Dried fish in Indonesia: Problems and a Possible Solution, a Review

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Abstract. Dried fish has become one of the favourite food for Indonesian. The drying technology has been passed down through generations especially in the coastal communities due to its simplicity. Despite the long history of dried fish in Indonesia, some problems need to be addressed. Maintaining the quality for both domestic and global markets in an integrated and sustainable manner is still standing as the major problem. Formalin residue had been found in some dried fish products in several areas in Indonesia. This safety matter is also drawn both researcher’s and policy maker’s attention. Several possible solutions are offered to iron out the issues. The development of new technology which easy to adopt and low cost is needed. A combination drying machine can be an alternative to solve the problems. The machine is designed to be able to operate using both electrical and solar sources. The machine can yield a good quality product which can be used throughout the year.

1. Introduction

Sun-drying is the oldest method to preserved food. Being a tropical country, Indonesia experience only rainy and dry seasons. Because of that, drying is the most common method to preserve food in Indonesia. The method has become popular due to its simplicity and considering as a low maintained technology [1]. Fish as one of perishable food has been the popular object to sun-dried, especially in the area around the coastline [2]. Owing to a high level of moisture and protein content, fish that handle poorly allowing the deterioration to happen fast. To prevent spoilage, salting and sun-dried been used and establish a stable and safe product. Despite a long history of dried fish in Indonesia, basic problems such as maintaining the product quality and safety and the availability of raw material still become the major problems of the products.

The demands of dried fish both salted and unsalted for the domestic and global market was growing as the world population expand. However, the demand seems to decline as many countries suffer from the pandemic. The export volume of dried salted fish in the first semester in 2021 was 499,25 tons, this number is almost half of the volume from the same semester in 2020 and the export destination countries also changed in both years at the same semester. In 2021 the destination countries are Sri Langka, United States, Taiwan, Australia and Singapore, while in 2020 the destination was Sri Langka, Thailand, United States, Australia, Canada and Taiwan [3]. The main reason for the downturn trend of exporting the dried salted fish is remaining unclear, since many
factors are involved. The factors could be the quality and safety issue of the product or the pandemic that caused many countries to need to refocus their economic strategy to tackle the problems.

Maintaining product quality and safety should be the main focus of these small-scale industries. The use of formalin has been a major concern for both the regulator and consumers. Formalin residue had been found in some dried fish from several regions in Indonesia such as, Lampung, Manado, Bandung, Gorontalo, Pekanbaru and Madura [4 – 10]. Besides the safety issue, the quality problems such as fungi associated with Indonesian dried fish are also a concern. Aspergillus sp, Cladosporium spp, Eurotium spp, Fusarium spp, Polypaecilum piece and Torula spp had been found in various dried fish [11 – 12]. In addition, the availability of raw materials seems still to be a problem for the industry.

Thus, a simple solution needs to be done to address the issues. This paper offers a possible solution to solve the quality and safety issues by introducing a simple drying machine that can be used in both rainy and dry seasons.

Fish drying techniques
The basic of drying technology is well understood. It is involved a physical process, in which when the heat from the sun evaporates the moisture of the fish, this process is also called convective mass transfer. The fish moisture level is slowly decreasing, by the reason for the alteration of the water inside the flesh to the surface. As follow, the water driving forces experience a downturn and the rate of drying will go slower until the equilibrium is attained [13].

In general, the drying process starts from washing the raw material with water upon arrival at the processing site and the drained. The fish then transferred on the trays and sun-dried. The processor checks the fish periodically to see if one side (the one facing the sun) is dry enough, then turns the other side to facing the sun to make the fish is evenly dried [1]. To avoid condensation during the storage and transportation, the dried fish are transferred into a bamboo basket and stored in a shady area. If it is desirable, salt can be added to produce salted dried fish. The washed fish is mixed with salt 20 – 30% (w/w) of fish weigh and storage at room temperature for about 10 – 12 hours.

This type of drying with the sun can be divided into two techniques. The first is drying with direct sun / direct drying (sun drying). The material is dried by drying it in a place exposed to direct sunlight. Direct drying is very easy to apply and does not require a lot of money. Investment costs and labour costs are relatively lower compared to other techniques. The disadvantage of direct drying is that it is very dependent on the intensity of light and weather, besides that, the drying time is longer, the required area is also wider and the quality of the drying results is not uniform. Because it is open, the product resulting from this type of drying is also at risk of being contaminated by dust, insects and other animals [14].

The second technique is called solar drying. Solar drying uses additional tools that can optimize solar energy during the drying process so that the quality of the resulting product can be improved. The device used is called a heat collector or heat collector. Many of these dryers are made simply using materials available in nature such as bamboo and other types of wood, which are then covered with clear plastic or glass [13]. This technique can provide a solution to the shortcomings of the direct drying technique because the solar drying method uses terraced shelves that are closed from the outside air. The advantage of using a multilevel rack in this method is that it can optimize the hot air trapped in the drying chamber, and distribute it evenly so that the dryer can operate more efficiently.

Besides those two techniques, mechanical drying was invented to solve the problems of those traditional methods. Mechanical drying is a drying system that uses heating from combustion products [15]. Hot air blows from the heater or direct contact with the product. This air heating can occur directly or indirectly. Mechanical drying also can be divided into two systems. The first system is called the batch system. In the batch system, the product is dried using a container and the contact between the product and hot air is prolonged or repeated. The second system is called a continuous system. In this system, the product is dried on a conveyor belt continuously and is in contact with hot air only when it is in the drying machine. This second system is not suitable for fishery products [15].

Many dryers have been developed in Indonesia, using kerosene as fuel [16], coal briquettes [17], a combination of firewood and sun [18]. The above studies have been able to improve the quality and quality of dried fish and make the drying process more efficient. The advantages of using a
mechanical dryer are that it can produce quality products, control temperatures, and speed up the rate. This drying system can be used at any time and does not depend on the weather. Meanwhile, the weakness is that this system requires high investment and operational costs.

2. Problems

2.1. Preserving the quality
It must be admitted that dried fish products, whether salted or fresh, are not premium products for both domestic consumption and foreign markets. Improper handling during processing including not paying attention to the material temperature and ambient temperature can cause quality damage to dried fish products.

A mould is a group of microorganisms that can cause damage to dried fish [11, 12, 19, 20]. Contaminant moulds can grow well on foodstuffs with low water content [20]. Moulds from the Aspergillus, Cladosporium and Penicillium families appear to predominate in dried fish products. In addition to reducing sensory and aesthetic values, the presence of moulds can release mycotoxins (toxic substances) that can harm consumers [21].

2.2. Safety issue
In recent years the use of formalin to preserve fish is quite significant. This is of course disturbing the community and fish processors. Research on the quality and quality of fishery products, especially formalin levels in dried fish is only partial in the area and is not integrated with other quality and quality parameters. Unfortunately, information about water activity (aw) is not visible in all these studies. Whereas aw has a major effect on mould growth in dried fish products [20].

The microplastic issue has raised attention about the safety of the fish product. Microplastic was found in 4 commonly consume dried fish (C. subvirdis, J. belangerii, R. kanagurta, and S. waitei) originated from Malaysia [22]. The identification was using Micro – Raman spectroscopy and it is reported that, 59% of the particles found confirmed as microplastic in plastic polymer or pigmented plastic polymer. The fact that the ability of microplastic movement from the digestive system to the flesh is concerning. Unfortunately, the information around microplastic in Indonesian products of dried fish is not well documented yet.

Heavy metals are other issues that raise an awareness. Twelve heavy metals (Cr, Mn, Fe, Co, Cu, Zn, Se, Rb, Hg, Pb, Ni and As) had been detected in ten types of dried fish from Bangladesh [23]. The study has shown that only Ni and As were below detection level. The study confirmed that the fish were grown in high pollution waters. Heavy metals are widely known as carcinogens that could raise the risk of cancer. Thus, regular monitoring of trace metals in dried fish and seafood products is worth conducting.

3. A combination of drying machines as a possible solution
The average fish drying temperature is 45°C to 80°C [24]. Several studies have stated that the average temperature of fish dryers using solar energy ranges from 37.30°C to 94.8°C [25-30]. This shows that solar energy can be used as thermal energy for drying fish. Solar energy is easily available in tropical countries like Indonesia. To get a stable drying rate of fish, heat storage is needed. Water is the most widely used substance as a heat store because it has the best specific heat compared to other easily obtained objects [30].

This fish drying machine is designed to provide an alternative solution to the fish drying method that has been done so far. This machine can be operated in normal conditions (clear weather) and when weather is cloudy, rainy or at night, so that production volume can be increased. The energy used is solar thermal energy and electricity. Fish drying machine design from various points of view can be seen in Figure 2. Some of the expected benefits with this fish drying machine such as, cost and energy effective and efficient, hygiene, does not require a large area and can be operated in all seasons. Figure 1 shows in detail the parts of the solar fish drying machine combined with electric power.
This dryer collects solar thermal energy to dry the product combined with electrical energy. The sun's heat is collected in a heat collector. The heat collector contains liquid (water) which functions to absorb the sun's heat. The water comes from the holding tank which is flowed by gravity. The heated water is transferred to a drying rack to dry the fish. The heat collector used is in the form of two flat plates between which a gasket is installed. The gasket is made in such a way that it becomes a path for water to flow. The top plate is given a colour that easily absorbs the sun's heat such as black, then covered with a layer of glass or another transparent object. Between the plate and the glass there is an air cavity. This construction aims to provide a greenhouse effect, where it is known that the greenhouse effect will store heat in the dryer. To avoid heat loss, this tool is insulated. Figure 3 shows the parts of the heat collector.

In general, the heat collector that is widely used is in the form of a pipe attached to a flat plate. However, the design of the heat collector of this drying machine uses a flat plate which aims to expand the area of water that is in contact with the heat-absorbing media (heat collector). The choice of flat plate as a heat collector because the flat plate model will speed up the heat transfer process, because one of the factors that affect the heat transfer process is the area of the media. The wider the media that is in contact, the better the heat transfer process will be. An insulated solar heat collector is able to raise the water temperature up to 60°C in sunny weather [24]. With the design of the heat collector designed on this machine, it is hoped that the heat energy from the sun can be utilized optimally.

The hot water is flowed by gravity to the drying rack (Figure 2). The drying rack is in a closed cabinet, so it is free from nuisance animals such as flies or rodents such as mice. Cabinet walls are insulated so that heat is not wasted. The drying rack also functions as a heat exchanger. The heat exchanger construction resembles a heat collector, except that the heat exchanger does not contain glass and insulation. The product is placed in a perforated tray and placed directly above the heat exchanger plate. The drying speed of fish is strongly influenced by the humidity of the surrounding air. To reduce the high humidity in the drying room, an exhaust fan is installed. After loading the product, the water will flow into the return tub. Then it is pumped into a holding tank to be flowed back by gravity.

At the bottom of each heat exchanger there is a heater (induction cooker). Electric heating can be used when the weather does not support the drying process that relies on sunlight, such as when it is cloudy, rainy and at night. Electric heating does not require running water. To maintain the temperature as recommended, a thermostat is installed. The heater will turn off when the desired temperature is reached and will turn on again after the lowest set temperature is reached. The number of heaters turned on corresponds to the number of drying racks filled with product. If there is a shelf that is not filled with product, then the heater on that shelf is not turned on.

![Figure 1. Design of a combination fish drying machine.](image)
4. Conclusion
To sum up, everything that has been stated, a combination of drying machines is designed to provide a solution to solve the problems. The drying machine can be operated in both dry and wet seasons as a result of the energy been used is can be from both solar thermal energy and electricity. With this machine, producers do not need to use formalin to preserve the raw material and the presence of fungi can be avoided as long as the product is kept in a good storage condition.
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