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DaingGrader: Quality Assessment of Dried Fish (*Sardinella*) using Surface Texture and Mold Detection

In Partial Fulfillment of the Requirements for the Subject
System Integration and Architecture 2

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CHAPTER 1
The Problem and its Background

Introduction

In the Philippines, dried seafood is considered as a staple food that is eaten frequently for Filipinos, such as Danggit, Pusit, Bangus, Galunggong, and Espada. This dried fishes provide the cheapest source of protein to low-income Filipino families, and also supports the livelihoods of the small-scale fishermen living in coastal areas. This traditional method of an open sun-drying technique to dry out the fish, is extensively practiced in the country, however, this exposes the fishes to pollution. One of the main safety concerns in this process is the fungal growth like molds that tends to grow on the fishes due to improper drying or poor storage conditions. Where customers can easily dispose of the visible mold, but in most cases, the early growth of fungi and deterioration of the quality may go unnoticed by the naked-eye, and may cause long-term health effects, like producing further harmful toxins and affecting other safe to eat fishes around it. To address this issue, there should be a change from subjective manual inspection to efficient food quality assurance with the help of technological advances. This paper "DaingGrader", proposes an automated system for quality grading and mold detection on five different variations of dried fish. The system is intended to take not only the mold on the fish but also analyze the color shifts and irregularities, defect pattern analysis, and physical defects on the fish that human's eye might overlook. By using an extensive analysis framework, the system will sort out the fishes in the category of: Export grade, Local grade, or Reject. The said innovation is aligned with Sustainable Development Goal 14 (Life Below Water) with a specific target of achieving an optimal use of marine resources by reducing post-harvest fish losses and ensuring processed dried fish is safe for human consumption. The use of AI-power computer vision, implemented in Python, will be a non-invasive, fast and efficient way of classifying dried fish, a step between the classical food processing and current food safety standards. This research is meant to provide an instrument both for the sellers and buyers to help them in dried fish maintenance and health assessment of the integrity of these staple foods in the country.

Background of the Study

The production of dried fish like Danggit, Galunggon, Banugs, Espada, and Pusit are basic economic activities in the Philippines as it serves an essential purpose as the main source of low-cost protein. Nevertheless, the sector is very dependent on traditional methods of sun drying, which are normally done in open air. A 2025 study on the practices of fish processing conducted in Camarines Sur showed that the product's articles are more vulnerable to contamination by dust, insect and microorganism by traditional processing practices due to the lack of controlled and clean processing facilities [1]. The humid tropical conditions of the drying and storing period favor a very suitable environment for the development of xerophilic molds, which grow in the product in significant numbers, thus besides ruining the aesthetic quality of the product, they also pose serious food safety threats. The biggest problem with the growth of fungi in dried marine fishes is the potential for the production- even after cooking- of mycotoxins, including aflatoxin that is harmful to human health. Despite these threats, quality management and inspection in their local markets is still done manually. Consumers and vendors use visual inspection and smell to check for freshness but this is inconsistent and in most cases will not detect microbial growth that initial onset or subtle discoloration anomalies. Studies by the Department of Science and Technology (DOST) shows that traditional processing is not standardized and therefore, the assessment of product safety is not always the same and can be threatening to the health of the population [2]. The fact that the human eye is not able to differentiate uniformly minute changes of texture and color with the initial growth of molds makes a more objective and efficient means necessary. To overcome these weaknesses, Artificial Intelligence (AI) integration in the food safety process is one of the possible technological interventions.

Current developments in Computer Vision (CV) and Machine Learning (ML) were found to be quite effective for non-destructive quality assessment. An example of such an application is algorithms and deep learning methods such as YOLO (You Only Look Once), which have been used to identify surface defects such as mildew and defects on agricultural productions including maize and fruits with high accuracy [3]. Moreover, a 2025 systematic review of machine learning applications emphasizes on the fact that automated visual inspection systems (especially founded on Convolutional Neural Networks (CNNs)) are becoming essential for defect detection and grading. These systems play an important role in the minimization of human error and material waste as products are sorted in real-time based on surface texture and visual anomalies [4]. Although the success of these technologies in the agricultural and food industries are proven, a specific apparent lack of low-cost and automated systems of quality assessment in the Philippine dried fish industry are evident. The available applications are mainly aimed for new products or large scale production and don't allow for small scale fishers and local markets to have access to latest safety tools. This study will focus on filling this gap by creating DaingGrader, a system that will provide analytics in identifying mold, color consistency analysis and defect map patterns from five different dried fish varieties. The aim of the research is to provide a viable solution which is sensitive to emerging food safety requirements while also promoting sustainability of the local fishery industry by applying machine learning approaches to these local commodities [1].

Statement of the Problem

This research's purpose is to create "DaingGrader" a web-based and mobile system integrated with Machine Learning for an efficient quality assessment of five different species of dried fish using image processing. The system blends the features of mold detection and tracking of mold severity area, color consistency analysis, and defect pattern analysis to determine the fish's commercial grade quality. The following questions are further sought in this study:

1. How can a dataset of dried fish images from five species (danggit, galunggong, espada, bangus and pusit) be gathered, labeled, and processed to train the system for mold detection, color consistency analysis, and grade classification?
2. How accurate will the developed machine learning model be on its model detection, severity level assessment, and identifying the common prone area of the fish's body in mold growth?
3. How effective will the color consistency analysis be in measuring the changes in color (like discoloration) and surface uniformity of the fish to classify its Export, Local, or Reject quality grades?
4. What are the frequently occurring quality defects in each of the five species, and how often do they appear, and what are their effects on the quality of the fish?

Objectives

General Objective:

To design a web-based and mobile system "DaingGrader" that uses machine learning algorithms for an efficient way of assessing five dried fish species (Danggit, Galunggong, Espada, Bangus, Pusit) quality through mold detection and defect pattern identification, color shift analysis, and its final commercial grade classification.

Specific Objectives:

- To collect and provide a dataset of the five different fish species (Danggit, Galunggong, Espada, Bangus, Pusit), and categorize them by mold presence and severity, and quality assessment.

- To apply a color consistency analysis and measure the surface uniformity and detect any discoloration to differentiate Export, Local and Reject quality of the dried fish.
- To develop and train a Python-based machine learning model capable of detecting mold contamination, analyzing severity levels, and mapping fungal growth distribution on the fish anatomy.
- To create a defect pattern analysis that identifies, categorizes, and tracks the frequency of quality defects such as mold contamination and color shifts across species to determine the causes of quality degradation.

Significance of the Study

This research is deemed significant to the following sectors:

Small-scale Fisherfolk and Vendors: This technology can be used as a quality control measure, such as ensuring that products are well sorted to prevent mold growth in storage and achieve higher prices for products that are assured to be safe.

Consumers: The system will provide a degree of safety assurance by reducing the risk of ingesting dried fish contaminated with mycotoxins and improving the population's health.

Bureau of Fisheries and Aquatic Resources (BFAR): This study is a prototype of digital, low-cost, food safety inspection devices that can be implemented in regulatory food safety inspections in the food market.

Future Researchers: This paper adds to the literature on the use of machine learning in the preservation of indigenous food that can be applied in future studies of other dried foods.

Scope and Delimitation

Scope:

The scope of this study is focused on the development of a machine learning model using the Python programming language for the quality assessment of five specific dried seafood varieties: Danggit (Rabbitfish), Squid (Pusit), Bangus (Milkfish), Galunggong (Round Scad), and Espada (Beltfish). The system employs a data-driven analytics framework that performs Mold Detection, Color Consistency Analysis, and Mold Spatial Distribution Analysis to evaluate surface quality. The key output of the system will be the classified report of the fish into three different commercial grades (Export, Local, or Reject). The research is in support of Sustainable Development Goals 14 which aims at minimizing post-harvest losses and ensuring food safety in marine catches. The data collection will include taking pictures of each of the five varieties under controlled lighting conditions as the AI's model training component.

Delimitation:

The system is limited to focus on assessing the visual quality of the fish and will not include any chemical or biological testing. While its feature is detects the presence of mold and at what severity, it will not identify the specific fungal type (i.e., classifying the type or name of the mold such as Aspergillus or Penicillium), or measure its mycotoxin levels(e.g., aflatoxin concentration). The system's "Color Consistency" and "Defect Pattern" analyses will be based solely on the pixel count and irregularities of the fish's surface, thus, the specific internal quality parameters like moisture content, salt level, and taste analysis are excluded beyond the capability of the system. Furthermore, the system will be designed to determine the state of the fish by the time it is scanned by the system and will not forecast its future shelf-conditions or expiration dates. The study is focused only on the five selected types of dried fish mentioned, and does not cover any other marine products like smoked fish.

CHAPTER 2
Review of Related Literature and Studies

Foreign Literature

The introduction of Artificial Intelligence (AI) into the process of food safety is a major paradigm shift where the quality assurance is shifting to a proactive strategy. According to the industry analysis done by Kumari, in 2025, AI will transform the food safety standards worldwide in rapid rates, allowing the real-time identification of any contaminants that cannot be seen by the human eye. The report adds that in 2025, AI-based platforms will be used to control quality, not as some kind of automating, but also to predictively analyze the spoilage. With such a technological advancement, manufacturers can detect hazards e.g. mold development before it turns into a health crisis thus maximizing production and reducing wastage of food [5].

Besides, AI is considered an opportunity to change inspection processes, which is emphasized in the recent regulatory discourse. Bowman and Sammer (2025) report that AI-enhanced vision systems that have the ability to scan printed products are slowly being advanced to the conventional metal detectors and manual inspections. These systems are able to identify non-metallic impurities and delicate surface disfigurements including the initial stages of fungal development that the human inspector might fail to notice owing to fatigue or impaired vision. This transformation reduces false rejections and enhances the quality of the consumer products into the market [6].

The capability of AI to evaluate the danger of mycotoxins is crucial in the specified case of fungus contamination. The article of Aggarwal et al. (2024) comprises the general description of the concept of training machine learning models to detect spectral and textual characteristics attributed to the presence of mycotoxin-producing fungi. With the help of modern imaging technologies, such AI systems will be able to identify the presence of contamination in food matrices within several seconds, without the need to destroy the food, by conducting time-intensive chemical analyses. It is a non-invasive approach that is also considered critical when dried food commodities are being used, and water and surface structure are the most significant consideration in the inhibition of aflatoxin formation [7].

The implementation of these technologies however, is grappling with the issue of data integration and infrastructure. The article by Dhal and Kar (2025) elaborates the significance of Traceability 4.0 which incorporates the concept of AI with Internet of Things (IoT) sensors to track the environmental conditions all along the supply chain. They state that the visual inspection tools are without any doubts helpful. Nevertheless, they must be part of a wider digital platform which is able to track the temperature and humidity because they are two of the primary factors influencing mould development in the farm-to-fork supply chain. It is the holistic methodology, with quality evaluation, not a finalization, but an ongoing process in the food lifecycle [8].

One of the most significant quality parameters of dried fish products is color which is typically measured using CIELAB color parameters (L, a, and b). Nawaz et al. (2022) elaborated that the difference in the lightness (L) is a result of the loss of moisture as well as the browning phenomenon of the drying process and the difference in the parameters a and b values is dependent on the degradation of the color changes of the dried fish. The outcomes indicate the support of using quantitative color analysis as a solid foundation of the use of automated grading and defect detection systems [9].

Foreign Studies

In a somewhat similar effort to resolve the issue of efficient processing in the fisheries industry, Pardeshi et al. (2025) proposed an automated system of classifying dried fish based on the MobileNet V2 framework. The researchers have acknowledged that manual sorting is time-consuming and unreliable and hence applied Transfer Learning to train a compact model that can be deployed on edge devices. Their experiment involved four different datasets of

India and Bangladesh and examined different modalities of images such as single fish image, bulk images of fish, and the body parts such as heads and tails. The findings showed that the system was capable of identifying the species with up to 100 percent accuracy and this revealed that lightweight deep learning models can efficiently generalize and analyze the compound surface textures of dried seafood in real-time without necessitating the heavy computational infrastructure [10].

Empirical studies recently have revealed that computer vision can be used to detect surface defects on food products. Jubayer et al. (2021) performed experiments to locate mold on different surfaces of food with the help of the YOLOv5 (You Only Look Once) algorithm. Their experiment employed over 2,000 images and they demonstrated that, deep learning-based models detected mold significantly faster and more often than traditional Convolutional Neural Networks (CNNs). The study can also be used as a benchmark in the implementation of a single-stage detectors into real time food processing systems, in ensuring that automated mold detection is feasible technology-wise [11].

In order to identify the spoilage of fishes within a short time, Yin et al. (2025) designed a novel biobased nanofiber label that transforms colorimetrically to communicate spoilage. Despite the fact that their work was chemical sensing based, an electronic eye system was included to process then, proving that freshness could be determined using the visual data. The suggested technique, which integrates the materials science with intelligent sensing, according to them, offered an effective platform of observing the quality of seafood and is a parallel technological way of solving the issue of texture analysis [12].

Thiyagarajan and Jamal (2021) conducted mycological analysis of dried fish in the open markets to identify mycotoxin-producing fungi in the localized region of dried food. Their results showed that Aspergillus and Penicillium species were extremely high in the dried fish sample which validates the fact that not all conventional drying and storage methods can prevent fungal contamination. In this paper, it is emphasized that the present screening tools should be enhanced since the visual methods of sorting that are applied in markets have failed to sort all the contaminated samples and this presents a direct health hazard to the consumers [13].

In their follow-up on technology in the area of quality assessment, Nikzadfar et al. (2024) approached the subject of Hyperspectral Imaging (HSI) with the assistance of artificial intelligence to determine the quality of food. In their study, they established that despite the overall effectiveness of RGB images in detecting visible defects, AI models trained on spectral data are capable of detecting chemical changes during the initial stages of spoilage when a naked eye cannot see them. The assumption that machine learning has the capability of detecting key features of food surfaces and subsequently employing them to determine safety to a high level of accuracy, therefore reducing the number of human elements in food inspection, is confirmed by the current paper [14].

Local Literature

The modernization of the food safety standards is a priority in the government agencies in the Philippines. To be enforced in the recent administrative orders, the traces of fish and sanitation standards are those that the Bureau of Fisheries and Aquatic Resources (BFAR) has been grappling to establish. It is also the requirement of the government that there must be more severe documentation and handling processes in regards to catches in order to guarantee that the fishery products even processed products are of safe quality since the time of harvesting. This regulatory impetus highlights the necessity to have compliance technologies that can assist the local processors address these evolving requirements [15].

In particular, the food industry publishes the issues of safety of the dried fish. In an article on Food Safety Trends in the Philippines, Glenwood Technologies (2024) emphasized the need to monitor the environment and maintain hygiene in wet markets. The paper addresses the problem of cross-contamination in open market, which is an old problem, and states that the use of conventional visual testing in most instances is useless with respect to identifying microscopic pathogens. It suggests better quality assurance equipment in order to avoid the contraction of food-borne illnesses by the Filipino consumers due to poor handling of seafood [16].

As part of these safety measures, the country is advocating Agriculture 4.0. Describing the Philippine agricultural technologies in general, Cordero and Park (2023) state that the sector is gradually going digital, and drones and the use of IoT are adopted. However, the literature has found a loophole in the new post-harvest processing because the small-scale fisherfolk do not have access to modern equipment. It has been seen that bridging this digital divide is the need to integrate low-cost, AI-driven technologies to improve the economic sustainability of the local fisheries industry [17].

The Oceana Philippines (2023) highlights the main problem of post-harvest loss, in which the provided data estimates the spoilage rates of fish in the country, 25-40 percent because of the inefficient infrastructure. The organization emphasizes civic fishermen especially in the sardine (Tamban) industry are mostly left to use primitive drying techniques as a survival mechanism to save their harvest. Nonetheless, Oceana cautions that such artisanal intervention is not yet enough to avoid waste unless there was proper technological support, and the full realization of the National Sardines Management Plan, and thus there was an urgent demand in having available the necessary tools to ensure that the food supply of the coastal population was not jeopardized [18].

Agriculture and Agri-Food Canada in a 2024 sector analysis reported the value of fisheries in the Philippine diet, saying that the average Filipino eats about 2.86 kilograms of dried fish every year. The report, however, found great structural obstacles to the development of the industry, particularly targeting the issues with the old trading facilities and a consistent battle of the local producers with the strict regulations on the quality and safety of food. This coupled with increased food prices and supply chain constraints has contributed to the drop in consumption of seafood by the low end households. This economic fact highlights why the need to modernize the control systems of quality is now urgent in order to make sure that the everyday products such as the dried fish are affordable as well as safe to the population consuming the products [19].

Local Studies

Local studies have started recording food safety violations unique to the dried fish business. The article by Ching et al. (2024) was about the small-scale fisherfolk processing of post-harvest in Rosario (Cavite) with a specific emphasis on the production of Tuyo (dried Sardinella). Their findings indicated that, the national microbiological standards were not met by many samples because of inadequate hygienic standards and improper drying procedures, and the growth of molds was detected as early as 12 days after production. This study gives real-life examples of the so-called pain point, the issue that automated quality assessment will solve. It demonstrates the need of such technology at the local level [20].

In the same manner, Magallanes and Aguanza (2024) assessed the quality of microbes of fish products and contact surfaces in wet markets in the Philippines. According to their case study, they found that, there were certain products that were over the limit of the FDA. Nevertheless, the high microbial count on chopping boards and display surfaces was also a major threat of cross-contamination. The study has established that the present methods of hygiene management are not sufficient to guarantee maintenance and that automated or non-contact evaluation instruments can be suggested in order to radically decrease the danger of contamination by handling [21].

Recently, in the evaluation of the local industry, Daet et al. (2025) conducted a study to examine the compliance of the fish drying processors in Camarines Sur, with Good Manufacturing Practices (GMP). Their research identified a serious gap in the standards of food safety, stating that most local processors use only traditional sun-dry methods and use few to no Standard Sanitation Operating Procedures (SSOPs) or hygienic practices because of insufficient infrastructure and capital. The researchers discovered that extensive use of poor quality tools and lack of proper packaging materials including cardboard boxes and wooden boxes greatly exposes the dried fish to microbial contamination and pest infestation. Such high incidences of unsanitary processing environments illustrate the immediate need to implement post market quality control measures because no preventive hygiene is provided during the processing process, thus the final product is very likely to be spoilt and have health risks [1].

In the field of using machine learning to local agriculture, David (2023) has also used machine learning to forecast crop yields in the Pampanga River Basin. Even though the paper has been devoted to rice, it shows how Filipino researchers have become more empowered to apply models like the Random Forests and the Neural Networks to solve problems in the home country in agriculture. It establishes a precedent with regards to utilizing Python-based ML techniques to the examination of environmental and biological information within the Philippine setting that can subsequently be implemented to fisheries [22].

Dwelling upon the wider scope of safety concerns, Acedo et al (2024) studied the food safety profile of fresh produce in Philippines, which is characterized with systemic issues of post-harvest losses and contamination. The study established that lack of a proper technological intervention in the supply chain is a key cause of food wastage and financial losses. Elements of this research that can be compared to the fisheries industry hint at the fact that the lack of objective quality control processes is a systemic issue that runs through Philippine agriculture and that AI and machine learning can adequately help to resolve [23].

Synthesis

The reviewed literature demonstrated that manual inspection is no longer sufficient for assuring the safety and quality of dried fish products which are highly susceptible to mold contamination and surface deterioration. Foreign research points out that the Artificial Intelligence (AI) and computer vision technology greatly enhance the quality evaluation of food, because they can find early mold formation, surface texture deviation and color change which are difficult to be observed by human eyes. In fact, machine learning models such as Convolutional Neural Networks or YOLO-based algorithms proven to be faster, more accurate and more consistent data set than traditional visual inspection, without any destructively and appropriate to be used in real time. These technologies are helping to reduce health risks of mycotoxin-producing fungi, and help reduce food waste due to early detection. In contrast, in the local literature, the Philippine dried fish industry is still highly dependent on traditional sun-drying and subjective sensory evaluation that are prone to poor sanitation, exposure to environmental factors and improper storage. Local studies prove that mold growth can occur in short periods of time in humid market conditions and can often be overlooked during manual inspection. Despite the ongoing efforts to strengthen food safety regulations, many of the small scale vendors do not have access to affordable and objective quality assessment tools. This gap between advanced inspection technologies and practices near local areas underpin the development of DaingGrader an automated system that integrates the detection of molds, color uniformity and surface defects as means to improve the quality grading process and increase food safety and minimize post-harvest losses in the dried fish industry in the Philippines.

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