



# Development and Performance Evaluation of a Convection-Type White Goby Dryer For Enhanced Moisture Reduction and Cost Efficiency

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**Abstract :** This study aimed to develop a convection-type white goby dryer capable of reducing the moisture content of white goby to 33%. The dryer utilized a wood charcoal-fueled furnace as the heat source, complemented by a blower for efficient air circulation within the drying chamber. Performance evaluation focused on drying efficiency, capacity, time, moisture reduction rate, and fuel consumption.

The dryer's performance was assessed through three different air speeds (3 m/s, 4 m/s, and 5 m/s) as treatments. A completely randomized design (CRD) was employed, and data analysis utilized analysis of variance (ANOVA) with a least significant difference (LSD) test for mean comparison. Treatment 3, with an air speed of 5 m/s, exhibited the highest efficiency at 70%. It achieved a drying capacity of 1.58 kilograms of white goby per hour, with a drying time of 7.28 hours. The moisture reduction rate reached 1.58 kg/hr. Fuel consumption averaged at 1.10 kg of wood charcoal per hour.

Moreover, the dryer proved to be cost-efficient, generating an annual net income of Php 40,406.02. Based on a custom rate of Php 60.00/kg of cleaned white goby, the dryer exhibited a remarkably short payback period of 0.27 years and a high rate of return of 51.87%.

Overall, the developed convection-type white goby dryer demonstrated excellent performance in terms of efficiency, capacity, drying time, moisture reduction rate, and fuel consumption. It presented a promising economic outlook, emphasizing its potential as a valuable tool for commercial white goby processing, delivering both operational effectiveness and financial gains.

**Keywords - White goby dryer, Convection-type, Economic viability.**

## I. INTRODUCTION

The white goby, scientifically referred to as *Glossogobius giurus* and locally known as "puting biya," is the largest and most abundant goby species discovered in the Philippines, with a size range of 40 mm to 130 mm (Marquez, 1960). This particular fish species thrives in freshwater environments and is highly prevalent in Naujan Lake. Spanning across 11,000 hectares, Naujan Lake is the fifth largest freshwater body in the country and a crucial source of livelihood for fishermen in Socorro, Victoria, Naujan, and Pola (Guerrero, 2018). In 2018, the Fisheries Statistics of the Philippines reported a total production of 2,892.24 metric tons of fish, with Oriental Mindoro contributing 49.31 metric tons.

Traditionally, the white goby is primarily sold in dried form to maximize profits, commanding a market value of Php 1,200 to Php 1,300 per kilogram. The local community commonly adopts the sun-drying method, involving the salting of approximately 3 kg to 4 kg of fresh fish (around ¼ kg of salt) and an average drying period of 3 days (Guerrero, 2018). The cleaned and brined white goby is typically arranged on homemade racks made of fishing nets and wood, positioned one meter above the ground in an open area, following the traditional drying technique. However, this approach is susceptible to problems such as insect infestation, dust accumulation, and contamination. Additionally, slow sun drying results in spoilage and product loss.

During rainy days, the locals resort to an improvised drying method utilizing direct heat from wood furnaces to dry the fish. However, this method can be seen as more of a smoking process rather than proper drying, consequently affecting the product's quality and texture, which differs from that of sun-dried variants. As a result, it diminishes the profitability for local processors, creating skepticism around the use of the improvised dryer. Therefore, to address these challenges, there is a pressing need to develop a convection-type goby dryer that enhances moisture reduction and cost efficiency.

### 1.1 Objectives of the Study

This study generally aimed to develop a white goby dryer. Specifically, the study aims to:

1. Design a convection-type White Goby dryer.
2. Fabricate a convection-type White Goby dryer.

3. Evaluate the performance of the convective-type White Goby dryer in terms of drying time, fuel consumption, moisture reduction rate, drying efficiency, and drying capacity.
4. Perform a simple cost analysis of the dryer.

**II. MATERIALS AND METHODS**

**2.1 Conceptualization of the Study**

The study focused on addressing the issues identified during benchmarking, field visits, and interviews conducted with local fishermen in a fishing and drying area within the province. It was discovered that local dried fish producers rely on a traditional drying method that takes approximately three days to complete. However, this method presents challenges such as the extended drying period, reliance on sunny weather, and exposure of the products to pests and contaminants due to the open-air setting. These factors pose potential health risks to consumers. Consequently, the development of a white goby dryer aims to resolve these fish preservation problems in the province. The study took into account the problems and suggestions provided by the target users, as well as the preferences of consumers, to inform the design of the machine.

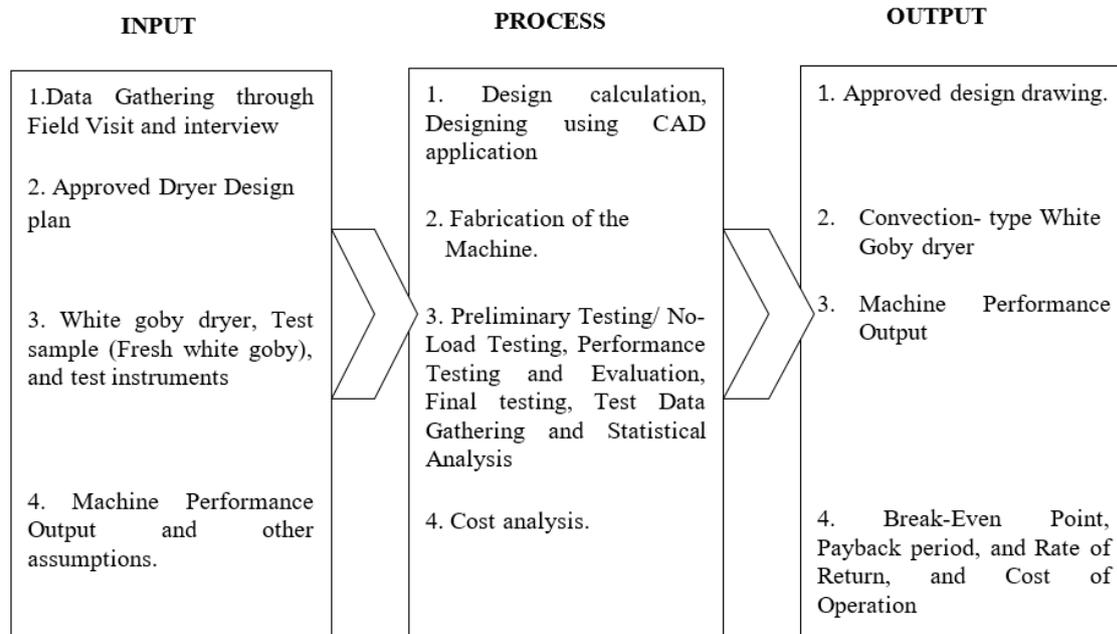


Fig 1. Conceptual framework of the study

**2.2 Design and fabrication of the dryer**

The design of the white goby dryer was determined by its capacity to dry a specific quantity of cleaned white goby within a single day. The selection of materials for the machine's design and construction was based on the functionality of each component, as well as the availability of materials in the local market. The convective-type dryer consists of four primary components: the drying chamber, drying tray, furnace, and air inlet and outlet. The fabrication of the machine involved the use of stainless steel, a 13W variable fan blower, double aluminum sheets, plywood, wire mesh, and angle bars. An overview of the developed dryer is depicted in Figure 2, while Figure 3 showcases the solar panel system storage.

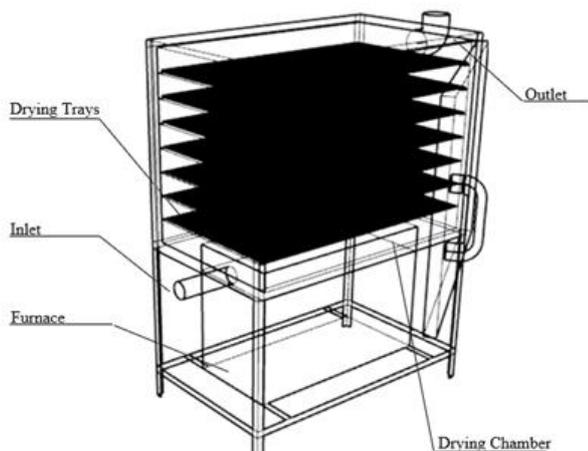


Fig 2. Overview components of white goby dryer

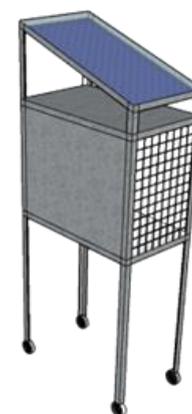


Fig 3. Solar panel system storage

*Drying Chamber*

The drying chamber serves as the storage area for the fish during the drying process, allowing heated air to enter from the thermal storage. It is designed as a cabinet-type structure, with the exterior made of marine plywood, the interior made of stainless steel, and double 10 mm insulation foam for efficient insulation. The drying chamber is equipped with six drying trays, all made of stainless steel. Each drying tray has a maximum capacity of 2 kg of fresh white goby.

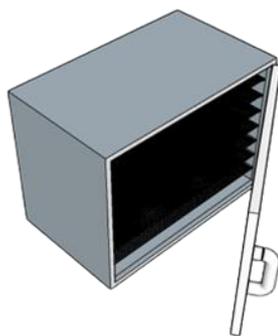


Fig 4. Drying Chamber

*Drying Tray*

The drying tray is responsible for securely holding the fish during the dehydration process. It is constructed using a wire mesh tray and a 1/8 round bar for added strength and durability.

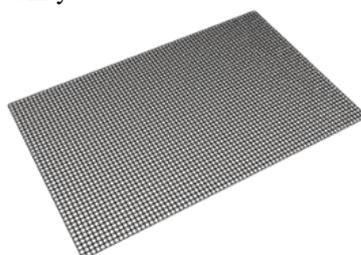


Fig 5. Drying Tray

Number of trays was determined using the Equation 1 below:

$$\text{Number of trays} = \frac{\text{capacity of dryer}}{\text{capacity of trays}} \quad (1)$$

*Furnace*

The furnace, positioned beneath the drying chamber, is powered by wood charcoal and serves to generate the necessary heat for drying the white goby. Constructed from stainless steel, the furnace incorporates a traditional charcoal clay stove as its heating element.

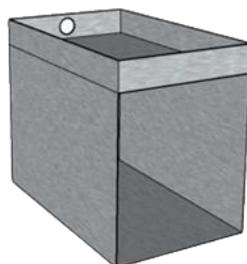


Fig 6. Furnace

*Inlet*

The inlet serves as an aperture for the placement of the blower fan, which facilitates the expulsion of moisture from the commodity towards the exhaust. Additionally, it aids in the circulation of heated air within the chamber to prevent the accumulation of moisture.

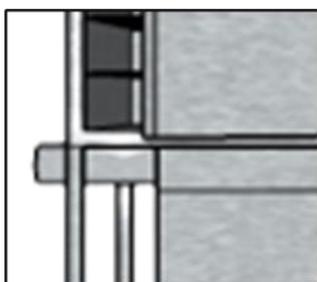


Fig 6. Inlet

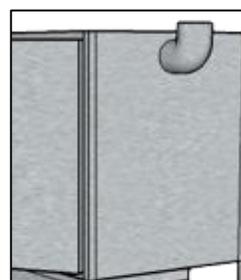


Fig 7. Exhaust

**2.3 Performance test and evaluation**

Fresh white goby was utilized as the test material in the study. The white goby dryer underwent three treatments, each involving different air speeds generated by the blower. The dryer's thermal profile, weight of the test materials, and drying rate obtained during the preliminary evaluation were utilized in the final testing. The machine was assessed using three replications, with each treatment receiving one replication. Following each replication, the dryer was cleaned and allowed to cool before proceeding to the next evaluation. This process was repeated for each subsequent replication.

For the dryer evaluation, a total of 12 kg of fresh white goby was used in each trial. The performance of the dryer was evaluated based on its drying efficiency, drying capacity, drying time, moisture reduction rate, fuel consumption, and electric consumption. The assessment was conducted using the equations outlined below:

Moisture Reduction Rate

$$MC_r = \frac{W_i - W_d}{T_d} \quad (2)$$

Where:

MC<sub>r</sub> = Moisture reduction rate  
 W<sub>i</sub> = initial weight of the sample, kg  
 W<sub>d</sub> = dry weight of the sample, kg  
 T<sub>d</sub> = Actual drying time, hr

Drying Efficiency, %

$$D_{eff} = \frac{\text{Heat utilized, kJ/hr}}{\text{Heat supplied to the burner, kJ/h}} \times 100 \quad (3)$$

Drying Capacity, kg/hr

$$D_c = \frac{\text{Initial Weight, kg}}{\text{Actual Drying Time, h}} \quad (4)$$

Overall drying time, hr

$$ODT = \text{Actual Drying Time} + \text{Rearrangement Time} + \text{Collection Time} \quad (5)$$

Fuel Consumption, kg/hr

$$F_c = \frac{\text{Fuel Consumed}}{ODT} \quad (6)$$

### III. RESULTS AND DISCUSSION

#### 3.1 Description of the dryer

The process of drying the cleaned and cut white goby involved soaking it in a brine solution for 5 minutes, after which it was placed onto the drying trays. The furnace positioned beneath the drying chamber was fueled by wood charcoal, generating the necessary heat to dry the commodity within the chamber. Through convection, the heat from the wood charcoal was transferred to the drying chamber. Prior to placing the drying trays inside the chamber, the dryer was pre-heated until it reached the desired temperature.

Once the drying process commenced, the fan blower, powered by the solar panel system, was activated to circulate the heated air and expel moisture from the chamber. The developed white goby dryer and a sample of the dried white goby produced can be observed in the accompanying figures. Furthermore, Table 1 presents the specifications of the White Goby Dryer.



Fig 8. Fabricated White Goby Dryer



Fig 9. Fresh Biya drying arrangement



Fig 10. Collected dried white goby sample

Table 3.1 Specifications of the White Goby Dryer

PARTICULAR	SPECIFICATION
Drying Chamber	
Interior	202 stainless steel sheets
Exterior	¼ marine plywood
Insulation	double 10 mm insulation foam
Frame	Angle bar 3/16 x 1
Trays	3/8 round bar, welded wire ½ x 4 thick
Furnace	202 stainless steel sheets Traditional charcoal clay stove
Inlet	2 in diameter metal pipe
Outlet	2.5 in diameter PVC pipe
Solar Panel System	
Solar Panel	50 watts, 12 volts
Charge controller	12v/24v, 30 A
Battery	12 V, 12 Ah
Blower	13W
Wires	12-gauge AWG wire
Number of Operator/s	1 person

### 3.2 Performance Evaluation of the White Goby Dryer

Based on the nine trials conducted during testing, the different treatments applied in the developed dryer exhibited significant variations in drying capacity, drying time, and moisture reduction rate. The results revealed that among all the treatments, treatment 3, which involved an air speed of 5m/s, proved to be the most effective for the drying operation. It exhibited faster drying time, higher moisture reduction rate, and a larger drying capacity.

The overall evaluation result indicated that the optimal air speed for the developed dryer during the drying operation was found to be 5 m/s, achieving a drying efficiency of 70%. At this air speed setting, the dryer was able to produce 1.58 kilograms of dried white goby per hour, with a drying time of 7.28 hours. Furthermore, it successfully reduced the moisture content at a rate of 1.20 kg/hr while consuming an average of 1.10 kilograms of wood charcoal per hour.

Table 3.2 The Performance Evaluation of the White Goby Dryer

Air Speed	Trial/Replication	Actual Drying Time (hrs)	Fuel Consumption (kg/hr)	MC Reduction Rate (kg/hr)	Drying Efficiency (%)	Drying Capacity (kg/hr)
3 m/s	T1R1	7.63	1.10	0.9	0.6805	1.28
	T1R2	7.25	1.12	1	0.613	1.34
	T1R3	8	1.10	0.89	0.7217	1.22
4 m/s	T2R1	7	1.08	1.02	0.7166	1.39
	T2R2	7.17	1.08	0.98	0.5292	1.36
	T2R3	7.67	1.04	0.92	0.6061	1.27
5 m/s	T3R1	6.25	1.07	1.19	0.6829	1.56
	T3R2	6	1.11	1.24	0.6942	1.62
	T3R3	6	1.12	1.18	0.7314	1.62

### 3.3 Cost Analysis and Financial Viability of the White Goby Dryer

The study focuses on the cost analysis and financial viability of the white goby dryer. The dryer was developed with an initial cost of Php 22,023.00 and a lifespan of 5 years. It operated for 7.28 hours per batch, accommodating 9.75 kg of cleaned white goby, resulting in 2.6 kg of dried white goby. The dryer had a salvage value of Php 2,202.30 (10% of the initial cost) at the end of its lifespan.

To determine the annual fixed cost, factors such as depreciation, interest on investment, and tax and insurance were considered. The annual fixed cost was calculated as Php 5,010.23. Additionally, the annual variable cost, comprising operator's wage, fuel consumption, and annual repair and maintenance, was projected to be Php 15,669.15. The total annual operating cost amounted to Php 80,679.38.

Based on these costs, the break-even point was calculated to be 231.69 kilograms, with a variable cost per hour of Php 60.63. The break-even point represents the production volume required to cover the total cost of the drying equipment and operation. The payback period was estimated to be 0.53 years, equivalent to 83 days of production, with a rate of return of 46.64%.

The financial analysis indicates that the white goby dryer is expected to generate an annual income of Php 37,631.02, considering a custom rate of Php 60.00 per kilogram of white goby. These findings demonstrate the cost efficiency and profitability of the developed dryer when utilized in white goby processing operations.

Table 3.2 Summary of Simple Financial Analysis of White Goby Dryer

PARAMETERS	VALUES	UNIT
Annual Fixed Cost	5,010.23	Php/yr
Depreciation	3,964.14	Php/yr
Interest on Investment	605.63	Php/yr
Tax and Insurance	440.46	Php/yr
Annual Variable Cost	75,669.15	Php/yr
Operator's Wage	49,920.00	Php/yr
Fuel	24,648.00	Php/yr
Annual Repair and Maintenance	1,101.15	Php/yr
Annual Operating Cost	80,679.38	Php/yr
Break-Even Point	231.69	Kg/yr
Variable Cost per Hour	60.63	Php/yr
Payback Period	0.53	Yrs.
Rate of Return	46.64	%

## IV. CONCLUSIONS

The performance of the developed white goby dryer was thoroughly assessed and yielded promising results. Based on benchmarking data, it was determined that the dryer effectively reduced the moisture content of fresh white goby to the marketable level of 33%. Furthermore, the utilization of solar panels successfully supplied the required electricity for a single operation.

Among the different treatments, Treatment 3, which employed an air speed of 5 m/s, emerged as the most effective for the drying process. It achieved a drying rate of 1.58 kg/hr, with a moisture content reduction rate of 1.20 kg/hr. Additionally, this treatment demonstrated an average drying efficiency of 70%. The overall drying time averaged at 7.28 hours, while an average consumption of 1.10 kg/hr of wood charcoal was observed during operation.

Cost analysis findings reinforced the cost efficiency of the developed dryer, projecting an annual net income of Php 37,631.02. Since drying activities were conducted three times a week, the payback period of 0.53 years was achieved after 83 drying days, with a rate of return of 46.64%. The break-even point was determined to be a production volume of 231.69 kilograms, with a variable cost per hour of Php 60.63 per year.

In conclusion, the developed white goby dryer demonstrated effective drying capabilities, utilizing solar energy and achieving optimal results under Treatment 3. The cost analysis supported the dryer's cost efficiency, indicating the potential for significant net income generation.

## V. ACKNOWLEDGMENT

First and foremost, the author would like to express heartfelt gratitude to the Almighty God, the ultimate source of wisdom and strength.

Special thanks are extended to Engr. Jeanamiah C. Macaraig and Engr. Maria Riverose A. Gasis for their invaluable contributions and encouragement throughout the research process.

The author would also like to acknowledge and appreciate all the individuals who may not be mentioned by name but have provided prayers, assistance, and support. Without their presence and contributions, this study would not have been possible.

Thank you sincerely to everyone involved, and all glory and praise be to God.

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