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Quality and safety assessment of dried white goby (*Glossogobius giuris*, Hamilton) from Naujan Lake, Philippines

*Ortega, J.T., Tolentino, P.D.H. and de la Cruz, C.P.P.

Laguna State Polytechnic University Los Baños Campus, Los Baños, Laguna 4030, Philippines

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Abstract

Dried white goby (*Glossogobius giuris*) is one of the major dried fishery products from Naujan Lake, Province of Oriental Mindoro, Philippines. Thus, the microbiological and physicochemical qualities of the dried fish are very important. This study investigated the quality and food safety of the dried white goby. The demographic profile and drying practices of the persons involved in fish processing were evaluated. Also, the safety and quality parameters such as organoleptic, microbiological, and physicochemical characteristics were investigated. Survey results showed that women are mainly involved in fish drying. The coastal communities practice the traditional sun-drying method. The organoleptic test revealed that there are no significant differences in the quality attributes of the dried fish except for flavor with Socorro receiving the highest acceptance. Microbiological analyses such as APC, presence of coliform, *E. coli*, *S. aureus*, yeasts, and molds, revealed that all three samples passed the Philippines' prescribed quality and safety requirement for commercial dried fish. All drying processes were effective in lowering the a_w values of the samples. Good hygiene and sanitary practices during the processing and storage of dried white goby produced in varying methods in Naujan Lake were observed and practiced by the processors.

1. Introduction

Dried fish, also known as "tuyông isda" in the Philippines, is a traditional product that is largely consumed by marginalized groups for its taste, nutritional value, and cost. The most common source of income for near-shore communities is the production of dried salted fish (Gabriel and Alano-Budiao, 2015). Furthermore, for most fishing communities, fish drying is an important method of fish preservation. The produced product is often sold in open markets where the fish are displayed and uncovered over tables in the marketplace. Several factors affect the quality of dried fish thus assessment of the sensorial attributes, microbiological load, and physicochemical qualities is very important to ensure that it meets the standards and preferences of the consumers (Huss, 1995). Consumers rely on the safety and quality of products with health-promoting and good organoleptic attributes (Paul *et al.,* 2018). In the Philippines, the Food Safety Act of 2013 ensures that such products meet quality standards and protect consumers' health from unwholesome and unsanitary foods.

Naujan Lake is a freshwater lake in the Philippines located in the northeastern corner of the province of Oriental Mindoro on Mindoro Island. It supports the thousands of fishermen who rely on fishing for a living (Pasumbal and Perez, 2001). The lake is vital as a natural habitat for endemic and endangered species, both terrestrial and aquatic (DENR, 2015). Particularly, the white goby (*Glossogobius giuris*), locally known as *"biyang puti"* is one of the documented and recorded native fish species which can be caught in Naujan Lake (Lit *et al.,* 2012). This fish is commonly consumed fresh and dried as "tuyông biya" by the local residents and tourists. It is regarded as one of the local delicacies and the product's popularity has grown over time as demand has increased. To date, there is no existing study about the quality and food safety of this product. This study aims to evaluate the quality parameters of dried white goby in different drying practices in Naujan Lake in terms of organoleptic, microbiological, and physicochemical quality and determine if such parameters meet the product's defined guidelines and standards.

*Corresponding author.
Email: *pdlherbalega@gmail.com*

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2. Materials and methods

2.1 Description of the study area

The study was conducted in the municipalities of Naujan, Victoria, and Socorro which are bordering Naujan Lake. The majority of the residents in the vicinity rely on the lake for their livelihood, mainly fishing (Ramsar, 1999). Locals in these municipalities were primarily involved in fish processing with dried goby as their main product. No distinct wet or dry season prevails in these areas with a typical temperature between 28-32° C (De Alban, 2010). Hence, dried fish processing is done all year round.

2.2 Sample collection

A pre-validated questionnaire was used during the interview to produce information on the following: a. demographic information of the respondents; b. dried white goby processor's information; and c. dried white goby processing practices. The respondents of this study (18 years old and above) were the dried fish processors from the three municipalities. Forty-five respondents from each municipality were chosen through simple random sampling. Preliminary documentation revealed each processor has a distinct process flow (Figure 1). All of the processors work with local fishermen who supply freshly caught white goby. A total of 10 kg was collected from white goby processors in each municipality during the dry month of April. Samples were placed in sterile polyethylene bags and immediately delivered to the Science Research Laboratory of the Laguna State Polytechnic University Los Baños Campus, municipality of Los Baños, Province of Laguna. The distance between the sampling site and the laboratory was 197 km. Then after 6 hrs of land and sea travel, samples were immediately subjected to microbiological and physicochemical analyses.

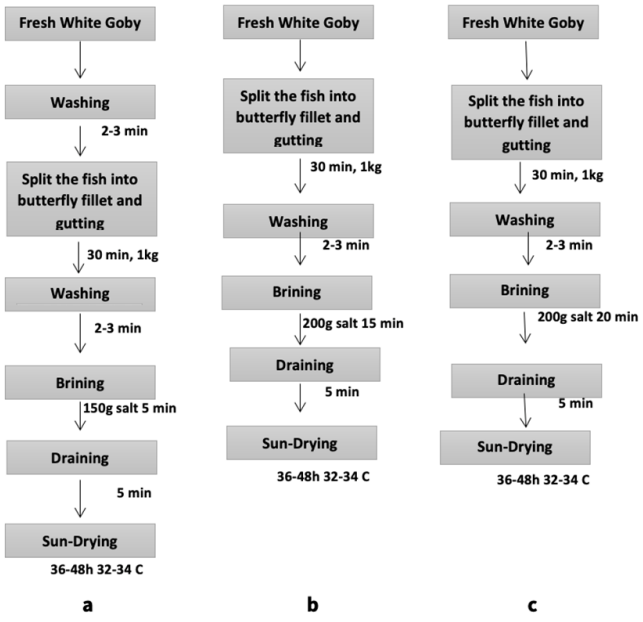

Figure 1. Dried salted white goby process flow of the municipalities of (a) Socorro, (b) Naujan, and (c) Victoria.

2.3 Organoleptic assessment

Dried fish samples were fried at 175°C for 1 min, and then subjected to a sensory evaluation test. The frying time and temperature used in this study were recommended by the local fish processors. The evaluators were 30 semi-trained consumer-type members who regularly consume dried salted fish. The samples were evaluated in terms of color, odor, flavor, texture, and general acceptability using a 9-point hedonic scale (Meilgaard *et al*., 1999). Prior to random presentation to each of the evaluators, individual fried fish samples were placed on identical plates and coded with random 3-digit numbers. The obtained results were converted to scores ranging from liked extremely (9) to disliked extremely (1).

2.4 Physicochemical analyses

2.4.1 Water content and activity

For the determination of the water content, samples were submitted to the Institute of Chemistry, Analytical Services Laboratory of the University of the Philippines Los Baños Campus. The gravimetric method used was based on AOAC (1995). Meanwhile, water activity was analyzed by the Department of Science and Technology (Region IV-A) Regional Standards and Testing Laboratory (DOST-RSTL), Los Baños, Laguna. The a_w of the samples was measured using Novasina (Weber Scientific) water activity meter.

2.4.2 Determination of salt content

Modified Mohr's method was followed to determine the salt content of the sample (Dharshini *et al.,* 2018). In the sample, 1 ml of 5% potassium chromate indicator was added and titrated against 0.1N silver nitrate solution. The endpoint was reached when the solution turned to form a red-brown precipitate. The salt content was calculated using the formula:

$$\text{NaCl \%} = \frac{\text{Titer value} \times \text{Normality of } AgNO_3 \times 58.4 \times 100}{\text{Weight of sample} \times 1000}$$

2.5 Microbiological analyses

2.5.1 Aerobic plate count

Approximately 10 g of each sample was weighed and blended aseptically in a sterile stomacher bag and 90 mL of sterile peptone water was added and blended for 1 -2 mins. Serial dilutions up to 10^{-5} were performed and 0.1 mL was spread plated on a sterile petri dish with standard plate count agar (Pronadisa, Spain) containing 0.5% sodium chloride (NaCl). Plates were incubated at 37°C for 24 hrs. After the incubation period, bacterial

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colonies were counted and recorded (Maturin and Peeler, 1998). Results were counted and expressed in $\log_{10}$ CFU/g.

2.5.2 Enumeration of coliform and Escherichia coli

Enumeration of coliform and *E. coli* were based on SLS 516:Part 3 (1982), with some modifications. Approximately 10 g of each sample was weighed aseptically and blended in a stomacher bag containing 90 mL peptone water. Serial dilution was done as described above. The most Probable Number (MPN) was done based on the method of Sanjee and Karim (2016). Nine test tubes containing 9 mL of single-strength MacConkey broth purple (Oxoid) with Durham's tube were sterilized. In every 3 test tubes, 1 mL of sample from 10^{-1}, 10^{-2}, and 10^{-3} serially diluted tubes were inoculated. Tubes were incubated at 37°C for 24 hrs and then examined for acid and gas production. Test tubes showing gas production were counted and recorded as positive for coliforms. From the positive fecal coliform tubes, the inoculum was streaked onto eosin methylene blue agar (Oxoid) and incubated at 37°C for 24 hrs. Presumptive *E. coli* colonies were inoculated into peptone water at 44°C for 24 hrs. Test tubes were added drop-wise with an indole reagent. The formation of a reddish/pinkish top layer indicates a positive indole reaction (Ginigaddarage *et al.,* 2018).

2.5.3 Detection of Staphylococcus aureus

In a sterile stomacher bag, 25 g of each sample was homogenized in 225 mL peptone water. After a series of serial dilutions, 0.1 mL of diluents were spread on Baird-Parker agar (Oxoid) plate and incubated at 37°C for 48 hrs. Colonies exhibiting a halo zone and gray-black appearance were presumptively identified as *S. aureus* (Sulieman *et al.,* 2014). Results were expressed in $\log_{10}$ CFU/g.

2.5.4 Determination of yeasts and molds

Following the initial methods for APC, 0.1 mL of samples were inoculated and spread in potato dextrose agar (Pronadisa, Spain). Plates were incubated in a dark room at 25ºC for 5 days (Tournas *et al.,* 1998). Colony-forming unit (CFU) results were expressed and presented as CFU/g.

2.5.5 Determination of halophilic bacteria

Five grams of each sample were prepared following the initial methods for APC. Samples were then serially diluted and incubated at 37°C for 24 hrs in NA plates containing NaCl at varying concentrations (2, 4, 6, 8, 10 w/v) (Rahman *et al.,* 2017). Results were expressed in $\log_{10}$ CFU/g.

2.6 Statistical analysis

All variables were measured in triplicates. Mean, standard deviation and significant differences were determined by analysis of variance (ANOVA) and Tukey's test using SPSS v. 20.

3. Results and discussion

The summary of the demographic profile of the respondents in the study area is shown in Table 1. The survey indicated that women were mainly involved in dried fish processing. The age of the respondents ranged from 18 to 60 years old with most respondents aged from 31-50 years old. In addition, 77.4% of respondents were married, 8.89% were single and 6.67% were widowed. In addition, the majority of processors attained primary education only (61.48%).

Table 1. Demographic profile of the dried fish processors.

Category	Subcategory	Percentage
Sex	Male	0
	Female	100
Age	18-30	2.96
	31-50	68.89
	51-60	28.15
	Above 60	0.00
Marital Status	Single	8.89
	Married	77.04
	Separated	1.48
	Living with partner	5.93
	Widowed	6.67
Educational Level	No formal education	2.96
	Primary School Education	61.48
	Secondary School Education	32.59
	College	2.96

The processing practices for dried white goby are presented in Table 2. All the white goby obtained were exclusively processed through the traditional sun-drying method. The fish were placed in elevated and sloping drying trays made of bamboo and fishnet. The fish are left uncovered throughout the drying process. Most of the respondents can process between 1-5 kg of fish daily. The most common process of salting was brining. The amount of salt used during the brining process varied among respondents with most of them mixing 50-100 g of salt in 1 L of water. Also, the majority would soak their fish in a brine solution for 20 mins. In terms of the spoilage factors, the respondents relayed that biological agents such as insects, birds, mold, do not affect the shelf -life of the product, especially during the summer season. However, the respondents admitted that the rainy season led to post-harvest losses due to longer and insufficient drying periods. Furthermore, drying a batch of filleted fish takes about 2 days and the degree of dryness was determined by touching the fish surface for moisture. After drying, the dried fish are stored at ambient

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Table 2. Processing practices of dried white goby (N =135).

Category	Sub-category	Percentage
Source of white goby	Naujan Lake	100
Processing Method	Traditional Method (Sun-drying)	100
	Mechanical Method	0
Amount of white goby processed per day (kg)	1-5 kg per day	92.59
	6-10 kg per day	7.41
	11-15 kg per day	0
	Above 15 kg per day	0
Salt application	Dry Salting	0
	Brining	100
Amount of salt applied per (kg of fish)	50-100 g	23.70
	100-150 g	20.74
	150-200 g	16.30
	200-250 g	21.48
	250-300 g	17.78
Amount of time used during soaking of fish in brine solution	5 mins	14.81
	10 mins	11.85
	15 mins	25.19
	20 mins	25.19
	25 mins	11.11
	30 mins	11.85
White goby spoiled during processing (kg)	None	100
Causes of spoilage	Insect	0
	Birds	0
	Molds	0
	Microorganism	0
Processing time	One day	0
	Two days	100
	Three days	0
	Four days	0
	More than four days	0
Ensuring dryness	Touching if no surface moisture	100
	Color change (silvery to brown)	0
Packaging	Polyethylene bags	100
	Hard Paper boxes	0
	Wood woven basket	0
	Plastic containers	0
Market	Production site	0
	Local market	14.81
	Vending	26.67
	Town market	58.52

Table 3. Organoleptic scores of dried white goby from three different drying methods of the municipalities (n = 30).

	Naujan		Socorro		Victoria	
Color	7.33±0.71[a]	Liked moderately	7.70±0.75[a]	Liked very much	7.27±0.83[a]	Liked moderately
Odor	6.97±0.77[a]	Liked moderately	7.13±0.78[a]	Liked moderately	7.10±0.80[a]	Liked moderately
Flavor	7.10±0.76[b]	Liked moderately	7.77±0.86[a]	Liked very much	7.40±0.85[c]	Liked moderately
Texture	7.43±0.73[a]	Liked moderately	7.60±0.72[a]	Liked very much	7.27±0.69[a]	Liked moderately
General Acceptability	7.30±0.54[a]	Liked moderately	7.60±0.66[a]	Liked very much	7.43±0.68[a]	Like moderately

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different ($p<0.05$). ND: Not detected.

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temperature in a cool, dry, and well-ventilated area. In terms of marketing, 58.52% of white goby were sold to adjacent town markets, 26.67% to vendors, and 14.81% to the local markets near the processing area.

The sensory characteristics of the dried white goby were summarized in Table 3. No significant differences ($P > 0.05$) in color, texture, odor, and general acceptability were observed among the dried fish from the municipalities of Naujan, Socorro, and Victoria. Meanwhile, significant differences in flavor were observed among samples with Socorro obtaining the most favorable score. The variation in the quantity of salt added to the dried fish can also be associated with the differences in the sensory score of the flavor attribute. Noticeably, the process of making dried fish in the municipality of Socorro (Figure 1), involved washing the fish samples twice before brining. This led to the further removal of extraneous materials that improved the flavor of the product.

Results in Table 4 showed the physicochemical parameters achieved after the drying process. There are no significant differences observed among treatments in all sample sites. Based on the results of the a_w of the dried fish samples, the values were below the limit where microorganisms like bacteria can proliferate. The application of salt and drying method reduces water to a sufficiently low level of 0.70 so that bacterial growth is inhibited (Doyle and Glass, 2010). The water activity of fresh fish samples ranged from 0.94 to 0.96 (Silva *et al.,* 2008). According to the Philippine National Standards (2006), the required a_w of dried fishery products should be 0.78. Thus, the drying process practiced by the processors from the three municipalities was effective in lowering the a_w of the product. According to Fuentes *et al.* (2010), a_w should be low to prolong the shelf-life of a product because microorganisms require water for metabolism. Moreover, water activity is a critical factor in determining the shelf-life of products. Mathlouthi (2011) reported that water activity has a direct proportionality to moisture content. Results showed that the water content of the dried fish samples was significantly decreased. According to Boiţeanu *et al.* (2014), the water content in fresh fish varies between 65-90%. The moisture content of dried fish should be less than 25% to ensure a longer shelf life (Erkmen and Bozoglu, 2016). A quality dried fish product should have a moisture content of less than 20% to achieve a shelf-life of 9-10 months (Gopakumar, 1997). Depending on the species and the type of desired product, the fish samples may be dehydrated to various degrees with a water content ranging from about 10-60% (Opstvedt, 1988). The present study revealed that the desired water content for dried salted fish has been achieved.

The salt content of the dried fish samples ranged from 10.4 to 11.8. The result agreed with the brine solution concentration commonly used by the dried fish processors which is 50-100 g salt per liter of water. The addition of salt reduces the moisture content of fish because of osmotic pressure between the brine and fish muscle solution (Horner, 1997; Turan *et al.,* 2006). Also, the chloride ions in salt are known to be toxic to most spoilage organisms (Leroi *et al.,* 2000). In a similar report by Gabriel and Alano-Budiao (2015), the salt concentrations of dried fish samples from different provinces in the Philippines were 12.85% to 14.35%. For the salt content, PNS (2006) requires not less than 12%, however, salt content may vary provided that the prescribed water activity is not exceeded. This means that dried fish products from the study sites conform with the prescribed salt content standard.

Table 4. Physicochemical properties of dried fish.

Sample	Water Activity (a_w)	Water Content (%, w/w)	Salt Content
Naujan	0.718^a	17.0 ± 0.30^a	10.4 ± 0.03^a
Socorro	0.714^a	17.7 ± 0.10^a	11.5 ± 0.08^a
Victoria	0.719^a	17.1 ± 0.10^a	11.8 ± 0.07^a

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different ($p<0.05$).

The microbiological quality of the dried white goby obtained from three different processing techniques was summarized in Table 5. Results showed that all three samples passed the prescribed quality and safety requirement for commercial dried fish as stated in PNS (2006) for dried salted fish. Based on the results, the total bacterial load of the samples did not exceed 5 $\log_{10}$ CFU/g which is the maximum count beyond which product safety and quality may be affected.

Samples from the different study sites were negative for the presence of coliforms and *E. coli*. According to PNS (2006), the total maximum count achievable under good manufacturing practices (GMP) for coliforms and *E. coli* is 10 MPN/g and 0 MPN/g, respectively. For fresh and frozen fish, the acceptable limits of total coliforms and fecal coliforms are <100 MPN/g and <10 MPN/g, respectively (ICMSF, 1986). Beyond this count is unacceptable since the safety and quality are already compromised. The presence of total coliform is an indicator of contamination from sewage during handling and transporting. Also, when the water and ice used during the cleaning process are contaminated, it can affect the safety of the product. Moreover, the presence of *E. coli* in the sample indicates fecal contamination (Griffiths and Fuller, 1935). Thus, to ensure the effectiveness of the procedures used during the process

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Table 5. Microbiological parameters of dried fish samples.

Sample	APC (CFU/g)	Total coliform (MPN/g)	*E. coli* (MPN/g)	*S. aureus* (CFU/g)	Yeast and molds (CFU/g)	Halophiles (CFU/g)
P1	3.38±0.45[a]	ND*	ND	1	2.40±0.23[a]	1
P2	3.20±0.11[a]	ND	ND	1	2.08±0.33[a]	1
P3	3.46±0.08[a]	ND	ND	1	2.87±0.07[a]	1

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different ($p<0.05$). ND: Not detected.

flow, the number of coliforms should be lowered (Elhadi *et al.,* 2004).

The level of *S. aureus* and halophilic bacteria in the dried fish samples was acceptable because the bacterial population was within the maximum allowable level of 3.70 log CFU/g as stipulated in PNS/BFAD 04:2006. *Staphylococcus aureus* can survive in low water activity (a_w) and can grow in media containing up to 18% salt (Sanjeev and Surendran, 1996). Also, high loads of *S. aureus* on a product pose a risk to safety since it can be a potential source of poisoning since they are known to produce enterotoxins. Its presence on fish indicates contamination during processing as a result of poor personal hygiene (Hennekinne *et al*., 2012). Low numbers of the halophilic population in the samples can be attributed to the effects of drying. Since halophiles can survive high salt concentrations, they may as well survive in salted fish products. However, halophiles can be particularly sensitive to the reduction of moisture content and water activity (Rahman *et al.,* 2003).

Lowering the a_w can halt the growth of several bacteria, however, molds and yeasts can still multiply (Karel *et al.,* 1975). PNS (2006) stated that the acceptable limit for molds and yeasts in dried salted fish is 3-4 log CFU/g. Results of this study showed that the yeasts and mold population in the samples were within the acceptable limit required for dried salted fish. Foodborne molds have low moisture requirements, and most species can grow at a water activity (a_w) of 0.85 or less, allowing them to survive in dried food products (Gould, 1991; Beuchat *et al.,* 2011). Yeasts and molds cause various degrees of spoilage and deterioration in food. Some of these can also be potentially hazardous to humans because of their ability to produce mycotoxins which are heat stable compounds that cannot be destroyed during food processing (Hussein, 2001; Bennett and Klich, 2009).

4. Conclusion

Dried white goby is the major dried fish product of the municipalities surrounding Naujan Lake, Oriental Mindoro. The quality and safety of the dried white goby were determined by evaluating the drying practices, organoleptic attributes, microbiological load, and physicochemical characteristics. The drying practices are almost similar in each municipality; however, Socorro washed the fresh fish samples several times before drying. Fish processors used the traditional sun-drying method by putting the fish in drying trays made of bamboo and fishnet and allowing it to dry for two days. Results of the sensory evaluation revealed that Socorro was most acceptable in terms of flavor. The microbiological load of the dried fish was found to be at a considerable safe level as prescribed by the quality and safety requirements for commercial dried fish. The salt content and drying practices were also effective in lowering the a_w and water content values of the samples. The favorable results can be attributed to the continued efforts to protect the lake from pollution and the good hygiene and sanitary practices during the processing and storage of dried white goby. This study can serve as a baseline for the ongoing efforts to improve and preserve the standard of quality and safety of such products.

Conflict of interest

The authors declare no conflict of interest.

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