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Effects of Substituting Soybean Meal by Unprocessed and Processed Peanut Cake Meal on the Growth, Body Composition and Survival of Tilapia (*Oreochromis niloticus*)

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Abstract

An 8-week feeding trial was conducted to investigate the effects of replacing soybean meal by unprocessed and processed peanut cake meal on the growth, body composition and survival of Nile tilapia fry. Five types of feed were produced: diet 1 containing unprocessed peanut meal (natural NPM), diet 2 toasted peanut meal (toasted TPM), diet 3 fermented peanut meal (fermented FPM), diet 4 steamed peanut meal (steamed SPM) and diet 5 containing soybean meal (SBM). For the diet containing FPM, the fermentation of the mill mixed with yeast lasted 7 days anaerobically. The diet containing SPM was formulated with a steam-treated cake on a couscous steamer held on a kettle. The diet made with TPM underwent heat treatment on a stove. The remaining part of the cake NPM did not undergo any transformation. The experiment was conducted in an open system at the University of Cheikh Anta Diop and lasted nearly for two months. The fish were first subjected to acclimatisation phase prior to the initiation of the trial. The five treatment diets were

triplicated and the stocking density was 15 fish per tank with a total of 225 fry with an initial average weight of 0.13 g. The fish were raised in plastic tanks of 50L each and fed three times a day (9 a.m, 1p.m and 5 p.m) at a feeding rate of 8% and 3% of their body weight during the 1st, 2nd to 3rd and 4th 2 weeks respectively. The temperature and dissolved oxygen were monitored in the morning and evening and the culture units were cleaned, siphoned and refilled with water at two third of their capacity prior to the feeding. The results of this study indicated that dietary NPM and TPM could replace SBM without a negative impact on the growth of tilapia. The FCR of the fish fed the diet containing NPM, SPM, TPM are not significantly different with FCR of those fed SBM. There were effects on the body composition of the fish fed diets containing the substitution of soybean meal with processed peanunut cake. The survival rate varied from 93 to 100%. The results of the analysis of the aflatoxin level in the four types of feed containing peanut meal showed that the heat treatment had no effect on the aflatoxin content. The substitution of soybean meal with natural and toasted peanut cake has no adverse effect on growth and feed efficiency of Nile tilapia fry. The authors suggested to use natural or toasted peanut cake for better growth.

Keywords: replacement, soybean meal, peanut meal, aflatoxin, growth, tilapia

1. Introduction

The fisheries sub-sector has always played an important role in the national economy through its contribution to macroeconomic indicators and food security. For example, the sub-sector contributed 1.8% of the national GDP (FAO, 2023).

For several years, the dynamics of the exploitation of fisheries resources have led to overinvestment and overexploitation of most fisheries resources of commercial interest. This evolution has resulted in a strong deterioration of this contribution over time. The fisheries GDP thus fell from 2% in 2006 to 1.3% in 2016 (ANSD, 2017).

Faced with this very alarming situation, the State of Senegal has been committed since 2006, through its sectorial development policies, respectively for the periods 2007-2013 and 2016-2023, to develop aquaculture as a growth relay to capture fisheries and to allow the sector to continue to play its role in wealth creation, employment provision and food security.

However, the results obtained remain below the ambitions for the development of aquaculture. Indeed, out of a production target of 30,000 tonnes by 2018, national production is estimated at 1600 tonnes at the end of 2022 (ANA, 2022). To meet this challenge, Senegal aims to move towards the promotion of a competitive commercial intensive aquaculture. In intensive aquaculture, feed is the main cost of farming (Tacon, 1996; Hoffman *et al.* 1997). In Senegal, fish farmers are confronted with the high cost of imported feed, most of which is made from soybeans that are not available locally and are very expensive on the international market.

Soybean meal is the main component of standard feeds for tilapia farming Lovell (1988). It is rich in essential macronutrients, but its high purchase price, lack of methionine and lysine and dependence on imports make its use possible only in high-value aquaculture production. Aquaculturists must therefore resort to other alternative sources of protein, especially plant protein, which are not directly usable for human consumption (Jackson *et al.* 1982; Shiau *et*

al. 1987; El-Sayed, 1990), and which provide the organisms with all the elements required for growth and survival.

Given that Senegal is a major groundnut producer, it would be appropriate to study the possibility of substituting soybean meal with industrial groundnut meal in the fish diet, given its availability and very important nutritional qualities; this would encourage the local manufacture of quality fish feed at competitive costs.

Groundnut meal is a by-product of the extraction of oil from the seeds of the groundnut, *Arachis hypogoea* L., a legume native to Peru that is abundant in Africa (Adrian and Jacquot, 1968; Hertrampf and Piedad-Pascual, 2000). They are plants in the Leguminosae or Fabaceae family and are an essential source of plant protein for human and animal nutrition (FAO 2014). The contamination of aflatoxins in food crops is common in subtropical and tropical areas, especially for the crops containing high starch and lipid content, such as peanut, cottonseed, maize, wheat, sunflower and soybean (Ostrowski-Messner et al., 1995). Increased use of vegetable sources in aquafeed may have adverse effects on fish welfare for the high risk of aflatoxin contamination in plant materials (Deng et al., 2010). Therefore, it is necessary to evaluate the aflatoxin content of unprocessed and processed penaut meal.

This study aims to evaluate the effects of the total substitution of soybean meal by unprocessed and processed peanut cake meal on the growth of tilapia, the survival, the feed efficiency and the flesh composition of tilapia.

2. Material and Methods

2.1 Study Area

The experiment took place at the aquaculture station of the University Institute of Fisheries and Aquaculture (IUPA) of the Cheikh Anta Diop University of Dakar (UCAD), Senegal.

2.2 Analysis of Aflatoxins

Since aflatoxins are likely to contaminate groundnut seeds, we considered it necessary to analyze the aflatoxin B1 content in groundnut cake. Therefore 04 samples of different types of groundnut cake were taken and analysed at the Institute of Food Technology (Institut de Technologie Alimentaire (ITA)) in Dakar.

With the ISO 14718:1998 standard, they used the High Performance Liquid Chromatography (HPLC) method. The principle of this method is as follows: the sample is extracted with chloroform. The extract is filtered and an aliquot is purified on a Florisil cartridge and on a C18 cartridge. The final separation and determination were carried out by high performance liquid chromatography (HPLC), using a C18 column with reversed phase polarity, followed by iodine or bromine derivatisation and fluorescence measurement at the column outlet. The lower limit of detection is 1 µg/kg aflatoxin B1.

2.3 Diet Preparation

Five iso-nitrogenous (32.51% CP) and isolipidic (7.73 %) practical diets were formulated in which the test diets were mainly from locally available ingredients. The macro ingredients

such as fishmeal, soybean meal, peanut cake meal, millet bran, rice polish meal, maize meal, fish and vegetable oil, vitamins, minerals, yeast and binder CMC were used to make the different diets. The control diet (SBM) was formulated to contain soybean meal, while four other diets were formulated to replace totally soybean meal with raw (NPM), toasted (TPM) and steamed (SPM) and fermented (FPM) peanut cake meal (table 1).

The peanut cake meal underwent for some transformations: one part was toasted, another steamed, a third fermented, and the rest was left in its natural state (unprocessed). Toasting consists in carrying out a heat treatment of the industrial peanut cake for 15 minutes. For steaming, the peanut cake was put in a steamer and placed it on a kettle of boiling water for about 10 minutes. For fermentation, the cake was mixed with yeast (*Saccharomyces cerevisiae*) dissolved in water (1kg of cake, 10g of yeast and 2 liters of water) and the mixture is kept anaerobic for 7 days. After fermentation, the fermented peanut cake meal in the mixture was collected by pressing with a filtered cloth and the flour was dried under the sun.

The dietary ingredients were first ground to give a small particle size using a hammer mill and then pass through a 1 mm mesh-size sieve. After all the dry ingredients have been homogenously mixed, appropriate amount of fish oil were added based on the formulation. Finally, water was added (approximately 30% of dry matter) to form moist dough that was then passed through a 3.0 mm diameter die producing spaghetti-like filaments with a meat grinder. The feeds were then dried in an oven at 60°C to approximately 15% moisture content and then stored frozen. The dried feeds were ground using local mortar and pestle and sieved to remove big particles. They were then sieved again to remove fine particles. The feeds in the form of crumbles were kept in air-tight containers at room temperature and required amounts were periodically taken for feeding during the experiment.

The proximate composition of the different diets NPM, TPM, SPM, FPM and SBM used for preparing the experiment is shown in table 1.

Table 1. Formulations of the experimental diets (% dry matter)

Ingredients	**Treatments**				
	NPM	**TPM**	**SPM**	**FPM**	**SBM**
Fish meal (g)	25	25	25	25	25
Yeast (g)	4	4	4	4	4
Peanut cake meal (g)	20	20	20	20	0
Soybean cake meal (g)	0	0	0	0	20
Rice polish flour (g)	15	15	15	15	15
Vitamins[a] (g)	1	1	1	1	1
Minerals[b] (g)	1	1	1	1	1
Corn flour(g)	20	20	20	20	20
Fish and vegetable oil (1 :1) (ml)	2	2	2	2	2
Millet bran (g)	10	10	10	10	10
CMC (g)	2	2	2	2	2
TOTAL	100	100	100	100	100
Crude Protein (%)	33.82	32.64	32.18	33.06	32.51
Crude Lipid (%)	8.73	8.65	7.89	9.30	7.73

[a] Vit A 250000 UI; Vit D_3 250000 UI; Vit E 5000 mg ;Vit B_1 100 mg ; Vit B_2 400 mg ; Niacine 1000 mg ; Pantothenate Ca 2000 mg ; Vit B_6 300 mg ; Vit K_3 1000 g ; Vit C 5000 mg ; Biotine 15 mg ; Choline 100 g ; BHT 1000 mg;

[b]Phosphorus 7%; Calcium 17%; Sodium 1.5%; Potassium 4.6%; Magnesium 7.5%; Manganese 738 mg; Zinc 3000 mg; Iron 4000 mg; Copper 750 mg; Iodine 5 mg; Cobalt 208 mg; Calcium and ground attapulgite qs 1000 g ; Fluoride 1.5%.

2.4 Growth Trial

The experiment was conducted for two months at the Institute of Fisheries and Aquaculture at the University of Cheikh Anta Diop of Dakar (UCAD), Senegal. The mixed-sex Nile tilapia fry (*Oreochromis niloticus)* was obtained from the experimental station of University Institute of Fisheries and Aquaculture at UCAD. Prior to the feeding trial, the fish were conditioned in the experimental station for two weeks in one FRP tank of 1200 L. During this period tilapia were fed with control diet. At the beginning of the experiment, the fish at the initial average size of 0.13g were randomly distributed in 15 plastic tanks with each containing 15 fish and 50 L of freshwater. Each of the five experimental diets was fed to triplicate group of fish at random for eight weeks. Water temperature and dissolved oxygen were recorded during the feeding times (08 :00 13 :00 and 17 :00). Uneaten feed and faecal matter, if any, were removed by siphoning prior to each feeding. Fish were fed at 8 % of their body weight during the first two weeks, and then this rate is gradually reduced according to the weights till the end of the experiment. Fish were pooled weighed every 2 weeks to determine the growth rate. Each aquarium was provided with continuous aeration through an air stone connected to a central air compressor. Feeding was stopped 12 h prior to weighing, and fish were weighed individually at the end of the feeding trial. All fish from each tank were sampled to determine the proximate composition of the fish body for each group. Fish were sacrificed by immersing in ice water, carefully homogenized and frozen for subsequent analysis.

The physicochemical parameters of water temperature and oxygen content are measured twice a day using a YI Model 58 multi-parameter oxygen meter (Yellow Springs Instrument, Yellow Springs, OH, USA).

2.5 Fish Sampling

At the beginning of the experiment, 225 fish were weighed individually and distributed to 15 tanks. At the end of the experiment, all the remaining fish for each treatment were individually weighed and sacrificed. The carcasses of fish from each treatment were separately combined and homogenized using a blender for subsequent proximate analysis.

2.6 Sample Analysis

The proximate composition of feed ingredients (unprocessed peanut meal (natural NPM), toasted peanut meal (toasted TPM), fermented peanut meal (fermented FPM), steamed peanut meal (steamed SPM) and soybean meal (SBM), experimental diets (1 to 5) and five samples of fish fed the different diets was carried out by following the procedures of AOAC (1995). Samples (5 feed ingredients, 5 experimental diets and 5 sets of fish body) were dried to a

constant weight at 105°C in order to determine their moisture levels. Ash was determined by combustion of the samples at 540°C in a muffle furnace. Crude protein was determined by measuring nitrogen (N x 6.25) using a micro-Kjeldahl method (Kjeltec System 1002 Distilling Unit, Tecator, Hoeganaes, Sweden). Crude lipid was extracted by Soxhlet method (Soxtec system, Foss, Model HT, Sweden). Crude fiber was determined by acid and alkaline digestion using a Fibertec system M 1020 (FOSS Tecator).

2.7 Calculations of Parameters

The following formulae were used for calculations:

Mean body weight (g/fish) = Group body weight (Biomass)/Number of fish

Absolute mean weight gain (AMWG, (g/ fish)) = Final mean body weight - Initial mean body weight.

Relative mean Growth Rate (RMGR, %) = 100 × (final mean weight – initial mean weight) / initial mean weight.

Specific Growth Rate (SGR (% /day) = ((ln Wt- ln Wi) /T) × 100; where Wt is the weight of fish at time t, Wi is the weight of fish at time 0, and T is the rearing period in days.

Feed conversion ratio (FCR) = total dry feed fed (g) / total wet weight gain (g)

Survival rate: (Initial Number –Final Number/ Initial Number) × 100.

2.8 Statistical Analysis

A one-way analysis of variance (ANOVA) was performed to test the differences in IMW, FMW, AWG, RGR, SGR, FCR and SR. When the significant level was $p < 0.05$, a Duncan's multiple-range test was used to compare the relevant mean differences. All statistical analysis was conducted using SAS software program for Window (V. 9.4, SAS Institute).

3. Results

3.1 Biochemical Composition of the Different Forms of Peanut and Soybean Cake

The dry matter, Ash, crude protein, crude lipid and crude fiber of the different ingredients used in this study are shown in table 2.

Table 2. Proximate composition of the feed ingredients

	DM (%)	Ash (% DM)	CP (% DM)	CL (% DM)	CF (% DM)
Natural PM	89.86	8.45	54.87	13.32	10.58
Fermented PM	86.54	11.40	51.07	16.17	10.61
Toasted PM	92.90	8.06	48.98	12.94	11.14
Steamed PM	88.92	8.17	46.69	9.12	17.79
SBM	95.68	6.36	48.34	4.23	8.32

PM : Peanut Meal, **SBM :** Soybean Meal, **DM** *:* Dry Matter, **Ash :** Ash, **CP :** Crude Protein, **CF :** Crude fiber, **CL :** crude lipid

The dry matter of SBM was the highest (95.68%), followed by toasted PM (92.90%), natural PM (89.86 %), Steamed PM. (88.92%) and Fermented PM (86.54%). Toasting and steaming of the groundnut cake did not affect the ash content. The ash content of the fermentation PM was the highest (11.40 %). The fermentation and toasting of the peanut cake moderately decreased crude protein. The steaming process significantly decreased crude protein. Only steaming of peanut cake meal greatly increased crude fiber. Toasting had no effect on peanut cake meal crude lipid. However, fermentation of peanut cake meal had increased crude fat level, while steaming process decreased it.

3.2 Aflatoxin Analysis

The concentrations of aflatoxin found in the different diets are presented in the table 3.

Table 3. Aflatoxin B1 content of the different diets

		Samples			
Parameter	**Limit by codex alimentarius**	**Diet TPM**	**Diet FPM**	**Diet NPM**	**Diet SPM**
Aflatoxin B1 µg /kg	15	8	7	7.5	13.3

The results showed that the aflatoxin level in the heat-treated samples were 8 µg/kg for the toasted and 13.3 µg/kg for the steamed while fermentation slightly reduced the level of 7 µ g/kg compared to the unprocessed peanut cake 7.5 µ g/kg.

3.3 Physicochemical Parameters

In this study, the water temperature varied between 20.32 and 28.85°C and dissolve oxygen levels between 1.82 and 4.97 mg/l.

3.4 Growth Parameters, Survival Rate and Feed Efficiency

Table 4. Growth, survival and feed efficiency parameters

Parameters	SBM	NPM	FPM	TPM	SPM
IMW (g)	0.13^{a}	0.14^{a}	0.13^{a}	0.14^{a}	0.14^{a}
FMW(g)	1.26 ± 0.19^{a}	1.63 ± 0.10^{a}	0.82 ± 0.09^{c}	1.33 ± 25^{a}	1.12 ± 0.04^{bc}
AMWG(g)	1.12 ± 0.20^{ab}	$1,49\pm0.09^{a}$	0.69 ± 0.08^{c}	1.19 ± 0.24^{a}	0.87 ± 0.15^{bc}
RMWG(%)	827.81 ± 141.63^{ab}	1064.16 ± 43.37^{a}	499.88 ± 61.05^{c}	850.80 ± 134.48^{ab}	622.94 ± 94.81^{c}
FCR	1.24 ± 0.12^{b}	1.15 ± 0.25^{b}	2 ± 0.13^{a}	1.24 ± 0.13^{b}	1.58 ± 0.27^{ab}
SGR(% / d)	3.96 ± 0.28^{ab}	4.38 ± 0.07^{a}	3.19 ± 0.18^{c}	4.01 ± 0.24^{ab}	3.71 ± 0.15^{bc}
SR(%)	100^{a}	100^{a}	93.33 ± 6.25^{a}	100^{a}	100^{a}

Values are means of the triplicates ± SD; values within the same row without a common superscript are significantly different ($p < 0.05$).

IMW: initial mean weight, FMW: final mean weight, AMWG: absolute mean weight gain, RMWG: relative mean weight gain, FCR: feed conversion rate, SGR: specific growth rate and SR: survival rate.

In this study we conducted feeding trial to evaluate the effects of replacement of soybean meal (SBM) with different forms of peanut cake meal (PM) as an alternative feed ingredient on growth performance, feed utilization parameters and survival of tilapia. The results of this study indicated that dietary NPM and TPM could replace SBM without a negative impact on the growth of tilapia.

For all growth indicators FMW, AMWG, RMWG and SGR fish fed with SBM, NPM and TPM did not show any significant difference. However fish fed with the diet containing FPM showed the lowest growth. Fish fed the diet containing FPM showed no statistical difference from fish fed SPM. The FCR of fish fed FPM was statistically different from the FCR of NPM, SPM and TPM. The FCR of fish fed with FPM shows no significant difference with those fed with diet containing SPM. Fish fed the diet base on SPM did not show any significant differences from those fed SBM, NPM and TPM. The survival rate varied from 93 to 100%. The fish fed with FPM showed the lowest survival rate. For fish fed with SPM, TPM and SBM the survival rate is 100%. Statistically, the survival rate of fish fed with NPM, SPM, TPM, FPM and SBM did not show significant difference.

3.5 Fish Body Composition

The body proximate compositions of the experimental fish are presented in table 5.

Table 5. Body composition parameters of Nile tilapia fry fed on different experimental diets at the end of 8 weeks

	DM	ADM	ASH(% ADM)	CP (% ADM)	CL (% ADM)
Natural PM	29.07	94.23	16.12	63.22	19.47
Fermented PM	25.77	94.61	9.26	53.45	36.59
Toasted PM	30.32	96.09	14.42	62.61	22.53
Steamed PM	30.93	95.00	16.14	65.32	19.61
SBM	28.13	95.58	17.09	64.08	16.47

DM: Dry Matter; ADM: *Analytical dry matter;* **C:** *Ash;* **CP:** *Crude protein and* **CL:** *crude lipid*

In the present study the body dry matter of the different diets is not significant. Fish fed with the diet containing natural, toasted and vaporised peanut cake contained more Ash than those fed the fermented peanut cake. However, they were not higher than that of fish fed SBM. The fish fed the diet containing steamed peanut cake meal are richer in protein, followed by those

fed with SBM and then, lastly, those fed with natural meal. Those fed the fermented peanut cake meal had low protein content. On the other hand, the analysis of the fat content results shows that fish fed with fermented peanut cake meal are fatter. Those fed with the diet containing natural and steamed peanut cake meal had acceptable amounts.

4. Discussion

The results of the present study showed that the temperature varied between 20.32 - 28.85°C. These values are in the optimal range of 23.7 to 28.6°C of tilapia growth as reported by EL-Khouly *et al*. (2008). The dissolve oxygen levels of the study ranged from 1.82 to 4.97 mg/l. According to Malcolm *et al*. (2000), the optimum level requested for tilapia is 5mg/l.

The aflatoxin levels in the heat-treated samples were 8 µg/Kg for the toasted and 13.3 µg/Kg for the steamed while fermentation slightly reduced the level of 7 µ g/Kg compared to the unprocessed peanut cake 7.5 µ g/Kg. The results of the present experiment are lower than the maximum limit 15µg/kg for the general standard for contaminants and toxins in food and feed products according to the Codex Alimentarius adopted in 1995 and revised in 2009.

In this study a feeding trial was conducted to evaluate the effects of replacement of soybean meal (SBM) with different forms of peanut cake meal (PM) as an alternative feed ingredient on growth performance, feed utilization parameters and survival of tilapia. The results of this study indicated that dietary NPM and TPM could replace SBM without a negative impact on the growth of tilapia. For all growth indicators FMW, AMWG, RMWG, and SGR fish fed with NPM and TPM did not show any significant difference compared to SBM. However, fish fed with the diet containing FPM showed the lowest growth. Fish fed the diet containing FPM showed no statistical difference from fish fed SPM.

Many studies have shown positive results on partial replacement of soya bean meal (SBM) with various plant ingredients in the diet of different fish species including tilapia (Fadel *et al*., 2017; Robinson and Li (2008). Jatta *et al*. (2022) conducted an experiment to evaluate the effects of replacing soybean meal, wheat flour and cassava flour with groundnut cake, poultry by-product meal, brewery waste and rice bran on the growth and body composition of *Oreochromis niloticus* fry at 3.77 g initial mean weight. The authors suggested that the substitution of soybean meal, wheat flour and cassava flour with groundnut cake or poultry by-product meal or the combination of groundnut cake and poultry by-product meal, brewery waste and rice bran is more cost-effective and economical for Nile tilapia farming. Dharmakar *et al*.(2022) reported that cottonseed meal has often been assessed to replace soybean meal in fish diets due to its high palatable nature. Deng *et al*. (2015) evaluated the effects of replacing soybean meal (SBM) with rubber seed meal (RSM) on growth of tilapia (*Oreochromis niloticus x Oreochromis aureus*). The results indicated that RSM could be included at level up to 30% in diet for tilapia without obvious adverse effects on the growth. Pradhan *et al*. (2020) conducted an experiment to replace soybean meal (SBM) with cashew nut meal (CNM) in the diet of tilapia. They concluded from the study that 50% replacement of SBM with CNM in the diet is suitable for the enhancement of growth, nutrient utilization and health status of tilapia. Ayyat *et al*. (2021) performed a feeding experiment to examine the impacts of partial or complete substitution of SBM with leaf protein concentrate from

carrot and sugar beet (CLPC and SLPC) on growth and body composition in *Oreochromis niloticus*. The findings demonstrated that SLPC and CLPC could replace 50% and 100% of SBM, respectively in *O. niloticus* feeds without any negative effects on growth. Fagbenro and Olurolea (2016) obtained values for weight gain and percentage weight gain were statistically similar as cassava LPC (leaf protein concentrate) replaced up to 60% and 80% of SBM in diets for *O. niloticus*. El-Saidy et *al*. (2012) suggested that up to 50% of SBM protein can be replaced by cotton seed meal protein in Nile tilapia diets without any adverse effects on biochemical analysis, the carcass characteristics and meat quality traits of Nile tilapia. Winston (2008) indicated that the main oilseed protein sources soybean meal (SBM), cottonseed meal (CSM) and groundnut cake (GNC) could replace at least 50% of fish meal protein in the diet of *O. niloticus* fingerlings, without adversely affecting growth and feed efficiency which agree with the results obtained in the present study.

Fish fed the diet containing FPM presented a FCR, which is statistically different from the FCR of fish fed NPM, SPM and TPM. The FCR of fish fed with FPM shows no significant difference with those fed with diet containing SBM. Fish fed the diet base on SPM did not show any significant differences from those fed SBM, NPM and TPM. Alegbeleye *et al.* (2008) reported that Nile tilapia (*O. niloticus*) fed with inclusion of 30% RSM give the best result with the highest SGR, best FCR and PER. Similarly, dietary RSM inclusion level up to 20-23% did not affect the growth response and feed efficiency in rohu (*Labeo rohita*) (Sharma and Saha, 2014) or catfish (Hosnol, 2013). However, these studies also demonstrated that higher inclusion level of RSM decreased the nutrient utilization, which mainly attributed to high level of cyanide present in RSM (Alegbeleye et *al.* (2008), Sharma and Saha (2014), Hosnol, (2013)).

The present study shows that the survival rate varied from 93 to 100%. These results are in line with those found by Deng et *al*. (2017), who reported that survival of juvenile tilapia (*Oreochromis niloticus* x *O. aureus*) ranged from 93.7% to 96.8%.

In previous studies with different fish species, it has been shown that the partial or total replacement of soya bean meal with plant protein sources (carob seed germ meal, canola meal, cottonseed meal, hazelnut meal and safflower) had no adverse effects on the body composition (Bilgüven and Barış, 2011); Fadel et *al*., 2017; Ustaoglu Tiril and Kerim, 2015). Ayyat *et al*. (2021) showed that replacing SM with carrot and sugar beet (CLPC and SLPC) did not affect the ash and moisture content of fish bodies. Acar & Türker, (2018) reported that there was no harmful impact on the biochemical composition of fish fillets with the use of PNM instead of soybean meal in rainbow trout diets. Contrary, in this study the replacement of soybean meal by peanut cake meal affected the fish body composition. For instance, the fish fed with the diet containing natural, toasted and vaporised oil cake contain more minerals and did not differ to those fed the SBM. The fish fed with the fermented peanut cake showed the lower ash content.

The use of PNM instead of soybean meal in Nile tilapia (*Oreochromis niloticus*) feeds have been reported to have lowered the protein ratio of fish meat relative to the control group (Da Silva et *al*., 2017). In the present study, the results of the analysis also allowed us to confirm

that fish fed the diet containing steamed peanut cake meal are richer in protein than those fed with SBM. Those fed the natural and fermented meal had lower protein content compared to the fed SBM.

Various studies were documented that plant origin raw materials added instead of soya meal in fish feeds have an effect on lipid ratios in fish fillets (Dernekbası et *al*., 2017; Pradhan et *al*., 2020). Similarly, the fish fed with the diet containing natural, toasted, steamed and fermented peanut cake had higher amounts compared to fish fed SBM. The analysis of the fat content results shows that fish fed with fermented peanut cake meal are fatter. These results are not in line with previous researches in *O. niloticus*, that have indicated a significant decline in the carcass crude lipid contents following feeding feeds in which SM was substituted by other plant protein sources such as *Eruca sativa*, roquette seed (Adebayo et *al*., 2004); *Cassia fistula* meal (Adebayo *et al*., 2004) and green algae *Ulva rigida* (Azaza et *al*., 2005), which reflect a reduction of lipid deposition.

5. Conclusion

The culture environment was favourable during the feeding test because the mean temperature and dissolved oxygen values of the water were within the optimal range for the culture of Nile tilapia (*Oreochromis niloticus*). The results of the present study allowed us to state that the total substitution of soybean meal by peanut cake meal had positive effects on the feed efficiency, growth and survival of tilapia. The processing affected the nutritional value of peanut meal. Concerning the aflatoxin level in the meal, we found that the treatments used did not reduce the aflatoxin level, but rather increased it in the steamed peanut cake meal except in the fermented peanut meal. In a further study, it would be appropriate to incorporate zeolite into peanut meal to try to reduce the amount of aflatoxin present in the latter**.**

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