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RESEARCH ARTICLE

# EVALUATION OF THE NUTRITIONAL PERFORMANCE OF THE FLESH OF TILAPIA FRY (OREOCHROMISNILOTICUS L.) FED TO LEAVES OF MORINGAOLEIFERA

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## ABSTRACT

This scientific research was carried out in the aquaculture farm of the Regional Center for Research and Education for Integrated Development (CREDI-NGO) in Benin. It focused on the assessment of the nutritional performance of the tilapia fry meat weighing between 6 and 8 g fed on leaves of Moringaoleifera. A total of sixty fry, divided into two groups of 30 each, were submitted to isoproteic diets of 30%, one of which is composed of fish meal (control group) and the other, powder of leaves of Moringaoleifera (lot test). The experiment lasted seven weeks or 49 days. To determinezootechnical performance, food consumption (CN), body mass gain (GMC), food conversion rate (TCA), and mean daily gain (ADG) were measured. At the end of the experiment, the fish were sacrificed and on their flesh were revealed the total proteins, the total lipids, the as hes, the profiles in amino acids, in fatty acids and in minerals. The zootechnical performances obtained show that the tilapias of the control group have a body mass gain of 11.8 g against 9.2 g for the test batch, for the average daily weight of 0.24 g / day against 0.18 g. / day. Food conversion rates (TCA) of 6.15 for the control group and 7.38 for the test batch were recorded. Total protein contents of 88.9 g / 100 g dry matter for the control group and 81.9 g / 100 g dry matter were obtained on tilapia fry meat, compared with only 1.95 g / 100 g and 1.7 g / 100 g dry matter total lipid respectively control and test batches. The protein profile obtained contains all the essential amino acids in appreciable quantity also in the test batch that in the test batch. The fatty acid profiles show a clear predominance of unsaturated fatty acids on total fatty acids. With regard to minerals such as phosphorus, potassium, calcium, magnesium, sodium and copper, their concentrations are higher in the test batch. For this purpose, the different results obtained show that the incorporation of Moringaoleifera leaf powder in the diet of tilapia fry has a positive impact on the nutritional quality of their flesh.

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## INTRODUCTION

Aquaculture is increasingly seen as an integral part of the means used to achieve food security and global economic development (FAO, 2002). Tilapia ranks as the second largest aquaculture fish in the world (FAO, 2012). In Africa, much of the production of fish farming remains by far the Tilapia (FAO, 2000). Of the Tilapia, that of the Nile Oreochromisniloticus, is the main species raised (FAO, 2000).

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It is appreciated for its tender flesh, its taste and nutritive values, the lack of edges and its relatively affordableprice (Watanabe, 2002). Its biological characteristics make it an adaptable fish for all farming systems and its diet corresponding to the lowest levels of the food chain (phytoplankton, detritus) makes it an inexpensive fish to produce (Lazard, 2007). Fishmeal is generally the major component of aquaculture feed. This conventional protein source accounts for 40-60% of total protein in standard Tilapia foods (NRC, 1993). Its high purchase price and market irregularity have directed research towards alternative sources of proteins, particularly plant proteins, which are not directly usable for human consumption (Shiau *et al*., 1987, Jackson and al. 1982, El-sayed, 1990). However, leafy vegetables like Moringaoleifera can be used as sources of vegetable protein in the diet of tilapia. To this end, Moringaoleifera is native to northwestern India (Ramachandran *et al*., 1980) but is currently widely distributed in the tropics (Lockett and al., 2000, Aregheore, 2002). It is the traditional leafy vegetable preferred by farmers in several tropical regions, where it contributes largely to the nutritional balance of local populations and is even exploited in monospecific plantations as a cash crop (De Saint-Sauveur and Hartout, 2001). . Moringa leaves are rich in protein and have an amino acid composition suitable for animal and human nutrition (Makkar and Becker 1996, Freiberger *et al*. In addition, Moringa is a good source of vitamins, minerals and essential aminoacids (Ramachandran *et al*., 1980). In this respect, the leaves of Moringaoleifera were used in this experiment to highlight their impact on the nutritional qualities of the flesh of Oreochromisniloticus.

## MATERIAL AND METHODS

### Experimental apparatus

The trial was conducted at the Pantodon aquaculture farm, located in Zinvié-Kpotomey, a Beninese non-governmental organization (NGO) called Regional Center for Research and Education for Integrated Development (CREDI-NGO). Sixty (60) Nile tilapia fingerlings of 6 to 8 g mass, initially bred in the farm pond, were used to carry out the experiment. This took place for seven (7) weeks, ie 49 days. Prior to the experimental period, fry were fed a standard food with an estimated total protein content of 30% (Hutabarat and Jauncey, 1987). Fry were randomly divided into two (2) lots of thirty (30) individuals. The two groups of fish, thus formed, are placed in hapas arranged in a concrete basin of 7 mx 3 m, filled at the start of the test at a height of 0.60 m, or 12.6 $m^3$ of water approximately. The hapas (2m x 1m x 1.20m) are made with mosquito net with a mesh of 1mm. The hapasare weighted so that the base rests on the bottom of the basin. Gaseous exchanges are exclusively those at the air-water interface because the basin is devoid of a device for recirculating water. The monitoring of the water quality during the experiment was done regularly by monitoring the physicochemical quality of the water.

**Progress of the experiment :** Before the start of the experiment, the fish are kept fasting for 48 hours to promote a good intake of food. The diets of the two lots are isoproteic with a protein level of 30% (Watanabe *et al*., 1993). The first control batch (R0) corresponds to that of fish subjected to the diet based on fish meal. The second test batch (R1) corresponds to that of the fish fed on the feed containing Moringa leaf proteins. The fish are fed manually, to satiety, three (3) times a day: at 8:00, 12:00 and 16:00. Once every five (5) days, fish from each hapaare weighed and counted for growth monitoring. To determine growth performance, the following parameters are analyzed: food consumption (CN), body mass gain (GMC), food conversion rate (TCA) and averagedaily gain (GMQ).

**Biochemical analyzes of fish carcasses :** On the 49th day, the fish are sacrificed and their flesh is analyzed for total lipids, total proteins and ashes. The amino acid, fatty acid and mineral profiles werealsodeterminedby:

- Hydrolysis with 4M methanesulfonic acid (150 ° C, 120 min, after degassing), HLPC ion exchange on cationic column with citrate buffer elution gradient 2.25 <pH <8.2, ninhydrin derivatization, spectrophotometric detection at 570 and 440 nm, internal calibration (norleucine);
- CPG after methylation on MGL, CP Sil 88 capillary column (Chrompack-Varian, 50 mx 0.25 mm, 0.2 µm), split injection 1/50 250 ° C (1 µl), He carrier gas 1 mL / min, FID 270 detector ° C, temperature programming 80 ° C / 2 min then 5 ° C / min up to 225 ° C then 225 ° C / 2 min;
- Extraction of ethanol / hexane (4: 3 v / v) with $MgCO_3$ and 0.1% butylhydroxytoluene (antioxidant), evaporation to dryness then taken up in a dichloromethane / MTBE / methanol mixture, reverse phase HPLC on a C30 YMC column (250 x 4.6 mm) □m; YMC Europe Gmbh, Germany), water / methanol / MTBE elution gradient, spectrophotometric detection at 290, 350, 400, 450 and 470 nm;
- Inductively coupled plasma emission spectrometry after desiccation (65 ° C, 48 h, Patm), dry digestion at 500 ° C followed by hydrofluoricaciddesilication.

## RESULTS AND DISCUSSION

The analysis in Table 1 shows that tilapia in the control group had a higher body weight gain (11.8 g) than those in the test group, which had a body weight gain of 9.2 g during the test period. This could be due to the small amount of food consumed per day, which is 67.9 g for the test lot versus 72.6 g for the control. These results show that for Tilapia, a diet containing only plant-derived proteins does not lead to good growth performance during pre-fertilization (Azaza *et al*., 2005). The results obtained are consistent with the work done on other Tilapia species such as Oreochromis aureus and Oreochromismossambicus, which show that the incorporation of animal proteins greatly increases the digestibility of the food and consequently the growth performance (Mathavan and Paudian, 1976). Davis and Stickney, 1978). Thabet (2017) reported growth rates after 50 days of pre-enlargement in the order of 10.51 and 12.7 respectively for tilapia raised in geothermal and freshwater. On the other hand, Sitasit and Sitasit (1977) and Mélard and Philippart (1981) have shown in Tilapia Oreochromisniloticus that the ratio of animal proteins to plant proteins has an important role in growth performance, which increases with the proportion of animal proteins. Indeed, according to Stickney (1986), in Oreochromisniloticus the replacement of animal proteins by vegetable proteins by 25% seems acceptable. Jauncey and Ross (1982) have also shown that the substitution of 11% of fishmeal for peanut flour in a 45% protein diet does not affect growth in Oreochromisniloticus fry. On the other hand, Médale and Kaushik (2009) have shown that the substitution of fish meal by vegetable flours could affect the growth of fish because of their low protein content, their deficiency of essential amino acids and the presence of antinutritional factors. The averagedaily weight varies from 0.24 g / day in the tilapias of the control group to 0.18 g / day in the test lot tilapia. Similar results from 0.179 g / d to 0.224 g / d have been reported respectively in geothermal and freshwater by Thabet (2017). On the other hand, they are lower than those reported by Azaza *et al*., (2010), which are 0.4666 g / day during 15 days of pre-fattening from 2 g fry to an average weight around 9 g.

**Table 1. Growthparameters of two tilapia batches**

| Growthparameters | Sample batch | Sample test |
|---|---|---|
| Duration of the test in days(D) | 49 | 49 |
| Initial body mass in grams(MCI) | 6,2 | 7,1 |
| Final body mass in grams(MCF) | 18 | 16,3 |
| Body mass gain in grams(GMC) | 11,8 | 9,2 |
| Food consumption in grams per day(CN) | 72,6 | 67,9 |
| Food conversion rate(TCA) | 6,15 | 7,38 |
| Averagedaily gain in grams per day(GMQ) | 0,24 | 0,18 |

**Table 2. Protein, fat, ash and energy content of the flesh of the two tilapia batches**

| Parameters | Sample batch | Sample test |
|---|---|---|
| Protein (g/100g of MS) | 81,9 | 88,9 |
| Lipid (g/100g de MS) | 1,95 | 1,7 |
| Ashes (g/100g de MS) | 16 | 8,9 |
| Energy (KJ/100g de MS) | 1466 | 1569 |

**Table 3. Amino acid profiles of the flesh of the two tilapia batches**

| Amino acids(g/100g) | Sample batch | Sample test |
|---|---|---|
| Threonine* | 3,78 | 3,44 |
| Valine* | 3,72 | 3,76 |
| Methionine* | 2,25 | 2,4 |
| Isoleucine* | 3,48 | 3,56 |
| Leucine* | 6,75 | 6,47 |
| Phenylalanine* | 3,49 | 3,32 |
| Histidine | 2,08 | 1,96 |
| Lysine* | 7,35 | 7,1 |
| Tryptophan* | 0,84 | 0,9 |
| A. Aspartic | 7,77 | 7,3 |
| Serine | 3,15 | 2,75 |
| A. glutamic | 13,36 | 12,66 |
| Wisteria | 6,12 | 5,88 |
| Alanine | 5,62 | 5,32 |
| Cysteine | 0,4 | 0,36 |
| Tyrosine | 2,85 | 2,77 |
| GABA | 0,04 | 0,02 |
| Arginine | 5,47 | 5,23 |
| Proline | 4,11 | - |

* essential amino acids.

**Table 4. Fatty acid profile of the flesh of the two tilapia batches**

| Fattyacids (g / 100g) | Sample batch | Sample test |
|---|---|---|
| C12:0 | 0,42 | - |
| C14:0 | 4,29 | 2,99 |
| C14:1 | 0,48 | 0,63 |
| C16:0 | 20,01 | 19,79 |
| C17:0 | 1,03 | 1,21 |
| C18:0 | 10,65 | 12,93 |
| C18:1 n-9 | 12,94 | 10,48 |
| C18:1 n-7 | 5,58 | 5 |
| C18:2 | 5,15 | 3,79 |
| C18:3 n-6 | 0,28 | 0,68 |
| C18:3 n-3 | 0,34 | - |
| C20:1 n-9 | 1 | 0,67 |
| C20:2 n-6 | 0,375 | 0,49 |
| C20:3 n-6 | 0,655 | 0,86 |
| C20:3 n-6 | 0,655 | 0,86 |
| C20:4 n-6 | 3,65 | 5,09 |
| C20:4 n-3 | 0,32 | - |
| EPA | 2,46 | 2,66 |
| C22:0 | 0,1 | - |
| C22:4 | 0,635 | 0,99 |
| C22:5 | 5,94 | 6,45 |
| C24:1 n-9 | 0,25 | - |
| DHA | 11,24 | 14,11 |

**Table 5. Mineral content of the flesh of the twobatches of tilapia**

| Minerals (mg / 100g) | Sample batch | Sample test |
|---|---|---|
| Phosphorus | 870 | 974 |
| Potassium | 1717 | 1715 |
| Calcium | 685 | 989 |
| Magnesium | 139 | 143 |
| Sodium | 181 | 193 |
| Copper | 0,24 | 0,27 |
| Manganese | 0,27 | 0,22 |
| Zinc | 6,16 | 6,82 |

The GMQs of 0.24 g / d and 0.18 g / d obtained are superior to that obtained by Goumissi (2008) where the incorporation of cassava chips made it possible to obtain a (GMQ), in the best case, 0.16 g / d. The food conversion rate (TCA) of the control group (6.15) is lower than that of the test (7.38). This shows the proteins of fish meal better allow growth performance in tilapia fry of the Nile. These results are much higher than those of Benabdellah (2011) who obtained TCA of 3.88 ± 0.34; 3.36 ± 0.28 and 3.96 ± 0.63 respectively in the ratio of vegetable proteins and animal proteins of 50% PV and 50% PA; PV 72% and PA 28%; and PV 90% and PA 10%. It has shown that the replacement of plant protein with animal protein at a 72% PV / 28% PA ratio in the diet of Nile tilapia fry responds better to their energy and growth needs.

On a nutritional level, the trend is reversed for both lots with respect to protein and energy (Table 2). The protein content of the flesh of fish from the test batch is higher than that of the control group with 88.9 against 81.9 g / 100 g of dry matter. Dergal (2015), by characterizing the nutritional profile of tilapia (Oreochromisniloticus) produced at Fat-Steppes in the preliminary stages of HACCP, has shown that the chemical composition of its flesh is characterized by a normal level of protein (17). , 3%). It is known that the percentage of proteins in fish is relatively stable between 17% and 20% (Lefèvre and al., 2008). In a study reported by Tongnuanchan and al. (2011), they demonstrated that tilapia could contain a significantly lower rate of protein (13.2%). The protein content of the fish flesh appears to be stable in all species. It increases gradually during growth to stabilize at a value close to 20% (Lefèvre *et al*., 2008). The analysis in Table 2 shows the lipid level of 1.95 g / 100 g of dry matter for the control batch and 1.7 g / 100 g of dry matter for the test batch. However, Dergal (2015) has shown that tilapia is not a good source of lipid for the consumer. He reported a very low fat percentage of 0.33%. Rates ranging from 0.98 ± 0.01% to 2.72 ± 0.23% have been reported in the literature (De Souza *et al*., 2007, Ibrahim and El-Sherif 2008, Suloma *et al*. Emire *et al*., 2009, Elagba and Al-Sabahi, 2011, Navarro and al., 2012, Dhanapal *et al*., 2012).

The ashes and energies of the resultsobtainedwere not negligible (Table 2). The centers range from 16 g / 100 g for the control group to 8.9 g / 100 g for the dry matter test batch; and the energies of 1466 KJ / 100g against 1569 KJ / 100g of dry matter. Hocine (2017) reportedashlevels in the order of 03.31% and 02.29% in the tilapia meat of the irrigation basin and in the tilapia meat of the aquaculture farm. The relativelylow tilapia ash content (<0.40%) has been reported by Dergal (2015). The literature has reported values close to that of Dergal (2015) (Ibrahim & El-Sherif, 2008, Emire *et al*., 2009, Tongnuanchan *et al*., 2011, Kulawik and al., 2013). With regard to energy, the averagecalorific values of 355 Kj / 100g with a minimum of 392 Kj / 100g and a maximum of 413 Kj / 100g wererecorded in tilapia meat (IFN, 2008). These values are very low compared to the resultsobtained in this study. 19 amino acids were detected in the flesh of the two control and tilapia test batches including 8 essential amino acids, threonine, valine, leucine, methionine, isoleucine, tryptophan, phenylalanine and lysine. This shows that this nutritional profile is interesting. In both lots, the amino acid values are almost identical with a very appreciable small difference in the GABA content which is twice as high for the control group compared to the test batch.

These results are similar to the protein profile reported by Dergal (2015) with eight essential amino acids whose average proportions range from a minimum of 0.95 ± 0.02 g for tryptophan to a maximum of 7.80 ± 0.02 g. for lysine. He also reported the group of so-called semi-essential amino acids which is composed of arginine and histidine with average proportions of the order of 5.70 g and 2.62 g respectively. However, Médale (2004) concluded that tilapia meat values change with age, sex, environment, season, and physiological status. In addition, the diet, whether natural or industrial, influences the nutritional profile of fish (De Souza *et al*., 2007, Elagba and Al-Sabahi, 2011, Navarro *et al*., 2012). Fish is an important source of sulfur amino acids (methionine and cysteine) that can significantly substitute and enhance the biological value of human diets based primarily on cereals (Huss, 1995). 23 fatty acids were found in the flesh of control batches and tilapia test including 13 unsaturated fatty acids. Fatty acid profiles show a clear predominance of unsaturated fatty acids over total fatty acids. This corroborates Dergal's (2015) finding that tilapia can provide a relative supply of polyunsaturated fatty acids (> 57% of total fatty acids) for the Algerian consumer. In addition, Table 4 shows that the DHA and EPA contents, respectively, of 14.11 and 2.66 g / 100 g for the test batch are higher compared to those for the control group (11,24 and 2). 46 g / 100 g respectively). Fish flesh contains a large amount of n-3 long-chain polyunsaturated fatty acids such as eicosapentaenoic acid and docosahexaenoic acid, which are beneficial to human nutrition through lower cholesterol and cardiovascular risks (Nettletan 1991, Ackman 1995). Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are known for the prevention of cardiovascular disease and the attenuation of inflammatory processes (Lecerf, 2007; Calder and al., 2011; Navarro and al., 2012). Tilapia has a higher ability, compared to marine fish, to bioconversion of longer chain or more unsaturated C18 fatty acids by enzymatic systems catalyzing their elongation and unsaturation (Tocher *et al*., 2002). Depending on the fish species, the bioconversion capabilities will differ. Long-chain polyunsaturated fatty acids (AGLPI) are synthesized from essential fatty acids (EFA) such as linoleic acid and linolenic acid following elongations (addition of 2 carbons) and desaturations (addition of a double bond) provided by Δ6, Δ5 and Δ4 desaturases (Sargent and al., 1989, Bézard and al., 1994).

For minerals such as phosphorus, calcium, magnesium, sodium, copper and zinc, their concentrations are higher in the test lot than in the control group (Table 5). The values of minerals such as phosphorus (974 mg / 100g), potassium (1715 mg / 100g), magnesium (143 mg / 100g), sodium (193 mg / 100g) are largely theirs from the literature. For these minerals, IFN (2008) and Project Nutritional Composition of Aquatic Products (2007) obtained respectively for phosphorus (131 mg / 100g and 118 mg / 100g), potassium (282 mg / 100g and 229 mg / 100g), magnesium (25.4 mg / 100g and 23.8 mg / 100g), sodium (28.3 mg / 100g and 23.9 mg / 100g). The most abundant mineral element in fish flesh is potassium, and its concentration is similar to that of meat (350-400 mg / 100 g on average). Fish meat is an excellent source of phosphorus, it contains 10 to 15 times more than meat. (IFN, 2008). Fish are a good source of minerals such as calcium, iodine, iron, phosphorus and potassium. As abundant trace elements in fish, mention may be made of cobalt, copper, manganese, molybdenum, selenium and zinc (Leduc, 2011).

## Conclusion

Through this study, it is possible to see how important it is to promote the use of Oreochromisniloticus in programs to combat malnutrition and hunger because of its exceptional nutritional profile. In fact, the flesh of fry contains the eight (08) amino acids essential to humans that threonine (3.78 and 3.44 g / 100g), valine (3.72 and 3.76 g / 100g) , methionine (2.25 and 2.4 g / 100 g), isoleucine (3.48 and 3.56 g / 100 g), leucine (6.75 and 6.47 g / 100 g), phenylalanine ( 3.49 and 3.32 g / 100g), lysine (7.35 and 7.1 g / 100g) and tryptophan (0.84 and 0.9 g / 100g) respectively in the batch of fry fed at the fishmeal and fry fed with moringa leaf powder. It is rich in polyunsaturated fatty acids such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) with respectively 2.46 g / 100g and 11.24 g / 100g for the control group, and 2.66 g / 100g and 14.11 g / 100g for the test batch. To this are added the minerals, in respective proportions for the control and test batches, such as calcium (685 g / 100 g and 989 g / 100 g), magnesium (139 g / 100 g and 143 g / 100 g), manganese (0.27 g / 100 g and 0.22 g / 100 g), phosphorus (870 g / 100 g and 974 g / 100 g), potassium (1717 g / 100 g and 1715 g / 100 g), copper (0, 24 g / 100 g and 0.27 g / 100 g), zinc (6.16 g / 100 g and 6.82 g / 100 g) and sodium (181 g / 100 g and 193 g / 100 g). In general, the incorporation of Moringaoleifera leaf powder into the feeding of Oreochromisniloticus fry has substantially improved the levels of nutritional constituents in their flesh. These results show that it is important to popularize the use of moringa leaf powder, as a source of plant-based protein to replace fish powder, in the manufacture of fish feed to combat malnutrition. protein in developing countries.

## REFERENCES


Ackman, R.G., 1995. Composition and nutritive value of fish and shellfish lipids. In Fish and Fisheries Products. Composition, Nutritive Properties and Stability. A. Ruiter (Ed.), CAB International, pp. 117-156.

Aregheore E. M., 2002. Intake and digestibility of Moringaoleiferabatiki grass mixtures by growing goats. Small Ruminant Res., 46: 23-28.

Azaza M.S., Mensi F., Abdelmouleh A., Kraïem M.M., 2005. Elaboration of dry foods for the Nile tilapia OreochromisNiloticus (L., 1758) in breeding in the geothermal waters of southern Tunisia. Bull. Inst. Natn. Scien. Tech. Sea of Salammbo, (32): 23-30.

Azaza MS, Dhraief MN, Kraiem MM &Baras, E., 2010. Influences of food particle size on growth, size heterogeneity, food intake and gastric evacuation in juvenile Nile tilapia, Oreochromisniloticus, L., 1758. Aquaculture, 309: 193 -202.

Benabdellah N., 2011. Experimental study on the activity of digestive enzymes (trypsin and chymotrypsin) in nil tilapia (Oreochromisniloticus) fry (Linnaeus, 1758) in relation to the quality of the distributed protein diet. Master's thesis in aquatic resources management. University of Oran, 94 p.

Bezard, J., Blond, J.P., Bernard, A., Clouet, P., 1994. The metabolism and availability of essential fatty acids in animal and human tissues. Reprod. Nutr. Dev., 34, 539-568.

Calder PC, Ahluwalia N., Brouns F., Buetler T., Clement K., Cunningham K., Esposito K., Jonsson LS, Kolb H., Lansink M., Marcos A., Margioris A., Matusheski N., Nordmann H., O'Brien J., Pugliese G., Rizkalla S., Schalkwijk C., Tuomilehto J., Warnberg J., Watzl B. &Winklhofer-Roob BM, 2011. Dietary factors and low-grade inflammation in relation to overweight and obesity. British Journal of Nutrition, 106: 1-78.

Davis A.T. and Stickney R.R., 1978. - Growth responses of Tilapia aurea to dietary protein quality and quantity. Trans. Am. Fish. Soc., 107, 479-487.

De Saint-Sauveur A. D. E., Hartout G., 2001. Moringa culture and economy in Niger, pp. 29-44.

De Souza N.E., Matsushita M., De Oliveira C.C., Franco M.R.B. &Visentainer J.V., 2007. Manipulation of fatty acid composition of Nile tilapia (Oreochromisniloticus) fillets with flaxseed oil. Journal of the Science of Food and Agriculture, 87: 1677-1681.

Dergal N. B., 2015. Evaluation of management systems for the safety and quality of aquaculture of Nile tilapia "Oreochromisniloticus" in western Algeria. Doctoral thesis. University of Liège, Belgium, Faculty of Veterinary Medicine Department of Food Sciences. 244 p.

Dhanapal K., Reddy G.V.S., Naik B.B., Venkateswarlu G., Reddy A.D. &Basu S., 2012. Effect of cooking on physical, biochemical, bacteriological characteristics and fatty acid profile of tilapia (Oreochromismossambicus) fish steaks. Archives of Applied Science Research, 4 (2): 1142-1149.

Elagba H.A.M. & Al-Sabahi G.N., 2011. Nile fishes in Sudan. International Journal of Fisheries and Aquaculture, 3 (6): 99-104.

El-Sayed A.F.M., 1990. Long-term evaluation of cotton seed meal for a protein source for Nile Tilapia Oreochromisniloticus. Aquaculture, 84: 315-320.

Emire S.A. &Gebremariam M.M., 2009. Influence of frozen period on the proximate composition and microbiological quality of Nile tilapia fish (Oreochromisniloticus). Journal of Food Processing and Preservation, 34: 743-757.

FAO., 2000. IFAD project. As part of the biological monitoring of fisheries resources National Center for Study and Documentation for Fisheries and Aquaculture Service Study (CNDPA), 40 p.

FAO. 2002. GLOBEFISH, World Production and Trade in Small Pelagics GLOBEFISH Research Program, vol. 39, 96 p.

FAO., 2012. The State of World Fisheries and Aquaculture.

Freiberger C.E., Vanderjagt D.J., Pastuszyn A., Glew R.S., Mounkaila G., Millson M., Glew R.H., 1998. Nutrient content of the edible leaves of seven wild plants from Niger. Plant Foods Hum. Nutr., 53 (1): 57-69.

Goumissi K. G. G., 2008. Substitution of wheat bran by cassava chips in fish farming: Effect on the growth of Oreochromisniloticus. Internship report for the preparation of a professional license diploma: pp. 15-60.

Hocine N. E., 2017. Evaluation of the organoleptic, hygienic and nutritional quality of Nile tilapia Oreochromisniloticus (L., 1758). Memory for graduation from Master. DjilaliBounaama University in Algeria. 73 p.

Huss H.H., 1995. Quality and its evolution in fresh fish. Technology Laboratory Ministries of Agriculture and Fisheries Denmark. In: F.A.O. Fisheries Technical Paper - 348 FAO. The United Nations Food and Agriculture Organization.

Hutabarat J. and Jauncey K., 1987. The effects of varying dietary protein level on the growth, food conversion, protein utilization and body composition of the first feeding of Oreochromisniloticus (Linnaeus). In: "Abstrat of paper presented at the second International Symposium on Tilapia in Aquaculture" 16-20 March 1987, DeptFish.Bangkok Thailand and I.C.L.A.R.M. Manila, Philippines, 68 p.

IIbrahim S.M. and El-Sherif S.A., 2008. Effects of some plant extracts on quality of frozen tilapia (Oreochromisniloticus, L) fillets. Global Veterinaria, 2 (2): 62-66.

Jackson A.J., Copper B.S. and Matty A.J., 1982. - Evaluation of some plant proteins in complete diets for the Tilapia Sarotherodonmossambicus, Aquaculture 27: 97-109.

Jauncey K. and Ross B., 1982. - A guide to Tilapia feed and feeding. Institute of Aquaculture, University of Stirling, Scotland. 111 p.

Kulawik P., Ozogul F and Glew R.H., 2013. Quality properties, fatty acids, and biogenic amines profile of fresh tilapia stored in ice. Journal of Food Science, 78 (7): 51063-51068.

Lazard J., 2007. Tilapia. Biological, zootechnical and economic data. AFSSA. 5 p.

Lecerf J-M., 2007. Fish products and omega fatty acids 3. Interest in cardiovascular prevention. Phytotherapy, pp. 14-21.

Leduc F., 2011. Evaluation of the quality of fresh poisons by chemical approaches. Doctoral thesis. University Lille 1. 182 p.

Lefèvre F., Cos I. and Bugeon J., 2008. Biological determinism of fish quality. 12th JSMTV Poster.

Lockett C.T., Calvert C.C., Grivetti L.E., 2000. Energy and micronutrient composition of dietary and medicinal wild plants consumed during drought. Study of rural Fulani, Northeastern Nigeria. Int. J. Food Sci. Nutr., 51: 195-208.

Makkar H. P.S., Becker K., 1997. Moringa and oleifera tree. Journal of Agricultural Science, Cambridge, 128: 311-322.

Mathavan S.V. and Paudian T.J., 1976. Food utilization in the fish Tilapia mossambica fed on plant and animal foods. Holgolanderwiss. Meereswits, 28 (1): 66-70.

Medale F. and Kaushik S., 2009. Protein sources in food for farmed fish. Cahiers Agricultures, 18 (2-3): 103-111.

Medale F., 2004. Nutritional characteristics of fish and factors of variation. Sp. Issue 10th JSMTV, 87-93.

Mélard C. and Philippart J.C., 1981. Production of Tilapia for consumption in industrial hot water discharges in Belgium. Book of Applied Ethology 2 (1), supp. 2, Inst. Zool. Univ. of Liège, 122 p.

Navarro R.D., Navarro F.K.S.P., Filho O.P.R., Ferreira W.M., Pereira M.M. &Filho J.T.S., 2012. Quality of polyunsaturated fatty acids in Nile tilapias (Oreochromisniloticus) fed with vitamin E supplementation. Food Chemistry, 134: 215-218.

Nettleton, J.A., 1991. GO-3 Fatty acids: comparison of plant and food sources in human nutrition. l Am. Diet. Assoc., 91: 331-337.

NRC (National Research Council), 1993. Nutrientrequirements of warmwaterfishes and shellfishes, revisededition. National Academy Press, Washington, D.C., USA. 225 p.

Projet Composition nutritionnelle des produits aquatiques, 2007. Valeurs nutritionnelles des produits aquatiques consommés en France Boulogne-sur-Mer : Pôle Aquimer. Pp. 10.

Ramachandran C., Peter K. V., Gopalakrishnam P. K., 1980.Drumstick *Moringaolefeira*: A multipurpose Indian Vegetable. *Econ. Bot*., 34 (3) : 276-283.

Sargent l, Henderson RJ., Tocher D.R., 1989. The lipids. In : Fish Nutrition. lE. Halver (Eds), *AcademicPress, Inc.*, 153-218.

Shiau S.Y., Chuang J.L. et Sun C.L., 1987. – Inclusion of soybeanmeal in Tilapia (*Oreochromisniloticus* X *O. aureus*) diets at twoproteinlevels, *Aquaculture*, 65 : 251-261.

Sitasit D. et Sitasit, V., 1977. Comparison of the production of Tilapia nilotica (Linn.) fedwithproteinfromdifferent sources. Symp. on Dev. andUtil. ofInld. *Fish. Res.*, Bankok, Thailand, ASFA, 9, 1594.

Stickney R.R., 1986. Culture of Non salmonFreshwaterFishes. R.R. Stickney (ed.), CRC Press, Boca Raton, Florida, 201 p.

Suloma A., Ogata H.Y., Garibay E.S., Chavez D.R. et El-Haroun E.R., 2008.Fattyacid composition of Nile tilapia *Oreochromisniloticus* muscles : a comparative studywithcommercially important tropical freshwaterfish in Philippines. 8th International Symposium on Tilapia in Aquaculture, 921-932.

Thabet R., 2017. Comparative study of Nile Tilapia breeding "Oreochromisniloticus" between fresh and geothermal waters in Tunisia. End of Studies dissertation. Higher Institute of Fisheries and Aquaculture of Bizerte - Tunisia. Aquaculture Technical Center -Tunisia. 72 p.

Tocher D.R., Agaba M., Hastings N., Bell J.G., Dick J.R. and Teale A.J., 2002. Nutritional regulation of hepatocyte fatty acid desaturation and polyunsaturated fatty acid composition in zebrafish (Danio rerio) and tilapia (Oreochromisniloticus). Fish Physiology and Biochemistry, 24: 309-320.

Tongnuanchan P., Benjakul S. and Prodpran T., 2011. Roles of lipid oxidation and pH on properties and yellow discolouration during storage of film from red tilapia (Oreochromisniloticus) muscle protein. Food Hydrocolloids, 25: 426-433.

Watanabe WO, Ernst DH, Chasar MP, Wichlund RI and Olla BL, 1993. The effects of temperature and salinity on growth and feeding utilization of juvenile, sex-inverted Florida Red Tilapia cultured in a recirculating system, Aquaculture, 11: 309- 320.

Watanabe W.O., Losordo T.M., Fitzsimmons K. et Hanley F., 2002. Tilapia production systems in the Americas : technologicaladvances, trends, and challenges. *Reviews in Fisheries Science*, 10(3-4) : 465-498.

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