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Quality characteristics of commercially available dried tilapia in two northern cities of Nueva Ecija, Philippines

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Abstract

Countries rich in aquatic resources, like the Philippines, depend on fish as a primary source of protein and other essential nutrients. Dried tilapia is one of the fish-processed products available all year round in local markets. However, the product's quality may vary, affecting its nutrient content and storage life. This study evaluated the proximate composition, sensory characteristics and shelf-life of dried tilapia sold in two cities of Nueva Ecija: Science City of Muñoz and San Jose City, as well as the tildaing sold by Central Luzon State University (CLSU). A significantly higher ($p>0.05$) protein content was attained by tilading compared to the other two treatments. However, no significant differences were observed in dry matter, moisture, crude fat and carbohydrate. As for crude fiber, ash and sodium chloride, significantly higher values were seen in dried tilapia from Muñoz and San Jose City. In terms of sensory evaluation, significantly the highest scores were attained by tilading indicating the best acceptance rate among the treatments. Moreover, it did not show any signs of spoilage after 3 months of storage at room temperature while the formation of molds and insect infestation was observed on the other two treatments after 5 weeks. Overall, tilading was observed to have the best quality based on the parameters evaluated in this study.

1. Introduction

Dried fish is one of the most common fish-processed products commercially marketed in the Philippines. It plays an important role in supplying food for the country, especially in rural areas due to its simple way of preparation and it does not need cold storage. Numerous families living in the coastal areas depend on fish drying as their source of income (Espejo-Hermes, 1998). However, the qualities of produced dried fish sometimes differ due to variations in the available raw materials and the ratio of ingredients used, fish characteristics (size, species, fat content) and the target marketplace of the product.

Several species of dried fish are usually available year-round in local markets due to their high demand. The high customer acceptance has also led to the exportation of Philippine dried fishery products to countries such as the USA and Canada (Cañet, 2020). In Central Luzon, where there are numerous freshwater ponds, dried tilapia is commonly sold in the market. Tilapia is a freshwater species that possesses high levels of protein, omega-3 fatty acids, and several vitamins and minerals (Hernández-Sánchez and Morales, 2012). It ranks second to milkfish as a major aquaculture species in the Philippines. However, during the harvest period in some farms, small-sized fish are often rejected and thrown away. To address this issue, the Central Luzon State University (CLSU), located in Nueva Ecija, Philippines, launched a collaborative project under four offices (Gender and Development, University Fish Production Project, Freshwater Aquaculture Center, College of Fisheries) which developed dried tilapia with smaller sizes called as tilading (previously known as tila-ding). This product can be compared to the "danggit" or dried rabbitfish from the Visayas region. The tilading offers a unique taste based on its established procedure and quality assurance. It has been showcased in various food presentations across the country and even featured in a national television show. Due to its high consumer acceptance, continuous production of the product has been ongoing until now.

Nutrient composition is an important factor for most consumers when selecting food, aside from the price. Since various kinds of dried fish are sold in local markets, it is crucial to understand the components of the product to determine its practicality. This study aimed to

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determine the proximate composition (dry matter, moisture, ash, carbohydrate, crude fat, protein, fiber and salt content), sensory characteristics and shelf-life of dried tilapia sold in two northern cities of Nueva Ecija (Science City of Muñoz and San Jose City), as well as the tilading sold by CLSU. The results will guide the consumers in choosing the best-dried tilapia in the area, help the processors improve their product quality and contribute to establishing the proximate composition of dried fish.

2. Materials and methods

2.1 Sample collection

There are three different treatments used in this study. These were differentiated based on the source of the samples, as outlined in Table 1. All dried tilapia samples were collected in the same month and had uniform sizes. Each treatment used three replicates for analyses. The study evaluated both the proximate composition and organoleptic characteristics of the samples.

Table 1. Different dried fish samples used in the study.

Treatments	Source of dried tilapia
1	CLSU (tilading)
2	Science City of Muñoz local market
3	San Jose City local market

2.2 Proximate composition analyses

The fins, head, tail and skin of dried tilapia samples were removed, leaving the dried flesh as the sample. The dried flesh was then cut into small pieces and ground using a pulverizer (Onoya powder grinder CM-50B, China). The resulting powder was utilized for the analyses of dry matter, moisture, fat, protein, carbohydrate, fiber, ash and sodium chloride content.

2.2.1 Dry matter and moisture content

Moisture content was determined by initially drying the sample at 105°C in a hot-air oven (TA-11 Isuzu convection oven, Tokyo, Japan). In parallel, a crucible was cleaned and dried in a hot-air oven for 15 mins to reach a constant weight and remove any residual moisture. Subsequently, a 3-gram sample was placed in the pre-weighed crucible and was subjected to oven drying at 105°C for 6 hrs. After the drying process, the sample was reweighed, and the following equation was utilized to calculate the moisture content of the dried fish:

$$\text{Dry matter \%} = \frac{\text{Weight of dried sample-Weight of crucible}}{\text{Weight of sample}} \times 100 \quad (1)$$

$$\text{\% Moisture} = 100\text{-\% dry matter} \quad (2)$$

2.2.2 Fat content

The fat content of the samples was measured using fat analyzer- Soxhlet method (Foss Soxtec 2043, Foss Analytical Co., Denmark). Initially, an aluminum beaker was dried in an oven for 45 mins to eliminate any moisture and then weighed. Next, a 3 g sample was placed in filter paper and inserted into the thimble. Each beaker was filled with 40 mL of petroleum ether to facilitate fat extraction for 1 hr and 30 mins. Subsequently, the petroleum ether was evaporated, and the extracted lipid was obtained in the aluminum beaker. The weight of the beaker containing the extracted fat was recorded and the following formula was used to determine the lipid content in the dried fish samples:

$$\text{Lipid \%} = \frac{\text{W2-W1}}{\text{Weight of sample}} \times 100 \quad (3)$$

2.2.3 Protein content

The micro-kjeldahl method was used to analyze the protein content of the samples. One gram of pulverized sample was digested into anhydrous potassium phosphate (15 g), copper sulphate pentahydrate (0.5) and sulphuric acid (20 mL). The procedure involves the conversion of organic nitrogen into ammonium sulphate by digesting it with concentrated tetraoxosulfate acid in a micro-Kjeldahl flask. Then, the digested samples were diluted with sodium hydroxide and distilled water to make them alkaline. The liberated ammonia through digestion was collected in a boric acid solution and determined titrimetrically. The percentage of protein in the sample was calculated using the following equation:

$$\text{\% Nitrogen} = \frac{\text{V1-V2} \times \text{N} \times 14.007}{\text{Wt. of sample}} \quad (4)$$

$$\text{\% Protein} = \text{\% nitrogen} - 100 \quad (5)$$

Where V_1 = Volume of HCl used in titration, V_2 = Volume of HCl used in blank titration, N = Normality of HCl used in titration, 14/1000 = Conversion ratio from ammonium sulphate to nitrogen and Wt. = Weight of sample.

2.2.4 Total carbohydrate content

The total carbohydrate content of the dried fish samples was calculated based on the equation below:

$$\text{Carbohydrate \%} = 100\text{- (moisture + ash + protein + fat + fiber)} \quad (6)$$

2.2.5 Analysis of crude fiber, ash and sodium chloride content

The samples were sent to the Department of Agriculture, Regional Feed Chemical Analysis Laboratory, Sto. Niño, San Fernando City, Pampanga, Philippines to analyze the remaining proximate composition of the samples. Crude fiber was analyzed

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using ANKOM™ 200 Fiber analyzer which uses the filter bag technology wherein samples are encapsulated allowing them to be processed all together in a single batch. Ash content was determined using the furnace-ignition method in which dried fish samples were dried in a muffle furnace at a temperature ranging from 900°C to 1400°C. Lastly, sodium chloride content was evaluated using the Mohr method wherein dried fish samples were subjected to the direct titration method (silver nitrate was used as the titrant while chloride ion solution was used as the analyte).

2.3 Sensory analysis

Dried fish from each treatment were cooked at similar conditions. Thirty college students trained in sensory evaluation were randomly selected as panelists. The specifications evaluated were odor, color, taste and texture using the 9-point hedonic scale.

2.4 Shelf-life evaluation

Three samples from each treatment were used for shelf-life evaluation for 90 days. All of the samples were placed in polyethylene bags, sealed, and stored at room temperature at the Fish Processing Laboratory. Quality changes were monitored throughout the experimental period.

2.5 Statistical analysis

This study used a completely randomized design (n = 3). The proximate analysis and sensory evaluation were analyzed using SPSS (11.0) One-way ANOVA. Differences between mean values were determined using the Duncan Multiple Range Test (DMRT) and the significant level was defined at $p<0.05$.

3. Results and discussion

3.1 Proximate composition

The proximate composition of dried fish samples is presented in Table 2. No significant difference was observed in dry matter and moisture content of dried fish in all treatments. However, the highest dry matter and lowest moisture content were both attained by tilading. A higher amount of dry matter may denote a higher concentration of nutrients present in the dried fish while a lower amount of moisture content is desired to prevent the growth of spoilage microorganisms. According to Sultana *et al.* (2011) and Van Ruth *et al.* (2014), sun-dried fishes contain an average of 10-20% moisture content which is also exhibited by all samples in this study. However, a moisture content of less than 15% is more desirable as it stops the growth of spoilage microorganisms such as molds (Oparaku and Mgbenka, 2012). Among the treatments, only the tilading obtained a moisture content of less than 15% since proper packaging and storage procedures are ensured unlike the available dried fish in the market which are often displayed in an open-air environment where the relative humidity is generally high.

Fats are essential in diets as it increases the palatability of foods by absorbing and retaining the flavors (Aiyesanmi and Oguntokun, 1996). No significant difference was observed among the treatments. During the drying process, moisture content decreases which leads to a higher concentration of nutrients including fats. In the study of Chukwu (2009), the fat content of tilapia increased after subjecting to kiln and electric drying methods. In terms of crude protein content, the significantly highest amount was seen in tilading (27.96%). According to Stancheva *et al*. (2013), protein content of fish is considered low if it is below 15%. In this study, T3 was just a little bit higher from the lower limit of crude protein whereas T2 had the lowest value. Protein is an essential nutrient present in large quantities in fish. Compared to other meats, fish offers a cheaper and more convenient source of protein, especially for consumers living in the coastal areas. Differences in protein values among the treatments can be attributed to different factors such as the dietary composition of fish. The nutrient absorption capability

Table 2. Proximate composition of dried tilapia (per 100 g) in all treatments.

Proximate composition (%)	T1	T2	T3
Dry matter	$85.49±1.33^a$	$83.91±4.55^a$	$84.60±3.17^a$
Moisture	$14.51±1.33^a$	$16.09±4.55^a$	$15.40±3.17^a$
Crude fat	$11.18±0.52^a$	$10.96±0.18^a$	$10.88±0.69^a$
Crude protein	$27.96±2.27^a$	$14.29±4.49^b$	$15.17±2.20^b$
Carbohydrate	$33.85±1.92^a$	$33.85±5.73^a$	$33.51±6.18^a$
Crude fiber	$0.87±0.55^b$	$1.53±0.32^{ab}$	$2.30±0.30^a$
Ash	$11.87±0.45^b$	$23.10±0.20^a$	$22.73±1.11^a$
Sodium chloride	$3.63±0.15^b$	$15.13±0.72^a$	$15.47±1.78^a$

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

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and conversion potential of essential nutrients in fish vary depending on several factors, such as environmental conditions, species, or strain (Onyia *et al*., 2010). Moreover, protein levels may be affected by the duration of the drying process. Lower moisture content is generally observed in fish dried for longer periods. Dehydration of molecules that exist between proteins results in higher protein content in fish (Ninawe and Rathnakumar, 2008). In the study of Kim *et al*. (2020), dried fish with the lowest moisture content had the highest protein content. Aside from lengthening the shelf life, the drying technique could also improve the protein and amino acid content of fish (Alahmad *et al*., 2021).

Generally, higher carbohydrates and crude fiber are present in the plant as compared to animal food products. Carbohydrates in a fish's body are usually in the form of glycogen. However, it does not contribute much to the reserves in the fish body tissue (Das and Sahu 2001; United States Department of Agriculture Nutrient Data Laboratory [USDA], 2010). Dried tilapia in all treatments in this study had no significant difference in terms of carbohydrate content. As for the crude fiber, a significantly higher level was observed in T3 followed by T2 and lastly, the tilading. Higher ash content was also attained by T2 and T3 as compared to tilading. The amount of these components in fish flesh may greatly depend on the type of diet given to fish or available in their environment (Ahmed *et al*., 2022).

Sodium chloride (NaCl) or salt is known to be a preservative agent for all kinds of food products. In fish, salting is commonly combined with drying not just to lengthen the shelf-life but to give more flavor and aroma. Low brine concentration leads to an increase in water-holding capacity because of the low protein denaturation resulting in a total higher yield of the salting process. On the other hand, higher brine concentrations may result in more protein denaturation which may change the texture and reduce the water-holding capacity (Wang *et al*., 2011). Even though the salt content of tilading was found to be significantly lower than the other two treatments, still, it exhibited the longest shelf-life due to proper hygiene and standard procedure followed by the processors.

3.2 Sensory analysis

Consumer acceptance greatly influences human food preference during purchase (Sajdakowska *et al*., 2017). In this study, the odor, taste, color and texture of the dried tilapia samples were analyzed (Figure 1). In all attributes, significantly highest scores were attained by tilading indicating the highest consumer preference among the samples. All scores correspond to "like very much" based on the 9-point hedonic scale. On the other hand, no significant difference was observed in T2 and T3. Both of the treatments attained a score range of 4-5 which corresponds to "neither like nor dislike" and "dislike slightly". Based on the panel observation, T2 and T3 exhibited an intense fishy odor attributed to the presence of unremoved blood and a saltier taste resulting from a higher salt content compared to tilading. Moreover, darker color and softer flesh were observed in T2 and T3 which can be associated with uneven drying conditions.

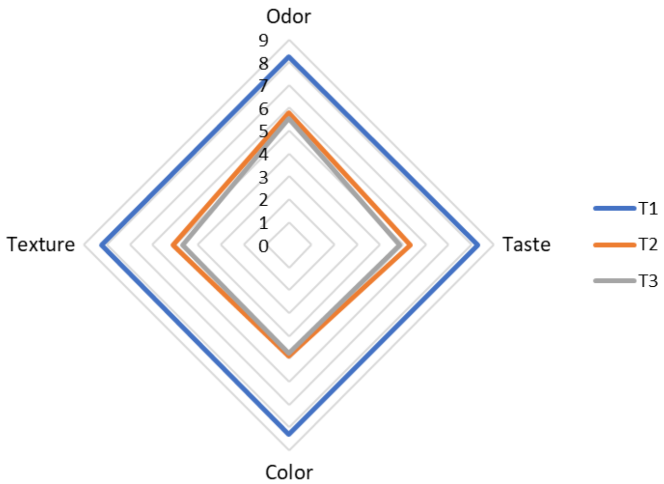

Figure 1. Sensory characteristics of dried fish analyzed in this study: (T1) tilading, (T2) dried fish from Science City of Muñoz market, (T3) dried fish from San Jose City market.

3.3 Shelf-life evaluation

Shelf-life of the dried tilapia samples was evaluated at room temperature. There was no sign of spoilage observed in all the samples in the first four weeks. However, in the 5th week, black spots and small insect larvae were seen in T2 and T3 samples. Two of the common signs of spoilage in dried fish are the occurrence of molds and insect infestation (Paler-Calmorin, 2006). Proper processing and handling are needed in every food product to minimize loss due to spoilage. Although all the treatments were well-kept during the shelf-life evaluation, dried fish sold in the markets of the Science City of Muñoz and San Jose City were observed to be totally exposed (without covers) in the market before the purchase, making it more vulnerable to contaminants, which may lead to the growth of spoilage microorganisms. In the production of tilading, standard procedures and methods are carefully followed by the processors to ensure the quality of the product. Moreover, the fish's belly which contains the viscera was thoroughly cleaned as well as the blood, kidney and spleen that may cause oxidation. Unhygienic processing, inadequate salting, improper drying, use of spoiled fish for processing, and lack of air-tight packaging lead to poor quality of sun-dried fish

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(Immaculate *et al*., 2013). Tilading did not show any sign of spoilage even after twelve weeks. According to Immaculate *et al*. (2013), dried fish may have a shelf-life of 3 to 6 months if proper processing procedures are applied and products are kept accordingly.

4. Conclusion

In this study, the proximate composition, sensory characteristics and shelf-life of dried fish from CLSU, Science City of Muñoz, and San Jose City local market were analyzed and evaluated. The CLSU product commonly known as tilading significantly attained the highest protein content among the samples. On the other hand, no significant differences were observed in dry matter, moisture, crude fat and carbohydrate. Also, the significantly lowest crude fiber, ash and sodium chloride were seen in tilading. Sensory evaluation revealed the highest positive acceptance of the panel for tilading in terms of odor, taste, color and texture as compared to the other two treatments. Moreover, the dried fish from CLSU did not show any sign of spoilage after 3 months of storage at room temperature while the formation of molds and insect infestation was observed in the other 2 treatments after 5 weeks. Overall, the tilading attained the highest values for protein as well as sensory attributes and has the longest shelf-life compared to other dried tilapia samples.

Conflict of interest

The authors declare no conflict of interest.

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