# Improve the Nutrition Value of Local Feed Materials in the Production of Freshwater Fish

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***Received:*** *17/10/2022*

**Abstract:** This investigation is to study the effect of processing technique of some raw materials on chemical analysis, growth performance and feed utilization of Nile tilapia fingerlings. This experiment was carried out at the Fish Research Center, Faculty of Agriculture Suez Canal University. Three plant protein sources were used (Linseed meal (LSM)), groundnut meal (GNM) and soybean meal (SBM)), three processing procedures was used (autoclaving (AC) - soaking (SK) and long term fermentation (L-TF). Four experimental diets were formulated to contain approximately 30% crude protein. At the end of experimental period growth performance, feed utilization and economical evaluation were statistically analyzed. The results revealed that processing effect on chemical analysis of all feed ingredients. In Linseed meal Autoclaving have major effect on nutritional composition than the rest of other raw materials were tested. Crude protein content increased in autoclaving (47%), soaking (43% and long term fermentation (49%). Crude lipid content increased from 20.5 to 22.1, 25.1 and 25.4% in AC, SK and L-TF respectively. Crude ash contents were reduced by all treatment processes except autoclaving process. In GNM, the results showed that Autoclaving approximately increase9% in crude protein, crude lipid significantly ($P<0.05$) increased by Sk and L-TF .While AC had no significantly effect on crude lipid content. While crude Ash content increased by AC, SK and L-TF. In soybean meal autoclaving had no significant difference in dry matter percent. While SK and L-TF significantly increased difference ($P<0.05$) in SK and L-TF. Crude protein content increased from 44.0 in UP to 48.0 and 52.0%in SK and L-TF. Crude lipid content increased significantly ($P<0.01$) from 18.5 to 21.8 and 20.6% in SK and L-TF. Moreover crude ash content decreased significantly ($P<0.01$) from 5 to 4.3 and 4.2% in SK and L-TF. After processing in SBM dry matter significantly ($P<0.05$) increased in SK and L-TF .While crude protein content significantly ($P<0.01$) increased to 48 and 52 in SK and L-TF. Crude ash content decreased significantly ($P<0.01$) to 44.30 and 4.20% in SK and L-TF. Results of growth performance parameters showed that final body weight (FBW), weight gain (WG) and specific growth rate (SGR %) of Nile tilapia *Oreochromis niloticus* fingerlings were significantly recorded the highest values on autoclaving and fermentation techniques while soaking and Unprocessed had the lowest final body weight, weight gain, weight percent and SGR. The highest values of FBW (39.24g), WG (18.80g) and SGR % (0.39%) were recorded in fish fed autoclave diet. Data indicated that Food Conversion Ratio (FCR) were significantly ($P < 0.05$) different and the best values were recorded in Autoclaving and fermented diets (1.80 and 1.80).

***Keywords:*** Processing by autoclaving, soaking, long-term fermentation, Nile Tilapia, Growth performance, Feed utilization, Improve the Nutrition Value

## INTRODUCTION

Nile tilapia is one of the most important fast-growing fish in the world, with an annual production of 4525.4 tons in 2018; thus, it represents about 8.3% of the global aquaculture market share (FAO, 2020a). Being an economical, rapid-growing, planktivorous-feeding habit, and a disease resistant fish, Nile tilapia became the most widely cultured fish (Canonico *et al.,* 2005). Egypt is a major Nile tilapia producing country with a production capacity of 11142.65 tons in 2020, representing 55.47% of the total fish production (GAFRD, 2020). Nutrition represents nearly 60%-70% of Nile tilapia aquaculture costs (Ismail *et al*., 2021). Therefore, enhancing feed quality and cost is an effective way of overcoming obstacles with Nile tilapia aquaculture. Water weeds, which have long been recognized as waste, is one of the cheapest and most abundant potential sources of protein. Presently, they could be used as an alternative feed to develop Nile tilapia-production system (Magouz *et al.,* 2020).

As the production volume of fish meal has leveled off in recent years, the commodity price has risen, driving research to focus on more sustainable, non-marine alternatives of dietary protein sources (Duodu *et al*., 2018) to satisfy rising demands from the animal production sector. Most often, agro-industrial by-products that are used in animal feeds are of modest economic value, but of reliable quantity (Agbo, 2008). Many plant-based feed resources that could be of considerable nutritional and financial value in animal production remain unexploited, undeveloped or poorly utilized (Agbo and Prah, 2014). Under-utilization and disposal of these resources are likely due to a lack of adequate information on how their nutritional quality could be improved. Considering the expected increase in world population and the high demand for animal products due to growth in most world economies, the prospect of feeding millions and safeguarding their food security will depend on the better utilization of non-conventional feed resources and implementation of circular bio-economy (NoRest, 2016).

There is a need to increase the nutritional value of oilseed by-products, and to offset certain antinutrients and toxins, in order to realize their full potential as animal feed ingredients (Annongu *et al.*, 1996). Techniques such as fermentation (Lopez *et al.*, 2001), boiling and sodium hydroxide (NaOH) treatment (Annongu *et al.*, 1996), heating and/or autoclaving (AC) (Clatterbuck *et al*., 1980), and sprouting or germination (Asiedu *et al*., 1993) have been proposed as ways of detoxifying and improving the nutritional value of these feed ingredients. The current study was designed to assess the effect of processing linseed meal (LSM), Groundnut meal (GNM) and soybean meal (SBM) by AC, soaking (SK), short-term fermentation (S-TF) or long-term fermentation (L-TF) on the proximate composition, amino acid profile and some antinutrients.

Study was designed to evaluate the effect of using some non-traditional raw materials as an alternative to conventional feeds and treating them by soaking, fermentation and sterilization on Nile tilapia production, growth performance, feed utilization, and body composition, also water quality and economic evaluation.

## MATERIALS AND METHODS

**Study site:**

This experiment was carried out at Fish Research Center Faculty of Agriculture Suez Canal University., Egypt. The experiment was established for 60 days from 24 July to 21 September 2021.

**Sources and preparation of raw materials:**

Groundnut was purchased from a groundnut paste processing factory, mechanically extracted GNM from a local producer, and screw-pressed LSM was purchased from a commercial agro-feed seller. Prior to powdering with a hammer mill, the GNM was dried in an oven (Gallenkamp Hotbox Oven) at 100 °C for 24 h, and cooled in a desiccator at room temperature. The other ingredients were also finely ground using a commercial hammer mill.

**Experimental Fish:**

One hundred and eighty healthy Nile tilapia *Oreochromis niloticus*, mean body weight were 20.45±0.45g; fish were obtained from Fish Research Center Faculty of Agriculture Suez Canal University, Egypt. Fish were transported to a laboratory then the health status of the experimental fish was inspected, and tank water was disinfected. Before the feeding trial, fish were acclimatized to laboratory conditions for 2 weeks and fed a commercial diet containing 29% crude protein. Fish were randomly distributed to 4 groups in three replicates of 15 fish per tank. Fiberglass tank filled with 120 L of water with continuous aeration. Settled fish wastes with one half of tank water were siphoned daily and water volume was replaced by ground water from a well water Fish were fed on the treated diets Unprocessed to apparent satiation twice a day for 8 weeks. Fish feeding was offered 6 days/week. Fish were weighed at the beginning of the experiment and biweekly for 8 weeks experimental period.

**Experimental tanks:**

Fiberglass tank filled with 120 L of water with continuous aeration. Settled fish wastes with one half of tank water were siphoned daily and water volume was replaced by aerated ground water from a ground water well.

**Experimental design:**

The oilseed by-products were subjected to 4 treatment processes by AC, SK, and L-TF and UP in addition to unprocessed samples. Each treatment was replicated 3 times per by-product and analyzed in duplicates which gave the total number of observation as 3 (oilseed by-products) × 4 (treatments) × 3 (replicates) = 36 for each variable.

***Experimental Diets:***

Four is nitrogenous and is caloric experimental diets were used in this study containing both animal and plant proteins sources to provide 30% protein and 4.27 kcal/ g diet. The composition and chemical analysis of the experimental diets represented in Table1. Diets were formulated from commercial ingredients. Four different experimental diets, the Unprocessed (the ingredient without any treatment), AC (autoclave), SK (soaking) and L-TF long term fermentation.

The three plant protein sources, (LSM), (GNM) and (SBM) were mixed to formulate four experimental diets of the three processing procedures were used (AC), (SK) and (L-TF) containing approximately 30% crude protein and the Unprocessed to investigate the improvement of the nutrition value of some local feed materials.

The ingredients of each diet were separately blended with additional 100 mL of warm water to make a paste of each diet. The pastes were separately passed through a grinder, and pelleted in a modified paste extruder to form the tested diets. The diets were dried in a drying oven model (Fisher oven 13–261– 28A) for 24 hours on 65°C and stored in plastic bags which were kept dry until they were used Table (1).

***Water quality*:**

Water temperature and dissolved oxygen were measured weakly early in the morning at a depth of 20 cm using a YSI Model 58 oxygen meter (Yellow Springs Instrument, Yellow Spring, OH, USA). Total ammonia, nitrite and nitrate were measured periodically using a DREL 2000 spectrophotometer by the method of Golterman *et al*. (1978). pH was monitored using an electronic pH meter (pH pen; Fisher Scientific, Cincinnati, OH, USA). Unionized ammonia was measured using DREL/2 HACH kits (HACH Co., Loveland, Colorado, USA).

**Growth Performance and Feed utilization**

Growth performance and feed efficiency parameter were calculated as the following equation:

Weight gain (WG) = $W_1$-$W_0$.

Specific growth rate (SGR%/day) = $[(\text{Ln } W_1 - \text{Ln } W_0)/T] \times 100$.

Where, Ln = natural log, $W_0$ = Initial body weight (g), $W_1$= Final body weight (g) and T= Time (day).

Feed conversion ratio (FCR) = feed intake (g)/body weight gain (g).

Protein efficiency ratio (PER) = total weight gain (g)/protein intake (g).

Protein productive value (PPV %) = 100 (protein gain/protein intake).

**Table (1):** Formulation and proximate analysis of the experimental diets

| Ingredients (%) | Diets | | | |
|---|---|---|---|---|
| | UP | AC | SK | L-TF |
| **Fish meal (66% CP)** | 4.5 | 4.5 | 4.5 | 4.5 |
| **Soybean meal (44% CP)** | 18 | 16.5 | 17 | 15 |
| **Linseed (40% CP)** | 25 | 21 | 23 | 20 |
| **Groundnut meal (35%CP)** | 28.5 | 25 | 26 | 25 |
| **Yellow corn meal** | 14 | 23 | 19.5 | 25.5 |
| **Sun flour oil** | 6 | 6 | 6 | 6 |
| **M. Premix[1]** | 2 | 2 | 2 | 2 |
| **V. Premix[2]** | 1 | 1 | 1 | 1 |
| **Molasses (as bender)** | 1 | 1 | 1 | 1 |
| **Proximate Analysis (%)** | | | | |
| **Moisture** | 10.70 | 11.00 | 10.60 | 11.30 |
| **Crude protein** | 30.00 | 30.30 | 30.40 | 30.20 |
| **Crude fat** | 8.00 | 8.30 | 8.40 | 8.30 |
| **Crude fiber** | 5.20 | 5.60 | 6.40 | 5.70 |
| **Ash** | 7.40 | 8.20 | 7.20 | 8.00 |
| **NFE[3]** | 38.70 | 36.60 | 37.00 | 36.50 |
| **Cost (L.E)** | 17.5 | 18.5 | 19 | 20.25 |
| **GE[4]** | 404.16 | 400.06 | 403.21 | 399.08 |
| **P/E[5]** | 74.23 | 75.74 | 75.39 | 75.67 |

1- Minerals premix (g/kg of premix): CaHPO4.2H2O, 727.2; MgCO4.7H2O, 127.5; KCl 50.0; NaCl, 60.0; FeC6H5O7.3H2O, 25.0; ZnCO3, 5.5; MnCl2.4H2O, 2.5; Cu (OAc) 2.H2O, 0.785; CoCl3...6H2O, 0.477; CaIO3.6H2O, 0.295; CrCl3.6H2O, 0.128; AlCl3. 6H2O, 0.54; Na2SeO3, 0.03.
2- 1.e Vitamins premix (per kg of premix): thiamine, 2.5 g; riboflavin, 2.5 g; pyridoxine, 2.0 g; inositol, 100.0 g; biotin, 0.3 g; pantothenic acid, 100.0 g; folic acid, 0.75 g; para-aminobenzoic acid, 2.5 g; choline, 200.0 g; nicotinic acid, 10.0 g; cyanocobalamine, 0.005 g; α-tocopherol acetate, 20.1 g; menadione, 2.0 g; retinol palmitate, 100,000 IU; cholecalciferol, 500,000 IU.
3. NFE=100-(Crude protein+Crude fat+Crude Fiber+Ash (Zayed *et al*., 2014).
4. Gross energy was calculated according to NRC (2011) as 5.65, 9.45, and 4.11 Kcal/g for protein, lipid, and carbohydrates, respectively.
5. P/E Protein energy rate.

***Chemical analysis of diets and fish***

Samples of the experimental diets and whole-fish body from each treatment at the beginning and at the end of the experiment were analyzed according to the methods of AOAC (2019) for moisture, crude protein, total lipids, ash and fiber. Moisture content was estimated by drying the samples to constant weight at 85°C in a drying oven (GCA, model 18EM, Precision Scientific group, Chicago, Illinois, USA). Nitrogen content was determined using a micro *Kjeldahl* apparatus (Labconco Corporation, Kansas, Missouri, and USA). Lipid content was determined by ether extraction in a multi-unit extraction Soxhlet apparatus (Lab-Line Instruments, Inc., Melrose Park, Illinois, USA) for 16 h. and ash was determined by combusting dry samples in a muffle furnace (Thermolyne Corporation, Dubuque, Iowa, USA) at 550 °C for 6 h. Crude fiber was estimated according to Goering and Van Soest (1970). Gross energy was calculated according to NRC (2011) as 5.65, 9.45, and 4.11 kcal/g for protein, lipid, and carbohydrates, respectively.

***Processing procedures***

The processes of AC, SK and L-TF were performed on 100 g samples of LSM, GNM and SBM weighed out on an electronic scale (Mettler Toledo, XS4002S, Switzerland) in triplicate. Samples of each raw material were treated as unprocessed (UP).

***Statistical analysis:***

Data were analyzed (means ± SE) using a one-way analysis of variance (ANOVA). (Duncan, 1955) Differences between means were tested at the 5% probability level using Duncan. Multiple Range test. All the statistical analyses were done using SPSS (Dytham, 2011) program version 18 (SPSS, Richmond, VA, USA).

**Economical evaluation:**

A simple economic analysis was conducted for different experimental treatments to estimate the cost of feed required to produce a unit of fish biomass. The estimation was based on local retail sale market price of all the dietary ingredients at the time of the study. These prices (in LE/kg) were as follows: fish meal, 50.00; soybean meal, 15, linseed 20,groundnut meal 30, yellow corn meal, 7; Sun flour oil 15.00;minerals mixture 50, vitamins mixture 50 and molasses 15.

## RESULTS

***Proximate composition***

Linseed meal after L-TF for (14 days), respectively, the nutritional contents of LSM, GNM and SBM were significantly ($P < 0.05$) affected (Table 2). Autoclaving has any major effect on nutritional composition of the raw materials tested. Dry matter (DM) content of LSM appreciably increased by 5.50%

(P < 0.0001) after 14 d of fermentation. Crude protein content increased in autoclaving (47%), soaking (43% and long term fermentation (49%). Crude lipid content increased from 20.5 to 22.1, 25.1 and 25.4% in AC, SK and L-TF respectively. Crude ash contents were reduced (P < 0.0001) by all treatment processes except AC. These are comparable to the report of Mukhopadhyay and Ray (1999).

In GNM, crude protein content was the highest (42.67%) in L-TF process, while, the lowest protein content was (38.065%) in SK process. Autoclaving however, resulted in approximately 9% increase in crude protein content of GNM. L-TF. In agreement with S*un et al. (2015)* Crude lipid significantly (P<0.01) increased by Sk and L-TF. While AC had no significantly (P<0.01) effect on crude lipid content. While crude Ash content increased by AC, SK and L-TF. In soybean meal autoclaving had no significant difference in dry matter percent. While SK and L-TF increased significantly difference (P<0.05) in SK and L-TF. Crude protein content increased from 44.0 in UP to 48.0 and 52.0%in SK and L-TF. In agreement with Nasseri *et al*. (2011). Crude lipid content increased significantly (P<0.01) from 18.5 to 21.8 and 20.6% in SK and L-TF. Moreover crude ash content decreased significantly (P<0.01) from 5 to 4.3 and 4.2% in SK and L-TF.

After processing in SBM dry matter significantly (P<0.05) increased in SK and L-TF .While crude protein content significantly (P<0.01) increased to 48 and 52 in SK and L-TF. Crude ash content decreased significantly (P<0.01) to 44.30 and 4.20% in SK and L-TF. These positive changes in protein content in the oilseed by-products may be attributed to the breakdown of soluble starch and losses of fine solids, which increased the relative contribution from protein. The increased content of crude lipid after SK of oilseed meals in the present study contradicts previous reports ( Nwaoguikpe *et al.*, 2011). However, the lipid increment observed in this study could be the result of the leaching of soluble components that caused that the content of lipid in the oilseed meals (Agume *et al.*, 2017), and the destruction of cell structure causing the efficient release of oil reserve (Cuevas-Rodriguez *et al.*, 2004), which were probably retained in the meals by the fine mesh cloth during removal of excess water. Fermentation has only previously been shown to moderately alter ash content (Sun *et al.,* 2015).

The moderate losses in crude protein content from AC raw materials were not significant in comparison to unprocessed samples, and do not appear critical. Nonetheless, these losses could be nutritionally detrimental if specific amino acids were more sensitive to AC treatment than others. The extent of protein change or destruction has been correlated with duration and temperature of AC treatment, as well as moisture content (Papadopoulos, 1989). This effect was demonstrated by Chrenkova´ *et al.* (1986) who found that lengthy exposure time (60 to 130 min) coupled with high hydrothermic temperatures (110 to 130°C) significantly decreased soluble crude protein content in soybean meal, alfalfa meal, and wheat meal and field pea. Although the samples in the present study were autoclaved at high temperature (121°C), the relatively short time of exposure (20 min) could account for the moderate losses observed. Nonetheless, these losses are not regarded as critical especially as the nitrogen contents in the samples were not limited.

**Table (2):** Proximate composition (100% DM, *n* = 3) of unprocessed and processed Linseed meal (LSM), Peanuts meal (GNM) and Soybeans meal (SBM)

| Item | Processing technique | | | | SEM | P-value |
|---|---|---|---|---|---|---|
| | UP | L-TF | A.C | SK | | |
| **LSM** | | | | | | |
| **Dry matter** | $91.45^{b}$ | $96.47^{a}$ | $91.77^{b}$ | $93.83^{b}$ | 0.04 | <0.0001 |
| **C.P** | $40^{b}$ | $49^{a}$ | $47^{a}$ | $43^{ab}$ | 1.44 | <0.0033 |
| **Crude lipid** | $20.65^{b}$ | $25.47^{a}$ | $22.14^{b}$ | $25.15^{a}$ | 0.29 | <0.0003 |
| **Ash** | $7.35^{a}$ | $3.164^{b}$ | $7.275^{a}$ | $4.550^{b}$ | 0.05 | <0.0001 |
| **GNM** | | | | | | |
| **Dry matter** | $93.93^{b}$ | $97.32^{a}$ | $92.41^{b}$ | $94.52^{b}$ | 0.05 | <0.0001 |
| **C.P** | $35.03^{b}$ | $42.67^{a}$ | $40.03^{a}$ | $38.07^{b}$ | 0.29 | <0.0001 |
| **Crude lipid** | $28.65^{b}$ | $31.895^{a}$ | $28.93^{b}$ | $32.16^{a}$ | 0.08 | <0.0001 |
| **Ash** | $12.545^{a}$ | $4.670^{b}$ | $12.425^{a}$ | $5.165^{b}$ | 0.01 | <0.0001 |
| **SBM** | | | | | | |
| **Dry matter** | $94.52^{b}$ | $97.73^{a}$ | $94.62^{b}$ | $95.12^{a}$ | 0.05 | <0.0001 |
| **C.P** | $44^{b}$ | $52^{a}$ | $50^{a}$ | $48^{b}$ | 0.12 | <0.0099 |
| **Crude lipid** | $18.52^{b}$ | $20.64^{a}$ | $18.82^{b}$ | $21.85^{a}$ | 0.27 | <0.0001 |
| **Ash** | $5.08^{a}$ | $4.29^{b}$ | $5.15^{a}$ | $4.33^{b}$ | 0.01 | <0.0001 |

UP = unprocessed; AC = autoclaving; SK = soaking; L-TF = long-term fermentation; SEM = pooled standard error of means.

[a,b]Mean values within a row without a common lowercase superscript differ at $P < 0.05$.

Soaking and fermentation (SK and L-TF) positively affected the crude protein and crude lipid contents of the CSM (cotton seed meal) and GNM (Ground nut meal) tested. These are comparable to the report of Mukhopadhyay and Ray (1999), in which marginal increases in protein (3.28%) and lipid (17.54%) contents of sesame seed meal were found after combined SK and fermenting with lactic acid bacteria (*Lactobacillus acidophilus*). They indicated that although small nutrient losses occur during fermentation and SK through microbial utilization or leaching, increases occur through microbial synthesis.

Likely, the increased protein content after fermentation resulted from yeast cells mixed with the fermented samples at termination of experiment. After 12 h of SK mungbean, Sattar *et al.* (1989) reported approximately 5% and 9% increases in protein content, with a positive temperature correlation. The increase in protein after SK in their work is somewhat similar to our observations for CSM (6.71%), while our results for GNM were considerably higher (22.30%). These positive changes in protein content in the oilseed by-products may be attributed to the breakdown of soluble starch and losses of fine solids, which increased the relative contribution from protein.

Sattar *et al.* (1989) reported approximately 5% and 9% increases in protein content, with a positive temperature correlation. The increase in protein after SK in their work is somewhat similar to our observations for (cotton seed meal) CSM (6.71%), while our results for GNM were considerably higher (22.30%). These positive changes in protein content in the oilseed by-products may be attributed to the breakdown of soluble starch and losses of fine solids, which increased the relative contribution from protein.

The increased content of crude lipid after SK of oilseed meals in the present study contradicts previous reports (Nwaoguikpe *et al.*, 2011). However, the lipid increment observed in this study could be the result of the leaching of soluble components that caused that the content of lipid in the oilseed meals (Agume *et al.,* 2017).

Fermentation has only previously been shown to moderately alter ash content (Sun *et al.*, 2015). In the current study fermentation resulted in large reductions in ash content, corresponding to 52% in CSM, 61% in GNM and 18% in GH. The loss in ash was accompanied by decreases in phosphorus content for all samples. This could be due to the hydrolysis of phytate by endogenous phytases which might have possibly transformed the free phosphorus as a result of phytate degradation into other phosphorus compounds such as inorganic phosphoric acids, orthophosphates and lower inositol phosphates (Shunmugam *et al.*, 2015). The reductive effect of SK on ash in all samples is likely due to the solubilization of some vitamins and minerals like phosphorus in the SK media (water) (Agume *et al.,* 2017). In general, some reductions could also be consequences of changes in other constituents such as increases in crude protein and lipid contents.

**Water quality Parameters**

In the present study, values of water quality parameters showed that temperature ranged from 28 to 29 °C, dissolved oxygen ranged from 5.3 to 6.3 mg/L, pH range was 7.8–8.1 and total ammonia ranged from 0.6 to 0.9 mg/L. All experimental water quality parameters are within the acceptable limits described by Boyd (1992).

**Growth performance**

Averages of initial weights, final body weights (g) and the weight gain (g/ fish) are presented in Table 3. As presented in this table averages of initial weights had ranged between20.30 to 20.44 g with insignificant differences ($p > 0.05$) among the experimental groups. Results of growth performance parameters are shown in Table (2). Data showed that final body weight (FBW), weight gain (WG) and specific growth rate (SGR %) of Nile tilapia *Oreochromis niloticus* fingerlings were significantly ($P < 0.05$) highest on autoclave and fermented techniques while soaking and Unprocessed had the lowest final body weight , weight gain, weight percent and SGR. The highest values of FBW (39.24g), WG (18.80g) and SGR % (0.39%) were recorded in fish fed autoclave diet. Therefore, several practical ways have been suggested to improve utilization of plant proteins including; blending Jackson *et al* (1982) and fermentation Kader *et al* (2012). Day and Gonzalez (2000) and Noaman *et al.* (2015). So, the improved growth performance of fish is attributed to a number of factors including improved palatability, digestibility and reduced exposure to antinutritional factors. These results are in agreement with Hammed (2012) for fingerlings African catfish, *Clarias gariepinus*. Also Khalafalla (2013) and Noaman *et al.* (2015). It was found that fermentation of soybean meal induced removal or inactivation of anti-nutritional factors (Lim *et al.,* 2010), improvement of the nutritional quality (Canella *et al.,* 1984), improvement of digestibility (Kiers *et al*., 2000) and shelf life of the processed food (Skrede and Nes, 1988). Fermented fish silage and fermented soybean meal (FSM) were reported as suitable protein sources in the diets of catfish, *Claris gariepinus* and Nile tilapia *Oreochromis niloticus L*. (Fagbenro *et al.,* 1994). It was shown that FSM induced higher growth and feed efficiency compared to non-fermented soybean meal in diets of yellowtail *Seriola quinqueradiata* (Shiu *et al.,* 2015).

**Feed Utilization;**

Values of feed conversion ratio FCR, protein efficiency ratio PER, of Nile tilapia (*Oreochromis niloticus*) are shown in Table (4). Data indicated that FCR were significantly ($P < 0.05$) lowest in Autoclaved and fermented diets (1.80 and 1.80).

With respect to FE values, results indicate that highest significant ($P<0.05$) value (0.55 and 0.55) for Autoclave and Fermented ingredient. While PER results indicate that highest significant ($P<0.05$) values in autoclave and fermented ingredients (3.34±0.20 and 1.85±0.20) and the lowest significant $P<0.05$) values in Unprocessed and soaked ingredient. These results are in agreement with the finding of Hammed (2012) for Clarias gariepinus fingerlings. Also, Khalafalla (2013) reported that when used digestion-1 (fermented soybean meal) for Nile tilapia (*Oreochromis niloticus*) fingerlings at level (0.5% and 0.7%).

**Table (3):** Growth performance of Nile tilapia (*Oreochromis niloticus*) fingerlings fed diets with different processing techniques.

| Parameters | Treatment | | | |
|---|---|---|---|---|
| | Unprocessed | Fermented | Autoclave | Soaking |
| **Initial body weight (g)** | 20.33±0.10 | 20.33±0.10 | 20.44±0.10 | 20.31±0.10 |
| **Final weight (g)** | 27.31±0.10$^{c}$ | 32.88±0.10$^{b}$ | 39.24±0.10$^{a}$ | 27.63±0.10$^{c}$ |
| **Weight gain (g)** | 6.98±0.10$^{d}$ | 12.55±0.10$^{b}$ | 18.80±0.10$^{a}$ | 7.32±0.10$^{c}$ |
| **Weight gain %** | 34.33±0.20$^{d}$ | 61.73±0.20$^{b}$ | 91.97±0.20$^{a}$ | 36.04±0.20$^{c}$ |
| **SGR** | 0.42±0.01$^{c}$ | 0.68±0.01$^{b}$ | 0.93±0.01$^{a}$ | 0.40±0.02$^{c}$ |
| **Fish survival (%)** | 100±0.0 | 100±0.0 | 100±0.0 | 100±0.0 |

Means with different superscripts in the same row are significantly different (P<0.05).
N= 3 Survival rate at the end of the experiment showed that there were insignificant differences (P > 0.05) among treatments

**Table (4):** Feed utilization of Nile tilapia (*Oreochromis niloticus*) fingerlings fed diets with different processing technique

| Parameters | Treatment | | | |
|---|---|---|---|---|
| | Unprocessed | Fermented | Autoclave | Soaking |
| **Feed intake (g)** | 16.12±0.10$^{d}$ | 22.59±0.10$^{b}$ | 33.84±0.10$^{a}$ | 19.25±0.10$^{c}$ |
| **FCR** | 2.31±0.10$^{b}$ | 1.80±0.10$^{c}$ | 1.80±0.10$^{c}$ | 2.63±0.10$^{a}$ |
| **FE** | 0.43±0.10$^{b}$ | 0.55±0.10$^{a}$ | 0.55±0.10$^{a}$ | 0.38±0.10$^{c}$ |
| **PER** | 1.43±0.20$^{c}$ | 1.85±0.20$^{b}$ | 3.34±0.20$^{a}$ | 3.33±0.20$^{a}$ |
| **SGR** | 0.42±0.01$^{c}$ | 0.68±0.01$^{b}$ | 0.93±0.01$^{a}$ | 0.40±0.01$^{d}$ |

Means with different superscripts in the same row are significantly different (P<0.05).

**Whole body composition**

With respect to body composition of Nile tilapia (*Oreochromis niloticus*), results in Table (5) observed a significant differences (P < 0.05) between treatments. Body the highest moisture percentage values were found in fish maintained on Unprocessed treatments 74.86%, while the lowest value were found in fish maintained on autoclave ingredient (71.36.%). Results of body protein content showed significant differences (P<0.05) between treatments where the highest values of body protein content (P<0.05) were found in fish maintained on fermented and autoclave ingredients with the values 15.67 and 15.96%.

Results of fish body lipid contents showed that there were significant differences (P<0.05) among treatments. Fish maintained on fermented and autoclave ingredient diet were significantly (P<0.05) the highest fish body lipid content than other treatments, while the lowest (P<0.05) values were found with fish maintained on the Unprocessed and soaking ingredient. Results of fish body ash contents showed that there were significant differences (P<0.05) among treatments. Fish maintained on fermented and autoclave ingredient diet were significantly (P<0.05) the lowest fish body ash content (15.00±0.25 and 15.70±0.25) than other treatments, while the highest (P<0.05) values were found with fish maintained on the Unprocessed and soaking ingredient (16.20±0.25 and 16.00±0.25). The same trend was observed with ether extracts (EE) and Ash content contents in dry matter of tilapia whole bodies. Hong *et al.* (2004). These results are in agreement with the finding of Khalafalla (2013) who used digestion-1 (fermented soybean meal) for Nile tilapia (*Oreochromis niloticus*) at level (0.5% and 0.7%). Liyan, (2013) found that dry matter content kept decreasing during fermentation, in parallel with the trend of protein increase.

The highest value of crude protein contents was recorded in fermented diet (15.67%) while the lowest value of crude protein contents was recorded in Unprocessed (14.08). These results in agreement with the finding of Khalafalla (2013) for Nile tilapia (*Oreochromis niloticus*).

**Table (5):** Body composition (mean ± SE) % based on dry weight of Nile tilapia (*Oreochromis niloticus*) fingerlings fed on feeds containing different levels of local feeds (LSM, GNM, SBM)

| Parameters | Treatment | | | |
|---|---|---|---|---|
| | Unprocessed | Fermented | Autoclave | Soaking |
| **Moisture%** | 74.86±0.136$^{a}$ | 72.46±0.256$^{c}$ | 71.36±0.121$^{d}$ | 73.84±0.266$^{b}$ |
| **Lipid%** | 5.79±0.68$^{c}$ | 6.29±0.086$^{ab}$ | 6.54±0.051$^{a}$ | 5.95±0.052$^{c}$ |
| **Protein%** | 14.08±0.105$^{b}$ | 15.67±0.112$^{a}$ | 15.96±0.135$^{a}$ | 14.55±0.185$^{b}$ |
| **Ash %** | 16.20±0.25$^{a}$ | 15.00±0.25$^{b}$ | 15.70±0.25$^{b}$ | 16.00±0.25$^{a}$ |

Means with superscripts in the same row are significantly different (P<0.05). N= 3

**Economic Evaluation**

Table (6) showed that economic evaluation of experimental diets used in the study. Feed cost to produce one kg fish gain was reduced by processing technique. The reduction in autoclave and Fermented ingredient. The reduction cost /kg gain in Autoclaved and Fermented ingredients were in agreement with growth performance and feed utilization parameters.

**Table (6):** Economic Evaluation of experimental diets used in the study

| Items | Experimental diets | | | |
|---|---|---|---|---|
| | Unprocessed | Fermented | Autoclave | Soaking |
| **Cost/kg**[1] | 20.25 | 19 | 18.5 | 17.5 |
| **Feed intake**[2] | 2.31 | 1.80 | 1.80 | 2.63 |
| **Feed cost/kg gain**[3] | 46.77 | 34.20 | 33.30 | 46.03 |
| **Reduction cost in kg gain (%)**[4] | 100 | 73.12 | 71.19 | 98.42 |

1-Cost /kg diet (LE) = Cost per Kg diet L.E.
2-Consumed feed to produce 1kg fish (kg) = Feed intake per fish per period/ final weight per fish Kg/Kg
3-Feed cost per kg fresh fish (LE) = Step 1X step 2
4-Relative % of feed cost/ kg fish = Respective figures for step 3/ highest figure in this step

## CONCLUSION

Autoclave and Fermentation (L-TF) were better tools for enhancing the nutritional composition of linseed, groundnut meal and soybean meal improving the crude protein, crude lipid contents. We concluded from the study that the treatments had a significant effect on the studied feed materials in terms of their impact on growth, nutritional utilization, water quality and economic evaluation, but the best of them are the two methods of autoclave and fermentation.

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# تحسين القيمة الغذائية لمواد العلف المحلية في إنتاج اسماك المياه العذبة

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تهدف الدراسة الحالية إلى معرفة تأثير تقنية المعالجة على التحليل الكيميائي والنمو ومعدل استهلاك الأعلاف على الأسماك. وقد أجريت هذه الدراسة في مركز بحوث الأسماك بكلية الزراعة جامعة قناة السويس. تم استخدام ثلاثة مصادر للبروتينات النباتية بذرة الكتان، والفول السوداني وفول الصويا. وتم استخدام ثلاث طرق للمعالجة (التعقيم - النقع والتخمير). استخدمت مائة وثمانون إصبعية من البلطي النيلي بمتوسط وزن بدائي (٤٥, ٠±٢٠جرام) مقسمة إلى أربعة معاملات (كنترول - تعقيم - تخمر - نقع). تمت عمل ٤ معاملات غذيت على علائق تحتوى على ٣٠ ٪ من البروتين الخام. استمرت التجربة لمدة ٦٠ يومًا. في نهاية الفترة التجريبية تم تحليل أداء النمو الاستفادة الغذائية وتم عمل تحليل إحصائيي وعمل التقييم الاقتصادي. أظهرت النتائج أن المعالجة تؤثر على التحليل الكيميائي لجميع مكونات العلف, في بذر الكتان يكون للتعقيم بالبخار تأثير كبير على التركيب الغذائي للمواد الخام المختبرة, زاد محتوى المادة الجافة بشكل ملحوظ بنسبة ٥.٥٠٪, زاد محتوى البروتين الخام في التعقيم (٤٧٪)، النقع (٤٣٪) والتخمر (٤٩٪)، زاد محتوى الدهون الخام من ٢٠.٥ إلى ٢٢.١ ، ٢٥.١ و ٢٥.٤٪ في التعقيم ، النقع و التخمرعلى التوالي. محتويات الرماد الخام قل خلال جميع عمليات المعالجة. في الفول السوداني كان محتوى البروتين الخام الأعلى (٤٢.٦٧%) بعد التخمر والأدنى (٣٨.٠٦٥ جم / كجم) بعد النقع. ومع ذلك ، أدى التعقيم بالبخار إلى زيادة بنسبة ٩٪ تقريبًا في محتوى البروتين الخام زاد الدهن الخام معنويا للفول السوداني بعد التخمر والنقع بينما لم يكن للتعقيم تأثير معنوي على محتوى الدهن الخام. بينما زاد محتوى الرماد الخام بواسطة التعقيم, النقع و التخمر. في التعقيم في فول الصويا لم يكن هناك فرق معنوي في نسبة المادة الجافة. بينما زاد فرقًا كبيرًا في النقع والتخمر و زاد محتوى البروتين الخام من ٤٤.٠ في الكنترول إلى ٤٨.٠ و ٥٢.٠٪ في النقع و التخمر و زاد محتوى الدهن الخام معنويا من ١٨.٥ إلى ٢١.٨ و ٢٠.٦٪ في النقع والتخمر علاوة على ذلك، انخفض محتوى الرماد الخام بشكل معنوي من ٥ إلى ٤.٣ و ٤.٢٪. النقع والتخمر. بعد المعالجة في ) فول الصويا زادت المادة الجافة معنويا (في التخمر والنقع بينما زاد محتوى البروتين. انخفض محتوى الرماد الخام معنويا في التخمر والنقع. في هذه الدراسة، أظهرت قيم معايير جودة المياه أن درجة الحرارة تتراوح من ٢٨ إلى ٢٩ درجة مئوية، والأكسجين المذاب تراوحت من ٥.٣ إلى ٦.٣ مجم/لتر، ومدى الأس الهيدروجيني يتراوح من ٧.٨ إلى ٨.١ ، وتراوحت الأمونيا الكلية من ٠.٦ إلى ٠.٩ مجم/ لتر. أظهرت نتائج بيانات معطيات أداء النمو أن وزن الجسم النهائي (وزيادة الوزن ومعدل الزيادة في الوزن النمو النوعي (٪) لأصبعيات البلطي النيلي كانت أعلى معنويا في معاملة الأوتوكلاف والتخمير, أثناء النقع والتخمير كان للسيطرة أقل وزن نهائي، زيادة في الوزن، نسبة وزن و SGR. تم تسجيل أعلى قيم في نظام الأوتوكلاف الذي يتم تغذيته على الأسماك. أشارت البيانات إلى أن معدل التحويل الغذائي كان معنويا (كانت افضل المعملات في معدل الاستفادة الغذائية في التخمر والتعقيم وأظهرت الدراسة فروق معنوية في نسبة البروتين والدهن في الجسم في العلائق التي تعرضت للتخمر والاتوكلاف. نستنتج من هذه الدراسة أن النقع والتخمير لبذر الكتان والفول السوداني ومسحوق فول الصويا حسن من البروتين الخام ومحتويات الدهون الخام