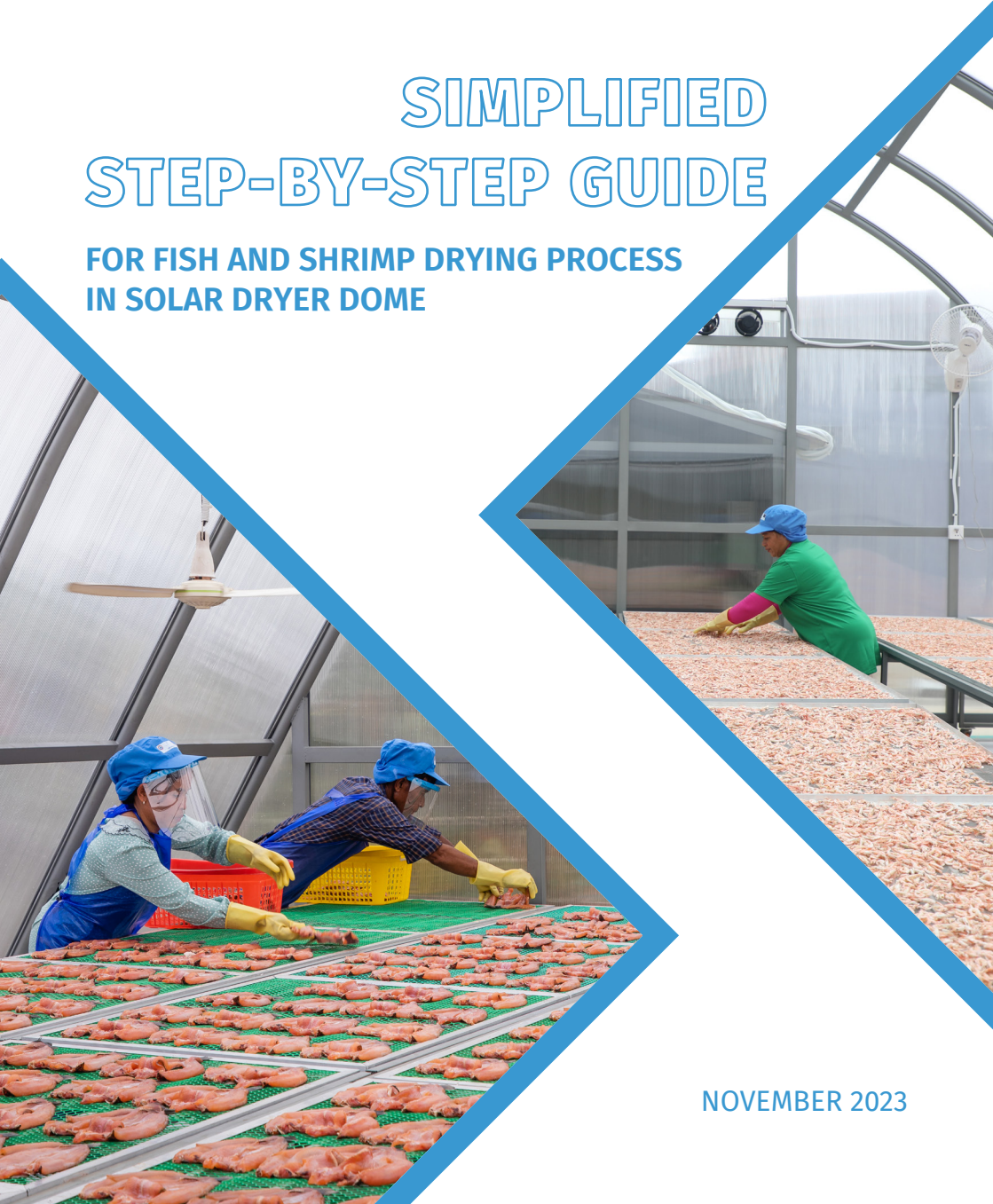


SIMPLIFIED STEP-BY-STEP GUIDE

FOR FISH AND SHRIMP DRYING PROCESS
IN SOLAR DRYER DOME



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DISCLAIMER

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FOREWORD

The CAPFISH-Capture project, co-funded by the European Union (EU) and implemented by the Fisheries Administration (FiA) and United Nations Industrial Development Organization (UNIDO), forms an essential component of the "Cambodia Programme for Sustainable and Inclusive Growth in the Fisheries Sector." Its primary aim is to align with the Royal Government of Cambodia's comprehensive vision for advancing social and economic development, ensuring food security, and alleviating poverty.

This booklet serves as a user guide for Solar Dryer Domes (SDD), crafted to bolster the capabilities of the post-harvest fisheries sub-sector, as part of CAPFISH-Capture's Value Chain Investment Support (VCIS) initiative for fishery post-harvest value chain enterprises.

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I. INTRODUCTION

By harnessing the power of the sun, the Solar Dryer Dome (SDD) is transforming the fish and shrimp drying process. It combines sustainable technology with traditional fish and shrimp drying techniques utilizing renewable energy from the sun to accelerate the drying process. Its transparent or translucent cover allows sunlight to penetrate and heat the interior. This solar heat, combined with adequate ventilation, creates an optimized drying environment. The SDD offers a clean and controlled environment that protects the fish from dust, insects, and other contaminants.

This green technology is promoted by CAPFISH-Capture project, co-funded by the European Union (EU) and jointly implemented by Fisheries Administration of Cambodia (FiA) and United Nations Industrial Development Organization (UNIDO). The specific objective of the CAPFish-Capture project is to develop the post-harvest fisheries through upgrading the regulatory and institutional system, as well as through the adoption of better practices and innovation by the private sector.

This innovative technology offers a multitude of benefits, including increased production capacity, enhanced food safety and quality, improved operational efficiency, and the opportunity to achieve competitive market prices. With this array of benefits, Cambodian dry fish and shrimp processors enter a new era of success.

This booklet on step-by-step fish and shrimp drying serves to guide and educate Cambodian fish and shrimp processors on the effective use of SDD. This step-by-step guide will equip them with the knowledge and techniques to optimise the drying process using SDD technology.

II. FISH AND SHRIMP SPOILAGE

Why Do We Dry Fish And Shrimp?

Fresh fishery products are highly perishable. The process of drying these products aims to sustain the quality and nutritional value over an extended duration by preventing spoilage. The drying process involves reducing the moisture content of the fresh fish and shrimp to a level where microorganisms cannot grow and multiply to spoil dry fishery products, thereby extending the shelf life.

What Causes Fish And Shrimp Spoilage?

Fish and shrimp spoilage refers to contamination, resulting in an undesirable change in the colour, texture, flavour, odour, appearance, etc. of the product. Fishery product spoilage results from three basic mechanisms: 1. Enzymatic decomposition, 2. Oxidation and 3. Microbial growth, which are further explained below.

Enzymatic Decomposition

Enzymes are found in the tissues of all living animals, which are powerful biological chemicals. They speed up chemical reactions inside the body of fish and shrimp. Each cell in the body contains enzymes. For example, the enzymes found in the stomach and gut break down large food compounds into smaller ones in digestion.

In the living animal body, enzymes are in control of the biological system. However, when an animal dies, the enzymes will attack its own body flesh and start enzymatic decomposition. The presence of water and a warm environment is essential for enzymatic activities. Hence, this type of spoilage can be prevented by reducing the activity of enzymes by lowering the temperature.

Rancidity Or Oxidation

The fish and shrimp contain oil or fat in their body. Oxygen in the air reacts with oil or fat, leading to an unpleasant smell or taste. This process is called rancidity or oxidation.

For example: Pangasius fish can be considered an oily fish as it is rich in Omega-3 fatty acids and can turn rancid quickly if not handled and stored correctly. Even dried and frozen fatty fish can still be subjected to rancidity.

Microbial Action

Bacterial spoilage is caused by the activities of microorganisms associated with the fish or shrimp. Fish and shrimp (any living organism) carry millions of bacteria on their skin, gills, and intestines. The fish and shrimp use its defence mechanism to protect it from those bacteria; however, when the fish and shrimp dies, the defence mechanism stops and allows the bacteria the opportunity to spoil the fish/shrimp.

Bacteria, minute living organisms, are present in every corner, and millions can coexist within the space of a pinhead. Their presence in food poses challenges in food handling, contributes to food spoilage and may lead to food poisoning. Bacterial activities are optimum in the presence of water, ambient temperature, and a source of food. In addition to bacteria, mould and yeasts can cause spoilage in fish, particularly dried fish with high levels of moisture, limiting the shelf life.

III. METHODS OF FISH AND SHRIMP DRYING

What Happens When We Dry The Fish And Shrimp?

Primarily, drying reduces the moisture content of the fish and shrimp to a level that can halt the enzymatic decomposition and microbial actions. This will help in preserving the fish/ shrimp for a long time. On the other hand, drying changes the organoleptic properties (appearance, flavour, odour, and texture) of the fish and shrimp.

In Cambodia, drying is typically done in three ways: traditional open sun drying, drying in electric dehydrator, and, most recently, solar dryer domes.

The Traditional Method Of Open Sun Drying

This is the most common method in Cambodia. Fish and shrimps are dried by the heat coming from the sun, and the wind carries the water (vapour) away. In the beginning, drying evaporation starts from the surface. Thereafter, eventually, from the inner tissues of the fish and shrimp. The drying duration and product properties are dependent on the environmental temperature, wind velocity, and existing moisture percentage in the environment (i.e., Relative Humidity - Rh). The traditional sun drying method greatly depends on natural weather conditions, and we do not have control over the drying process.



Traditional Open Sun Drying Fish

Electric Dehydrator

An electric dehydrator or drier is a machine that generates hot air that removes moisture from food, including fish and shrimp with a range of temperature settings between 35 and 90 °C. It works by circulating warm air around the food, which causes the water in the food to evaporate. Dehydrators can be used to dry fish whole, filleted, or sliced. Dehydrating fish is a common method of preservation because it is a quick and easy way to extend the shelf life of fish. Due to the high cost of this type of drying method, investment should be done carefully.



Electric Dehydrator

Solar Dryer Dome (SDD)

Solar Dryer Dome (SDD) is a specialized structure designed for drying purposes. The SDDs resemble greenhouses and are constructed using polycarbonate sheets that are secured to a robust metal frame. SDDs are advantageous to open sun drying, and the polycarbonate sheets used in the SDDs protect foods against the Sun's harmful ultraviolet (UV) rays. Moreover, the interior temperature of the dryer is significantly higher than the external environment, leading to an enhanced drying process due to the additional heat. Humidity levels can be regulated effectively inside the SDD, allowing the drying process to be completed faster than open sun drying.



Solar Dryer Dome

Fish and Shrimp Drying by Traditional Open Sun and in Solar Dryer Dome

TRADITIONAL OPEN SUN DRYING

- A simple and inexpensive method of drying
- Depend on the daily weather conditions
- No control over the operations
- No protection from dust, insects, birds and animals
- Flip the fish / fish slices periodically to ensure even exposure to sun light and consistence drying
- Drying duration vary depending on the weather conditions - generally it takes several days
- Regular monitoring is needed
- High post-harvest losses

SOLAR DRYER DOME

- Faster drying time because of higher temperature, movement of air and lower humidity inside the solar dome
- Higher temperature deters insects and the faster drying rate reduces the risk of spoilage
- Weather resistance because wind and rain no longer the obstacles
- Low spoilage: minimum contamination from rain, bacteria, fungus, dust etc
- Higher product quality because of filtering of ultraviolet (UV) that causes loss of vitamin and important nutrient values
- Hygenic because no contamination from animals birds and insects
- Insulation minimizes heat losses
- Less labour because fish do not need to be moved and turned
- Low cost of operation and maintenance
- Increased income due to better product quality

IV. FACTORS INFLUENCING THE RATE OF DRYING

Air Temperature

The temperature of the drying environment affects the evaporation rate. Higher temperatures can accelerate the drying process, while lower temperatures slow it down.

Air Circulation

Adequate air circulation around the fish and shrimp is crucial for efficient drying. Proper ventilation helps carry away the moisture released from fish and shrimp, promoting faster drying.

Humidity

The relative humidity (RH) of the drying environment impacts the drying rate. Lower humidity levels facilitate faster drying, as the air can absorb more moisture from the fish and shrimp.

Size and Thickness of the Fish/shrimp

The size and thickness of the fish or shrimp (big, medium, and small) will affect the drying rate. Slicing the fish into smaller/thinner pieces or fillets can expedite drying compared to leaving it whole.

Fish Species

Different fish species have varying moisture content and composition, which can influence drying rates. Some species may dry faster than others due to their inherent characteristics such as meat structure, fat, and oil content, etc. Pangasius is an oily fish common in Cambodia that takes a longer time to dry.

Pre-Treatments

The preparation of fish or shrimp before drying can have an impact on the rate at which it dries. Common methods such as salting, sweetening, plain drying, and marinating can be used. The density of pre-treatment, such as the amount of salt used, the duration of the treatment, and the inclusion of various ingredients such as spices, all influence the drying process.

Drying Method

The chosen drying method, whether it is open sun drying, hot air drying, or using a SDD, can impact the drying rate. Each method has its own characteristics and may yield different drying rates.

Weather Conditions

External weather conditions, such as ambient temperature and relative air humidity, can affect the drying rate during sun drying or outdoor drying methods.

It is essential to consider these factors when drying fish or shrimp to ensure proper drying times and to achieve the desired results. Monitoring and adjusting these variables can help optimise the drying process for the specific fish/shrimp being dried.

V. PROCESSING DRIED FISH IN THE SOLAR DRYER DOME

Different Types Of Fish Species

PANGASIOUS (PANGASIOUS MEKONGENSIS/ PANGASIOUS LARNAUDI)

Pangasius is a rich source of high-quality protein, omega-3 fatty acids, vitamins, and minerals. It is an oily fish whose fresh weight ranges from 01 – 1.2 kg. Dried Pangasius offers headless, split, and dried with two quality options. Quality #1 features boneless fillets, while Quality #2 includes fish with bones. The drying process should ensure optimal preservation and flavour enhancement.



Pangasius Mekongensis



Pangasius Larnaudii

SNAKEHEAD (CHANNA STRIATA)

Snakehead is a predatory freshwater fish well-adapted to both stagnant and flowing waters and can tolerate low oxygen levels and varying environmental conditions. The snakehead 500 – 700g size is commonly used for drying.



Snakehead

GIANT SNAKEHEAD (CHANNA MICROPELTES)

The giant snakehead or giant mudfish is a commercially important fish now in the aquaculture sector in Cambodia. On average, a fish weighs in the range of 1.5 kg to 2 kg.



Giant Snakehead

WALKING CATFISH (CLARIAS BATRACHUS)

Walking Catfish is an important food fish popular live, fresh and dried in Cambodia. On average, a fish weighs in the range of 250 - 300 grams.



Walking Catfish

Fish Drying Steps

1. Cleaning And Filleting

- Clean the freshly caught fish. Cut off the scales and cut open the stomach. Remove the gut and its contents inside, wash the fish in clean water and drain off well.
- The Snakehead is dried split, skin on and skin less. Walking Catfish is commonly dried as a whole fish.



Cleaning And Filleting

2. Pre-Treatments (Salt/ Sweet/ Plain)

- After cleaning (headless, split), the fish are kept chilled for about 3 hours. Then it can be marinated according to your own formula.
- The other changes are tabulated in the below table.

PANGASIUS	SNAKEHEAD AND GIANT SNAKEHEAD	WALKING CATFISH
Immediately after cleaning (headless, split), the fish can be marinated according to your own formula. Quality #1 features boneless fillets, while Quality #2 includes fish with bones.	After cleaning (headless, split), the fish were kept chilled for about 3 hours. Then it can be marinated according to your own formula.	No pre-treatments are particularly required with walking catfish drying.

3. Drying Process in SDD

- Lay the fish fillets on drying racks for efficient drying.
- Transfer the racks to the SDD for controlled drying conditions.

4. Temperature Control

- Set the temperature range inside the dome between 40-50°C.
- In the early morning (6 am - 7 am), the dome temperature typically remains 36-37°C. With the rising sun, the temperature gradually increases to 40°C at 10 am - 11 am and then continues to rise slowly.



Temperature Control

5. Efficient Air Circulation

- To facilitate consistent drying and air circulation, use a combination of electric fans throughout the drying process.
- Recommended fan combination includes 5 small fans, 2 standing fans, and 3 wall fans from morning (6 - 7 am) until the evening (6 - 7 pm).
- Continuous air circulation ensures optimal drying results.
- In the night, maintain at least two fans for air circulation inside the dome until 6 - 7 am the next day.

6. Flipping Schedule

- Perform the first fish fillets flipping 2-3 hours after loading to achieve uniform drying.
- Flip the fish fillets back around (12) noon (4-5 hours after loading) while maintaining a temperature range of 40-50°C inside the SDD.



Flipping Fish

7. Continued Drying Process Management

- Continue the drying process until 7 pm, even during low sunlight conditions.
- The SDD's heat remains around 40°C at night (in the non-rainy season), ensuring thorough drying.
- Leave the dried fish in the dome overnight until the next morning.
- The temperature during this period remains approximately 36-37 °C, allowing the fish to settle and reach the desired texture.

8. Moisture Content

PANGASIOUS DRIED FISH	SNAKEHEAD-DRIED FISH	GIANT SNAKE-HEAD-DRIED FISH	WALKING CATFISH DRIED FISH
The dried Pangasius fish should achieve a moisture content of approximately 25-35%.	The dried Snakehead fillets should achieve a moisture content of approximately 25-33%.	The grade 1 (split) should be dried to 33 percent. The grade 02 (non-split) should be dried to 28-33% moisture.	The moisture content of dried walking catfish should be 25-35%.

** Ideally the moisture content of 15-20% with Water activity (aw) levels below 0.6 are aimed to stop microbial growth with proper protection through packing. Any moisture content above these levels reduces the shelf-life unless stored at low temperature.*



Vacuum Packed Dried Snakehead- Boneless



Vacuum Packed Dried Pangasius

9. Packaging And Storage

- Collect the dried fish fillet or whole from the dome for packaging after achieving the optimum drying level for each product type.
- Vacuum pack the dried fish according to market requirements to maintain freshness and quality. Label the product accordingly. Some wholesale buyers may demand other packing methods as well.
- Store the vacuum-packed (or other ways) dried fish refrigerated, ready for market delivery.

10. Use Of Backup Heat Source – Liquefied Petroleum Gas (LPG)

- LPG is used to compensate for a day's loss of hours of the drying cycle due to overcast or rainy weather. As an example, if rain starts at 3pm, you would use LPG gas from 3pm to 5pm or 5.30pm (covering the drying cycle).



LPG Heater

VI. PROCESSING DRIED SHRIMP IN THE SOLAR DRYER DOME

Type Of Shrimp

Small size shrimp belonging to Penaeus spp and Metapenaeus

In Cambodia, dried shrimp is referred to as boiled, dried and peeled shrimp. The dried shrimp produced in Cambodia are exported to Thailand and neighbouring countries and used widely for salads, soups, and condiments.

The processing method and the hygiene practices at all stages of the production affect the quality of dried shrimp quality.

1. Receiving shrimps

- Receiving good quality shrimp for drying is the first critical step for a quality product. Broken, decomposed, foul-smelling and black coloured shrimps will not produce a quality product, causing high loss.

2. Sorting

- After receiving shrimps, clean debris (leaves, sticks, dirt and mud), and remove other small fish and snails. Then grade shrimps according to size (ex. Large, medium, small or grade 1, 2 or 3).

3. Cleaning (Washing)

- To remove dirt and bacteria, wash each grade separately with potable water and drain off any excess water. Do not apply excessive physical force (pressured water) when washing.

4. Pre-Treatments And Boiling: (Salt)

- Boil the shrimps soon after cleaning (the sooner, the better); this will help give the shrimp the ideal flavour and colour. Use clean fresh water for cleaning and boiling the shrimp. The temperature of boiling water should be exactly 100 °C.
- Though there is no exact pre-treatment when boiling shrimps, salt should be added, of which the quantity depends on the amount of shrimp. For example, 200g of salt is to be used with 20kg of fresh shrimp and 30 L of fresh water. Boiling or steaming is done for about 20–40 minutes, depending on the shrimp size. Use a lid to cover the boiling pan to speed up the heating process. Do not use the same boiling water more than twice when boiling shrimps.



Boiling Shrimp

5. Drying Process

- After boiling, let the shrimp drain properly. Then ensure that the SDD is free from dust, flies, insects, other animals, to avoid cross-contamination.
- Transfer the shrimps to drying racks and place them inside the SDD for controlled drying conditions.
- To achieve uniform drying, flip the shrimp periodically. The drying process spans one and a half days, commencing from 9 am to 4 pm on the first day and continuing from 9 am to 12 pm on the second day. It is crucial to regularly monitor and regulate moisture levels to prevent the shrimp from drying excessively, which can make peeling difficult and result in a high rate of breakage.



Drying and Flipping Shrimps

6. Temperature Control During Drying

- Set the temperature range inside the dome between 40-53°C.
- In the early morning (6 am - 7 am), the dome temperature typically remains 30-40 °C.
- With the rising sun, the temperature gradually increases to 53°C at 10 am - 11 am.

7. Efficient Air Circulation In The SDD

- To facilitate consistent drying, use a combination of electric fans throughout the drying process.
- Recommended fan combination includes 5 small fans, 2 standing fans, and 3 wall fans inside the SDD.
- Continuous air circulation ensures optimal drying results.

8. Use Of Backup Heat Source – LPG Gas

- LPG is used to compensate for a day's loss of hours of the drying cycle. For example, if rain starts at 3pm, you would use LPG from 3pm to 5pm or 5.30pm (covering the drying cycle). If it rains the full day, LPG gas will be used the whole day.

9. Moisture Content

- The dried shrimp should contain 10 – 12% moisture after drying for better shelf-life.

10. Peeling

- Ideally, the process of manually removing (peeling) the heads and shells from shrimp involves careful hand-threshing. Shrimps are placed in small bags, typically weighing between 0.5 kg and 1 kg per bag. These bags are moved back and forth to ensure the complete removal of the shells. For instance, during the initial round of threshing, the bag is moved back and forth around 100 times, followed by gentle rubbing against the bag for a similar count. If any un-peeled shells persist, they are individually removed using a knife.
- Peeling by hand is highly recommended, but if the quantity is large, use a rotating mechanical peeling machine with careful operation.

11. Grading

- Grading of the final product is done manually. The MSMEs separate the sizes, broken pieces and dust. Then, they set a standard of selling price.



Good Quality Dried Shrimps

12. Packing

- Separate the broken dried shrimp into different baskets.
- Dried shrimp should be packaged in clear plastic bags, 1kg to 5kg per bag, and kept at low temperatures or as per order from buyers. Ideally, store the products in a refrigerated condition at a temperature between 4°C and 6°C.



Dried Shrimp Packed In Transparent Bags

VII. SENSORY CHARACTERISTICS OF DRIED FISH & SHRIMPS

The sensory properties of dried fishery products can be assessed by their colour, odour, texture, flavour, appearance, and general acceptability. The dried fishery product from SDDs shows the most desirable sensory characteristics. Therefore, the processors must be specific sensory properties to maximise these dried fishery products characteristics to be competitive in the market. The prominent factors affecting the sensory properties of dried fishery products are the quality of raw materials, pre-treatments of raw materials, drying method, use of additives, storage, and extrinsic factors.

The sensory properties of dried fishery products heavily depend on the initial quality and freshness of the fish and shrimp used for drying. Pre-treatments for fish include cleaning, splitting, blanching, peeling, degutting, and bleeding. Dried shrimp, the drying technique employed, whether sun-drying, air-drying, smoke-drying, or mechanical drying, can significantly influence the texture, flavour, and colour of the dried fish and shrimp. Some processors may use drying aids like salt, sugar, or chemical additives to enhance the preservation process or add specific flavours. These can impact the taste and aroma of the dried fish and dried shrimp.

The drying condition, dimensional characters (thickness, surface area) and composition of the fish and shrimp to be dried are some of the extrinsic factors significant for end product quality. The size and thickness of the fish and shrimp can influence the drying time. The temperature and duration of the drying process impact the degree of moisture removal and can affect the texture and taste of the final products.

Colour

This is an important sensory characteristic. When a fishery product is dried, its colour undergoes changes that contribute to the overall visual appeal and perception of the product. Colour uniformity should be maintained throughout the same product batches. The deep rich colour of dried fish that aligns with the local perceptions can serve as a visual signal for consumers, indicating the uniqueness of your product.

The unique Cambodian dried shrimp typically have a reddish-orange colour, of which the exact hue can vary depending on factors such as drying process and the size of the shrimp.

Texture

Dried fish have a firm and chewy texture due to moisture removal. The drying process transforms the fish flesh into a denser and more compact form. Depending on the specific fish species and drying method, the texture can range from slightly pliable to extremely tough and leathery.

Cambodian dried shrimp are usually quite dry and firm in texture. They can range from slightly chewy to crunchy, depending on how they are prepared and the size of the shrimp. Smaller dried shrimp tend to be crunchier, while larger ones may have a chewier texture.

Aroma

The aroma of dried fishery products is a distinctive asset. As the fish dries, its natural oils and compounds become more concentrated, resulting in an apparent fishy scent. The aroma may also carry hints of product quality and taste. Best quality of dried fishery products should be free of ammonia smell.

In addition, the aroma of Cambodia's dried shrimp is strong and distinctive. This unique aroma is an essential component in many Cambodian dishes, especially when used to make prahok, a fermented fish paste that's a staple in Cambodian cuisine.

Flavour

Dried fishery products offer an intense and concentrated flavour profile. It typically has a savoury and umami taste resulting from natural moisture reduction during drying. The flavour can vary depending on the fish species. The unique taste of dried shrimp depends on the freshness of shrimp used for drying.

Appearance

Dried fish have a visually appealing appearance. The fish fillets undergo a transformation during drying, resulting in a darker coloration, often ranging from golden brown to a deep reddish-brown or pink colour. The surface of the dried fishery products may have a slightly shiny or glazed appearance.

Dried shrimp typically come in various sizes, ranging from small to large. They are often wrinkled and shrivelled, a direct result of the drying process. The ideal appearance of dried shrimp should exhibit no shells, absence of any black discoloration, and no signs of breakage.

General Acceptability

It suggests the best quality of the product is based on the overall acceptability derived from the above sensory properties.

VIII. BEST PRACTICES OF SOLAR DRYER DOME

By following these Do's and Don'ts, you can optimise the solar drying process and produce high-quality and safe dried fishery products. Proper hygiene, monitoring, and attention to environmental conditions are key factors for successful solar drying.

DOs

Cleanliness: Ensure that the solar dryer dome and all equipment used are clean and free from any contaminants that could affect the quality and safety of the dried fish/shrimp.



Hygiene: Follow proper hygiene practices (personal and equipment) during handling to avoid contamination and foodborne illnesses.



Preparation: Properly prepare the fish/shrimp before placing it in the solar dryer. Gutting and cleaning the fish will help prevent spoilage and improve drying efficiency.



Air Circulation: Arrange the fish/shrimp in the solar dryer dome in a way that allows good air circulation. Proper spacing between fish pieces will promote even drying.



Arrange Properly: Arrange the fish/shrimp in a single layer on drying trays to allow adequate airflow and even drying.



Monitor Drying: Regularly monitor the drying process to avoid over-drying or under-drying the fish. Remove dried fish promptly to prevent further moisture absorption.



DON'Ts

Don't Practice Overloading: Avoid overloading the trays with fish/shrimp, as this can impede proper airflow and lead to uneven drying.



Don't Practice Inadequate Cleaning: Do not neglect to clean the solar dryer dome and trays between batches, as residual contaminants can affect the quality of subsequent batches.



Don't Skip Hygiene Practices: Neglecting hygiene practices during fish/shrimp handling can lead to contamination and affect the safety of the dried product.



Don't Ignore Temperature: Be mindful of the ambient temperature during drying. Extremely high temperatures might cause over-drying, while low temperatures can prolong drying time and increase the risk of spoilage.



Don't Forget Uniformity: Paying attention to uniformity (slicing, grading) ensures consistent drying times and results.



Don't Vacuum Product Immediately without allowing to cool: Do not vacuum-seal fishery products just after getting out from the SDD. It is recommended to keep it in a clean dry place (ideally in the SDD for overnight) to cool and release any residual moisture.





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