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EFFECTS OF DIFFERENT BRINE CONCENTRATIONS ON THE DRYING CHARACTERISCTICS OF MILKFISH (*Chanos chanos*)

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An undergraduate thesis presented to the faculty of the Department of Teacher Cavite State University-Cavite College of Arts and Trades Campus, Rosario, Cavite in partial fulfilment of the requirements for the degree of Bachelor of Science in Industrial Education with Contribution No. ____________. Prepared under the supervision of Gee Jay C. Bartolome.

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INTRODUCTION

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Fish is a highly nutritious food. It is particularly valued for its protein which is of high quality compared with meat and egg (Ojutiku et al., 2009). It contains high quality protein, amino acids and absorbable dietary minerals (Idah, 2013) and also provides several other nutrients such as vitamins A, B, E and K and some minerals like calcium, phosphorus and iron (Bakhiet, 2011). However, fish is highly perishable because it provides favorable medium for the growth of microorganisms after death (Ojutiku et al., 2009). In order to prolong the shelf life of fish, it is preserved by many processes salting, brining, smoking, and drying among others.

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Sodium chloride has traditionally been used in curing and preservation of fish due to its capacity to improve the water holding capacity of proteins while reducing the microorganisms count on dry fish. The preservative nature of salt decreases water activity, making water less available for microbial activities and enhancement of functional properties leading to an increased shelf life (Aubourg and Ugliano, 2002). Salt concentration and length of time of exposure depends on the expected final product (Bellagha et al., 2007).

Drying is a process of moisture removal resulting from simultaneous heat and mass transfer (Ertekin and Yaldiz, 2004). The major target of drying is to remove mostly the physically held water in order to promote longer shelf life of the product.

Bartolome et al. (2016) in their study on the drying activities of *Decapterus macrosoma* (scod) soaked in four different brine concentrations and different brining time found that the brine concentration is proportional to the moisture content of the fish samples. The drying rate constants increased quadratically with brine concentration. High coefficients of determination from the simple linear regression revealed a strong correlation between moisture content, drying rate constant and brine concentration.

This study focused on the investigation of the drying characteristics of milkfish as affected by different levels of brine concentration and brining time. This followed the recommendations of Bartolome et al. (2016) to observe the significant difference on the moisture content, moisture curves, drying rates, and sensory properties of *Chanos chanos* as preliminary studies to support optimization activities in smoked fish processing.

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Objectives of the Study

Generally, the study aimed to determine the effects of different brine concentrations on the drying characteristics of *Chanos chanos*.

Specifically, the study aimed to:

1. establish the relationship between brine concentration, brining time and drying characteristics of milkfish;

2. compare the final moisture content of the fish samples after the drying experiment;
3. conduct a water activity analysis for the fish samples; and
4. perform a sensory evaluation among the fish samples subjected to different brine concentrations.

Significance of the Study

Through this study, the proponents were able to know the effects of different brine concentrations and brining time on the drying characteristics of milkfish. This helped identify the appropriate brine concentration and brining time to be used in preparing dried and salted fish. This research will help the fisher folks and *tinapa* makers to improve their traditional processing activities. The results of this study will be a significant undertaking to support and optimize the *tinapa* processing.

Scope and Limitations of the Study

This study focused on determining the effects of different brine concentrations on the drying characteristics of milkfish. The drying characteristics include the moisture content, moisture curves and drying rate curves of the fish products. Water activities of the dried products were also measured and compared. Sensory evaluation was conducted for the acceptability of the dried products.

Time and Place of the Study

This study was conducted from September 2015 to November 2016 in Cavite State University-Rosario Campus in Rosario, Cavite.

Research Framework

(Discussion of the related theories, principles, or concepts considered as foundations of the research)

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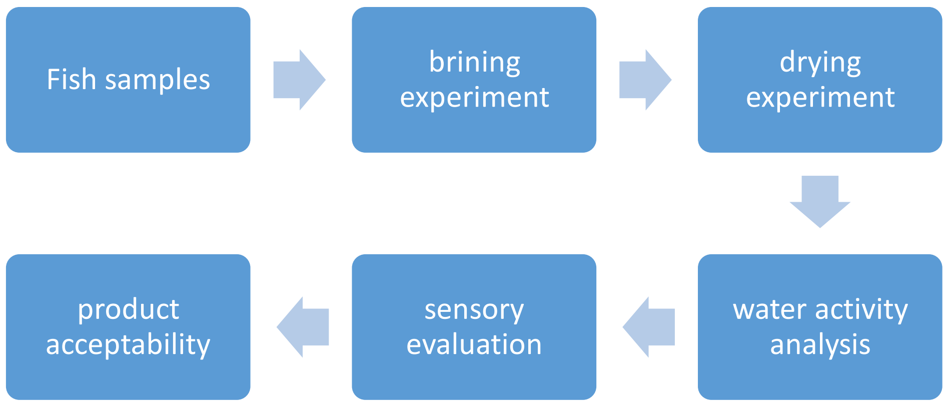

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Definition of Terms

Brine refers to the solution of salt and water used as preservative.

Brining is the process of soaking of fish or meat of fish in different brine concentrations with corresponding time of exposure.

Drying is a process removing water from fish by evaporation and can be done by natural drying, mechanical drying, freeze drying and solar drying.

Moisture is the amount of liquid removed on the meat of fish set in a constant temperature and time.

Salting is a traditional processing method and can be used with combination of drying and smoking.

Solar drying is the process of drying fish with the use of solar dryers or solar energy. The energy of the sun is collected and concentrated to produce elevated temperatures and an increased rate of drying.

Tinapa or smoked fish is a style of fish preservation wherein the fish are cured by smoking.

(Terms in this section are arranged alphabetically; the term being defined is written in boldface and italicized. Definitions are in complete sentences without citations.)

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REVIEW OF RELATED LITERATURE

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This chapter presents the related literature and related studies used to support the concepts and ideas of the research.

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Fish

Fish is a highly nutritious food and it is particularly valued for its protein which is of high quality compared with meat and egg (Ojutiku et al., 2009). It contains high quality protein, amino acids and absorbable dietary minerals (Idah, 2013) and also provides several other nutrients such as vitamins A, B, E and K and is a good source of minerals like calcium, phosphorus and iron (Bakhiet, 2011). However, fish is highly perishable because it provides favorable medium for the growth of microorganisms after death (Ojutiku et al., 2009). To prolong the shelf life of fish, it is preserved by many processes including salting, brining, smoking, drying and others.

Brining and Drying

Drying refers to a process of moisture removal as a result of simultaneous heat and mass transfer (Ertekin and Yaldiz, 2004). The major target of drying is to remove mostly the physically held water, thus extending the product shelf life. The dehydration process is a complex heat and mass transfer phenomenon that depends on internal and external variables.

Sun drying is the simplest and cheapest method of fish preservation, but known to affect protein quality the most. Removal of water decreases and stops the microbiological activities or any cellular breakdown. The drying rate depends on the condition of the air and on the rate at which moisture can be brought to the surface of the fish. During the drying process, the fish surface dries faster and hardens, thereby locking moisture inside, which slows the drying process and encourages degradation of protein and oxidation of fatty acids. Degradation of protein is also accelerated when fish products are subjected to high temperature for an extended period (Kabahenda, Omony, and Husken, 2009).

Bartolome et al., (2016) in their study on the drying kinetics of *Decapterus macrosoma* (scod) soaked in different concentrations of brine (10%, 15%, 20% and 25%) exposed to different brining time (1 h, 2 h, 4 h, and 16 h) found out that the brine concentration is proportional to the moisture content. The drying rate constant increased quadratically with brine concentration. The results of the experiment also showed strong correlation among moisture content, drying rate constant and brine concentration.

Ikrang, Okoko, and Etuk (2014) in their study on the effects of brining on the drying kinetics of Nile tilapia (*Oreochromis niloticus*) fish fillets found out that the pre-treatment concentration process significantly influences the drying characteristics of tilapia fish fillets. It has been shows that as the salt concentration increased, the moisture content decreased linearly with increase moisture ratio and decreasing drying rate. The results of their study also revealed that low drying rates were attained at higher brine concentrations.

Flick (2010) suggests that slow and even drying and salting procedures provide good product color and form a skin on the fish that holds in juices and readily accepts smoke. Salt concentration and length of time of exposure depends on the expected final product (Bellegha et al., 2007 as cited by Ikrang, Okoko, and Etuk, 2014) and on the size and fattiness of fish. Saturated brine with 70 to 80 percent salt is usually employed for all the common types of smoke fish providing a salt pick up of 2-3 percent. Pigott (n.d.), in his study involving three different brine concentrations (15%, 21%, and saturated brine) exposed to different drying conditions (35°C, 50% RH; 45°C,30% RH; 55°C,18% RH) found out that for fish process at a saturated brine, temperature and humidity had no impact on the drying rate and the impact of salt concentration on the drying rate decreases with the concentration value. However, the role of salt is always significant and must be understood when a change to a drying process are considered. In the sensory evaluation of the dried products, the results showed that consumers prefer for fish that had been brined using 15 percent salt followed by 21 percent salt, both dried at 45°C. The salt concentration is low, water activity is low and tasters showed a mark preference for the product.

Sodium Chloride

Sodium chloride has traditionally been used in curing and preservation of fish due to its capacity to improve the water holding capacity of proteins while reducing the microorganisms count on dry fish. The preservative nature of salt decreases water activity, making water less available for microbial activities and enhancement of functional properties leading to an increased shelf life (Aubourg and Ugliano, 2002).

Water Activity

Water activity is defined as the ratio of water vapor pressure of the food substrate to the vapor pressure of pure water at the same temperature (Jay, 2000). It is generally understood that microorganisms need water in an available form to grow in food products. The control of moisture content in foods is one of the oldest exploited preservation strategies. Food microbiologists generally describe the water requirements of microorganisms in terms of the water activity (a_w) of the food or environment.

During curing or salting, it is the addition of salt which lowers a_w and preserves the foods. The principal preservation action of salt is achieved by the lowering of the moisture content and consequently a_w of the foods or solution in which it is contained. At high salt concentrations, most bacterial action is halted or at least greatly retarded, although halophilic bacteria are not so affected. Furthermore, in the brine salting process which is used for salt preservation of various oily fish such as herring and salmon, the fish are kept beneath the surface of the brine. This helps minimize oxidation of the oils in such fish by keeping oxygen away to a large extent.

Synthesis

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METHODOLOGY

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This chapter presents the research design, materials, data gathering procedures and statistical analysis of data gathered.

Research Design

The study was 2 x 4 factorial experiment laid out in Completely Randomized Design (CRD). Sixteen treatments were applied with two replications each. The independent variables used in the study are presented in Table 1 and the treatments prepared are shown in Table 2.

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Table 1. Independent variables used in the study

FACTOR A **BRINE CONCENTRATION** **(% NaCl grms/H_2O L)**	**FACTOR B** **BRINING TIME (hour)**
10	0.5
15	1.0
20	1.5
25	2.0

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Table 2. Treatments used in the study

FACTOR B	**FACTOR A**			
	A_1	**A_2**	**A_3**	**A_4**
B_1	A_1B_1	A_2B_1	A_3B_1	A_4B_1
B_2	A_1B_2	A_2B_2	A_3B_2	A_4B_2
B_3	A_1B_3	A_2B_3	A_3B_3	A_4B_3
B_4	A_1B_4	A_2B_4	A_3B_4	A_4B_4

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Preparation of Samples

Thirty-five kilos of fresh milkfish (*Chanos chanos)* were purchased at Carms Food at Bagbag II, Rosario, Cavite. Using a weighing scale, the fish were divided to 32 equal parts. The fish were washed and cleaned carefully in running water, its bone and viscera were removed, and butterfly splitted. The length and width of the samples were cut in near uniform size at 5 x 6 inches.

Moisture Content Determination

Moisture content of the samples was measured by oven-drying method. Thirty-five grams of samples are collected from each replicate and placed in a constant temperature oven set at a temperature of 105ºC for 12 hours. Moisture content of fresh, brined and dried fish were measured.

Brining

Samples were subjected to different brine concentrations and brining time following the experimental design. The brine temperature was maintained at ≤4ºC by addition of ice. To prevent dilution of brine, salt was added maintaining the preset concentration. After soaking, weight of samples per treatment were recorded.

Drying

A cabinet type solar dryer was used for drying the brined fish. Samples were properly arranged in drying trays. The quantity of water removed during drying were recorded by periodic weighing the samples every two hours using an electronic balance. Drying was carried out until the moisture content of the samples were constant for three consecutive readings. The drying condition was kept uniform throughout the experiment by providing additional heat using biomass stoves as heaters placed on the air vents of the solar drier. Digital hygrometer and thermometer were used to monitor the relative humidity and temperature.

Water Activity (a_w) Determination

Water activities of dried fish samples were measured using a Novasina water activity meter. The analysis of a_w was conducted at the College of Agriculture, Food, Environment and Natural Resources in Cavite State University-Main Campus. Samples were prepared as defined by operations manual of the testing equipment.

Sensory Evaluation

The dried products were subjected to a sensory evaluation. Thirty respondents composed of BSIE students major in Foods Technology and faculty members were selected by purposive sampling. The products were evaluated in terms of appearance, taste, texture and aroma using a nine-point Hedonic scale as shown in Table 5.

Table 5. Nine-point Hedonic scale for the sensory evaluation of dried products

RATING	EQUIVALENT
9	Like Extremely
8	Like Very Much
7	Like Moderately
6	Like Slightly
5	Neither Like or Dislike
4	Like Slightly
3	Dislike Moderately
2	Dislike Very Much
1	Dislike Extremely

Data Analysis

The following formulas were used by researchers to calculate the following parameters:

Moisture content

Equations numbered chronologically

$$\text{Wet basis:} \quad MC_{wb} = \frac{\text{weight of moisture}}{\text{weight of moisture} + \text{weight of dry matter}} \times 100 \qquad (1)$$

Dry basis: $$MC_{db} = \frac{\text{weight of moisture}}{\text{weight of dry matter}} \times 100 \qquad (2)$$

Weight of moisture removed

$$WMR = Wi\,(1- \frac{1 - MC_{wb}}{1 - MC_{db}}) \qquad (3)$$

where: WMR = weight of moisture removed, kg

W_i = initial weight, kg

MC_{wb} = moisture content wet basis, %

MC_{db} = moisture content dry basis, %

Final weight of dried material

$$Wf = \frac{Wi\,(100 - MCi)}{(100 - MCf)} \qquad (4)$$

where: Wf = final weight of dried material, kg

Wi = initial weight of fish, kg

MCwb = moisture content wet basis, %

MCdb = moisture content dry basis, %

Drying rate

$$Dr = \frac{W_i - W_f}{T_d} \qquad (5)$$

where: Dr = drying rate / moisture reduction rate, kg/hr

Wi = initial weight of fish

Wf = final weight, kg

Td = drying time, hr

Statistical Analysis of Data

This two-way analysis of variance (ANOVA) was used to determine if there is a statistically significant difference on the moisture content, drying time, drying conditions, and water activity of the fish samples. Post-hoc Tukey test was used to locate the differences among treatments means.

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RESULTS AND DISCUSSION

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This chapter presents the discussion of the results of the brining and drying experiments and the statistical analysis and interpretation of data.

Initial Moisture Content

Table 6 shows the average moisture content (in dry basis) of fish samples after brining. Treatment A_3B_2 has the highest moisture content at 238.22 while Treatment A_4B_2 has the lowest moisture content at 105.72. The two-way ANOVA showed that there is no significant difference on the moisture content of the fish samples after brining (*p* = *0.133*). This suggests that the moisture content is unaffected by the concentration of brine and brining time.

Table 6. Moisture content of fish samples after brining (in dry basis)

TREATMENT	**MEAN**	**TREATMENT**	**MEAN**
A_1B_1	173.02	A_1B_3	131.80
A_2B_1	126.56	A_2B_3	152.50
A_3B_1	163.34	A_3B_3	160.24
A_4B_1	127.32	A_4B_3	135.30
A_1B_2	209.81	A_1B_4	156.41
A_2B_2	209.81	A_2B_4	156.41
A_3B_2	238.22	A_3B_4	198.76
A_4B_2	105.72	A_4B_4	229.71

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Drying Characteristics

Figure 2 shows decrease in moisture (in grams) of the samples measured during the drying experiment. All the samples showed a decrease in mass over the whole drying period. The highest moisture loss was established during the first early period of drying process with average value of 180.97, 57.47 and 48.69, respectively. The lowest moisture loss was recorded during the last three period of drying process with average value of 8.66, 6.66 and 1.94.

Treatment A_1B_4 showed the highest decrease in moisture at an average of 179.5 grams, followed by Treatment A_2B_4 with an average of 91 grams. In terms of moisture loss per unit time, the results revealed that Treatment A_1B_4 and Treatment A_1B_3 were highest at 17.17 and 15.98 g/h, respectively. Treatment A_4B_4 and Treatment A_3B_1 has the lowest moisture loss per unit 12.35 and 12.69 g/h, respectively.

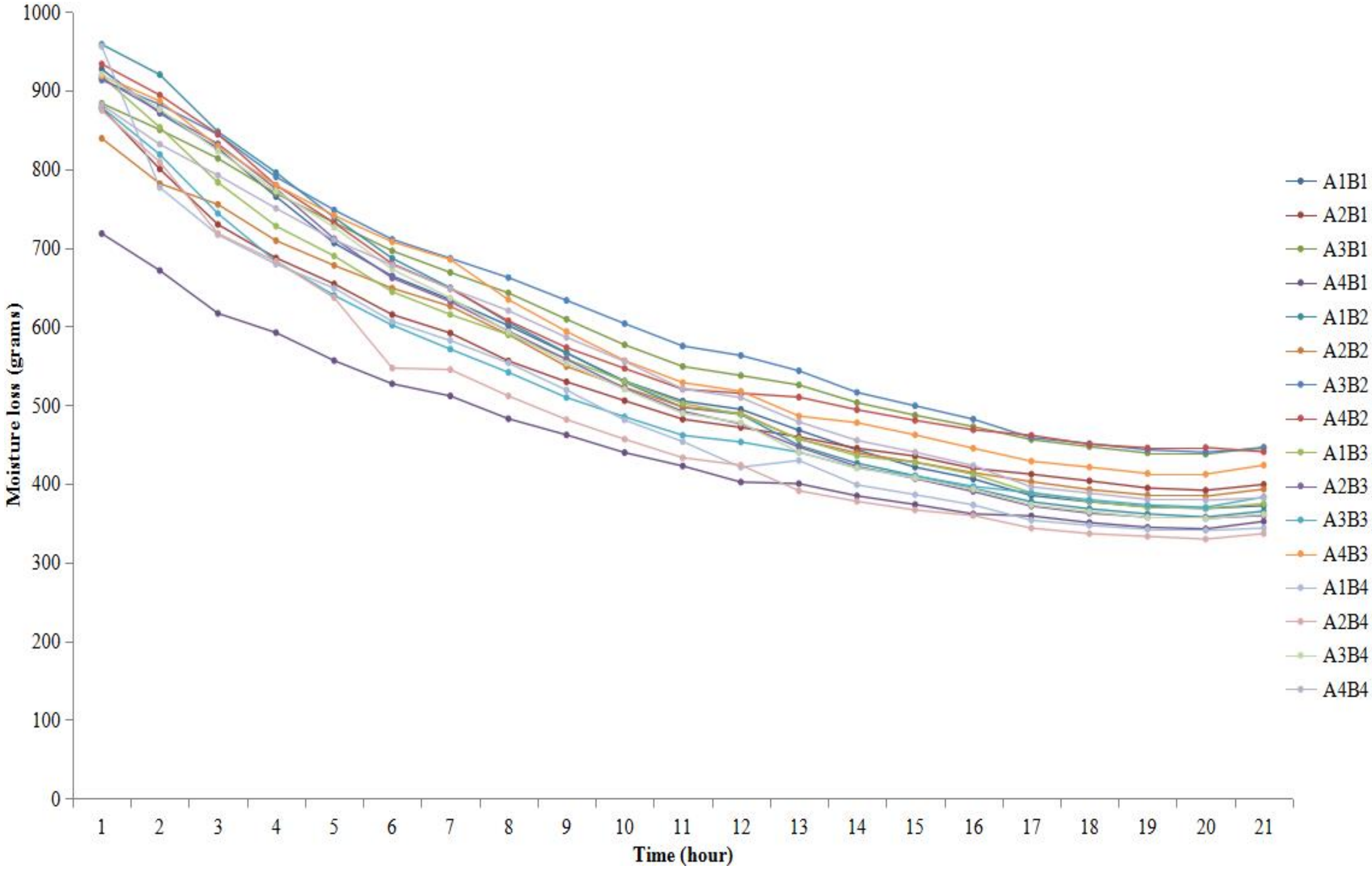

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Figure 2. Moisture loss in fish samples every two hours

Figure 3 shows the drying rate constant of fish samples. Drying rate constant is highest for Treatment A_4B_4 at 0.0409 per hour and lowest for Treatment A_4B_2 at 0.0178 per hour. The scatter diagram shows no clear relationship between drying rate constant, brining concentration and brining time. The two-way ANOVA also revealed that the brine concentration and brining time have no significant effect on the drying rate constant of the fish samples ($p = 0.299$).

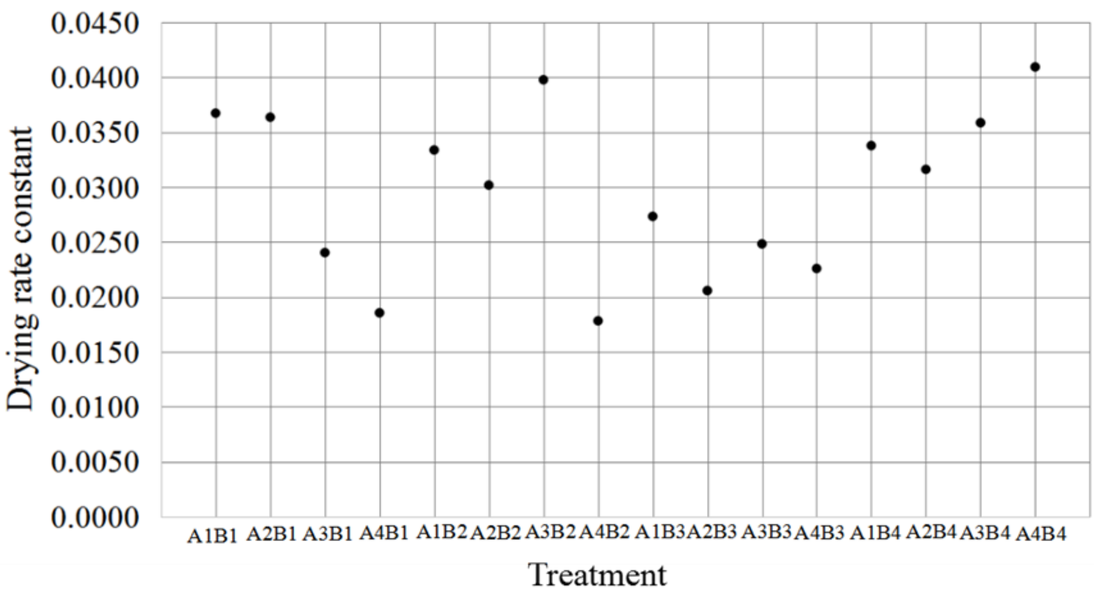

Figure 3. Drying rate constants of fish samples

Water Activity

Table 7 shows the water activity of the different samples subjected to different brine concentrations and brining time. Water activity of samples ranged from 0.67-0.70. Treatment A_2B_4 has the highest a_w and Treatment A_2B_3, A_3B_3 and A_3B_4 has the lowest a_w. Nevertheless, the water activities of all samples were below the maximum limit of

0.78 stipulated in the Philippine National Standards for Dried Fish (PNS/BFAD 04:2006).

Table 7. Water activity (a_w) of fish samples

TREATMENT	MOISTURE CONTENT	WATER ACTIVITY
A_1B_1	28.93	0.69
A_2B_1	24.31	0.68
A_3B_1	51.53	0.69
A_4B_1	54.46	0.68
A_1B_2	42.27	0.69
A_2B_2	32.42	0.69
A_3B_2	34.64	0.68
A_4B_2	44.86	0.69
A_1B_3	31.33	0.69
A_2B_3	56.66	0.67
A_3B_3	48.71	0.67
A_4B_3	45.75	0.68
A_1B_4	30.97	0.69
A_2B_4	39.25	0.70
A_3B_4	37.63	0.67
A_4B_4	32.67	0.68
Maximum limit		**0.78**

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Sensory Evaluation

Table 8 shows the results of sensory evaluation of fish samples. Thirty evaluators were selected to evaluate the sensory properties of the products in terms of texture, aroma, color and taste using a 9-point Hedonic scale. Treatment A_1B_3 has the highest mean score of 6.80 while Treatment A_3B_2 and A_3B_4 has the lowest mean score of 6.46. However, all the samples were liked moderately by the evaluators.

Table 8. Sensory evaluation

TREATMENT	MEAN	INTERPRETATION
A_1B_1	6.54	Like moderately
A_2B_1	6.63	Like moderately
A_3B_1	6.60	Like moderately
A_4B_1	6.53	Like moderately
A_1B_2	6.51	Like moderately
A_2B_2	6.65	Like moderately
A_3B_2	6.46	Like moderately
A_4B_2	6.56	Like moderately
A_1B_3	6.80	Like moderately
A_2B_3	6.52	Like moderately
A_3B_3	6.68	Like moderately
A_4B_3	6.66	Like moderately
A_1B_4	6.65	Like moderately
A_2B_4	6.59	Like moderately
A_3B_4	6.46	Like moderately
A_4B_4	6.52	Like moderately

SUMMARY, CONCLUSION AND RECOMMENDATION

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Summary

The study was conducted from September 2015 to November 2016 to determine the effects of different brine concentrations on the drying characteristics of milkfish (*Chanos chanos*). Specifically, the study aimed to: 1) establish the relationship between brine concentration, brining time and drying characteristics of milkfish; 2) compare the final moisture content of the fish samples after the drying experiment; 3) conduct a water activity analysis for the fish samples; and 4) perform a sensory evaluation among the fish samples subjected to different brine concentrations.

Thirty-five kilos of fresh milkfish (*Chanos chanos)* were purchased at Carms Food in Bagbag II, Rosario, Cavite. The milkfish were eviscerated, split-open longitudinally, thoroughly washed, and drained and divided into 32 equal parts for the experiment. The study was a 2 x 4 factorial experiment laid out in Completely Randomized Design (CRD). The brine concentration and the brining time were used as independent variables, each having four levels. The brine concentrations used in the study contained 10, 15, 20, and 25 percent salt content and the brining time were set at 0.5, 1, 1.5 and 2 hours. A cabinet type solar dryer was used in to dry the fish samples subjected to these treatments. The moisture content before and after brining and after 48 hours of solar drying was determined by oven drying method. The quantity of water removed during the drying was recorded every two hours by weighing the samples using an electronic balance. The relative humidity and drying temperature were also held uniform as much. After the drying experiment, the dried fish products were subjected to water activity analysis using a Novasina water activity meter and to sensory evaluation.

The results of the statistical analysis of data revealed that brine concentration and brining time does not have a significant effect on the drying characteristics of milkfish. The sensory evaluation showed that it all the products were liked moderately by the consumers. Furthermore, the water activity of all products passed the minimum requirement of the Philippine National Standards for dried and salted fish.

Conclusion

The effects of different brine concentrations and brining time on the drying characteristics of milkfish were investigated. The results of the experiment showed that these factors do not affect the drying characteristics of fish samples. This result implies that the products can be prepared using any of the combinations of brine solution and brining time.

Recommendations

Based on the results of the study, the following recommendations were made:

1. observe the drying characteristics under controlled temperature and relative humidity; and
2. measure the shelf life of dried products as influenced by different brine concentrations and brining time.

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APPENDIX TABLES

Appendix Table 1. ANOVA table for moisture content

SOURCE	TYPE III SUM OF SQUARES	df	MEAN SQUARE	f	SIG.
Concentration	9294.243	3	3098.081	2.146	0.134
Time	11225.527	3	3741.842	2.592	0.089
Concentration & Time	24180.279	9	2686.698	1.861	0.133

α = 0.05
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Appendix Table 2. ANOVA table for drying rate constant

SOURCE	TYPE III SUM OF SQUARES	df	MEAN SQUARE	f	SIG.
Concentration	0.00	3	9.076E-02	1.232	0.331
Time	0.001	3	0.00	2.513	0.095
Concentration & Time	0.001	9	9.747E-05	1.323	0.299

α = 0.05
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Appendix Table 3. List of materials used in the study

QUANTITY	UNIT	ITEM DESCRIPTION
35	kg	Medium-sized milkfish
10	kg	Iodized salt
3	sack	Charcoal
3	unit	Kalan de uling
6	unit	Orocan Utility Can
3	pack	Resealable plastic bag, 2” x 3”
3	block	Tube ice
3	bottle	Denatured alcohol
2	pack	Plastic bag, medium size
1	unit	Pitcher, 1.2L

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APPENDIX FIGURES

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Appendix Figure 1. Preparation of fish for brining

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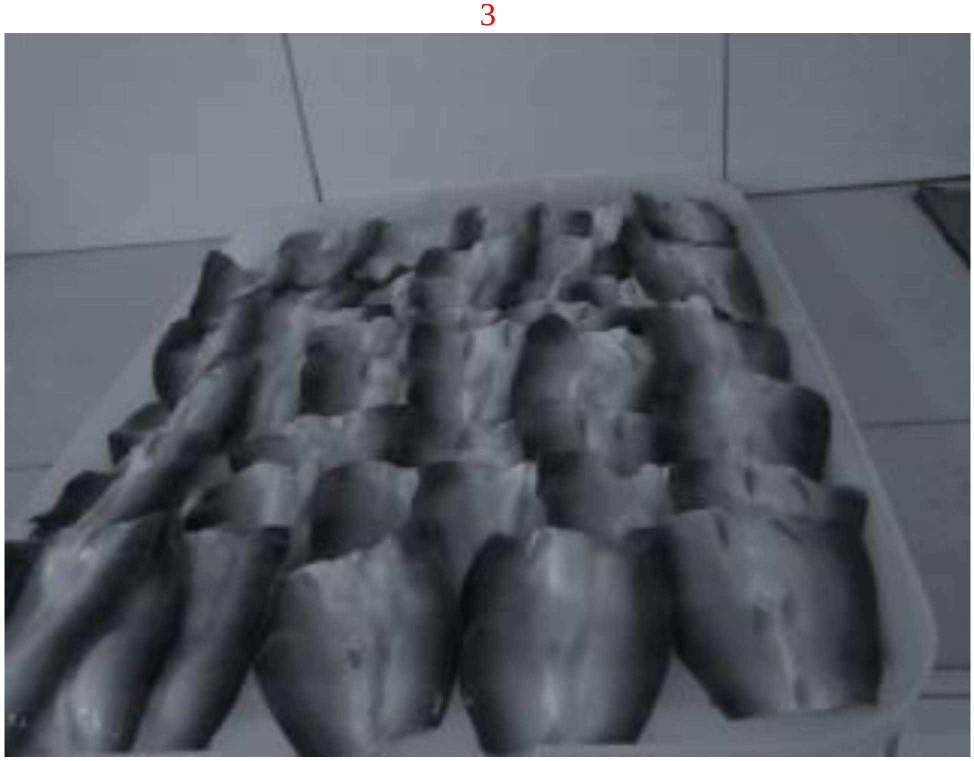

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Appendix Figure 2. Draining of fish

Appendix Figure 3. Weighing and dividing of fish samples

Appendix Figure 4. Preparation of brine solution

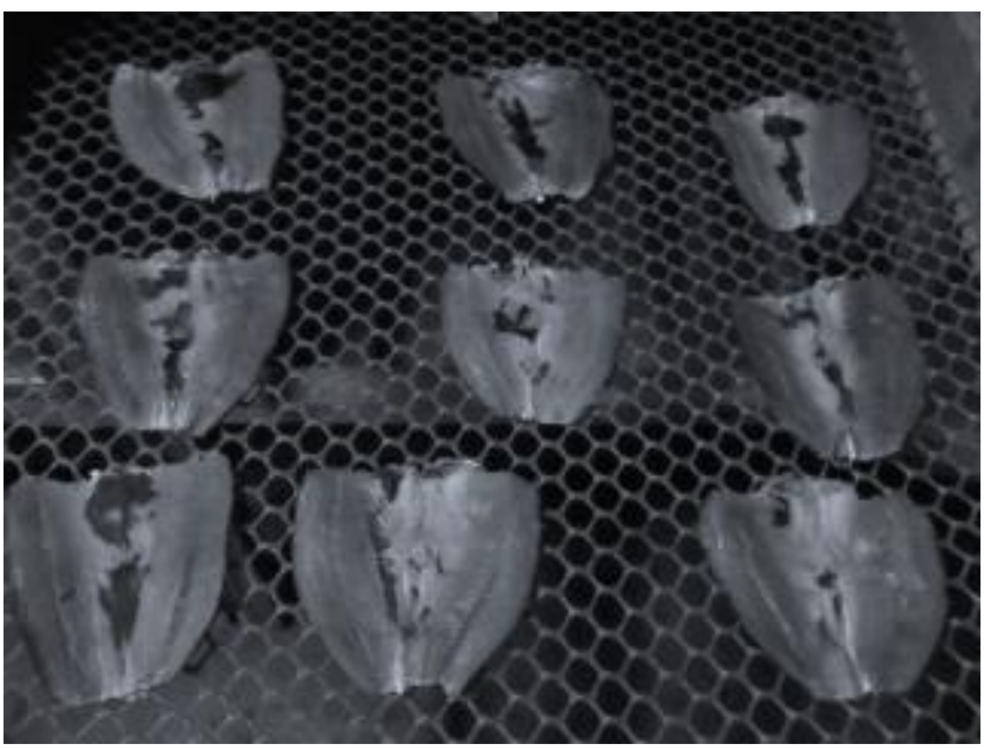
Appendix Figure 5. Pouring of salt for the brine solution

Appendix Figure 6. Brining

Appendix Figure 7. Weighing of brined samples

Appendix Figure 8. Preparation of samples for oven drying

Appendix Figure 9. The solar dryer



Appendix Figure 10. Fish samples in the drying trays

Appendix Figure 11. Weighing of dried samples

Appendix Figure 12. Recording of temperature

Appendix Figure 13. Periodic recording of the mass of samples

Appendix Figure 14. Storing of dried samples

Appendix Figure 15. Sensory evaluation of dried products

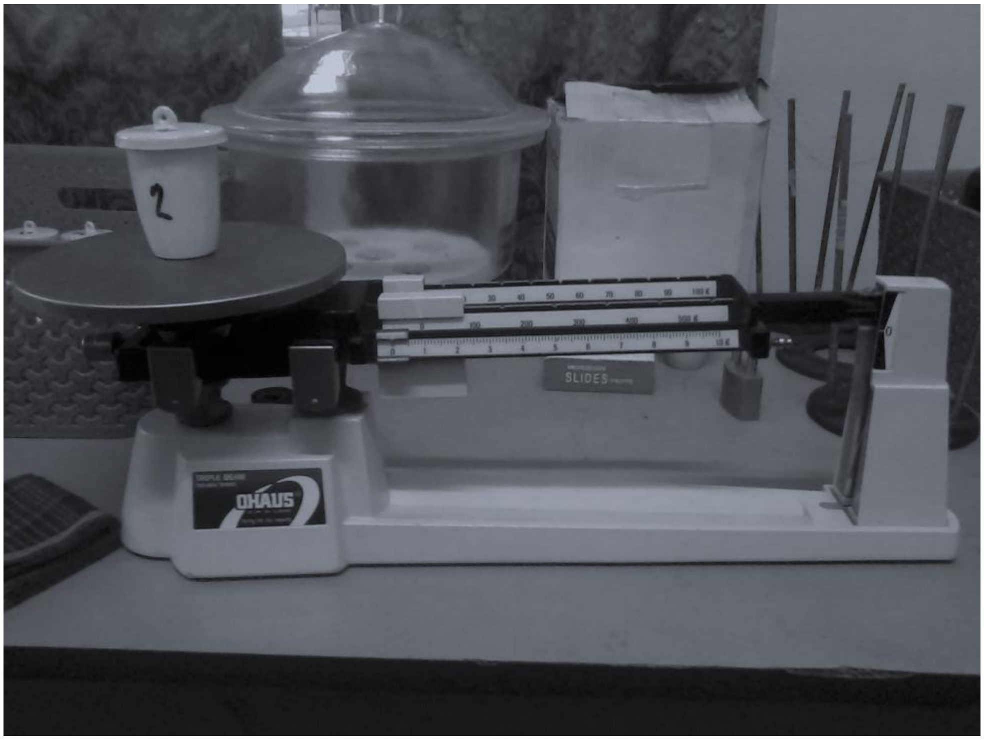
Appendix Figure 16. Weighing of samples for oven drying

Appendix Figure 17. Pre-heating of the forced convection oven

Appendix Figure 18. Fish samples in a crucible for moisture content determination

Appendix Figure 19. Loading of the samples in the oven dryer

Appendix Figure 20. Oven dryer set at 105°C for 12 hours



Appendix Figure 21. Final weighing of samples after 12 hours

Appendix Figure 22. Water activity analysis of samples

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APPENDICES