Chemical Composition and Storage Stability of FLYING FISH (*Cheilopogon abeir)* EMBUTIDO from MAITUM, Sarangani Province under Chilled and Frozen Conditions

ABSTRACT

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| --- |
|  This study was conducted to determine the effect of different storage conditions (chilled and frozen) in the quality, acceptability, and shelf life of flying fish embutido. Lipid oxidation was analyzed by Peroxide Value (PV) determination on Days 0, 20, 40, and 60. On the same intervals, changes in organoleptic properties, particularly color, odor, flavor, and texture, were also determined using a Descriptive Sensory Score Sheet. General acceptability was likewise assessed using a 9-point hedonic scale. All samples in Day 0 and Day 20 did not exceed the USFDA standard for peroxide value which is 7.8 meq/kg. Progressive oxidation took place afterwards, leading to peroxide values that exceeded the acceptable limits for safe human consumption. All treatments exhibited an increase in PV and had a final peroxide value of 25.0 meq/kg for Treatment I (Chilled) and 16.5 meq/kg for Treatment II (Frozen) at Day 60. This indicated that slower oxidation occurs in frozen samples than those stored in chilled condition. Sensory evaluation revealed that among treatments, frozen flying fish embutido retained better organoleptic properties, which was consistently observed during the 60-day study. |

*Keywords:* peroxide value, organoleptic properties, oxidation, sensory evaluation, flying fish

1. INTRODUCTION

Flying fish are the most dominant catches of gillnets in the predominantly small- scale fisheries of the municipality of Maitum, Sarangani, Philippines. Flying fish fishes, which is very important source livelihood in Maitum, Sarangani and many coastal communities in the Philippines. Five genera were recorded in Maitum, Sarangani Province namely: Cheilopogon, Cypselurus, Hirundichthys, Parexocoetus, and Exocoetus. Flying fish shared 83.88% to the total harvest, ranked the second most dominant species in town. Due to the abundance of the species, thousands of households in Maitum depend on the flying fish fishing industry as their main source of livelihood. Aside from being sold as fresh, local skills in fish processing, and unique technology on marinating flying fish was also practiced by the residents and turned-out the most potential business in town (Emperua et. al., 2017). Despite the importance of flying fish to the local fisheries in Maitum, there is limited scientific study on it.

Our country has a rich food culture since it has numerous indigenous and foreign influences, and one example is the embutido. Embutido is a meatloaf made with a festive mixture of any type of meat, carrots, and raisins wrapped around slices of eggs, cheese, and sausage (Filipino cuisine, 2018). Embutido, a traditional Filipino meatloaf typically made from ground pork, is often prepared in advance and stored for later consumption. Proper storage methods, such as chilling and freezing, are essential to maintain its quality and safety.

Spoilage of food products is due to chemical, enzymatic or microbial activities. It is estimated that approximately one-third of all food produced globally is lost or wasted, amounting to about 1.3 billion tons annually (FAO, 2019). The impact of microbiological spoilage is most pronounced in highly perishable foods such as fruits, vegetables, dairy, meat and seafood, which are especially vulnerable during transportation and storage (Parfitt et al., 2010). With the ever-growing world population and the need to store and transport the food from one place to another where it is needed, food preservation becomes necessary to increase its shelf life and maintain its nutritional value, texture, and flavor. The freshness and quality of fish have always gained the attention by Food Regulatory Agencies and Food Processing Industry.

Proper seafood handling practices from harvest to consumption are important to prevent spoilage and maintain premium quality (Watts, 2022). Historically salting, drying, smoking, fermentation and canning were the methods to prevent fish spoilage and extend its shelf life. In response to consumer demand for texture, appearance and taste, new methods were developed including cooling, freezing and chemical preservation (Ghaly at. al., 2010). Generally, this study aimed to determine the acceptability and nutrient value of flying fish embutido during long-term storage. Specifically, this study observed the peroxide value and sensory attributes of flying fish embutido stored in either chilled or frozen condition.

2. material and methods

**Raw Materials**

A total of 60 pieces of flying fish embutido processed by Maitum Fish Processors Association 1 were purchased at Maitum, Sarangani Province. Samples were placed in a polystyrene box and transported immediately to the Fish Processing Laboratory of the College of Fisheries, Mindanao State University- General Santos City. Upon arrival, the said products were stored under chilled (0–5°C) and frozen (-18°C) conditions prior to chemical composition analysis and sensory evaluation.

 **Proximate Composition**

The proximate composition of the samples was determined according to Association of Official Analytical Chemists methods (AOAC, 2000). Determination of fat content in samples was determined by Soxhlet method. The crude protein was determined using Kjeldahl method. Ash was determined by gravimetric method with a sample weighing 5 to 10g placed in a partly open crucible and incinerated in a furnace. Moisture content was done by oven-drying method with a sample weighing 5g.

**Oxidation Parameters**

**Lipid Oxidation**

Two replicates (5g of oil extract) from each treatment were analysed during Days 0, 20, 40, and 60 at the College of Natural Sciences and Mathematics Laboratory at Mindanao State University, General Santos City. Peroxide value was determined using the AOAC titration method.

Peroxide Value (meq/1000)= (A - B x M x 1000) / weight of the sample

**Sensory evaluation**

A sensory panel consisted of ten (10) students from Mindanao State University – General Santos assessed the samples for descriptive sensorial qualities such as color, texture, flavor, and odor. Treatments were coded and evaluated using 9-point hedonic scale for the general acceptability of the product, where 9 is the most acceptable and 1 is the most unacceptable.

**Statistical analysis**

Peroxide values (n=2) and data from sensory evaluation (n=10) from Days 0, 20, 40, and 60 were analyzed for significant differences between treatment using Independent Samples t-test. Differences were considered significant at α=0.05. Computations were done using IBM SPSS.

3. RESULTS AND DISCUSSION

 **Proximate Composition**

In this study proximate composition of flying fish embutido were determined by measuring crude fat, crude protein, crude ash, and moisture content (Table 1).

Table 1. Proximate analysis of flying fish embutido.

|  |  |  |  |
| --- | --- | --- | --- |
| Sample  | Crude Fat (%) | Crude Protein (%) | Ash (%) |
| Flying Fish embutido | 23.76 | 14.38 | 2.09 |

According to the findings, the moisture and fat value were 58.8% and 23.76%, respectively while the crude protein and ash values were 14.38% and 2.09%, respectively. According to Espejo- Hermes (1989), protein content of the fish flesh is within 16 to 22% thus, the crude protein content of the finished product is below the usual average. One factor affecting protein content is sex, environmental and season of the species (Espejo-Hermes, 1989). Additionally, minced fish used in these studies leached in three washing cycles with the same salt concentrations. Repeated leaching will affect the overall composition of the material, resulting in decreased protein content (Baxter and Skonberg, 2008). This is because most of the proteins, including sarcoplasmic proteins, heme proteins, and blood are eliminated during surimi processing due to their water-soluble characteristics.

Table 1 shows that the sample met the criterion of top graded and industrial surimi product. According to Lee (1986) the moisture content of the industrial surimi should be less than 85%. Results of crude fat analysis shows this component was uncharacteristically high, and may be due to the incorporation of ½ cup cheddar cheese in the embutido formulation. Cheddar cheese contains at least 9.28g of fat (Fatsecret 2019).

Egg could also contribute to the fat content in product as it contains about 5 grams of fat per 100g. The majority of fat in an egg is unsaturated and is regarded to be the best type of fat to be included in a balanced diet (McIntosh, 2018). Ash content of the samples was also higher than the standard content in raw fish. Adding salt during the pre-processing may increase the ash content (Ahmed et al., 2010; Alsaban et al., 2014; Beachamp and Engleman, 1991). It may also be because of the flying fish flesh is composed of 1.28% crude ash (Borgstrom et al., 1961).

**Lipid Oxidation**

a

a

b

b

NS

NS

Figure 1. Peroxide values of flying fish embutido stored in chilled and frozen condition

Based on Figure 1, the peroxide value, an indicator of lipid oxidation, was monitored in two storage treatments: chilled storage (Treatment I) and frozen storage (Treatment II) over a 60-day period. The results demonstrate a clear distinction in oxidation rates between the two methods.At the initial stage (Day 0), both treatments exhibited low peroxide values, with Treatment I recording 1.89 and Treatment II at a similar level. By Day 20, a gradual increase was observed in both treatments, with chilled storage reaching 4.3 and frozen storage at 5.3. This suggests that lipid oxidation was beginning, but remained relatively controlled.

By Day 40, a significant increase in peroxide values was noted. Treatment I (chilled storage) experienced a sharp rise to 20.74, while Treatment II (frozen storage) increased more moderately to 15.82. The steeper increase in chilled storage indicates a higher oxidation rate, likely due to the continuous exposure to higher temperatures compared to freezing.

At the final observation on Day 60, the peroxide value in chilled storage further increased to 25, whereas frozen storage showed a slower rise, reaching 16.5. This confirms that freezing effectively slows down the lipid oxidation process, while chilling allows oxidative reactions to progress more rapidly.

Statistical analysis of these trends suggests a significant difference in oxidation rates between the two storage methods. Chilled storage follows a linear increase, whereas frozen storage demonstrates a more controlled rise, likely due to the reduced enzymatic and oxidative activities at lower temperatures. The divergence in peroxide values after Day 40 indicates that oxidation accelerates more rapidly in chilled conditions, while freezing helps maintain lipid stability. Based on these findings, frozen storage is statistically more effective in preserving the quality of the product by reducing oxidative deterioration.

According to Aminah (2010), there are several factors that can affect the oxidation, which include oxygen presence, temperature and light exposure. Increased in peroxide value can be due to factors such as degree of fatty acids present particular in fish oil, level of concentration of natural antioxidant added, storage, exposure to light, and the content of metals or other compounds that may catalyse the oxidation process (Choe and Min, 2006).

Results demonstrate that chilled samples are more prone to oxidative rancidity than the samples subjected to frozen condition. According to Gandotra et al. (2012), chilling the products allows the comparatively rapid proliferation of bacteria, protein denaturation, lipid hydrolysis, and oxidation, thereby reducing the shelf-life of the product.

Oxidation typically involves the reaction of oxygen with the double bonds of fatty acids. Therefore, fish lipids which consist of polyunsaturated fatty acids are highly susceptible to oxidation. Lipid oxidation also involve three stages, first is the initiation which involves the formation of lipid free radicals through catalysts such as heat, metal ions and irradiation. At this point, oxidation occurs relatively slow, uniform rate of speed during what is called as the induction period (Talbot, 2004) as the result in Day 0. Second is the first propagation reaction where peroxy radical is formed and there is no other component formed that is why we have a lower result Day 20 than in Day 40. In the second propagation reaction is where peroxy radicals is react with another triglyceride, and formed hydroperoxide and regenerating new components, which are aldehydes and alcohols, causing an accelerated reaction to occur that is why we have a sudden increase in measurement of peroxide value (Hamilton, 1994). The present study shows that flying fish embutido that were subjected in frozen condition are less prone to oxidation process.

Additionally, high peroxide value indicates that oil has been oxidized but low value does not necessarily indicate the condition of premature oxidation. The peroxide value may occur as a result of new peroxide formation rate which is smaller than the rate of degradation into another compound (Aminah, 2010).

In the present study, statistical analysis was in agreement with the study conducted by Gandotra et al. (2012) where frozen storage sample had a lower peroxide value than the chilled storage sample. WFLO (2008) reported that shelf-life of product can be extended significantly as storage temperature become colder. For most products, a temperature of 0℉ (-18℃) or below is required if storage is expected to exceed 6 months.

Accordingly, the acceptable limit for peroxide value of crude fish oil is between 7 to 8 meq/kg, not exceeding 20 meq/kg (Hras et al., 2000) and ≤5.0 meq/kg as maximum level for fish products (USFDA, 2017). All examined fish oil samples exceeded the acceptable limit for peroxide value after Day 20. The products of lipid oxidation are known to be health hazards since they are associated with aging, membrane damage, heart disease, and cancer. The consumption of such oxidized fats has been reported to cause diarrhea and liver enlargement (Suja et al., 2004).

**SENSORY EVALUATION**

Appearance

 Descriptive organoleptic evaluation test was on 9-point hedonic scale. Figure 2 below shows the gradually decreasing scores until Day 60 for all samples stored at chilled and frozen temperatures. Samples were acceptable and passed the limit of acceptability of the panelist. There was no significant difference (p>0.05) among treatments throughout the storage period.

 Figure 2. Acceptability of appearance of flying fish embutido stored in chilled and frozen condition.

The appearance of flying fish embutido were judged acceptable even as the storage time progressed. There were no significant changes (p>0.05) in all treatments on all observation periods. Samples were light brown on Day 0 and turned dark brown later as shown in the Table 2. The most acceptable color as scored by the panelists was Dark brown.

Table 2. Appearance profile of fried flying fish embutido.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment** | **Day 0** | **Day 20** | **Day 40** | **Day 60** |
| I (Chilled) | Light brown | Dark brown | Dark brown | Dark brown |
| II (Frozen) | Light brown | Dark brown | Dark brown | Dark brown |

Flavor

Figure 3. Acceptability of flavor on fried flying fish embutido stored in chilled and frozen condition.

Figure 3 shows that Frozen flying fish embutido were rated high in flavor (p>0.05). Freezing fish products for storage purposes slows down the bacterial growth and helps retard lipid hydrolysis and oxidation, which may lead to food spoilage and cause loss of flavor, thereby preserving the quality of the product (Gandotra et. al., 2011, Tirloni, 2013). On the other hand, chilling allows the comparatively rapid proliferation of bacteria, protein denaturation, lipid hydrolysis, and oxidation; thereby reducing the shelf-life of the product (Gandotra et. al., 2011).

Table 3 shows that flying fish embutido in Treatment I was consistently salty while Treatment II was only salty at Day 0, but savory from Day 20 onwards. This differences in their flavor profile could be due to multiple factors, including the sensitivity of the taste buds of the panelist. There was no significant difference (p> 0.05) among treatments and al samples had acceptable flavor.

Table 3. Flavor profile of fried flying fish embutido.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment** | **Day 0** | **Day 20** | **Day 40** | **Day 60** |
| I (Chilled) | Salty | Salty | Salty | Salty |
| II (Frozen) | Salty | Savory | Savory | Savory |
|  |  |  |  |  |

**Odor**

Figure 4. Acceptability of odor on fried flying fish embutido stored in chilled and frozen condition.

The organoleptic evaluation of food products subjected to any processing technology is important in determining the acceptability (Mohamed et. al., 2011). Figure 4 shows gradually decreasing scores in terms of odor. All treatments had a pleasant odor since they underwent leaching process which eliminated unpleasant odor of raw materials (Hermes, 2004). It is also suspected that the pleasant odor of embutido after frying was contributed by the addition of spices that can eliminate the fishy smell of the fish (Park, 2004) and gives a distinctive smell to the embutido.

Table 4. Odor profile of fried flying fish embutido.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment** | **Day 0** | **Day 20** | **Day 40** | **Day 60** |
| I (Chilled) | Neutral | Pleasant | Pleasant | Pleasant |
| II (Frozen) | Neutral | Pleasant | Pleasant | Pleasant |

Table 4 shows the odor characteristics of the developed product. All treatments had a neutral odor in Day 0 and a consistently pleasant odor for the rest of the storage period.

**Texture**

Figure 5. Acceptability of texture on dried flying fish embutido stored in chilled and frozen condition.

All treatments obtained a decreasing trend as the day progress for all samples stored at chilled and frozen storage condition. All samples had acceptable texture scores. There were, however, no significant differences in the mean scores of the treatments (p>0.05). Treatment II obtained higher panelist scores, indicating that its firm texture was more acceptable even until Day 60. Relatively lower scores were noted in chilled samples, probably attributed to the softer texture of the product. It is expected that the texture of foods changes as their temperature does (Green et al., 1979). Chilled samples already show early indications of spoilage, which were still acceptable, but were noticeably different and quite inferior from those which were frozen. If the fish meat undergoes storage in ice (chilled), there are often texture changes, such as the fish flesh are being mushy (Oka et al., 1990; Toyohara and Shimizu, 1988).

Table 5. Texture profile of fried flying fish embutido.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment** | **Day 0** | **Day 20** | **Day 40** | **Day 60** |
| I (Chilled) | Firm | Firm | Soft | Mushy |
| II (Frozen) | Firm | Firm | Firm | Firm |

Table 5 shows that the textures of the samples were changing as days progressed. Frozen flying fish embutido remained firm throughout the study while chilled samples were firm on the earlier stages, but became soft and later, mushy.

**General Acceptability**

Figure 6. General Acceptability of fried flying fish embutido stored in chilled and frozen condition.

The overall acceptability of fried flying fish embutido stored at different storage condition was done to evaluate the consumer acceptance in the product. Higher scores indicated better acceptability of the products. Results show that both treatments were liked very much from the beginning of the study until the end. There were only significant differences in general acceptability as it reached Day 60. Effects of lipid oxidation and spoilage have been noted in chilled products (Treatment I) but were less pronounced in frozen flying fish embutido (Treatment II). As a synergistic effect of the individual sensory characteristics of the treatments, it appears that storing flying fish embutido at frozen conditions yields to products with the most preferable qualities (p<0.05).

Table 6. General acceptability profile of fried flying fish embutido.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment** | **Day 0** | **Day 20** | **Day 40** | **Day 60** |
| I (Chilled) | Like very much | Like very much | Like very much | Like very much |
| II (Frozen) | Like very much | Like very much | Like very much | Like very much |

The organoleptic evaluation of food products of any food processing technology is very important in determining the consumer acceptability **(Mohamed et al., 2011).** The exposure of lipid to oxidative rancidity and the degradation of biochemical components of food will lead to the formation of low molecular compounds, which affect the sensory profile of the fish products, including its flavor, odor, and texture **(Franke et al., 1996).**

**4. CONCLUSION & RECOMMENDATION**

The spoilage of fish and fish products depends on a number of factors. These factors, as well as the spoilage mechanism, must be thoroughly understand before developing proper handling and pre-treatment methods and preservation techniques for food products. To stop the rapid spoilage of fish, it is essential to store the fish at 0°C after catching during harvesting. However, the energy-intensive freezing operations is only a temporary method for preservation of fish as freeze storage can decrease microbial and enzymatic spoilage but cannot prevent oxidative spoilage.

This study has proven that frozen condition helps slow down lipid oxidation and prolong the shelf-life of food products. The preservative effect of storage at lower temperatures was observed to be more pronounced compared to products that were only stored at chilled conditions. This led to differences in the organoleptic profiles of the treatments, but did not result to significantly different acceptability scores. Overall, the choice of storage condition does not have a strong influence in the sensory qualities and acceptability of the products, but mattered significantly to the peroxide values of the developed product. Considering their peroxide values, both treatments were only deemed acceptable for human consumption before Day 40 of prolonged storage. Overall, it is recommended to store flying fish embutido at frozen temperatures to slow down oxidative rancidity.

More efforts are required to understand the role of proximate composition of fish, postharvest history, environmental conditions, initial microbial load, type and nature of bacteria and their interaction in order to optimize the shelf-life of fish. For future studies, peroxide values during an extended storage period at consistently low temperatures may be monitored. It is likewise recommended that storage studies in much lower storage condition, the packaging style and use of other fish species may also be conducted to give more information on their effect against spoilage and pathogenic microorganisms in processed flying fish.

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Competing interests

Authors have declared that no competing interests exist.

Authors’ Contributions

This work was carried out in collaboration among all authors. Author JBA conducted of the experiment including writing or drafting of the manuscript. Author LFB assisted in the conduct and the writing of the paper, checked the content, and submitted the manuscript to the publisher. Author GSH worked primarily in the editing of the proposal and final manuscript including data analysis and interpretation. Author ETM worked primarily in the editing of the proposal and final manuscript including conceiving and designing the experiment. All authors read and approved the final manuscript.

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Details of the AI usage are given below:

1. ChatGPT

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