ISBN: 978-628-95207-4-3. ISSN: 2414-6390. Digital Object Identifier: https://dx.doi.org/10.18687/LACCEI2023.1.1.1281

# Cooking methods and determination of the nutritional content of tilapia (oreochromis sp)

Juvencio Brios-Avendaño, Doctor[1], Jose Garay-Torres, Maestro[2], Silvia Rua-Pomahuacre, Doctor[3], Bertha Villalobos-Meneses, Doctor[4], Ciro Teran-Dianderas, Doctor[5], Carlos Alfaro-Rodriguez, Doctor[6], Milagros Neyra-Benites, Bachiller[7].

[1,2,3.4,5,6,7]Universidad Nacional del Callao, Perú, jhbriosa@unac.com.pe, jmgaraytg@unac.edu.pe, spruap@unac.edu.pe, bmvillalobosm@unac.edu.pe, citerand@unac.edu.pe, chalfaror@unac.edu.pe, mreynaneyra@gmail.com

***Abstract*– The objective of this study was to determine the different cooking methods on nutritional properties of Tilapia fish (Oreochromis ps) and two physiochemical parameters (wáter activity aw and pH). A completely randomized experimental design with two replicas with three repetitions was used, the treatments were: electric oven at 60 and 80ºC, vapor at 60 and 80ºC, and microware at 140 and 1400 Watts and the response variable were: protein, lipids, ash, moisture, aw and pH contents. For the statistical analysis of data, an analysis of variance was used and the mean values were compared using the Tukey test (P<0.05).***

***The proximal compositions of the Tilapia fish were: protein 22.16 ± 0.04%, lípidos 1.3 ± 0.01%, cenizas 1.14 ± 0.008% y humedad 78.11 ± 0.18%. The values of the physiochemical parameter were: wáter activity of 0.98 ± 0.008 y pH de 6.64 ± 0.008. The proximal compositions and physiochemical parameter were***

***significantly affected (P<0.05). The best treatments for the conservation of proteins were microwave at 140 and 1400 watts, and the method that most greatly decreased proteins was the oven at 80ºC. On the other hand, there was decrease of fat in the vapor treatment at 60ºC and in the microware treatment at 140 watts compared with electric oven treatment at 60 and 80ºC. The application of cooking methoda in the microware (140 and 1400 Watts) and vapor (60ºC) there were more protein bands, compared with the electric oven (60 y 80ºC) and vapor (80ºC). The electric oven treatment (60 y 80ºC) showed fewer protein bands. This information is useful to enrich data from chemical composition tables, in which concentrations are usually presented in raw food.***

***Keyword: Cooking, replicas,variance, proximal, nutrients.***

**Digital Object Identifier:** (only for full papers, inserted by LACCEI).
**ISSN, ISBN:** (to be inserted by LACCEI).
**DO NOT REMOVE**

# Cooking methods and determination of the nutritional content of tilapia (oreochromis sp)

Juvencio Brios-Avendaño, Doctor[1], Jose Garay-Torres, Maestro[2], Silvia Rua-Pomahuacre, Doctor[3], Bertha Villalobos-Meneses, Doctor[4], Ciro Teran-Dianderas, Doctor[5], Carlos Alfaro-Rodriguez, Doctor[6], Milagros Neyra-Benites, Bachiller[7].

[1,2,3.4,5,6,7]Universidad Nacional del Callao, Perú, jhbriosa@unac.com.pe, jmgaraytg@unac.edu.pe, spruap@unac.edu.pe, bmvillalobosm@unac.edu.pe, citerand@unac.edu.pe, chalfaror@unac.edu.pe, mreynaneyra@gmail.com

***Abstract–* The objective of this study was to determine the different cooking methods on nutritional properties of Tilapia fish (Oreochromis ps) and two physiochemical parameters (wáter activity aw and pH). A completely randomized experimental design with two replicas with three repetitions was used, the treatments were: electric oven at 60 and 80ºC, vapor at 60 and 80ºC, and microware at 140 and 1400 Watts and the response variable were: protein, lipids, ash, moisture, aw and pH contents. For the statistical analysis of data, an analysis of variance was used and the mean values were compared using the Tukey test (P<0.05).**

***The proximal compositions of the Tilapia fish were: protein 22.16 ± 0.04%, lípidos 1.3 ± 0.01%, cenizas 1.14 ± 0.008% y humedad 78.11 ± 0.18%. The values of the physiochemical parameter were: wáter activity of 0.98 ± 0.008 y pH de 6.64 ± 0.008. The proximal compositions and physiochemical parameter were significantly affected (P<0.05). The best treatments for the conservation of proteins were microwave at 140 and 1400 watts, and the method that most greatly decreased proteins was the oven at 80ºC. On the other hand, there was decrease of fat in the vapor treatment at 60ºC and in the microware treatment at 140 watts compared with electric oven treatment at 60 and 80ºC. The application of cooking methoda in the microware (140 and 1400 Watts) and vapor (60ºC) there were more protein bands, compared with the electric oven (60 y 80ºC) and vapor (80ºC). The electric oven treatment (60 y 80ºC) showed fewer protein bands. This information is useful to enrich data from chemical composition tables, in which concentrations are usually presented in raw food.***

***Keyword: Cooking, replicas,variance, proximal, nutrients.***

## I. INTRODUCTION (HEADING 1)

This work, which I am pleased to present and share with the university community, with the community business, the same that will serve as a reference and support in their decisions that they want to undertake in this sector of the economy, which has great potential.

The daily consumption of Tilapia, the main source of polyunsaturated fatty acids (PUFA) n-3 (DHA), provides numerous health benefits.

The ways of cooking can significantly alter the composition of the fish, since chemical reactions occur and physical, such as oxidation, loss or concentration of nutrients due to changes in humidity, exchange of fatty acids.

There are several studies that have shown that the nutritional content of different Tilapia species varies according to the cooking techniques used. When cooking food in the microwave oven, electromagnetic waves are propagated

that cause thermal elevation and changes in the nutritional content.

Tilapia cooked in a gas oven suffers from a great loss in moisture content and in the concentration of different nutrients of the food, mainly total lipids (TL) and fatty acids. During frying, the fillets of

Tilapia absorb part of the fatty acids from the medium and their lipid content generally rises; furthermore, it occurs a variation in the concentration of fatty acids

## II. THEORETICAL BACKGROUND

Steiner-Asiedu M. (1991) evaluated the effect of 3 cooking methods (stove-cooked, fried and smoked) on the

chemical and biochemical composition (protein and ash content), fatty acid profile and analysis of some minerals (Na, K, Mg, Ca, P, Fe, Cu, Zn and As) from 2 types of marine fish (Sardinella sp and Denter sp.) and on Tilapia (Oreochromis sp.), to carry out their experiments I apply a temperature above 80ºC for two hours for the smoked and stovetop cooking methods. For frying, the same temperature was used at a time between 20 and 30 min. To the To evaluate the fatty acid profile, the same results were obtained as in the case of chemical composition. (STEINER-ASIEDU M. 1991).

Atta M.B. (1997) evaluated the effect of the type of cooking (steaming and baking) on the heavy metal content of Tilapia nilotica (Oreochromis niloticus), cultured in ethical water conditions in cadmium, copper, lead and zinc at concentrations of 5, 10 and 15 ppm. Concluding that the concentrations of metals decreased due to the effect of these 2 cooking methods but a greater decrease was obtained with steam cooking. In this way it could propose a beneficial application to the use of steam cooking and baking in the case of requiring the elimination of heavy metals in Tilapia cultured under these conditions or when exposed to metals in their environment atmosphere. (ATTA MB (1997).

Azizah (2002) evaluated the nutritional quality, that is, the content of proteins, lipids, ashes, moisture and digestibility in in vitro protein hydrolyzate from Tilapia (Oreochromis mossambicus) after being spray dried. (AZIZAH (2002).

Chuk wu O. (2009), evaluated the effect of two different drying methods (electric oven and smoked oven cooking) on the following nutritional properties of Tilapia (Oreochromis niloticus); moisture, protein content, lipids, ash, fiber and carbohydrates, as well as vitamins (A and C) and some minerals (P and K). He used a temperature range from 70 to 85ºC for 20 hours for smoking and 110ºC for 45 min for the electric oven. The investigator concluded that there were significant differences between the two methods studied on these properties, however, it was not evaluated the steam cooking method and its impact on the quality of proteins and lipids. (CHUK WU O. (2009),

Justification: The present investigation was justified because due to the application of heat it allows to reserve the food products because it eliminates pathogenic microorganisms. However, a bad heat treatment accelerates chemical or physicochemical reactions of deterioration, denaturation of nutrients and affectation of the properties sensory. Among the processes that involve the use of heat in the food industry are the following: pasteurization, baking, roasting, frying, evaporation and condensation. (CHARLEY, H.).

In the case of Tilapia fish (Oreochromis sp.), cooking is applied to alter its texture, develop its flavor and destroy microorganisms present. (CHARLEY, H.).

The objective: To determine to what extent different cooking methods affect the nutritional value of Tilapia (Oreochromis sp.).

Importance: This research is important because aquaculture products have shown a rapid growth, which is why the production of Tilapia has increased.

The proximal composition of tilapia (Oreochromis sp.) varies considerably with culture conditions (temperature, dissolved oxygen, pH, salinity, turbidity, altitude, light or luminosity, etc.) and therefore the proximal composition of Tilapia (Oreochromis sp.) can be better predicted.

## III. MATERIALS AND METHOD

The Type of Research: The type of research of this project is experimental. Design of the investigation experimental with posttest and control group.

The population: The population is constituted by the samples of the Tilapia muscles to determine the methods of cooking on the nutritional content of Tilapia (Oreochromis sp.).

Materials: Fish of the genus Oreochromis sp. “Tilapia”. The fish acquired had an approximate weight of 300 to 400 g and 20 to 25 cm. The operation and behavior of the cooking equipment involved in this project was studied, taking care its good management to achieve its best use.

Electric oven: The choice of the electric oven in this project is due to the type of cooking it performs (dry heat cooking), Same as food baking process. The temperatures that were used were 60 and 80ºC (operating temperatures more stable in the convection oven) at a constant speed of 3 m/s (air from the equipment fan).

Steam system: The choice of the steam system as a cooking method was due to its wide use in the culinary art for cooking the Tilapia. For this process, steam was generated inside a container with water, through an electric grill with temperature controlled (85 to 100ºC). Samples wrapped in aluminum foil were placed inside the steam system. Subsequently they monitored the internal temperatures of the samples (60 and 80ºC) and external temperatures from 85 to 100ºC for 40 min. The reading of temperatures was performed with type K thermocouples adapted to a temperature reader.

Microwave oven: Due to the new trends in cooking food, it was decided to use the microwave oven as another method of cooking Tilapia. To carry out this process, a domestic microwave oven with a power of 1400 Watts with two power levels high (1400 Watts) and low (140 Watts) in the characteristic "cooking" function of the equipment.

Methods: To determine the use of the cooking method on the nutritional content of Tilapia (Oreochromis sp) it was used the fish of the genus Oreochromis sp. Tilapia from the departments of Piura and San Martín for analysis, cooking, control of the raw sample, the operating conditions of the cooking equipment of the Laboratory of Chucuito, INASSA, LOPU., its study, operation and behavior of the cooking equipment involved in this research project, taking care of its good management to achieve its best use and the materials used in the investigation.

The most commonly used cooking methods are:

a) Frying: Food cooking process resulting from the immersion of the food material in oil or fat, which is found at a temperature of 150 to 200ºC. During this process, heat transfer is carried out by mechanisms of conduction and convection.
b) Baking: Cooking method, in which the food is introduced into a hot and closed space, called an oven. Although that the oven must remain closed during cooking, there is circulated air inside. In general, it is baked by turning on the unit of heating, whose energy causes the nearby air to warm up and circulate upwards, which causes, in turn, that the air is less heat from the top moves down and so on and convection currents are generated during baking.
c) Microwave; cooking process where the Tilapia is introduced into the oven the food is cooked through the microwaves that spin the dipolar water molecules in the food. Microwaves mainly heat the content of food water. The microwave, like all electromagnetic waves, is an oscillating force field that pushes charges electricity in matter, and although the water molecule is completely neutral, it has two poles of charge: one positive and the other negative negative.

d) Steam: It is carried out by the direct contact of the food with the water vapor, less dense than it and therefore its molecules make less frequent contact with food. Two transport phenomena occur in this process: convective and conductive.

Hypothesis: To what extent the use of different cooking methods will have a significant effect on nutritional quality Tilapia muscle (Oreochromis sp.).
Independent Variable: Cooking methods, time and temperature.
Dependent Variable: Nutritional Value.
Intervening Variable: Tilapia (Oreochromis sp.) muscle thickness.
The proposed hypothesis was contrasted through the alternating hypothesis in the investigation.

## IV. RESULTS

Table Nº 1 describes the operating conditions of the cooking equipment and the characteristics of the samples. He electric oven and steam system were operated under the following conditions: 60 and 80ºC for 40 min. for the oven Microwaves two powers were handled: 140 and 1400 Watts in 10 s. The samples used were 2.5 cm3 and with a humidity percentage of 79.02 ± 0.19%.

TABLE No. 1
Cooking methods on Tilapia samples

| cooking method | Initial humidity X(kg of water/kg of wet matter) | Characteristics of the initial sample size (cm3) | Temperature (ºC) or cooking power (Watts) | Time |
|---|---|---|---|---|
| Electric oven | 79.02 ± 0.19 | 2.5 | 60 y 80 | 40 min |
| Steam | 79.02 ± 0.19 | 2.5 | 60 y 80 | 40 min |
| Microwave | 79.02 ± 0.19 | 2.5 | 1400 y 140 | 10 s |
| Control | 79.02 ± 0.19 | 2.5 | Room temperature | -- |

Table Nº 2 determines the nutritional content of tilapia meat:

**TABLE No. 2**

**Nutritional content per portion of 100 gr. tilapia meat**

| NUTRITIONAL VALUE PER PORTION OF 100 G OF TILAPIA MEAT | |
|---|---|
| calories | 79.3 a 85 |
| Calories Fat | 9 |
| Full Fat | 1 a 1.5 hr. |
| Saturated fat | 0.4 gr |
| Cholesterol | 50 mg |
| Sodium | 35 mg |
| Potassium | 0 mg |
| Iron | 0 mg |
| Protein | 18 g |
| Omega 3 | 0.3 |

The Benefits of tilapia, a fish especially rich in nutritional properties, which provides DHA and high-quality proteins biological value. Its most important virtues are known in Table N° 3. In Tables N° 4, 5, 6 and 7, the different compositions of tilapia.

TABLE No. 3
Chemical composition (% of fresh resource) of co-products from the Nilotic tilapia filleting industry (floating cages and land-based ponds).

| production system | co-product | Humidity (%) | Crude protein (%) | Ethereal extrac (%) | Ashes (%) | Ca (g/100g) | P (g/100g) | gross energy (kcal/kg) |
|---|---|---|---|---|---|---|---|---|
| Tilapia in floating cages | Head | 61.20±0.4 | 14.31±0.03 | 17.47±0.74 | 6.08±0.16 | 2.17±0.29 | 0.84±0.04 | 2531±28 |
| | Skeleton (ETJ)1 | 54.50±0.29 | 18.39±0.03 | 13.26±0.08 | 14.12±0.16 | 5.70±0.04 | 1.89±0.06 | 2218±46 |
| | Cuts (RTJ) | 54.33±1.88 | 15.04±0.02 | 30.10±0.58 | 0.74±0.00 | 0.05±0.00 | 0.09±0.00 | 3683±16 |
| | CMS (CTJ)2 | 70.38±0.18 | 14.32±0.02 | 14.74±0.12 | 0.87±0.01 | 0.01±0.00 | 0.07±0.00 | 2171±47 |
| Tilapia in land ponds | Head | 58.93±1.66 | 15.47±0.05 | 18.61±0.42 | 5.71±0.14 | 2.05±0.00 | 0.72±0.02 | 2699±19 |
| | Skeleton (ETJ)1 | 58.56±0.37 | 15.14±0.01 | 20.72±0.35 | 6.16±0.20 | 2.18±0.04 | 0.81±0.04 | 2750±30 |
| | Cuts (RTJ) | 58.87±1.74 | 17.33±0.06 | 24.99±0.45 | 1.17±0.02 | 0.09±0.00 | 0.13±0.00 | 3323±7 |

[1]Skeleton without meat;2CMS: Mechanically separated meat;3Skeleton with meat
Source: self-made

TABLE No. 4
Mean content of protein (% DM), lipids (% DM) and energy (cal g-1) for the stalls analyzed

| | Protein | Ethereal Extract | Energy |
|---|---|---|---|
| Maximum | 61.28 | 66.46 | 7167.79 |
| Minimum | 50.71 | 16.17 | 3245.91 |
| Average | 55.95 | 27.45 | 6320.91 |
| OF | 2.35 | 9.01 | 786.65 |
| CV | 4.20 | 32.83 | 12.45 |

DE: standard deviation; CV: coefficient of variation

TABLE No. 5
Moisture content, ashes, total fat and protein g/100g.

| Species | Moisture | Total Protein | Ash | Total Fat |
|---|---|---|---|---|
| Salmon | 60.0 – 68.6 | 19.4 – 20.9 | 1.1 – 1.3 | 7.4 - 17.0 |
| Trout | 69.8 – 75.9 | 17.8 – 20.4 | 1.0 – 1.2 | 4.1 – 8.1 |
| tilapia | 72.3 – 76.9 | 18.4 – 20.8 | 1.1 – 1.5 | 2.2 – 4.5 |
| bocachico | 75.2 – 78.1 | 16.4 – 20.4 | 1.1 – 1.3 | 1.3 – 5.2 |
| Catfish | 74.9 – 77.5 | 20.3 – 22.1 | 1.0 – 1.1 | 0.4 – 1.9 |
| cachema | 74.8 – 79.3 | 16.7 – 19.3 | 1.0 – 1.2 | 1.6 – 6.3 |

Results are expressed on a wet basis.

TABLE No. 6
Tilapia phosphorus, iron and calcium (mg/100g of fillet)

| Species | Phospho us | Calcium | Iron |
|---|---|---|---|
| Salmon | 283 – 361 | 10 – 24 | 2 – 6 |
| Trout | 217 – 331 | 16 – 43 | 3 – 6 |
| tilapia | 191 – 285 | 15 – 33 | 1 – 3 |
| Catfish | 215 – 264 | 13 – 25 | 3 – 6 |
| bocachico | 224 – 286 | 17 – 32 | 3 – 3 |
| cachema | 157 – 248 | 12 – 23 | 1 – 2 |

Results are expressed on a wet basis.

TABLE No. 7

Fatty acid composition of Tilapia (mg/100g of fillet)

| Fatty acid | Salmon | Trout | Tilapia | Catfish | Bocachico | Cachema |
|---|---|---|---|---|---|---|
| myristic | 400 – 1300 | 100–300 | 100-200 | 0-100 | Nd** | 100-300 |
| palmito | 1400–3100 | 900-1800 | 600-1300 | 100-600 | 400-1800 | 500-1800 |
| stearic | 300 – 700 | 200-500 | 200-300 | 0-200 | 100-300 | 200-600 |
| oleic | 1600–2900 | 1000-2200 | 0-100 | 0-100 | 0-100 | 500-1900 |
| □-Linolenic | 10-20 | 10-20 | 10-20 | nd** | 10-40 | 0-2 |
| EPA | 400-1000 | 10-20 | 0-10 | 0-10 | 0-10 | 0-10 |
| DHA | 720-1250 | 240-480 | 50-120 | 10-40 | 20-60 | 10-50 |
| Linoleic | 700-2200 | 600-1300 | 400-700 | 0-100 | 0-100 | 200-800 |
| □-Linolenic | 160-330 | 50-130 | 20-50 | 10-80 | 40-220 | 10-40 |

### Microwave cooking

When cooking with a microwave oven, the Food Code requires that all potentially hazardous foods be containing meat, poultry, fish or eggs are cooked to a minimum temperature of 165ºF (73.8ºC). In addition, these foods must be cooked in accordance with the following standards:

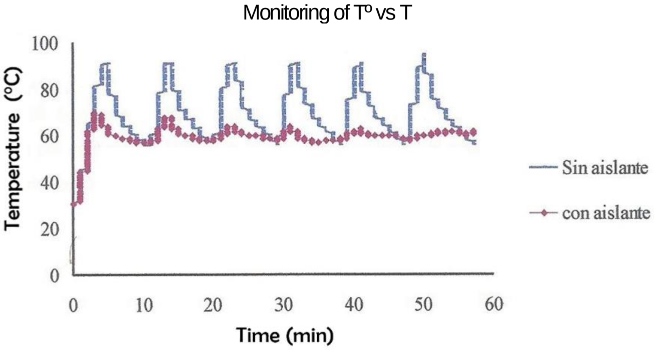
1. They should be turned or resolved during or in the middle of the cooking process to compensate for uneven heat distribution.
2. They should be covered to maintain surface moisture.
3. They must be heated to an initial temperature of at least 165ºF (73.8ºC) in all parts of the food; and
4. Covered should be allowed to rest for two minutes after cooking to obtain a balanced temperature.

### Electric oven

According to the measurements made of the temperature as a function of time (60 min) with type K thermocouples inside Hamilton Beach convection oven, without sample and with an air velocity of 3 m/s, large variations in the two selected temperatures (60 and 80 ºC). Graph Nº 1 shows the variation of the temperature of 60 ºC depending on the time of the oven without insulation and of the same oven with insulation.

GRAPH No. 1

Monitoring of Tº vs T

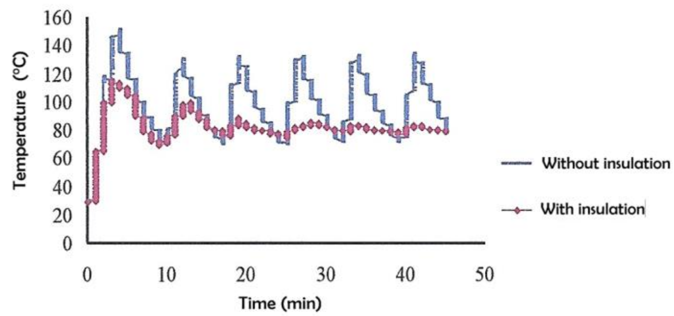



Source: self made

Graph Nº 2 shows the behavior of the temperature (60ºC) inside an oven without insulation and of the same oven with insulation as a function of time. In the furnace without insulation, it will be observed that the temperature is not constant, when showing the presence of oscillations throughout the process, with peaks of 90 ± 2 ºC at different times (5, 13, 23, 32, 42 and 51 min approximately) and valleys of 58 ± 2 ºC at different times (10, 20, 28, 38 and 47 min approximately). while with the application of the insulation, the internal temperature of the oven presented less variation: in the first 20 min a peak of 70 ± 1 ºC for the times of 4 and 15 min. After 20 min, the temperature was kept constant (60 ± 2ºC).

GRAPH No. 2

Monitoring of Tº vs T




Graph Nº 2 also shows the behavior of the temperature at 80ºC inside an oven without insulation and the same oven with insulation as a function of time. In the oven without insulation it is observed that the temperature is not constant, by showing the presence of oscillations (similar to what happened with the temperature at 60ºC) throughout the process, with peaks of 150 ºC at 5 min, 135 ± 2 ºC at different times (approximately 13, 21, 29 and 42 min) and valleys of 70 ± 2 ºC at different times (10, 18, 25, 34 and 40 min approximately). With the application of the insulation, the temperature variations they decreased considerably. In the first 18 min. Approximately, only two floors were observed, one corresponding to 120 ± 2 ºC at minute 4 and the other at 100 ºC at 13 min. After 22 min an improvement was observed at the temperature that was kept constant (80 ± 2 ºC) until the end of the process.

Due to the behavior of temperatures of 60 and 80 ºC, it was decided to introduce the samples from 22 min after of the ignition of the oven with insulation, since the controller of the equipment maintained a temperature (60 and 80 ºC) with a variation of ± 2 ºC from this time.

After 20 min of lighting the oven with insulation, the samples were placed for periods of 30, 40 and 60 min at temperatures of 60 and 80 ºC. The samples were evaluated by 10 commercial judges using a scale from 0 to 9 and were determined the moisture content (AOAC), after each time (Table Nº 8 and Nº 9

TABLE No. 8
Moisture percentage of samples subjected to firing for periods of 30, 40 and 60 min at a temperature of 60 ºCa.

| Time (min) | % humidity |
|---|---|
| 30 | 75.87 ± 0.21 |
| 40 | 67.27 ± 0.18 |
| 60 | 57.84 ± 0.27 |

Table Nº 8 shows the moisture percentage of the samples subjected to firing at 60 ºC for different times. At 30 min the sample presented a humidity of 75.87 ± 0.21% at this humidity the texture of the sample was similar to that of the from a raw sample, that is, without cooking, therefore this cooking time was discarded. On the other hand, at 40 min the sample obtained a humidity of 67.27 ± 0.18% with this humidity the tissue of the sample was soft and optimal to be consumed (evaluated by consumer judges). The time of 40 min was considered a good cooking time. at 60 min the sample obtained a humidity of 57.84 ± 0.27%, the tissue at that humidity was dry and hard to be consumed and therefore so much, this time was discarded.

**TABLE No. 9**
**Moisture percentage of samples subjected to firing for periods of 30, 40 and 60 min at a temperature of 80 ºC[a].**

| Time (min) | % humidity |
|---|---|
| 30 | 71.18 ± 0.31 |
| 40 | 58.50 ± 0.31 |
| 60 | 50.12 ± 0.15 |

Table Nº 9 shows the moisture percentage of the samples subjected to firing at 80 ºC at three different times. With the time of 30 min the sample presented a humidity of 71.18 ± 0.31%. At this humidity the texture of the sample was similar to the raw sample and the sample treated at 60 ºC for 30 min, therefore, this cooking time was also discarded. At 40 min the sample obtained a humidity of 58.50 ± 0.31%. With this humidity, the tissue of the sample was soft and optimal to be consumed, therefore, this was considered an ideal time for cooking. At 60 min the sample obtained a humidity of 50.12 ± 0.15%. The tissue of the sample at that humidity was dry and hard to be consumed, for this reason the cooking time at 60 min was discarded.

Based on the previous results, the following firing conditions were chosen for the convection oven with insulating.

a) Cooking at 60 ºC for a period of 40 min.
b) Cooking at 80 ºC for a period of 40 min.

**Steam system**

The samples were placed in the steam system for 30, 40 and 60 min at two different temperatures (60 and 80 ºC); the external temperature was maintained in a range of 85 to 100 ºC. The internal temperatures of the samples were 60 ± 1 and 80 ± 1 ºC (measured with type K thermocouples). The optimal cooking time of the sample was 40 min, the same in which obtained humidities of 78.58 ± 0.01% at 60 ºC and 76.00 ± 0.22% at 80 ºC. At these humidities the tissue of the sample it was soft and optimal to be consumed (evaluated by 10 consumer judges).

Based on the previous results, the following firing conditions were chosen for the steam system.

c) Cooking at 60 ºC for a period of 40 min.
d) Cooking at 80 ºC for a period of 40 min.

**Microwave**

In the case of the microwave, we worked with two powers, the high (1400 Watts) and the low (140 Watts) according to the manual of the team. To define the cooking time of the samples in the microwave, first the time recommended by the manual this is 5 and 7 min, under these conditions it was observed that the Tilapia samples were charred and therefore they were discarded. Subsequently, 2 and 1.5 min of cooking were used, however the samples were charred. as third step it was decided to use the time of 10 s. With this cooking time, the samples presented pleasant characteristics and optimal to be consumed.

Effect of the cooking method on the nutritional quality of Tilapia was observed that the proximal composition (percentage of proteins, humidity, ashes and lipids) of the Tilapia were significantly affected by the three cooking methods used (Table Nº 10).

**TABLE No. 10**
**Effect of cooking methods on the proximal composition (g/100 g) of Tilapia (Oreochromis sp.)[a].**

| Equipment | Protein [b](%) | Lipids (%) | Ashes (%) | Humidity (%) |
|---|---|---|---|---|
| Microwave control | 22.16 ± 0.04 a | 1.30 ± 0.01 f | 1.14 ± 0.008 e | 71.02 ± 0.19 a |
| 140 Watts | 19.90 ± 0.13 b | 1.54 ± 0.01 e | 1.19 ± 0.008 d | 65.11 ± 0.21 d |
| 1400 Watts | 19.10 ± 0.02 c | 2.04 ± 0.008 e | 1.31 ± 0.008 c | 59.50 ± 0.14 e |
| Steam | | | | |
| 60 ºC | 18.16 ± 0.04 d | 1.56 ± 0.004 e | 1.08 ± 0.008 f | 78.58 ± 0.01 a |
| 80 ºC | 17.86 ± 0.04 e | 1.97 ± 0.004 d | 1.05 ± 0.008 f | 76.00 ± 0.22 b |
| Oven | | | | |
| 60 ºC | 16.22 ± 0.01 f | 4.31 ± 0.004 b | 1.43 ± 0.02 b | 67.22 ± 0.18 c |
| **ºC** | 14.50 ± 0.03 g | 4.83 ± 0.01 a | 1.79 ± 0.008a | 58.50 ± 0.31 f |

[a] Average values of three repetitions ± standard error. Values followed by the same letter in the same column are not significantly different at P<0.05..
b N x 6.25

**Total proteins**

The value of the protein content in the fresh or control sample was 22.16 ± 0.04%, (Table Nº 11), which reveals that the Tilapia fillet has a high protein content, with this value Tilapia is considered a species of high value protein, being the protein values comparable with other meats such as bovine, ovine and porcine.

**Total lipids**

The value found for lipids in the fresh or control sample was 1.30 ± 0.01% (Table Nº 12), a value considered low. describes a range of fat content used to compare fish species, this range includes fatty species with more than 15%, semi-fat from 5 to 15% and lean with less than 5% fat content.

**Humidity**

The high moisture content in Tilapia muscle favors the growth of microorganisms as well as the rapid deterioration caused by enzymatic reactions such as proteolysis and oxidation of lipoxidases (Fennema, 1985). Therefore, it could be interesting to apply cooking methods in order to decrease the moisture content and better conserve the nutritional characteristics of Tilapia.

After subjecting the Tilapia samples to the different cooking methods, significant differences were found. (P<0.05) between the different treatments on moisture content. The treatment that presented the highest content of humidity in the final product was that of steam at 60ºC (78.58 ± 0.01%) and resulting statistically equal to the control (79.02 ± 0.19%), the treatment that presented the lowest moisture content in the final product was the oven at 80 ºC (58.50 ± 0.31%). This result is similar to that found by Steiner - Asiedu (2006) 72% humidity. Yanar (2006) and Chukwu (2009) who observed a decrease in the moisture content of Tilapia after being subjected to different methods of cooking.

**Ashes**

The determined value of the ash content for the control sample was 1.14 ± 0.008% (Table Nº 6.3). Content ashes is related to the environmental conditions in which the Tilapia lives, as well as the diet supplied in hatcheries. Studies carried out report average values of 1.08 ± 0.08% (Garduño, 2007), 1.94% (Izquierdo et al., 2000) and 1.09 ± 0.02% (Yanar, 2006).

As a result of the application of the cooking methods, significant differences (P<0.05) were observed between the different treatments on the ash content. The treatment that most affected the ash content was an oven at 80 ºC (1.79 ± 0.008%) and those that altered less were steam at 60 and 80 ºC with 1.08 ± 0.008% and 1.05 ± 0.008% respectively. The data were statistically not different (P<0.05). Mustafa-Medeiros (1985) found, by using different methods cooking, an increase in the ash content when using frying.

**Percentage of reduction and increase of total proteins and lipids**

Considering that proteins and lipids are the components with the highest nutritional value in the case of Tilapia, in table No. 11 shows the percentage of reduction and increase of proteins and lipids after the application of each one of the cooking methods.

**TABLE No. 11**
**Percentage reduction in protein and increase in total lipids**

| Equipment | Protein Reduction [b](%) | Lipid Increase (%) |
|---|---|---|
| Microwave control | 0 | 0 |
| 140 Watts | 10.19 | 18.46 |
| 1400 Watts | 13.80 | 56.92 |
| Steam | | |
| 60 ºC | 18.05 | 20.00 |
| 80 ºC | 19.40 | 51.53 |
| Oven | | |
| 60 ºC | 26.80 | 231.53 |
| ºC | 34.56 | 271.53 |

According to table Nº 11, a greater reduction in proteins was presented for the conventional oven cooking method at 60 ºC (26.80%) and 80 ºC (34.56%), followed by the steam cooking method at 60 ºC (18.05%) and 80 ºC (19.40%) and the method The cooking method with the least effect on protein reduction was the microwave at 140 Watts (10.19%) and 1400 Watts (13.80%). On the other hand, the cooking method with the greatest increase was conventional oven at 60 ºC (231.53%) and 80 ºC (271.53%), followed by microwave cooking methods at 1400 Watts (56.92% and steam at 80 ºC (51.53%) and cooking methods with the least effect on the increase in lipid content were steam at 60 ºC (20.00%) and microwave at 140 Watts (18.46%).

Effect of cooking methods on physicochemical parameters. Table Nº 12 shows how the physicochemical parameters (water activity and pH) of Tilapia were affected significantly by the three cooking methods used.

**TABLE No. 12**

**Effect of cooking methods on the physicochemical composition of Tilapia (Oreochromis sp.)[a]**

| Equipo | Protein [b](%) | Lipids (%) |
|---|---|---|
| Control Microondas | 22.16 ± 0.04 a | 1.30 ± 0.01 f |
| 140 Watts | 19.90 ± 0.13 b | 1.54 ± 0.01 e |
| 1400 Watts | 19.10 ± 0.02 c | 2.04 ± 0.008 e |
| Steam | | |
| 60 ºC | 18.16 ± 0.04 d | 1.56 ± 0.004 e |
| 80 ºC | 17.87 ± 0.04 e | 1.97 ± 0.004 d |
| Oven | | |
| 60 ºC | 16.22 ± 0.01 f | 4.31 ± 0.004 b |
| ºC | 14.50 ± 0.03 g | 4.83 ± 0.01 a |

**Water activity (aw)**

The water activity (aw) determined for the control was 0.98 ± 0.008%, the water activity of 0.98 develops many microorganisms which alter the texture, flavor, color, taste, nutritional value of the product and the time of conservation.

In this work, significant differences were also found between the different cooking methods on the content of water activity (aw), where the treatment that caused less effect was the steam at 60 ºC with 0.97 ± 0.008 and the treatment that caused the most effect was the microwave oven at 1400 Watts with 0.91 ± 0.008 ($P < 0.05$). microwave treatments at 140 Watts and Oven at 60 ºC presented the same effect.

**pH**

The pH value found for the control was 6.64 ± 0.008. This value may be related to the diet to which it was subjected to the fish in captivity or to the conditions of the environment where it lived. It is argued that the acidity of diets reduces the acceptance of food and affects the activity of proteases in the intestine of fish, therefore it is necessary to have a diet close to neutral pH.

Studies have been carried out with Tilapias (Oreochromis nilotieus) grown in captivity, reporting valuesaverage pH of 6.6.

**Sample treatment**

With an automatic micropipette, 50 µl of sample was placed in an Eppendorf tube plus 50 µl of the buffer solution. This mixture was stirred and heated at 100ºC in a water bath for 2 min. At the end of this time, the mixture was allowed to cool to room temperature (25ºC). The required sample volume was placed so that the same concentration of total proteins could be obtained in each well.

At the end of the run, the gels were placed for 15 min in the fixative solution and at the end of this time they were placed for one hour in the Coomassie blue staining solution. Then, the gels were transferred to the low methanol destaining solution for periods of 20 min, until the blue bands and the transparent background were observed.

To calculate the molecular weights, a catalog with number 10748-010 was used, where the molecular weight standards were observed, which show molecular weight bands of 180, 115, 82, 64, 49, 37, 26, 19, 15 and 6kDa. An aliquot of these standards was placed in well number 1 of each gel. A transilluminator was used to observe the bands.

**Whose experimental statistical design is shown in table No. 13.**

The experimental design was determined completely at random, the experiment was carried out with two replicates with three repetitions and all the data were used for analysis. The treatments were: T1: Microwave at 140 Watts; T2: Microwave at 1400 Watts; T3: Steam at 60ºC; T4: Steam at 80ºC; T5: Oven at 60ºC; T6: Oven at 80ºC and T7: Control at room temperature. The response variables were protein content (%). Lipids (%), Ashes (%) and Moisture (%), as well as water activity (aw) and pH.

**TABLE No. 13**
**Statistical design used in the experiment**

| Cooking methods | Working conditions of firing methods | | | |
|---|---|---|---|---|
| | 140 Watts | 1400 Watts | 60ºC | 80ºC |
| Microwave | ---- | ---- | | |
| Steam | | | ----- | ----- |
| Conventional oven | | | ----- | ----- |

**Solutions used**

- ✓ Fixing solution: 40% methanol (CH3OH) plus 10% acetic acid (CH3COOH)
- ✓ Low methanol (CH3OH) destaining solution: 30% methanol (CH3OH) plus 7.5% acid (CH3COOH).
- ✓ Staining solution: 0.2% solution of coomassie blue R-250 dissolved in 50% methanol (CH3OH). 7 ml of acetic acid (CH3COOH) was added for each 100 ml of the total volume.
- ✓ Chamber buffer: 10 ml of solution C, 14.4 g of glycine (NH2CH2COOH), 3.0 g of Trizma-HCl (SDS, C12H25O4SNa) and made up to volume with bidistilled water to a final volume of 1L with pH 8.3.
- ✓ Sample buffer: 5.0 mL glycerol (C3H2O3), 2.5 mL solution D, 1.0 mL solution C, 0.1 mL $\beta$ -mercaptoethanol (C2H6OS), 0.1 mg bromophenol blue dye (C19H10Br4O5S) and volumetric to 100 ml with bidistilled water

Using the above solutions, a 12% acrylamide separating gel was prepared as follows: 2.025 ml of bidistilled water, 1.875 ml of solution B, 3.0 ml of solution A, 0.075 ml of solution C, 0.54375 ml of solution E and 0.00375 ml of solution F was added. Polymerization began in a matter of seconds, so the gel was added between the glass plates immediately with the help of a Pasteur nugget. Once this was done, isopropanol was added so that the surface of the gel will remain homogeneous. When the gel was polymerized, the isopropanol was removed and the excess was cleaned with filter paper, carefully placing it on the surface of the polymerized gel.

The concentrator gel was prepared by mixing 1.425 ml of bidistilled water, 0.250 ml of solution A, 0.00625 ml of solution C, 0.625 ml of solution D, 0.175 of solution E, and added 0.0025 ml of solution F. It was homogenized by shaking and quickly placed on the separating gel. The comb was immediately placed to form the wells, where the samples are placed. Once the gel had polymerized (approximately 10 min) the comb was removed and the wells formed were washed with chamber buffers.

## DISCUSSION

The cooking techniques to which Tilapia is subjected are a determining factor for its consumption, but it is necessary to know the effect they have on nutrients, either favoring their concentration or loss. Techniques that concentrate beneficial nutrients, such as n-3 AGP, should be recommended.

Izquierdo et al., studied the effect that the steamed and fried techniques had on Cysnoscionmaracaiboensis, the fish of the present study. The LT content in the crude sample was higher than that of the present study. Said raw fillet presented 25.53% SFA and 74.65% unsaturated FA, while in the present work the raw tilapia presented 33.19% SFA and 74.65% unsaturated FA; in the steam, the AGS increased to 116.6%, and the rest of the AGs presented a decrease in their concentration, from 1.19% (AGPIn-6) to 5.28% (EPA+DHA). Izquierdo et al. determined that this technique did not produce significant changes in the FA of C. maracaiboensis. This is similar to what was found in the present study, since the FA of steamed tilapia did not present significant differences with respect to the raw values, and only the TL increased significantly, despite the fact that the values are different from those reported. by Izquierdo et al.

Compared with the raw values, the TL of Tilapia increased. The AGS and AGMI of another species were concentrated and all the AG decreased the concentration. With this technique, the highest levels of SFA and AGMI were found in tilapia, and the lowest concentration of all AGMI (except AGMI). This method implies loss of moisture for the food, which explains the concentration of some of the studied nutrients. On the other hand, the decrease in certain AG may be due to the effect that heat exerts on them.

Previous studies have analyzed the effect of different cooking techniques on fish species such as Oncorhynchusmykiss tilapia and Sardinepilchardus sardine, with a lipid content similar to tuna fat, respectively. By subjecting the tuna to cooking in a gas oven, all the nutritional components analyzed were concentrated, from 127.9% (LT) to 499.6% (EPA+DHA). These results agree with the study by Gokoglu et al (10), in which the lipid content of O. mykiss increased by 180.0%.

In the pompano cooked in a gas oven, the content of LT, AGS and AGMI increased, compared to the raw values, from 101.8% to 107.0%. The rest of the AGs analyzed decreased from 0.9% to 6.93%. Gall et al analyzed the effect of four cooking techniques. In this study, it was found that when baking Tilapia fillets there were no significant alterations in their AG, while in the present, differences were found between this technique and raw for AGS, AGMI, AGPI, AGPIn-3 and EPA+DHA, which may be due to differences between the cooking technique of the studies, as well as factors related to the species, such as time of capture, gender, age, among others. For this reason, it is important to continue evaluating the effect that different cooking techniques have on different species of fish, in order to generate more specific knowledge that can be applied by the population that consumes said food.

With the microwave oven technique, the TL of tuna and trout increased, but those of Tilapia decreased compared to raw values. This technique decreased the concentration of all FA in Tilapia of the AGS, AGMI and AGPIn-6 in tuna; and of all AGs, except AGS, for sea trout. This technique presented the lowest concentration of SFA in tuna. These results show that even though the same cooking technique is applied, the concentration or loss of nutrients varies according to each species.

Izquierdo et al., analyzed the effect of three cooking techniques on the proximal composition and FA of tuna, a species of the same genus as the one in this study. These authors recommend this technique since it maintains high concentrations of AGPIn-3, which was also observed in the present study, in which a decrease in AGS was also found, making the microwave oven an adequate cooking technique. for the tuna.

In the tuna cooked in a microwave oven, the PUFA, PUFA In-3 and EPA+DHA were concentrated (from 3.7 to 16.8%, while the content of SFA, PUFA and PUFA In-6 decreased from 0.5 to 56.3%. In the study of Gokoglu et al found an increase of 131.0% in the TL of O. mykiss, a higher percentage than that found in the present work Izquierdo et al found that the microwave produced a 265.1% increase in the TL, a higher percentage than that found in the study. The AGS is the species analyzed by Izquierdo et al.

They increased by 102.9%, the AGMI by 108.5% and the PUFA and PUFA In-3 decreased by 18.8%; different results from this study, possibly due to differences in cooking technique and the difference in species of fish.

The microwave oven increased the concentration of trout AGS and the rest of the AGS presented a decrease from 27.6% to 42.2%. Studies carried out in O. mykiss, found that the microwave does not produce significant changes in the AG compared to other cooking techniques, although an increase was found in comparison with the raw sample. Sahin et al (24) found that most of the FA of trout is not lost during cooking in the microwave oven and recommend this technique for trout, cooked for 20 seconds and at 60% microwave power.

According to the results of this study, cooking the fish at regular power for 2 minutes implies a loss of some AG, so it would not be the most recommended cooking technique for this species.

In Tilapia, a loss was found in all the components studied from 11.54% (LT) to 25.33% (AGS). Gally cols concluded that the FA of Tilapia are not significantly modified when cooked with this technique. In the present study, the behavior of the analyzed nutrients did have significant modifications, although to a lesser extent than the other Tilapia cooking techniques.

**The conclusions of the investigation are established:**

The results of this study suggest that the application of an insulator around the oven decreases the temperature variations (60 and 80 ºC) as a function of time. In the steam system, the application of an insulator was not required, because no temperature variations were observed.

The values of the proximal composition of Tilapia (Oreochromis sp) were: moisture content 79.02%, fat 1.3%, ash 1.14% and protein 22.16%. The high moisture value can contribute to the proteolytic activity. It also shows that it is a high protein, low lipid fish species. On the other hand, the values of the physicochemical characterization of Tilapia were: water activity of 0.98 and pH of 6.64.

The found value of water activity is very high, indicating that it is a food that has a juicier, more tender and chewy texture, but favors the proliferation of many microorganisms, which is why its consumption should be carried out in the first hours after its capture.

The design that was applied in this study to determine the effect of the cooking methods on the nutritional quality of Tilapia, showed that there was a great influence of the cooking processes on the measured variables (proteins, humidity, lipids, ash, activity of water and pH). These results show that the different nutritional components of Tilapia undergo significant changes ($P < 0.05$) at two temperatures (60 and 80 ºC) and at two powers (140 and 1400 Watts). However, the statistical analysis showed that microwave cooking at 140 and 1400 Watts presented better protein content, compared to the other cooking methods. On the other hand, the steam (60 ºC) and microwave (140 Watts) cooking method showed greater loss of lipid content, compared to the higher yield obtained in the oven (60 and 80ºC).

The information obtained in this work may influence the population consuming Tilapia by providing them with more information about the cooking methods and the equipment used.

Depending on the nutrients that are required to be ingested by a consumer, the microwave and steam cooking methods present a greater amount of Tilapia protein after cooking, but if you want to ingest a greater amount of lipids, the convective oven cooking method can be used, which retains higher lipid content in tilapia.

## REFERENCES


- ✓ Al-Saghir S., Thurner K., Wagner K.H. et al. Effects of different cooking procedures on lipid quality and colesterol oxidation of farmed salmon fish (Salmo salar). Journal of Agriculture and Food Chemistry. 52.5290-5296.2004.
- ✓ Alceste, C. (2000). Estado de la Acuicultura de la Tilapia. Artículo publicado en Acuicultura del Ecuador. CNA. Ecuador. Marzo – Abril 2000, 25-29.
- ✓ Andrade, Marco Antonio de, (2009). cocimiento sobre el contenido nutricional de la Tilapia (Oreochromis sp)
- ✓ Aparecida Ferreira de Castro F., Pinheiro Sant’ Ana H. M., Milagres Campos F., Brunoro Costa N. M., Coelho Silva M.T., Salaro A. L., Castro Franceshini S.C., Fatty acid composition of three freshwater fishes under different storage and cooking processes, Food Chemistry, 103, 4, 1080-1090. 2007.
- ✓ Atta M. B., L.A. El-Sebaie. M.A. Noaman. H.E. Kassab. The effect of cooking on the content of heavy metals in fish (Tilapia nilotica). Food Chemistry, 58, 1-2, 1-4.1997.
- ✓ Azizah Abdul-Hamid., Jamilah Bakar., Gan Hock Bee., Nutricional quality of spray dried protein hydrolysate from Black Tilapia (Oreochromis mossambicus). Food Chemistry, 78, 1, 69-74.2002.
- ✓ Badui Dergal S., Química de los alimentos. Proteínas: proteínas de algunos alimentos. Editorial Pearson. 2006.
- ✓ Basurco, F. (1998). Cultivo comercial de tilapia: oportunidad productivo para el Perú. Información CEPIS-OPS – OMS. Lima-Perú 15pp.
- ✓ Burmester G. (2001) Aspectos económicos del cultivo de tilapia en el Perú.
- ✓ Burmester G. (2001) El Mercado de la Tilapia en el Perú y el Mundo. Workshop Internacional de Tilapia. Tarapoto-Perú. Julio 2001.
- ✓ Castillo, C, LF. (2003). La calidad genética factor determinante sobre el mercado y comercialización de tilapia roja. Horizonte Acuícola.
- ✓ Cely, I, N. (2000). Estudio de Mercado de USA para tilapia. Artículo publicado en Acuicultura de Ecuador-CNA-Ecuador. Enero-Febrero – 2000:38-41.
- ✓ Cohen, D. (1999). Tilapia a sustainable Aquaculture system for Peru Aquaculture Production Technology: Lima-Perú. 12pp.
- ✓ Charley H. Tecnología de Alimentos. Procesos químicos y físicos en la preparación de alimentos. Ed. Limusa. 10 a ed. 608-611, 2011.
- ✓ Chukwu O., Influences of Dryng Methods on Nutritional Properties of Tilapia dish (Oreochromis niloticus)., World Journal of Agricultural Sciences., 5, 256-258, 2009.
- ✓ FAO. Informe del mercado de la tilapia., Globefish., Food and Agriculture Organization., 2010.
- ✓ FAO (2000). El estado mundial de la pesca y la acuicultura. Dirección de información de la FAO. Toma, Italia: 215pp.

- ✓ Garduño-Lugo M, Herrera-Solís J. R., Angulo-Guerrero J. O., Muñoz-Córdova G., Cruz-Medina J., Nutrient composition and sensory evaluation of fillets from wild-type Nile tilapia (Oreochromis niloticus; Linnaeus) and a red hybrid (Florida red tilapia x red O. niloticus)., Aquaculture Research., 38, 1074-1081,2007.
- ✓ Gokoglu N, Yerlikaya P .. Cengiz E .. Effects of cooking methods on the proximate composition and mineral contents of rainbow trout (Onchorhynchus rnykiss)., Food Chemistry., 84, 19-22, 2004.
- ✓ Gonzales Jr. J. M., Brown P.B., Nile tilapia Oreochromis niloticus as a food source in advanced life support systems: lnitial considerations. Advances in Space Research., 38,6, 1132-1137.2006.
- ✓ Hart F. L Análisis moderno de los alimentos, Acribia. Zaragoza (España), 1991.
- ✓ Hoffman Le, Prinsloo J.F., Casey N.H., Theron .J., Effects of' five cooking methods on the proximate. fatty acid and mineral composition of fillets of the African Sharptooth Catfish (Clarias garipinus)., Die SA Tydskrif vir Voedselwetenskap en Voeding, 6, 146-152.1994.
- ✓ Hurtado Totocayo, Nicolás, La Tilapia Roja en el Perú, Revista aqua Tic, 2003.
- ✓ Hurtado Totocayo, Nicolás, La Tilapia, la especie del futuro Acuícola del Perú, 2007
- ✓ Hurtado Totocayo, Nicolás, La Tilapia, Alternativa Social y Económica del tercer milenio, 2009.
- ✓ Izquierdo Córser P., Torres Ferrari G, Barbosa de Martinez.. Márquez Salas E., Allara Cagnasso M., Análisis proximal, perfil de ácidos grasos, aminoácidos esenciales y contenido de minerales en doce especies de pescado de importancia comercial, Arch Latinoamer Nutr .. 50: 187-194,2000.
- ✓ JAMES CS., Analytical Chemistry of Foods. Second Edition, ASPEN Publishers, New York 1999.
- ✓ Kirk R. S., Sawyer R., Egan H. Composición y análisis de alimentos de Pearson: Métodos químicos genero/es. Editorial Patria, 2009.
- ✓ Morales Díaz A. Biología, Cultivo y Comercialización de la tilapia. Ed. AGT Editor S.A. 4ta ed. México D.F. 2003.
- ✓ Marín Marcado, Manuel. (2009). Práctica de Manejo en una Producción de Tilapia roja(Oreochromis sp).
- ✓ Moscoso, C, J. (2001). Producción de alevinos revertidos de Tilapia., Workshop International de Tilapia, Tarapoto-Perú 5pp. Julio-2001
- ✓ Mustafa F.A., Medeiros D.M. Proximate composition, mineral content, and fatty acids of catfish (Ictularus punctatus, Rafinesque) for different season and cooking methods. Journal of Food Science. 50, 585-588. 1985.
- ✓ Parias Cardenas., Y.J. Caracterización Físico-Química y Microbiológica de Filetes de Tilapias Fenotípicamente Rojas y Negras, criadas en condiciones de cautiverio 2008.
- ✓ Pearson D. Técnicas de laboratorio para el análisis de alimentos. Acribia S.A. Zaragoza (España) 1993.
- ✓ Perea Tejeda, Alberto, (2010). Efecto de la salinidad en el crecimiento de tilapia híbrida Oreochroims mossambicus
- ✓ Quispe, Ch. M.A. (2002). Algunos avances en el Policultivo de langostinos y tilapia roja como estrategia de convivencia con el virus de la mancha blanca en el Perú.
- ✓ Valderrama, C. y Vila, B (2004) Producción de Tilapia. MINCETUR.
- ✓ Valdivieso, V. (2000). La acuicultura en el Perú. Agroenfoque, abril 2001: 37:40pp, tomado de revista peruana de acuicultura – FONDEPES vol seti, 2000, Lima. Perú.
- ✓ Vásquez A., (2001) Acuicultura en la Granja acuícola Milán, Moyobamba-Perú.
- ✓ Visentainer J.V., Souza N.E, Makoto M. Hayashi C., Franco M.R.B., Influence of diets enriched with flaxseed oil on the alinolenic, eicosapentaenoic and docosahexaenoic fatty acid in Nile tilapia (Oreochromis niloticus)., Food Chemistry., 90, 557-560. 2005.
- ✓ Wu W., Lillard D.A. Cholesterol and proximate composition of cannel catfish (letularus punctatus) fillets-changes following cooking by microwave heating, deep-fat frying, and oven baking., Journal of Food Quality., 21, 41-51. 1998.
- ✓ Yanar Y., Celik M., Akamca E., Effects of brine concentration on shelf.life of hot.smoked tilapia (Oreochromis niloticus) stored at 4 ºC Food Chemistry., 2006.