NUTRACEUTICAL RESEARCH

Research Article

Effect of Pre-Treatment and Drying Temperature on Drying Rate and Proximate Composition of Tilapia Fish (*Oreochromis niloticus*)

Calista Oluebubechukwu Ifeka[1]*, Agomuo Jude Kelechi[1], Ismaila Ayuba Ramadan[1]

[1]Department of Food Science and Technology, Faculty of Renewable Natural Resources, Federal University, Dutsin-ma, Katsina, Nigeria

***Corresponding author:**

Calista Oluebubechukwu Ifeka,

Department of Food Science and Technology, Faculty of Renewable Natural Resources, Federal University, Dutsin-ma, Katsina, Nigeria, Phone: 08141291985,
E-mail: ifkcalista@gmail.com

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ABSTRACT

This study evaluated the effect of preliminary processing and drying temperature on the drying rates and proximate composition of tilapia fish (*Oreochromis niloticus*). Two hundred and fifty (250) grammes of Tilapia fish samples were descaled, eviscerated and cleaned before application of different treatments (control, blanching, salting, sugaring and a mixture of salt and sugar), and coded as FWT, FBL, FST, FSU and FSS. The samples were dried at varying temperatures of 60oC, 70oC and 80oC. The weights of the samples were taken as drying process occurred. This was done to study the rates of drying of the different samples. Samples were analysed for proximate composition after drying. After storage period, free-fatty acid, peroxide values, TBA of the samples were also analysed. The data obtained was analyzed using standard analytical method. The results obtained from the proximate analysis before storage showed that Sample FWT had the highest moisture content (18.43%) while sample FSU had the lowest (12.09%). The sample FWT had the highest ash content (13.24%) while sample FSU had the lowest (8.90%). Sample FST had the highest values (27.00%) for fat content while sample FWT has the least value (20.17%). For protein content, sample FSU had the highest while sample FWT had the lowest (32.08%) value. After storage, the result of the proximate analysis showed significant increase ($p<0.05$) in protein content of the samples, sample FSS had the highest value (62.35%) while sample FWT had the least value (53.15%). Sample FST had the highest value for ash content (16.39%) while sample FWT had the highest fat content (18.87%). The values for chemical properties of the fish indicated that sample FSS had the highest (0.61%) for free fatty acid, while sample FSU had the lowest of all samples (0.36%). The values for peroxide values indicated sample FSS as the highest (3.04 meq/kg) while sample FST and FSU (2.76 and 2.72 meq/kg) as the lowest. Highest values for TBA was recorded in sample FSS (0.98 mg/100g) and sample FSU (0.58 mg/100g) recorded the lowest values. Salt - sugar treated tilapia dried at higher temperatures showed better drying efficiency, higher

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protein retention, and higher lipid oxidation compared to other treatments.

Keywords: Drying Rate, Pre-treatment, Tilipia Fish, Proximate Composition, Drying Temperature

INTRODUCTION

Fish are the most successful vertebrates in aquatic habitats and also make up more than half of all living vertebrates in the world. Fish species number roughly 28,000, of which about 1000 have cartilage (sharks, Skates and rays), 108 have no jaws (hagfishes, lampreys), and the remaining 26,000 are bony fishes. They are very diverse in species than any other group of vertebrates [1]. Fish are an important source of food especially protein to humans and are considered sea-foods or marine foods. Fresh Fish is said to contain 70 -84 % water, 15-24 % protein, 0.1-22% fat and 1-2 % minerals and 0.1- 1% carbohydrate [2]. In Nigeria, the predominant fishes farmed are catfish and tilapia fish. Nigeria has the resources (12 million ha inland water and aquaculture) to produce 2.4 million metric tonnes of fish annually, however, the predicted demand is now greater than the supply of 1.4 million metric tonnes [3]. Tilapia (*Oreochromis niloticus*) is a type of bony fish, covered in scales. It is primarily a freshwater fish that lives in shallow streams, ponds, rivers and lakes but are barely found in brackish water. Tilapia is low in fat and saturated fat, omega-3 fatty acids, calories, carbohydrates, and sodium. However; it is a rich source of protein, phosphorus, potassium, selenium, niacin and vitamin B-12. Tilapia possess three main species namely; Nile tilapia, Mozambique tilapia and blue tilapia.

According to Dan-Brennan [4], the presence of selenium in Tilapia helps in preventing cancer, heart disease, thyroid disease and cognitive decline, it also helps to reduce or lower blood pressure, cholesterol, blood clotting and also the risk of stroke. Tilapia, though scaly, is inexpensive and eaten in different forms in Nigeria. It can be boiled, fried, roasted, grilled, sautéed, baked and served with other side dishes [5]. According to Ghaly et al. [6], about 25 % of main agricultural and fishery products are lost annually due to chemical and microbiological degradation. Changes in physical traits including colour, odour, texture, eye colour, gill colour, softness of the muscle and so forth are frequently associated with spoilage. Freshly caught fish's shelf life is difficult to predict due to many factors including variances in species' tissue composition, the impact of the season on composition, differences between freshwater and salt water fish, unhygienic handling and more. Traditionally, fish has been preserved by sun drying, smoking, salting, smoke drying, fermenting, grilling and frying. Recent methods of preserving fish are by use of chemical preservatives (such as benzoate or sorbic acid) irradiation, refrigeration, freezing, freeze drying and canning [7]. New techniques have emerged to replace sun drying using equipment such as oven, drum dryers, solar dryers etc. to achieve effective and efficient drying and produce wholesome product fit for consumption. Drying or dehydration helps to reduce the amount of moisture available in the foods, thereby reducing water activity, concentrating nutrients and preventing microbial spoilage and increasing the shelf life. Fresh fish can be dried to a moisture level of 25 %, which will inhibit bacterial development and lessen autolytic activity. Water activity in fishes, can be regulated by drying, chemical treatment or a combination of the two. To bind the free water molecules and produce an osmotic imbalance that inhibits cell growth, scientists have utilized sugars and sodium chloride [8]. This technique has been extensively investigated as a practical way to enhance the economics of the dehydration process and is excellent for partially removing water from foods. The use of sugars, sodium chloride and other acids to lower water activity in fish (foods) has been reported in many studies. In depth research on the autolytic activity of endogenous proteinases in Indian anchovy was reported by Siringan et al. [9]. They discovered a 48 % reduction in autolytic activity when 25 % (w/w) sodium chloride (NaCl) was added. Sen [10] proposed blanching shrimp for five minutes at 80 °C in a10 % solution of sodium chloride inactivated the autolytic enzyme. According to Yongsawatdigul et al. [11], when tilapia surimi was incubated in 1M sodium chloride (NaCl) at 65 °C for 1.5 hours, proteolysis decreased by almost 76 % compared to the control (0% NaCl). Jasmina et al. [12] also reported using three osmotic solutions to reduce water activity of fish (Crassus gibelio), R1: sugar beet molasses, R2: NaCl + sucrose, R3: (NaCl + sucrose+ sugar beet molasses).

Fresh fish tissue is more perishable than other animal tissues even under conditions of refrigeration and frozen storage as deterioration sets in as soon as fish is caught and removed from water and these results to loss of quality. Drying of fish is one of the methods most commonly used in preserving fish. In Nigeria, dried fish are faced with the problems of insect infestation, microbial proliferation, loss in quality and lower shelf life during storage. This could be due to inefficient drying, making moisture available for chemical interactions and microbial proliferation. Drying temperature/time regime

for efficient enhancement of fish quality and shelf life has been studied, but the effect of pre-treatments on these conditions (temperature and time) has not been well studied. Fish is an important source of protein in the human diet. It provides essential nutrients required for health. Tilapia contains phosphorus, potassium, selenium, niacin, and vitamin B-12, required for various functions. This research work if successful will provide information on the best pre-treatment method among brining, blanching and sugaring to be used to achieve efficient drying.

Objective of the Research

The broad objective of this study was to evaluate the effect of pre-treatment and drying temperature on drying rate and proximate composition of Tilapia fish (*Oreochromis niloticus*).

MATERIALS AND METHODS

Sources of Raw Materials

Two hundred and fifty (250) grammes of Tilapia fish were purchased from the Federal University Dutsin-Ma Fish Farm in Katsina State. Table Salt and sugar were purchased from Dutsin-Ma Local Government of Katsina State and taken to the Department of Food Science and Technology Laboratory for processing and further analysis.

Sample Preparation

The fish samples were descaled, eviscerated, carefully washed and weighed before pre-treatment. The brine solution was prepared by mixing 15g of salt into 1litre of water while the solution of salt and sugar was prepared by mixing in 10 g of salt and 10 g of sugar into 1litre of water. For blanching, the water was boiled at 100 °C.

Application of pre-treatment

The sample was pre-treated by dipping the fish samples into the brine solution for 15 minutes then removed and placed on gauze, for 30 minutes to allow removal of surface water and dried in the oven. The samples were dipped into the prepared solution of salt and sugar for 15 minutes then placed in gauze to drain the surface water. Boiled water was poured over the fish to blanch and then placed on gauze to allow removal of surface water before drying. Thereafter, the samples were submerged into the prepared sugar solution for 15 minutes and was drained to remove surface water. For the control, the sample for this was placed on gauze without pre- treatment to drain the surface water before placing in an oven for drying.

Drying procedure of the tilapia fish

The oven was preheated to the desired temperature of 60 °C, 70 °C and 80 °C before placing the fish samples to be dried. The samples were weighed at interval until constant moisture content is achieved. The moisture content of the samples at interval was calculated using the standard drying formula;

$$M.C(d.b) = \frac{\mathrm{mi}-\mathrm{mf}}{\mathrm{mf}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (\mathrm{i})$$

While the drying rate was calculated using the formula;

$$R = \frac{dM}{dt} = \frac{Mi-Mf}{t} = -\frac{M}{A}\frac{dM}{dt} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (\mathrm{ii})$$

where; M.C= moisture content, Mi. = initial moisture content Mf = final moisture content, T = time, R = drying rate, dM = change in moisture content dt = change in time. $\frac{M}{A}$ = constant

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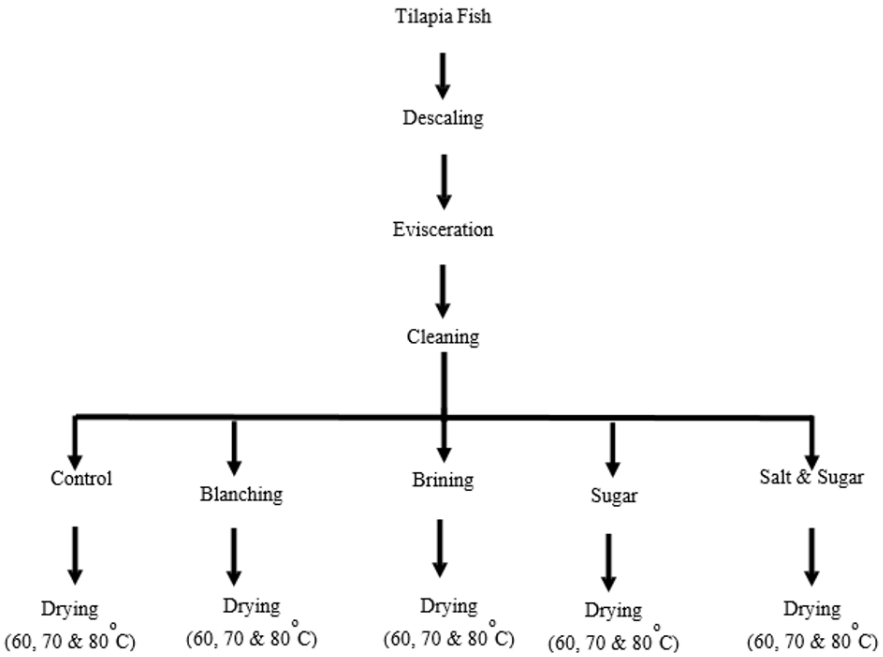

Figure 1: Processing of Tilipia Fish

Analyses

Determination of proximate composition of the tilapia fish

This was carried out on the fish samples before and after storage to determine the moisture, ash, crude fibre, fat, protein and carbohydrate content using the method described by AOAC [13].

Determination of moisture content

Five (5) grams of the fish samples were weighed into Petri dish of known weight. It was then dried in the oven at 105 ± 1 °C for 4 hours. The samples were cooled in desiccators and weighed.

The moisture content was calculated as follows:

$$\%\ moisture\ content = \frac{Change\ in\ weight}{initial\ weight\ of\ food\ before\ drying} \times 100 \quad \text{..... (iii)}$$

Determination of ash content

Five (5) grammes of each fish sample was weighed into crucibles in duplicate, and then the sample was incinerated in a muffle furnace at 550 °C until a light grey ash was observed and a constant weight obtained. The ashed fish samples were cooled in the desiccators to avoid absorption of moisture and weighed to obtain ash content.

$$\text{Ash content} = \frac{w3-w1}{w2-w1} \times 100 \quad \text{..... ..... (iv)}$$

W1= weight of crucible

W2 = weight of fish + crucible

W3 = weight after ashing

Determination of fat content

Five (5) grams of fish sample wrapped in a filter paper were weighed using a chemical balance. It was then placed in an extraction thimble that was previously cleaned, dried in an oven, and cooled in the desiccator before weighing. Then, 25 milliliters of petroleum ether solvent was measured into the flask and the fat content was extracted. After extraction, the solvent was evaporated by drying in the oven. The flask and its contents were cooled in a desiccator and weighed. The percentage fat content was calculated as follows:

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$$\% \text{ Total fat content} = \frac{weight\ of\ fat\ extracted}{weight\ of\ food\ sample} \times 100 \quad \ldots\ldots\ldots\ldots\ldots (v)$$

Determination of protein content

Two (2) grams of the fish sample were measured into the digestion flask. Ten (10) grams of copper sulphate and sodium sulphate (catalyst) in the ratio 5:1 respectively and 25 ml concentrated sulphuric acid were also added to the digestion flask. The flask was placed into the digestion block in the fume cupboard and heated until frothing ceased giving clear and light blue green coloration. The mixture was allowed to cool and diluted with distilled water until it reached 250 ml of volumetric flask. Distillation apparatus was connected, and 10 ml of the mixture was poured into the receiver of the distillation apparatus also 10 ml of 40 % sodium hydroxide was added. The released ammonia by boric acid was then treated with 0.02 m of hydrochloric acid until the green colour change to purple. Percentage of nitrogen in the fish sample was calculated using the formula below:

$$\text{Nitrogen } (\%) = (T - B)\frac{100 \times N \times 14 \times Vf}{100 \times Va} \quad \ldots\ldots\ldots\ldots\ldots\ldots (vi)$$

Crude protein = % Nitrogen x 6.25

Where: N = Normality of the titrate (HCl = 0.1N)

Vf = Total volume of the digest (100ml)

T = Titre value of sample

B = Blank titre value

Va = Aliquot volume distilled

Determination of crude fibre

Five (5) grams of each fish sample were weighed into a 500 ml Erlenmeyer flask and 100 ml of TCA digestion reagent was added. It was then brought to boiling and refluxed for exactly 40 minutes counting from the start of boiling. The flask was removed from the heater, cooled a little then filtered through a 15.0 cm no. 4 Whatman paper. The residue was washed with hot water stirred once with a spatula and transferred to a porcelain dish. The fish sample was dried overnight at 105 °C. After drying, it was transferred to desiccators and weighed as W1. It was then burnt in a muffle furnace at 500 °C for 6 hours, allowed to cool, and reweighed as W_2.

$$\% \text{ crude fibre} = \frac{w1 - w2}{w0} \times 100 \quad \ldots\ldots \ldots\ldots\ldots\ldots (vii)$$

W1=weight of crucible +fibre +ash, W2=weight of crucible +ash, W0=Dry weight of fish sample

Determination of nitrogen free extract content (NFE)

Nitrogen free extract content was determined by subtracting the total sum of the percentage of fat, moisture, ash, crude fibre, and protein content from hundred (100).

i.e % NFE = 100 – (% fat + % moisture + % Ash + % crude fibre + % protein)

Lipid stability of the stored tilapia fish

Determination of free fatty acids, peroxide value test, thiobarbituric acid test and trimethylamine test (TMA) were carried out to test the level of rancidity in the stored fish samples. This was done using the method as described by Onwuka [14].

Determination of acid value/ Free fatty acids (FFA)

Twenty-five milliliters (25) of diethyl ether was mixed with 25 ml ethanol, 1 ml of phenolphthalein solution (1 %) and neutralized with 0.1 M sodium hydroxide. Five (5) grams of the oil from the fish was dissolved in the mixed neutral solvent and titrated with aqueous 0.1M sodium hydroxide shaking constantly until a pink colour which persisted for 15 second is obtained. Acid value = titration (ml)/weight of sample used x

The FFA value was calculated as oleic acid, where 1ml of 0.1 M sodium hydroxide = 0.0282 g of oleic acid, in which case the acid value = 2 x FFA.

Peroxide value

A 100 ml of round bottomed flask with a ground glass joint was attached to a plain reflux tube, long 9 mm internal diameter the upper 15 cm of which was cooled by a water jacket. 10 ml

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of chloroform and 10 ml of glacial acetic acid was added to the flask and, using a micro gas flame close to the flask, the mixture was boiled to top of the tube where it condenses by the water jacket. One gram (1) of potassium iodide dissolved in 1.3 ml was poured slowly down the condenser when the mixture was boiling steadily so that the refluxing was not interrupted; 0.3 ml water was added to dissolve any precipitated iodide. One (1) gram of the fish oil was added down the condenser without interrupting the refluxing and condenser water was turned off so that the entire sample is washed into the flask. The mixture was boiled for more 4 minutes; the flask then removed, and cooled rapidly. Fifty (50) milliliters of water was added and the liberated iodine titrated against 0.01M sodium thiosulphate.

Statistical Analysis

Tilapia fish products were analysed in triplicates. All the data obtained were subjected to one-way analysis of variance (ANOVA) at 5 % level of significance using SPSS (Statistical Package for the social sciences) version 20.0 and the results presented as mean ± standard deviation. Duncan Multiple Range Test was used to compare the means.

RESULTS AND DISCUSSION

Effect of Pre-treatments and Drying Conditions on Moisture Content of Tilapia Fish

The effect of Pre-treatments and Drying conditions on the moisture content of tilapia fish are shown in figures 2.1 to 2.3. The moisture content curves (Figures 2.1 to 2.3), showed that the samples followed the same drying pattern at different temperatures, although there was a significant difference ($p < 0.05$) among the samples drying at 70 °C (Figure 2.1) and 80 °C (Figure 2.2). The effect of the pre-treatments used was evident at high temperatures indicating that temperature is an important factor to be considered during drying. The rate of moisture loss from the samples increased with an increase in temperature (60, 70, and 80 °C) for all samples as seen that the drying time decreases with the increase in temperature, this is in line with the work of Omodara and Olaniyan, [15] who reported that high moisture loss from drying catfish samples was experienced as the temperature increased. From figure 2.2, the salted tilapia fish samples dried faster at 70 °C that indicated that salting is a good pre-treatment method as it helps to draw water out of the fish samples and reduces the moisture content, thereby facilitating drying. This is also in agreement with the study of Binici and Kaya [16], that a decrease in moisture content was observed in brine salted and dry salted group of chub (*Squalius cephalus*) and that dry matter increases as with decrease in humidity rate along with water outrun. The blanched tilapia fish samples dried faster at 80 °C, (Figure 2.3) this could be due to the fact that blanching enhances moisture loss by increasing porosity, enabling the muscle to open up, release moisture and also allowing heat to penetrate the tilapia fish sample. Similar reports were given by Orikasa et al. [17] who reported that drying constant of the blanched paprika sample was larger than that of the non-blanched, thereby increasing the drying rate by the blanching treatment given.

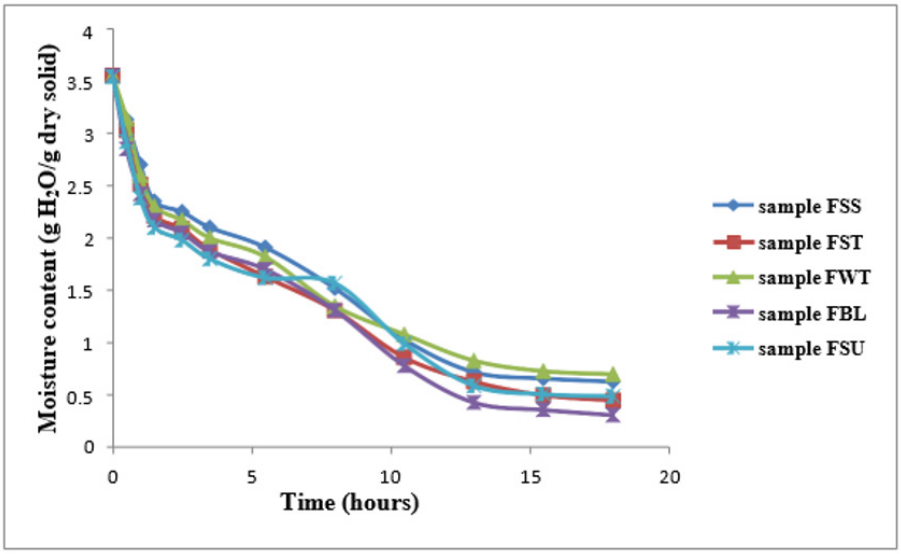

Figure 2.1: Effect of Pre-treatments and Drying Conditions on Moisture Content of Tilapia Fish at 60°C.

Key: FWT =Fish without treatment (control) FBL=Fish Blanched, FST= Fish Salted FSU= Fish Sugared, FSS= Fish sugared+ salted

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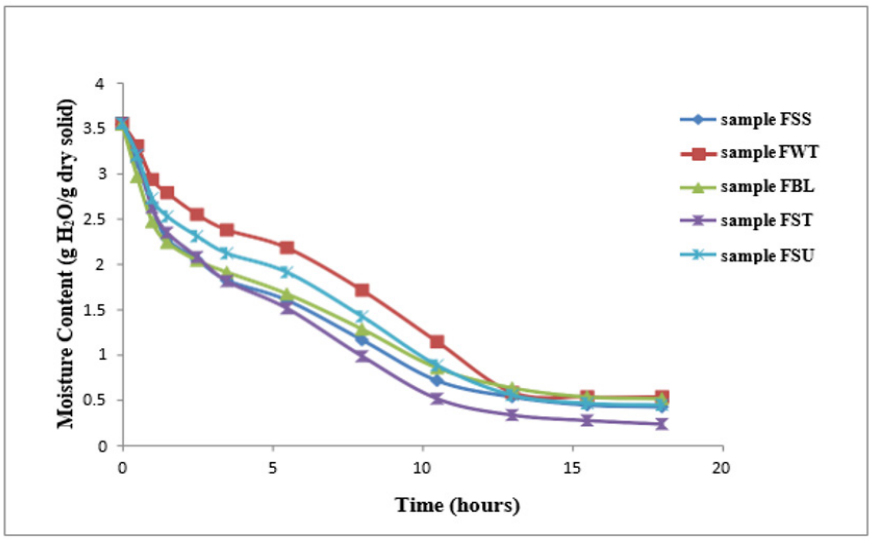

Figure 2.2: Effect of Pre-treatments and Drying conditions on Moisture Content of Tilapia Fish at 70°C.

Key: FWT =Fish without treatment (control) FBL=Fish Blanched, FST= Fish Salted FSU= Fish Sugared, FSS= Fish sugared+ salted

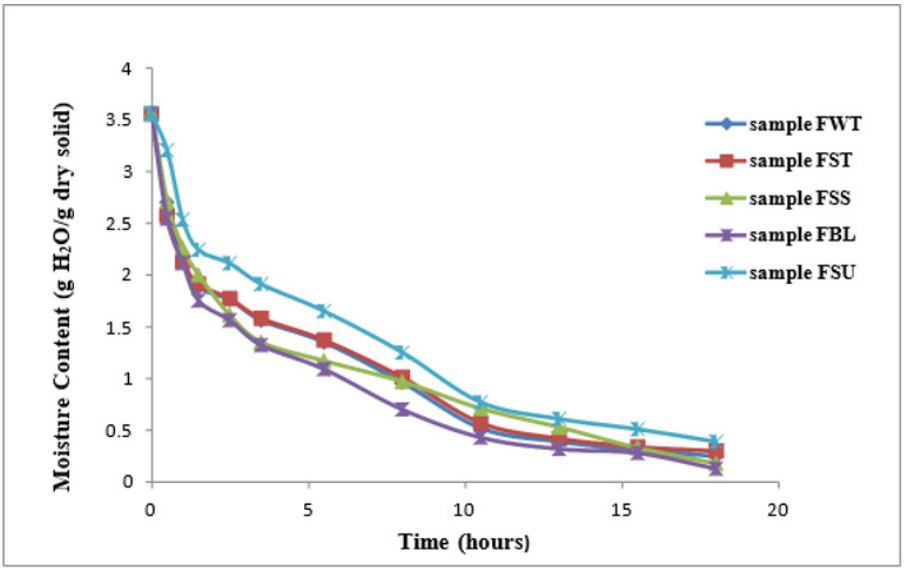

Figure 2.3: Effect of Pre-treatments and Drying conditions on Moisture Content of Tilapia Fish at 80°C

Key: FWT =Fish without treatment (control) FBL=Fish Blanched, FST= Fish Salted FSU= Fish Sugared, FSS= Fish sugared+ salted

Effect of Pre-treatment and Drying Conditions on Drying Rate of Tilapia fish

The effects of pre-treatments and drying conditions on the drying rates were shown in the Figures 2.4 to 2.6. The drying rate of the samples from figures 2.4 to 2.6 showed that the drying rate of the tilapia fish samples had constant drying rate and falling rates, although constant drying rate period was absent in sample FBL (blanched sample) in figure 2.4, FBL (blanched sample), FST (salted sample) and FSS (sugared + salted sample) in figure 3.6, this could be due to the reduction in free water content of the fish since the fish samples were already pre-treated through blanching and salting, which helped to reduce moisture content of the fish samples. This is in line with the investigations by Vijaya [18], that constant rate period occurs in a product if a continuous film of water exists on drying surface and evaporation of water occurs from the film of water.

The graphs also showed that drying occurred mostly at the falling rate period and the falling rate is divided into two; the first falling rate and the second falling rate. The first falling rate

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was longer for the different pre-treatments which proved that drying rate is controlled by the rate of moisture movement within the sample while the second falling rate is controlled by the diffusion of the water in the internal parts of samples. Similar reports were given by Omodara and Olaniyan [15], that internal water movement was controlling the drying rate from the beginning of the drying process. Generally, the drying rate is controlled by temperature regardless of the different pre-treatment used. The critical moisture content of the different pre-treated tilapia fish samples from the graphs (Figures 2.4 to 2.6) occurred between 3.55 to 3.13 gH2O/g dry solid.

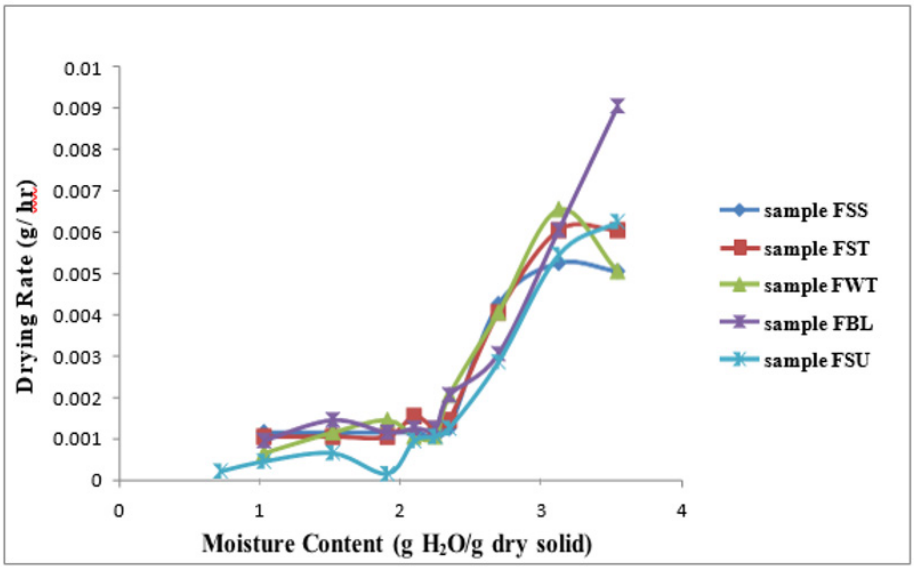

Figure 2.4: Effect of Pre-treatments and Drying conditions on Drying Rate of Tilapia fish 60°C

Key: FWT =Fish without treatment (control) FBL=Fish Blanched, FST= Fish Salted FSU= Fish Sugared and FSS= Fish sugared+ salted

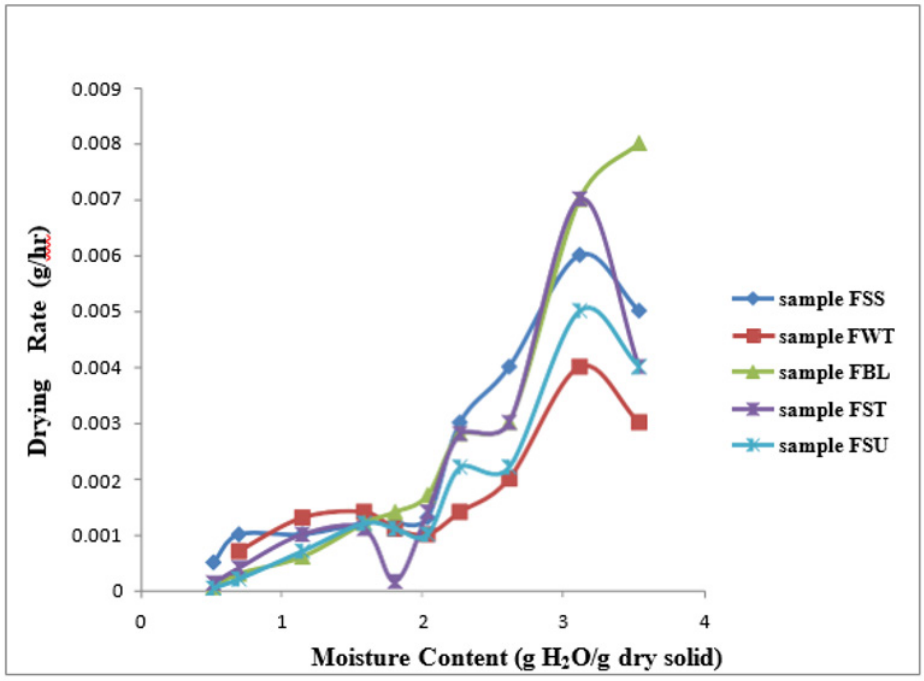

Figure 2.5: Effect of Pre-treatments and Drying conditions on Drying Rate of Tilapia fish at 70°C

Key; FWT =Fish without treatment (control) FBL=Fish Blanched, FST= Fish Salted FSU= Fish Sugared and FSS= Fish Sugared+ Salted

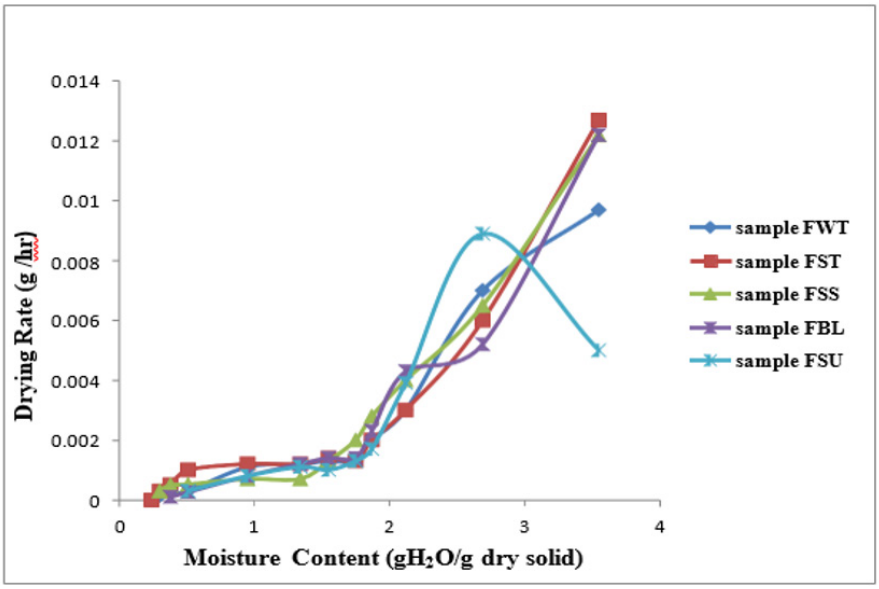

Figure 2.6: Effect of Pre-treatments and Drying conditions on Drying Rate of Tilapia fish at 80°C

Key: FWT =Fish without treatment (control) FBL=Fish Blanched, FST= Fish Salted FSU= Fish Sugared and FSS= Fish sugared+ salted

Effect of Pre-treatments on the Proximate Composition of the Dried Tilapia Fish

The result of the moisture content in Table 1 showed that the moisture content ranged from 12.09 % to 18.43 %. The moisture contents of the samples were significantly different ($p < 0.05$) from each other. There was a reduction in moisture content of the pre-treated samples when compared to the control samples, this could be attributed to the type of pre-treatment used which includes blanching, salting, sugaring, a mixture of sugar and salt. Findings from this research are in agreement with that of Jasmina et al. [15] who reported reduction in water activity of fish samples (*Crassus gibelio*) after pre-treatment with osmotic solutions. According to Nursyah *et al.* [24], salt and spices are added to dried fish to enhance the flavours and to decrease the water activity (a_w) of the fish.

The values for moisture content showed that sample FSU (sugared sample) and sample FSS (sugared + salted samples) had low moisture content after drying this indicates that sugaring and a mixture of salt and sugar is a good pre-treatment method for reducing the moisture content of foods. These findings are in agreement with that of Omodara and Olaniyan [15] which specifies that sugared and salted cat fish samples show a higher drying rate than those of blanched and control samples as salting and sugaring enhance water movement from the fish head under the drying condition investigated. The moisture content of food products goes a long way in suggesting the shelf life of the product. The moisture content of foods is influenced by type, variety and storage condition [20].

Ash is described as the inorganic residue remaining after the ignition of the organic materials in a food sample [21]. The result for ash content from Table 1 showed that the values ranged from 8.90 % to 13.24 %. The samples were significantly different ($p < 0.05$) from each other. There was a reduction in the ash content of the samples as pre-treatment were applied, this could be attributed to the temperature used and the type of drying equipment. Likewise, Omodara and Olaniyan [15] reported that increasing the drying temperature from 40°C to 55 °C led to a reduction of 24.4% for sugared and control sample and 22.3% for the salted samples. The ash content is an indication of the minerals present in that food.

The result for fat content showed that there was a significant difference ($p < 0.05$) between the samples as the values ranged from 20.17 % to 27.00 %. The fat content increased with the pre-treatment used. This increase in fat content could be attributed to the loss of moisture because reduction in moisture content led to the concentration of fat in the tilapia fish samples. This finding agrees with the report from Ambele [21] who opined that the difference in fat contents between drying methods could be attributed to the differences in their drying modes and final moisture contents of sardine samples.

Fish oil, is a biologically active and valuable compound and it is highly recommended for normal human growth and development [22,23].

The values for protein content ranged from 32.08 % to 52. 17 %. The protein content of the tilapia fish samples increased significantly ($p < 0.05$) as pre-treatment was applied. The protein content of the control sample (FWT) was lower than the pre-treated samples this is attributed to reduction in moisture content of the pre-treated samples. This observation is in line with the report of Ambele [21], who opined high protein value in solar dried sardines was due to low moisture content. Similarly, Moddibo et al. [22], reported that reduction in moisture content of dried fish samples led to increase in crude protein, crude lipid and ash contents thereby increasing the tendency of the fish to store for longer periods.

The protein value showed that the sample FSU (sugared sample) had the lowest protein content and also recorded the highest value for the protein content indicating that as moisture content reduces, there is concentration in proteins. This is also reported by Agomuo *et al* [23], that more drying time leads to higher concentration of proteins in the dried okra samples when compared to fresh okra samples. Dehydration of water molecules that are present between protein molecules caused the aggregation of protein [24,25]. The protein and fat content in fish rely on various factors such as sex, age, size, seasonal fluctuations and habitat [26]. Protein from fish sources has been considered as having a high nutritional value and has immense beneficial health effects in human nutrition. It is mainly accountable for building and repairing muscle tissues and improving blood quality and immunity. The protein immunoglobins act as an effective defence mechanism against viral and bacterial infections and also aid in the maintenance of water balance and electrolyte systems in humans [27]. The values for Nitrogen free extract ranged from 2.27 % to 16.08 % showing significant differences ($p < 0.05$) between the samples. The Tilapia fish samples had low values for NFE. Fish generally has low NFE and high protein content, as it known to be a good source of protein. This observation is in line with that of Nursyah et al. [20] who stated that the carbohydrate composition in dried fish is generally much lower than the other components. Similarly, Sajib *et al.* [28] reported that the carbohydrate content in fresh chela was less in amount as compared to its protein and lipid contents. Nitrogen-free extract (NFE) includes other extracts remaining in the food after protein, moisture, fat and ash has been analysed. It is the fraction that contains the sugars and starches plus small amounts of other material.

Table 1: Effect of Pre-treatments on the Proximate Composition of the Dried Tilapia fish

Sample	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	NFE (%)
FWT	18.43 ± 0.06^{a}	13.24 ± 0.02^{a}	20.17 ± 0.75^{d}	32.08 ± 1.01^{c}	16.08 ± 0.18^{a}
FBL	16.25 ± 0.10^{b}	11.24 ± 0.16^{c}	22.88 ± 0.70^{c}	42.55 ± 0.42^{b}	7.08 ± 0.73^{b}
FST	16.50 ± 0.20^{b}	10.47 ± 0.29^{d}	27.00 ± 0.69^{a}	41.32 ± 1.37^{b}	4.71 ± 1.04^{c}
FSU	12.09 ± 0.01^{d}	8.90 ± 0.06^{e}	24.57 ± 0.23^{b}	52.17 ± 0.04^{a}	2.27 ± 0.24^{d}
FSS	15.50 ± 0.22^{c}	12.68 ± 0.03^{b}	24.40 ± 0.36^{b}	42.41 ± 0.94^{b}	5.01 ± 0.84^{e}
LSD	0.062	1.000	0.735	0.139	0.603

Values are expressed as means ±SD of three different determinations. Means with different superscripts in the same column indicate significant differences ($P< 0.05$).

Key: FWT =Fish without treatment (control) FBL=Fish Blanched, FST= Fish Salted FSU= Fish Sugared and FSS= Fish sugared+ salted

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CONCLUSION

The findings of this research revealed that the pre-treatment and drying conditions affects drying rates and moisture content of tilapia fish used. This renders the food unpalatable to the consumer. The different pre-treatments used had effect in drying the products as seen that the pre-treated samples dried faster than the untreated sample and their moisture content were lower than that of the untreated sample.

The pre-treatment used had effect on the chemical composition of the processed tilapia fish. The results of the proximate composition of the fish, the fat and protein content of the pre-treated samples increased after drying. However, after storage, the protein content increased significantly. For the lipid stability, the free-fatty acid of the fish samples did not exceed 5%. The values for peroxide values of the stored tilapia fish samples were within the acceptable range for good quality food. Likewise, the thiobarbituric acid values were within that given for good quality fish. The use of sugaring and a mixture of sugaring and salting increased the acceptability of the products due to the taste of sugar in the fish. However, after storage, the sugar moisture content from the samples as these samples had lower moisture content when compared to other samples.

RECOMMENDATION

Based on the findings from this study, the pre-treatment and drying conditions affects the drying rates and chemical composition of the tilapia fish. However, It is recommend that; further research should be carried out to ascertain other pre-treatment methods to store fish, the rate of diffusivity of different pre-treatment into the samples at different temperatures" be carried out, proper enlightenment be given to the small scale off shore fish processors on how to handle and process fish products to avoid contamination of the fish.

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