure 3). Papaya leaf is a good source of proteolytic enzymes, used for removal of surface lime in smoked-dried sea cucumber. Nishanthan et al. (2018) mentioned that papain from papaya leaves react with calcium carbonate or lime deposits in the sea cucumber's epidermis. Peranginangin et al. (1994) supported this claim, with their observation that the use of papaya leaves in processing sea cucumbers significantly lowered the ash content, specifically that of Calcium in final products. Application, however, should be controlled to prevent side effects such as degradation of muscle tissue due to uncontrolled protein hydrolysis (Peranginangin et al. 1994).

Figure 3. Upper side and underside appearances of dried sandfish, *H. scabra* washed with 75 g papaya leaves at varying time lengths

The color of the dried samples brushed for 80 minutes shows the highest score. All dried sandfish have black to brown-black at the upper side and brown at the underside. The samples' odor brushed with different brushing time lengths was found to have moderate smoke flavor and show no significant difference with each other. Thus, the length of brushing time did not affect the color and odor of the final product.

Dried sandfish brushed for 120 minutes were evaluated to have 86–100% of the outer spiculy layer removed. Continuous brushing for 120 minutes, however, is time- and work-consuming. Brushing for 80 minutes is recommended for samples evaluated had 71–85% outer spiculy layer removed, which is still high in score and acceptable. The remaining outer spiculy layer can be easily removed during the inspection using a scrubbing pad. Dried samples were evaluated as "stone-hard" and completely dry.

4. CONCLUSION AND RECOMMENDATION

The study results showed that approximately 71–85% of the hard spiculy layer could be effectively removed by brushing the sandfish using 75 g papaya leaves for 80 minutes. The remaining hard spiculy layer can be removed during inspection with less time and effort using a scrubbing pad. Sensory evaluation showed the competitiveness of the product according to the grading characteristics set by South Pacific Commission (1994). Dried sandfish has 69.5% protein, 1.42% fat, 1.88% total carbohydrates, and food energy of 298 kcal/100 g.

The study was conducted on a laboratory scale, and that commercialization should be carried out.

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AUTHOR CONTRIBUTIONS

Bassig RA: Project Leader, Conceptualization, Data gathering, Writing-Original Draft Preparation, Writing-Reviewing and Editing. **Obinque AV:** Assistant Project Leader, Data gathering. **Nebres VT:** Data Gathering. **Delos Santos VH:** Data Gathering. **Salem GM:** Data Processing, Writing-Original draft preparation. **Cabigao JS:** Data Gathering, Data Processing. **Ramos CAM:** Writing-Reviewing and Editing. **Madrid AJJ:** Writing-Reviewing and Editing. **Ragaza RJ:** Supervision.

CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

ETHICS STATEMENT

No animal or human studies were carried out by the authors.

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