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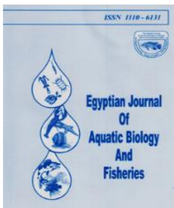

Effect of replacing soybean meal with fermented cottonseed meal on growth performance and feed utilization of the Nile Tilapia (*Oreochromis niloticus*) fingerlings

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ABSTRACT

A feeding trial was conducted to evaluate the effect of replacing soybean al diet with fermented cottonseed meal (FCSM) on the growth performance, d utilization, body composition and economical evaluation of Nile tilapia gerlings at rates (20, 40, 60, 80 and 100% FCSM for T1, T2, T3, T4 and T5, pectively. The basal diet was designed to contain (FCSM-0%) as a itrol). Three hundred and sixty Nile tilapia (*Oreochromis niloticus*) gerlings with initial weight of 3.5 ± 0.12 g were divided into six groups (20 ı per tank, Triplicate per treatment). Fingerlings Nile tilapia were hand-fed to ıal satiation at two meals per day for 90 days. Fish were fed diets containing erent levels of FCSM had no significant differences regarding survival. Final ight, Weight gain, SGR and PER were significantly higher in group of fish on and T4 groups, respectively. FCR was the lowest in T5 (100%) and T4 %) replacement of soybean meal with fermented cottonseed meal compared h the control group and other experimental dieys. Feed and protein intake re significantly highest in group of fish fed on control and T1diets and the vest in group of fish fed on T5and T4. Body protein significantly increased h increasing level of incorporation of fermented cottonseed meal in the diets. ese results indicated that incorporation of fermented cotton seed meal into gerlings Nile tilapia fingerlings diets reduced the price of one kg diet to 82.93, 93, 64.71, 57.66 and 61.25% for the T1, T2, T3, T4 and T5, respectively npared to the control group (100% of the price). . In conclusion, fermented ton seed meal can be replaced soybean meal at levels 80 or 100% without ;ative effects on growth performance and feed utilization of Nile tilapia gerlings under experimental conditions.

INTRODUCTION

The 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, 2020)**. 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 in2020, 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. (**Magouz *et al*., 2020).**

Protein is basis for aquaculture animals, and feeding protein costs make up a large percentage of the total expenses of aquafeeds. Soybean meal (SBM) has been the most common source of plant protein as a fish meal replacer in aquaculture feed because of its high protein content, relatively well-balanced amino acid profiles, reasonable price and steady supply (**EI-Sayed, 1999**). However, high demand of SBM has made it a relatively expensive protein source after fish meal. Therefore, the search for alternative plant proteins to replace soybean meal has been gained increasing interest in the research of aquaculture

Cottonseed meal (CSM) is one of the most important alternative protein sources which have long been used to feed terrestrial and aquatic animals (**Lim and Lee 2008).** Cottonseed meal is the third largest oil-seed meal product in world production after soybean meal and rapeseed meal **Lee *et al.(* 2006)** and it is a rich source of arginine, an essential amino acid for aquatic animals, which is higher than that in fish meal and soybean meal. The amount of CSM that can be included in aquaculture diets depends mainly on the species and levels of gossypol and available lysine (**EI-Saidy and Gaber 2004)**

Fermentation is a process allows microorganisms such as *Bacillus subtilis* to degrade protein macromolecules to a large extent water-soluble low molecular weight compounds (**Kiers *et al*., 2000**). 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**). Fermentation strategy was followed to handle the environmental impact of agricultural wastes and provide safe and affordable feedstuff. According to **Zhang *et al.* (2017)** and **Sun *et al.* (2015)**, fermentation techniques improved vitamin availability, protein, and fiber quality, besides, palatability of feedstuff. Moreover, it improved the innate immunity of fish (**Siddik *et al.*, 2019).** Bacterial fermentation using useful bacteria such as *Bacillus subtilis* was revealed to have antitumor and immunomodulatory effects. Interestingly, it enhances the growth and viability of intestinal lactic acid bacteria (**Liu *et al*., 2012).** Therefore, as soybean meal prices have continued to rise in recent years, the development and utilization of new plant protein sources with a low price and low content of anti-nutritional factors has become the primary way to solve the industry's dilemma.

The aim of the present study is to investigate the effect of replacing soybean meal protein of diets with fermented cottonseed meal at levels 20, 40, 60, 80 and 100% on growth performance, feed utilization, body composition and economic evaluation of Nile tilapia (*O. niloticus*) fingerlings.

MATERIALS AND METHODS

This experiment was conducted at fish Research center in Suez Canal University Ismailia- Egypt to study the effect of replacing different levels of soybean meal protein with fermented cotton seed meal on growth performance and feed utilization of Nile tilapia fingerlings. The experiment was carried out for 90 days.

Fermentation Cotton Seed meal

Microbial hydrolysis (M-FPH) steps were carried according to **Samaddar and Kaviraj (2014)** and **Khiari and Mason (2018).**At first, starter culture of *Lactobacillus plantarum* was cultured into 5ml nutrient broth and incubated at 37°C for 48h. Then, 2ml of culture was transferred into 100 ml of sterile *Lactobacilli MRS* (DeMan, Rogosa and Sharpe) broth and incubated at 37°C for 48h to get the adequate microbial inoculum (LAB) (108 CFU/ml) for fermentation process. A grinded cotton seed meal was mixed with glucose solution (175g/ L), and pH was adjusted to 5. Then, 800ml of LAB inoculum was added, and the mixture was incubated at 37°C for 9 days. After centrifugation at 6000 rpm for 20min, the hydrolysate was collected and pH was adjusted to 6 with 2N NaOH. Then, the hydrolysate was dried at 60˚C for 24h (M-FPH). The composition of fermented and non-fermented cotton seed meal is presented in (Table 1).

Table 1: Fermented and un-fermented cotton seed meal composition .

Ingredient	Crude protein	Crude fat	Crude fiber	Ash
Cottonseed meal	42	1.1	7.3	6.3
Fermented cotton seed meal	46	0.8	9.3	6.20

Experimental Diets

Six isonitrogenous and isocaloric diets were formulated from practical ingredients (Table 2) where the control diet and the other five diets protein content was replaced by 20, 40, 60, 80 and 100% with fermented cotton seed meal. The composition and proximate analysis of the experimental diets are presented in Table (2). The fish were hand-fed to apparent satiation within half an hour, twice/day (11 am and 3pm) for 90 days. The experimental diets were formulated to contain almost 25% crude protein. The experimental diets were prepared by individually weighing of each component and by thoroughly mixing the mineral and vitamins with corn. This mixture was added to the components together with oil. Water was added until the mixture became suitable for making granules. The wet mixture was passed through CBM granule machine with 2mm diameter. The produced pellets were dried at room temperature and kept frozen until experiment start.

Table 2: Ingredient formulation (%) and proximate composition of the experimental diets

Ingredients %	Control (Basal diet)	20% FCSM T1	40% FCSM T2	60% FCSM T3	80% FCSM T4	100% FCSM T5
Fish meal	4	4	4	4	4	4
Soybean meal (SM)	25	20	15	10	5	00
FCSM	0	5	10	15	20	25
Corn	48	48	48	48	48	47
Wheat bran	9.5	9.3	8	7.3	6.8	6.5
Corn gluten	10.5	11	12.3	13.3	14.2	15.5
Soybean oil	1	1	1	0.7	0.5	0.5
Vit. & Min. Premix[1]	2	1.7	1.7	1.7	1.5	1.5
Proximate Analysis%						
Moisture	8.1	8.5	7.9	8.7	8.3	8.4
Crude protein	25.17	24.91	25.02	25.02	24.98	25.1
Ether extract	5.56	5.54	5.58	5.31	5.11	5.13
Crude fiber	3.14	3.44	3.74	4.05	4.35	4.64
Ash	4.42	4.41	4.40	4.41	4.42	4.410
NFE[2]	54,61	54.50	53.96	54.11	54.02	53.52
G E(Kcal/100 g)[3]	419.20	417.09	415.87	413.93	411.06	410.26

1 each Kg vitamin & mineral mixture premix contained Vitamin A, 4.8 million IU, D3, 0.8 million IU; E, 4 g; K, 0.8 g; B1, 0.4 g; Riboflavin, 1.6 g; B6, 0.6 g, B12, 4 mg; Pantothenic acid, 4 g; Nicotinic acid,8 g; Folic acid, 0.4 g Biotin,20 mg ,Mn, 22 g; Zn, 22 g; Fe, 12 g; Cu, 4 g; I, 0.4 g, Selenium, 0.4 g and Co, 4.8 mg.

2-Nitrogen Free Extract = 100 – (%Protein + %Fat + %Fiber + %Ash).

3-Gross Energy based on protein (5.65 Kcal/g), fat (9.45 Kcal/g) and carbohydrate (4.11Kcal/g**). (NRC, 2011).**

Experimental Unit

Fish were stocked in 18 fibre glass tank (200litre) randomly divided into six equal experimental groups (20 fish each treatment, three replicate/treatment) .All tanks supported with air blowers. The tank water was exchanged with freshwater 2-3 time/week. Tanks were washed and changed with fresh water every 4 weeks.

.Experimental Fish

Nile tilapia fingerlings used in this study with average initial weight of 3.50 ± 0.12 g were obtained from Fish Research Center, Suez Canal University, Ismailia, Egypt. Fish were weighed individually at the beginning and at the end of feeding trial. Fish were homogenous in body weights and apparently healthy. Fish were acclimated to laboratory conditions for 2 weeks before the beginning. Fish from each tank were weighed every fifteen days of the experiment (90 days), 5 fish were randomly taken from each experimental group for chemical analysis of the whole body by using standard methods (**AOAC, 2019).**

Fish Feeding

Fingerlings Nile tilapia was fed to satiation two times daily (9:00 am, 3:00 pm) and body weight were recorded every 15 days. After a stipulated period of feeding (20 to 30 min.), unconsumed feed, if any was collected on a fine mesh sieve, dried weighed and subtracted from food offered. Fish were deprived offood on the day of weighing and tanks were thoroughly scrubbed and rinsed with water. Each treatment had three replicates and was fed according to the experimental protocol.

Chemical Analysis of Diets.

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 fibre. Moisture content was estimated by drying the samples to constant weight at 85°C in a drying oven (GCA, model 18 EM, 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 (1970).** Gross energy was calculated based on 5.65, 9.45, and 4.11 kcal/g for protein, lipid, and carbohydrates, respectively according to **NRC (2011)**.

Sample Collection

At the end of the feeding trial, all fish in each tank were individually weighed and counted for the calculation of weight gain (WG), feed conversion ratio (FCR), protein efficiency ratio (PER) and survival rate (SR). Fish were anesthetized with 0.1% tricane methane sulfonate (MS-222; Argent Chemical Laboratories Inc., Redmond, WA, USA).

Blood Sample Collection

At the end of trial, four fish were sampled randomly from each replicate group. The fish were anaesthetized using clove oil (20 mg L-1) of water. Blood samples (1 ml from each fish) were drawn from the caudal vein of each fish using a sterile syringe, previously rinsed with 2.7% Ethylene- diamine –tetra-acetic acid (EDTA) solution as an anticoagulant (Plate 4). Blood samples were collected and processed according to standard methods described by **Svobodová *et al*.(1991).** The blood samples were used immediately for analysis of hemoglobin, red blood cells (RBC) and white blood cells (WBC).

Growth Performance Parameters:

The growth performance parameters are calculated according to the following equations:

Average Weight Gain (AWG):-=Average final weight(g)– Average initial weight(g)
Average Weight Gain (AWG):-=Average final weight(g)– Average initial weight(g)
Average Daily Gain (ADG):=[Average final weight(g)– Average initial weight (g)] /time (days)
Specific Growth Rate (SGR %/day):- (SGR % / day) = 100 [Ln Wt_1 – Ln Wt_0 / t]
Where: - Ln: normal log Wt_0: initial weight (g). Wt_1: final weight (g) T: time of days.

Feed and Protein Utilization Parameters:

Feed and protein utilization parameters are calculated according to the following equations:-

Feed Conversion Ratio (FCR):- = Total feed consumption (g)/ weight gain (g).

Feed efficiency (FE):-= weight gain (g)/ Total feed consumption (g)

Protein efficiency ratio (PER):- = body weight gain (g)/ protein intake (g).

Protein Intake (PI):=protein quantity (%)in the diet x feed intake per fish/ 100

Survival rate (SR**, %):=** N_i x 100/N_0

Water quality Parameters:

A digital thermometer was used to test the water's temperature and dissolved oxygen content (DO), and a Milwaukee-PH600 pH meter was used to assess the water's pH once a week. Ammonia nitrogen (NH_3-N), nitrite (NO_2) values were detected on a biweekly basis using water analysis using photometer and test kits), and nitrate (NO_3) was weekly determined. While, alkalinity (expressed as Ca CO_3) was biweekly monitored by titration with sulfuric acid till pH point reached 4.5 (**APHA, 1998).**

Economical Evaluation:

The cost of feed to raise unit biomass of fish was estimated by a simple economic analysis. The estimation was based on local retail sale market price of all the dietary ingredients at the time of the study (**Eid and Mohamed, 2008**).

Cost/kg diet (LE) = Cost per Kg diet L.E

Consumed feed to produce 1kg fish (kg) =Feed intake per fish per period/ final weight per fishKg/Kg

Feed cost per kg fresh fish (LE) = Step 1X step 2

Relative % of feed cost/ kg fish =Respective figuresfor step 3/ highest figure in this step

Feed cost/1Kg gain (LE) = Feed intake per Kg gain Xstep 1

Relative % of feed cost of Kg gain =Respective figures for step 5/ highest figure in this step.

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 by using SPSS 17.0 analysis software (**SPSS) (Statistical Packages for Social Sciences, 2007)**

RESULTS

1-Growth Performance:

Averages of initial weights, final body weights (g) and the weight gain (g/ fish) are presented in Table 4. As presented in this table averages of initial weights 3.50 g with insignificant differences (p <0.05) among the experimental groups. The group of fish fed on T5 and T4 diets had significantly highest (P<0.05) FBW, weight gain, SGR compared to fish groups fed on control and the other experimental diets, the lowest values of FBW and SGR were recorded in group of fish in T1and control diets.

Table 3: Effect of different dietary fermented cotton seed meal on growth performance of Nile tilapia *(Oreochromis niloticus*) fingerlings fed experimental diets.

ITEM	Control	(T1) 20% FCSM	(T2) 40%FCSM	(T3) 60% FCSM	(T4) 80%FCSM	(T5) 100%FCSM
IBW (g)	3.50±0.10	3.50±0.12	3.50±0.13	3.50±0.14	3.50±0.15	3.50±0.15
FBW (g)	30.12^{c}±0.26	31.80^{c}±0.24	34.31^{b}±0.23	36.39^{a}±0.25	37.16^{a}±0.20	38.10^{a}±0.15
WG (g)	26.62^{d}±0.20	28.30^{c}±0.23	30.81^{b}±0.24	32.89^{a}±0.22	33.66^{a}±0.21	34.60^{a}±0.20
(SGR)%/day	2.07^{c}±0.01	2.12^{b}±0.01	2.19^{b}±0.02	2.25^{a}±0.02	2.27^{a}±0.03	2.30^{a}±0.20
Survival rate %	100	100	100	100	100	100

Means in the same row having different super script letters are significantly different (P<0.05).

2- Feed Utilization

Results of the effects of experimental diets on nutrient utilization in terms of feed conversion ratio (FCR), (FI), (FE) and protein Efficiency ratio (PER) are illustrated in Table (5). It was found significantly (P<0.05) different among experimental groups. The highest value of feed and protein intake was recorded in group of fish fed control diet and T1 followed by T2, T3, T4 and T5, respectively. The best value of feed conversion ratio was recorded for T5 (1.03) and T4 (1.30) while the worst feed conversion ratio value was recorded for control group (2.14) followed by T1 (1.90) and T2 (1.60), respectively. The same trend was observed in PER T4 (3.01) and T5 (4.21). (FE) value was recorded for T% group (0.99) followed by T4 (0.77), respectively and for control group was (o.47) .The same trend was observed in PER, fish group fed T4 and T5 were (3.08) and T4 (3.86).

Table 4.Effect of different dietary fermented cotton seed meal on feed utilization of Nile tilapia *(Oreochromis niloticus*) fingerlings fed experimental diets.

Item	Control	(T1) 20% FCSM	(T2) 40% FCSM	(T3) 60% FCSM	(T4) 80%FCSM	(T5) 100% FCSM
Feed intake (g)	56.96^{a}±0.12	53.77^{a}±0.1	49.29^{b}±0.1	47.36^{b}±0.12	43.75^{c}±0.14	35.70^{d}±0.12
(FCR)	2.14^{a}±0.10	1.90^{a}±0.1	1.60^{b}±0.12	1.44^{c}±0.14	1.30^{c}±0.12	1.03^{d}±0.13
(PER)	1.86^{c}±0.10	2. 11^{c}±0.1	2.50^{b}±0.13	2.78^{b}±0.12	3.08^{a}±0.14	3.86^{a}±0.12
(FE)	0.47±0.15	0.53±0.1	0.63±0.13	0.50±0.12	0.77±0.10	0.97±0.14

Means in the same row having different super script letters are significantly different (P<0.05).

Whole body composition

Average of whole body chemical compositions including crude protein (CP) ether extracts (EE), ash,nitrogen free extract (NFE) ,average of DM contents in tilapia bodies fed on experimental diets are presented in Table (5). It was found no significantly (P<0.05) different among experimental groups in dry matter, while the results showed that ether extracts (EE) and Ash content in dry matter of tilapia whole bodies were significantly different. The highest value of crude protein contents was recorded in T5 (58.40%), while the lowest value of crude protein contents was recorded in control group (55.0.**).**

Table 5 . Effect of different dietary Fermented Cotton seed meal on body chemical composition of Nile tilapia *(Oreochromis niloticus*) fingerlings fed experimental diets.

Treatment	**Initial**	**Control**	**(T1)20% FCSM**	**(T2)40% FCSM**	**(T3)60% FCSM**	**(T4)80% FCSM**	**(T5)100% FCSM**
Dry matter	25.80±0.01	22.25±0.01	22.83 ±0.01	23.70±0.02	23.83±0.22	24.40 ±0.21	24.89±0.20
Crude protein	53.15±0.16	55.0^{cb} ±0.16	56.49^{cb} ±0.23	56.50^{bc} ±0.26	57.76^{b} ±0.24	57.94^{a} ±0.20	58.40^{a} ±0.25
Ether extract	15.98±0.16	16.28^{b} ±0.16	18.90^{a} ±0.10	18.78^{a} ±0.12	18.69^{a} ±0.13	18.60^{a} ±0.15	18.73^{a} ±0.14
Ash	21.26±0.13	22.26^{b} ±0.13	23.98^{a} ±0.10	23.88^{a} ±0.01	23.66^{a} ±0.02	$23..59^{a}$ ±0.03	23.55^{a} ±0.04

Means in the same row having different super script letters are significantly different (P<0.05).

Hematological index

Values for red RBC, Ht and Hb were affected by dietary levels of FCSM (Table 6). Significant differences were observed for the values of RBC as the replacement of SBM with FCSM increased from 0 to 100% ($P > 0.05$). Ht values significantly increased as the replacement level of SBM with FCSM increased from 0 to 80%, however, significantly decreased as the replacement level increased up to 100% ($P < 0.05$). Fish fed diets T4 and T5 which containing FCSM as replacements of 80 and 100% of SBM had improved Hb ($P < 0.05$) compared with groups of fish of other treatments, but total replacement of SBM by FCSM significantly increased Hb ($P < 0.05$).Mean blood cell count and hematocrit hemoglobin of Nile tilapia fed diets containing various levels of fermented cottonseed meal for 90 days.

Table 6. Effect of different dietary Fermented Cotton seed meal on blood parameters of Nile tilapia *(Oreochromis niloticus*) fingerlings fed experimental diets.

Item	**Control**	**(T1) 20%FCSM**	**(T2)40% FCSM**	**T360%FCS M**	**(T4) 80%FCSM**	**(T5) 100%FCSM**
RBC ($\times 10^{12}$ l^{-1})	2.40^{c} ± 0.3	2.40^{c} ± 0.21	2.45^{b} ± 0.29	3.15^{a} ± 0.29	3.35^{a} ± 0.25	3.75^{a} ± 0.25
Ht (%)	٢٧.50^{d} ± 0.63	٣٠.50^{c} ± 0.6	37.50^{b} ± 0.63	37.50^{b} ± 0.63	45.90^{a} ± 0.94	42.90^{a} ± 0.94
Hb (g l^{-1})	77.0^{d} ± 2.48	84^{c} ± 2.54	93^{b} ± 4.35	99^{b} ± 5.83	114^{a} ± 3.54	111^{a} ± 6.54

Values are means ± SD. Values in the same row with different superscripts are significantly different ($P < 0.05$).

5. Economic Evaluation

Results of Economic Evaluation including feed costs of one kg gain in weight and its ratio to that of the control group are presented in Table (7). As presented in this table cost of one kg of the diet for fermented cotton seed meal in T1, T2, T3, T4 and T5 were 24.40, 24.09, 23.77 ,23.46 and 23.14 LE, respectively. Costs of one kg gain in weight were 52.90, 46.36, 38.54, 34.23 and 30.50 and 23.80 LE for control, T1, T2, T3, T4 and T5 respectively. These results indicate that incorporation of fermented cottonseed meal into tilapia diets reduced the price of one kg diet to 87.64, 72.93, 64.71, 57.66 and 61.25% for the T1, T2, T3, T4 and T5, respectively, compared to the control group (100% of theprice).

Table 7. Effect of Different Dietary Fermented Cotton seed meal levels on the Economic Efficiency of Nile Tilapia *(Oreochromis niloticus*) Fingerligs

Parameters	Treatment					
	control	T1	T2	T3	T4	T5
Cost /kg diet (LE)	24.72	24.40	24.09	23.77	23.46	23.14
Feed intake(g)	0.060	0.054	0.049	0.047	0.044	0.036
Feed intake cost (LE)[1]	1.48	1.32	1.18	1.12	1.03	0.83
Relative to feed cost %[2]	100	89.12	79.73	75.68	69.59	56.17
FCR[3]	2.14	1.90	1.60	1.44	1.30	1.03
Feed cost/kg fresh fish[4] (EGP)	52.90	46.36	38.54	34.23	30.50	23.83
Relative % of feed cost/ kg fish[5]	100	87.64	72.85	64.71	57,66	61.25

1. Feed cost X feed intake
2. value of each treatment feed intake cost / highest value x100
3. Feed Conversion ratio
4. Feed cost / kg gain = FCR x Feed cost /Kg EGP
5. Feed cost /kg fresh fish EGP value for each treatment / highest value x100

DISCUSSION

The growth performance of Nile tilapia fingerlings was higher in $FCSM_{60,}$ $FCSM_{80}$ and $FCSM_{100}$ groups with no significant difference .whereas, control and the other experimental diets were the lowest growth rate . This results was agree with **Fenglu Han *et al* . (2022)** who showed that in low fish meal diets, a high content of soybean meal can significantly reduce the survival and weight gain of *L. vannamei*, and the replacement of 75 % soybean meal by FCSM can change this adverse effect. These positive effects on the growth performance of fermentation production may be realized due to the improvement of the reduction of anti-nutritional factors in plant proteins. In contrast, some studies indicated that the growth of *L. vannamei* was significantly inhibited when soybean meal was replaced by cotton meal at levels above 70 % (172 $mg\,kg^{-1}$ free gossypol) **(Junxian *et al*., 2020).** This may be due that cottonseed meal contains high levels of free gossypol, low doses of free gossypol in fermented cottonseed meal are an essential factor to increase the level of substituted soybean meal. In addition, fermentation improves the availability of amino acid patterns and the digestibility of nitrogen, organic matter, fiber, and calcium (**Sun *et al*., 2015, Hassaan *et al*., 2018 and Junxian *et al.* (2020**)**).**

This study shows that up to 60% of dietary FCSM could be replaced by SBM without any significant negative impact on growth performance and feed utilization of Nile tilapia fingerlings. On less than 60% replacement, negative effects on both growth performance and feed utilization efficiency were observed. This potential SBM substitution level was similar to that observed by other authors such as **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%). These results may indicate that fermented soy bean meal could replace up to 100% by soy bean meal in growing tilapia diets. Whereas **Junxian *et al.* (2020**) found that the CSM in the feed increased, the PER of the shrimp first increased and then decreased. Furthermore, the PER of the shrimp fed with the D30 diet was significantly higher (P < 0.05) than that of the shrimp fed with the other diets. In the present results may indicate that fermented cotton seed meal could replace up to 100% by soy bean meal in growing tilapia diets without any adverse effect on feed utilization parameters FCR or PER, As presented in Table (5).

In this study, the content of whole body protein and moisture were not affected by different dietary FCSM inclusion. Ether extracts (EE) content in dry matter of tilapia whole bodies were significantly affected when SBM was replaced with FCSM (P < 0.05), in the diet. These results agreed with **Junxian *et al.* (2020)** These results in agreement with the finding of **Khalafalla (2013)** for Nile tilapia **(***Oreochromis niloticus*) and **Junxian *et al.* (2020)** who found a significant decrease in ash (P < 0.05) among the different treatments. Shrimp that were fed D30 and D50 diets had significantly lower ash compared to shrimp fed D0 diets (P < 0.05), and significantly higher ash compared to shrimp fed D70, D90, and D100 diets (P < 0.05). **Liyan Chen (2013)** found that dry matter content kept decreasing during fermentation, in parallel with the trend of protein increase. Average of CP was found to be a significantly (P<0.05) different among experimental groups

The effects of dietary CSM on hematological factors in fish are not consistent in some studies. Some researchers reported a decrease in Ht and Hb values with an increase in dietary gossypol (**Dabrowski *et al.* 2001**). However, **Barros *et al*. (2002)** reported that hematological values of juvenile channel catfish were not affected by dietary CSM level of up to 55.0% (671 mg free gossypol/kg diet), even though this level of CSM reduced growth performance. The results obtained in our study were similar to those of **El-Saidy and Gaber (2004)** and **Yue and Zhou (2008)** who reported that hematological values were not affected as the dietary CSM levels remained in a reasonable range, but significantly decreased as the dietary CSM levels were too high.

As shown in Table (7), feed costs (LE/kg) decreased gradually with increasing substitution level of SBM by FCSM. Increasing substitution level of SBM by FCSM at 20, 40, 60, 80 and 100% decreased feed costs by 46.36,, 38.54, 34.23, 30,50 and 23.83%, respectively. These results are in agreement with the finding of **Hammed (2012)** for *Clarias gariepinus* fingerlings and also of **Khalafalla (2013)** who used digestion (fermented soybean meal) for Nile tilapia (*Oreochromis niloticus*) at level (0.5% and 0.7%).

CONCLUSION

It could be concluded that fermented cottonseed meal can be used instead of soybean meal as percentage (80 and 100%) in Nile tilapia fingerlings diets in terms of growth performance, feed utilization and economic analysis under experimental conditions.

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