POTENTIAL OF USING RAW AND PROCESSED CANOLA SEED MEAL AS AN ALTERNATIVE FISH MEAL PROTEIN SOURCE IN DIETS FOR NILE TILAPIA (*OREOCHROMIS NILOTICUS*)

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SUMMARY

Two growth trials were conducted to assess the potential for incorporation of canola seed meal (CSM) as a partial or complete replacement for fish meal in diets of Nile tilapia, *Oreochromis niloticus*. Fish meal protein in the control diet was replaced progressively (25, 50, 75 and 100%) by either raw canola seed meal (RCSM) in the first experiment or treated (soaking in 0.1 citric acid followed by heating) canola seed meal (SHCSM) in the second experiment, so that each of RCSM or SHCSM was incorporated in the experimental diets at rates of 9.30, 18.60, 27.90 and 37.20% in the diets 2, 3, 4 and 5 (for each experiment), respectively.

The levels of anti-nutritional factors, trypsin inhibitor, total polypenolic compounds and phytic acid in RCSM were determined to be 0.13%, 0.70% and 5.10%, respectively. Soaking in water for 12 hrs destroyed 23.08, 7.14 and 18.04% of trypsin inhibitor, total polyphenolic compounds and phytic acid while soaking in citric acid (0.1% solution for 12 hrs) destroyed 12.31, 17.00 and 30.00% of these compound presented in RCSM, respectively. Soaking in water followed by heat treatment (100°C for 40 min) reduced 80.00, 69.00 and 63.00% of trypsin inhibitor, total polyphenolic compounds and phytic acid in RCSM while soaking in citric acid solution (0.1%) followed by heat treatment (100°C for 40 min) destroyed 63.85, 81.71 and 72.00 of trypsin inhibitor, total polyphenolic compounds and phytic acid, respectively.

Compared to control fish group, replacing fish meal by RCSM at all replacing levels significantly adversed final body weight (BW), body length (BL), weight gain (WG), specific growth rate (SGR) and the same trend was also observed for feed utilization parameters whereas all replacing levels of fish meal by RCSM significantly adversed feed conversion ratio (FCR), decreased feed intake (FI) and protein efficiency ratio (PER).

Results of the second experiment indicated that, replacing of fish meal by SHCSM up to 50% did not significantly affected all growth parameters (BW, BL, WG and SGR) and all feed utilization parameters (FI and FCR) and PER but the higher replacing levels (75 or 100%) significantly adversed all growth and feed utilization parameters.

From economic view, it was observed that replacing 50% of fish meal by SHCSM in tilapia diets reduced feed costs by 22.47% without significant effect on growth and feed utilization parameters.

***Keywords**: Canola meal, fish meal replacement, growth, feed utilization, tilapia.*

INTRODUCTION

At present, feed can account for up to 50% of the operating costs of production with the protein sources of the feed comprising about 48% of the total feed price. One approach to reduce feed cost is to partially or totally substitute more expensive animal protein sources with less expensive plant protein ones. Fish meal is an important ingredient in aquafeeds because of its high protein quality and palatability however, of all diet ingredients, fish meal is the most expensive one. Use of less expensive animal and / or plant protein sources as partial or total replacement of fish meal is an important research area in aquaculture nutrition. Of all the plant protein feedstuffs, soybean meal considered to be the most nutritious and is used as the major protein source in many fish diets (Lovell, 1988). Partial or even total replacement of dietary fish meal by soybeans (meal, extruded product or protein concentrate) had successfully accomplished in tilapia diets (Viola and Arieli, 1983; Shiau *et al.*, 1990 and Soltan *et al.*, 2001). However, since production of soybean in Egypt is extremely limited, it is considered worth exploring the possibilities of using other ingredients (cereal or oil seeds) as fish meal substitutes.

Canola meal is a potential substitute for fish meal (Burel *et al.*, 2000 b). Canola is the name given to varieties of rapeseed (*Brassiea napus* and *B. campestries*) that are low in both glucosinolates and erucic acid (Higgs *et al.*, 1983). It is mainly oil-source (40-45%), but the canola meal obtained after oil extraction is an interesting protein source with protein content varying between 32% and 45%. The protein quality of canola meal is equivalent to that of herring meal and higher than that for soybean meal and cotton seed meal based on the essential amino acid index (Higgs *et al.*, 1990). Therefore, canola meal has been the object of numerous studies in rainbow trout as potential substitute to fish meal (Hilton and Slinger, 1986; Gomes and Kaushik, 1989; Abdou Dade *et al.*, 1990; McCurdy and March, 1992; Gomes *et al.*, 1993 and Burel *et al.*, 2000 a and b). Although the high quality of its protein; canola meal contains phenolic compounds (such as sinapine and tannine) that may reduce palatability (McCurdy and March, 1992) and reduce protein digestibility (Krogdahl, 1989), has a high fiber content that reduces protein and energy digestibility (Higgs *et al.*, 1983). The fiber content of canola is primarily found in the hull and ranges from 12-30% in canola meal (Uppström, 1995). It has glucosinolates, anti-thyroid factors (Teskeredzic *et al.*, 1995). When glucosinolate (presented in RCSM) hydrolyzed in the digestive tract, it give rise to several compounds that may suppress thyroid function in fish (Higgs *et al.*, 1995 a), consequently, this may reduce growth, feed intake, feed and protein utilization and histological changes in the liver and kidney (Kissil *et al.*, 1997).

However, the quality of canola meal has considerably improved over the recent past with genetic selection of new varieties called "colza 00" with no erucic acid and with low glucosinolate content (< 20-50 µmol/g) compared with the rapeseed varieties with 110-150 µmol/g of oil free dry matter (Bell, 1993). Besides, technological treatments, such as dehulling and the utilization of high temperatures and organic solvents during oil extraction, allow the decrease of the content of glucosinolate, fiber, sinapin and tannins (Mawson *et al.*, 1995 and Higgs *et al.*, 1996). The beneficial effects of dry extrusion for reducing the anti-nutritional factors content has been shown (Fenwick *et al.*, 1986 and Smithard and Eyre, 1986), but such treatment is not yet currently applied on a regular basis.

The present study was undertaken to determine the effect of soaking or soaking followed by heating on the destruction of anti-nutritional factors content of canola meal and studying the effect of substituting fish meal by each of raw or treated (heating after soaking in 0.1% citric acid solution) canola meal in Nile tilapia diets on growth performance, feed utilization and proximate analysis of whole fish.

MATERIALS AND METHODS

Processing of canola meal:

Seeds of Pactol cultivar of rape (*Brassica napus* L.) described as "double zero" because of the absence of erucic acid and low glucosinolate were used. Seeds were supplied from Oil Crops Research Section, Agricultural Research Center, Ministry of Agriculture, Egypt. Part of raw seeds was soaked at room temperature in distilled water or in 0.1% citric acid solution (pH 4.94) for 12 hrs. The soaked seeds were drained and ground according to Vidal-Valverde *et al.*, (1994). Soaked seeds were heated at 100°C for 40 min and were left to cool at room temperature. Soaked and unsoaked seeds were cleaned and finely ground. Hexane (B.P 40 - 60°C) was used for the extraction of oil from ground seeds according to Vidal-Valverde *et al.*, (1994). After extraction, raw and treated canola meal was air dried and incorporated in the experimental diets.

Experimental diets:

Ten experimental diets were formulated (Table, 1 a and b) to replace 0, 25, 50, 75 or 100% of fish meal by raw (untreated) canola meal (RCSM) or treated (soaking in 0.1% citric acid solution followed by heating) canola meal (SHCSM) as a partial or total replacement of fish meal. All diets were formulated to be isonitrogenous (30% protein) and isocaloric (2600 kcal metabolizable energy/kg diet). In preparing the diets, dry ingredients were first ground to a small particle size. Ingredients were thoroughly mixed and then water was added to obtain a 30% moisture level. Diets were passed through a mincer with diameter of 2 mm and were sun dried for 48 hrs.

Experimental system and animals:

For each experiment, ten (2 replicates for each treatment) rectangular aquaria 100×50× 40 cm (200 liter for each) were used and the water volume in each aquarium maintained to be 180 liter. All experimental aquaria were aerated with compressed air and each aquarium was stocked with 20 Nile tilapia fish. The average body weights (BW) were nearly similar and ranged between 8.38 to 8.49 and 8.16 to 8.30 g for the 1st and 2nd experiments, respectively. Fish in the two experiments were given the pelleted diets (2 mm in diameter) at a daily rate of 10% of total biomass (during the 1st month), then gradually reduced to 7% (2nd month) and 4% (3rd month). Fish were fed 6 day/week (twice daily at 9.00 am and 3.00 pm) and the amount of feed was bi-weekly adjusted according to the changes in body weight throughout the experimental period (90 days). About 25% of water volume in each aquarium was daily replaced by aerated fresh water after cleaning and removing the accumulated excreta. Water temperature and dissolved oxygen were measured daily at 2.00 pm. Water temperature averaged 25.4±0.7°C and dissolved oxygen averaged 6.1±0.4 mg/l, total ammonia 0.13±0.6 mg/l and pH 8.7±0.2 during the two experimental periods, these averages were within acceptable limits for fish growth and health (Boyd, 1979).

Records of live BW (g) and BL (cm) of individual fish were measured at the start and the end of the two experimental periods for each aquarium. Growth performance parameters were measured by using the following equations:

Specific growth rate (SGR) = $\frac{LnW2 - LnW1}{t}$ x 100

Where:- Ln = the natural log, W1 = initial fish weight; W2 = the final fish weight in "grams" and t = period in days.

Weight gain (WG) = final weight (g) – initial weight (g)

Feed conversion ratio (FCR) = feed ingested (g)/weight gain (g)

Protein efficiency ratio (PER) = weight gain (g)/protein ingested (g)

At the end of each experiment, four fish were chosen at random from each aquaria and subjected to the proximate analysis of whole fish body.

Chemical analysis:

Moisture, dry matter (DM), ether extract (EE), crude protein (CP), crude fiber (CF) and ash contents of RCSM, SHCSM, diets and fish were determined according to the methods described in AOAC (1990): dry matter after drying in an oven at 105°C until constant weight; ash content by incineration in a muffle furnace at 600°C for 12 hrs; crude protein (N×6.25) by the Kjeldhal method after acid digestion; and ether extract by petroleum ether (60-80°C) extraction.

The trypsin inhibitor activity was measured as described by Hamerstrand *et al.*, (1981). Phytic acid content in raw and treated canola meal samples was estimated colorimetrically using Wade reagent (Latta and Eskin, 1980). Total polyphenolic compounds were calorimetrically determined in the ethanolic extracts by using the Folin Denis reagent as described by Gutfinger (1981). Amino acid analyzer (Model 121) was used for determination of amino acids in canola meal as described by Moore *et al.*, (1958).

Statistical analysis:

The statistical analysis of data was carried out by applying the computer program, SAS (1996) by adopting the following model :-

$$Y_{ij} = \mu + \alpha_i + E_{ij}$$

Where, Y_{ij} = the observation on the ij^{th} fish eaten the i^{th} diet; μ = overall mean, α_i = the effect of j^{th} diet and E_{ijk} = random error.

RESULTS AND DISCUSSION

Results of feeding Nile tilapia, *Oreochromis niloticus* on the different experimental diets containing different levels of RCSM or SHCSM during the two feeding trials are going to be discussed under three points: a) proximate analysis of canola meal, b) effect of soaking and soaking followed by heating treatments on the reduction of anti-nutritional factors and c) effect of replacing fish meal by RCSM or SHCSM on growth performance, feed utilization and proximate analysis of whole body of Nile tilapia.

a) Proximate analysis of canola seed meal (CSM):

Proximate analysis of RCSM and SHCSM used in the present study are shown in Table (2). As shown in this table, RCSM contained 95.22, 35.15, 1.42, 6.15, 8.12 and 49.16%, DM, CP, EE, ash, CF and NFE, respectively and these values are relatively similar to that obtained for SHCSM (Table 2). The high protein content of each of RCSM and SHCSM indicated that canola seed meal (CSM) is considered to be an excellent protein source in tilapia diet.

As described in Table (2) fish meal displayed better amino acid profile as it had higher levels of all essential amino acids except for phenylalanine, therionine, histidine and arginine compared to those of canola meal. With respect to requirements of amino acids for Nile tilapia, data of Table (2) also indicated that, amino acids content of CSM covered all amino acid requirements for Nile tilapia except for cystine and methionine. These results are in good agreement with those of Higgs *et al.,* (1990) who reported that, protein quality of CSM is equivalent to that of herring meal and higher than that of soybean meal and cotton seed meal based on the essential amino acid index.

b): Effect of different treatments on the reduction of anti-nutritional factors from CSM:

Soaking of canola seeds in water or in 0.1% citric acid reduced 23.08 and 12.31% of trypsin inhibitor; 7.14 and 17.00% of total polyphenolic compounds and 18.04 and 30.00% of phytic acid, respectively (Table 3). The obtained results clearly showed that soaking in 0.1% citric acid was more effective than water in removing anti-nutritional factors except trypsin inhibitor. Similar results were obtained for mung bean by Abd El-Aleem, (2000). Also, Vidal-Valverde *et al.,* (1994) found that, soaking lentil seed in $NaHCO_3$ did not seem to be as efficient as water in reducing the phytic acid content, whereas the citric acid solution was more efficient than water alone.

Results of Table (4) indicated that soaking of canola seeds in water followed by heating (100°C for 40 min) destroyed 80.00, 69.00 and 63.00% of trypsin inhibitor, total polyphenolic compounds and phytic acid while soaking of canola seeds in citric acid followed by heating destroyed 63.85, 81.71 and 72.00% of these anti-nutritional factors, respectively. It clear that, soaking canola seeds in water or in citric acid solution destroyed low proportions of anti-nutritional factors (Table 3), while soaking in water or in citric acid followed by heat treatment was very effective in removing anti-nutritional factors compared to soaking alone (Table 4). These results showed also that, a single processing technique was relatively ineffective in the reduction of anti-nutritional factors of canola meal. Results obtained are relatively similar to those of Siddhuraju and Becker (2003). They found that, soaking of mucuna seeds in various solutions (water, sodium bicarbonate 0.07%, ascorbic acid 0.1% or water containing 3% of freez-dried morings leaf powder) followed by autoclaving more effective in destroying the heat labile antinutrients such as trypsin (93 – 94%) and chemotrypsin (100%) inhibitor activities and lectin activity (100%) than heat-stable anti-nutrients such as total phenolic (50-64.4%), tannins (50-83%) and phytates (46.3–65.3%) compared to the raw samples. In the same trend, Mwachireya *et al.,* (1999) demonstrated that, aqueous methanol-ammonia washing of sieved rapeseed meal dramatically decreased levels of total glucosinolates

(>88%) and phenolic compounds (59%) compared to raw rapeseed meal. Satoh *et al.,* (1998) evaluated three rapeseed protein products, commercial rapeseed meal, low temperature extruded rapeseed meal (90°C) and high temperature extruded rapeseed meal (150°C) as partial replacement of herring meal. They found that the phytic acid content of commercial rapeseed meal was reduced by about 10% and 30% from the original level by extrusion cooking at low (90°C) and high (150°C) temperatures, respectively. Moss *et al.,* (2000) demonstrated that, the optimum heat treatment of rapeseed was 120°C for 35 min. Burel *et al.,* (2000 b) indicated that, heat treatment of rapeseed meal decreased the total glucosinolate level from 40 to 26 μ mol/g.

Growth trials:

1. First experiment:

Results of Table (5) indicated that, the initial body weight (BW) and body length (BL) ranged from 8.38 to 8.49 g and 7.86 to 8.01 cm, respectively with insignificant differences between fish groups. Final BW and BL averaged 28.71 to 43.69 g and 11.55 to 13.12 cm with significant (P<0.001) differences between fish groups for BW and BL, respectively. Values of final BW, BL, WG and SGR after 90 days were observed to be inversely related to the level of RCSM in the tested diets. Accordingly, the best growth performance among the fish fed the experimental diets occurred in fish group fed the control fish meal-based diet (RCSM0). Feed utilization parameters (FI and FCR) and PER were paralleled that for growth performance parameters. The obtained results showed that, the incorporation of RCSM in tilapia diet irrespective of its level (9.30, 18.60, 27.90 and 37.20%) as fish meal substitute (25, 50, 75 and 100%) led to significant reduction in all growth parameters (BW, BL, WG and SGR) and feed utilization parameters (FI and FCR) and PER. Studies by Davies *et al.,* (1990) indicated a practical inclusion limit of 15% of RCSM in tilapia diet. Higher growth and feed efficiency were obtained in young Yellowtail fish with diet containing 10% of RCSM and further increase up to 20 or 30% had a negative effect on growth parameters (Shimeno *et al.*, 1993). Similarly, Webster *et al.,* (1997) found that, incorporation of RCSM in channel catfish (*Ictalurus punctatus*) diets up to 12% did not significantly affected BW, FCR and PER however, the higher incorporation levels (24 or 48%) significantly adversed these parameters.

Our findings indicated that, even the lowest dietary concentration of RCSM (9.3% of the diets) significantly reduced growth performance of Nile tilapia and the reduction in BW, BL, WG and SGR increased with increasing RCSM content in tilapia diets. The progressively poorer of growth performance and feed utilization of Nile tilapia as the dietary content of RCSM was increased may be attributed to lack of some amino acids such as cystine and methionine (Table 2); the high content of crude fiber and anti-nutritional factors presented in RCSM compared to fish meal.

The high fiber content of RCSM increased fiber content of the practical diets which can decrease transit time of intestinal contents and reduces protein and energy digestibility (Higgs *et al.,* 1983). The high levels of phytic acid presented in RCSM may be of concern since this compound may not only complex with protein at acidic pH but also with polyvalent cations especially zinc and phosphorous at intestinal pH and thereby decrease their availability (Higgs *et al.,* 1995 b). The negative effects of phytic acid were seen when rainbow trout was fed purified diets containing 0.50% phytic acid. The presence of phytic acid reduced growth and feed conversion between 8-10% over 150 day period (Spinelli *et al.,* 1983). Phenolic compounds in RCSM such as tannins and sinapine reduce palatability (McCurdy and March, 1992) and hinder protein and dry matter digestion through protease inhibition or through the formation of indigestible protein complexes (Krogdahl, 1989; Higgs *et al.,* 1995 a and Burel *et al.,* 2000 b).

One or more of these factors (the high fiber content of RCSM, lack of some essential amino acids and presence of anti-nutritional factors) could lead to a sub-optimal essential amino acids balance at the sites of tissue protein synthesis, particularly in the fish group fed the diet RCSM100 where fish meal was totally replaced by RCSM and this reduced fish growth and feed utilization.

Results of proximate analysis of whole fish at the end of the first experiment are presented in Table (5). Fish fed the diets RCSM0, RCSM25 and RCSM50 contained significantly the lowest DM content, while fish fed the other two diets RCSM 75 or RCSM100 contained the highest DM content. The graded increase in RCSM as substitute of fish meal in tilapia diets (25, 50 or 75%) did not significantly affected protein content of whole fish while the complete substitution of fish meal by RCSM significantly decreased protein content compared to the control group. Fish fed control diet (RCSM0) contained the lower fat content. Increasing incorporation levels of RCSM as substitute of fish meal up to 50% did not significantly altered fat content of fish while the higher incorporation levels (75 and 100%) significantly increased fat content of fish bodies. The ash content of fish fed diets RCSM25 was significantly higher than fish fed the other experimental diets followed in a decreasing order by fish fed the diets RCSM50, RCSM0, RCSM75 and RCSM100, respectively. Lim *et al.,* (1998) found that, incorporation of rapeseed meal in the diets of channel catfish at levels of 0, 15.4, 30.8, 46.2 and 61.6% did not affect DM and protein contents of fish and fish fed on the diet containing 30.8% rapeseed meal had the lowest body fat content.

Second experiment:

The growth and other related parameters for Nile tilapia, *O. niloticus* fed the experimental diets are presented in Table (6). As shown in this table, the initial BW and BL ranged 8.16 to 8.30 g and from 7.82 to 7.94 cm with insignificant differences for both traits, respectively. Final BW and BL averaged 29.34 to 46.86 g and 11.56 to 13.63 cm with significant ($P<0.001$) differences between fish groups for BW and BL, respectively.

The higher BW and BL were recorded for fish fed the diet SHCSM25 whereas, the lower ones were observed for fish group fed the diet SHCSM100 where fish meal was totally replaced by SHCSM. A similar trend was also observed for WG and SGR. The trend for feed utilization paralleled that for growth whereas the diet SHCSM25 showed the higher FI and the best FCR values and the diet SHCSM100 showed the worst values for FI and FCR.

Results of growth and feed utilization (Table 6) indicated that, substitution of 25 or 50% of fish meal in the control diet by SHCSM did not significantly affect growth performance parameters (BW, BL, WG and SGR) and also feed efficiency parameters (FI and FCR) and PER while the higher replacing levels (75 or 100%) significantly reduced all growth and feed efficiency parameters and this is probably because of the reduction in diet palatability and presence of low levels of anti-nutritional factors. The depression in growth performance (at the high incorporation levels of SHCSM, 75 or 100%) was also due to a decrease in feed intake. A lower feed intake of the SHCSM-based diets may be due to the presence of sinapine or tannins, which affect the palatability of the diet. Similar results have been previously found in rainbow trout (Hilton and Slinger, 1986).

The high potential of SHCSM (soaking in 0.1% citric acid solution followed by heating) compared to raw canola seed meal (RCSM) as fish meal substitute in tilapia diets could be attributed to destruction of different proportions of the anti-nutritional factors (63.85, 81.71 and 72.00 of trypsin inhibitor, total polyphenolic compounds and phytic acid, respectively). These results are in good accordance with those of Burel *et al.,* (2000 b). They demonstrated that, incorporation of raw rapeseed meal as a substitute of fish meal at the level of 30% in turbot, *Psetta maxima* diets significantly decreased BW, WG and FI however, the incorporation of heated rapeseed meal in these diets by the same level (30%) did not lead to significant decrease in growth performance and they concluded that, preliminary heat treatment of rapeseed meal is necessary to improve its nutritional quality. In another study, Burel *et al.,* (2000 c) concluded that, incorporation of rapeseed meal with two levels of glucosinolates (5 or 41 μmol/g DM) in rainbow trout diets significantly reduced growth performance, feed efficiency and the digestibility of DM and this deleterious effect was increased with increasing of glucosinolates content of the diet. Also, Satoh *et al.,* (1998) suggested that, extrusion cooking of rapeseed meal improves its nutritive value for chinook salmon held in seawater and the high thermal treated (150°C) rapeseed meal could comprise 240 g/kg of the dietary protein without adversely affecting performance. Trypsin inhibitors in raw or inadequately heated soybean meal adversely affected growth of trout (Sandholm *et al.,* 1976), carp (Viola *et al.,* 1983), and channel catfish (Robinson *et al.,* 1981 and Wilson and Poe, 1985).

Proximate analysis of whole fish body (Table 6) indicated that, fish fed the control diet (SHCSM0) gained the lower DM. Increasing substitution levels of fish meal by SHCSM up to 25% (SHCSM25) did not significantly altered DM content whereas the higher levels of substitution (50, 75 or 100%) significantly increased DM content and the same figure was observed for fat content of fish. These results disagreed with that of Kissil *et al.,* (2000) who found that, the complete replacement of fish meal by rapeseed meal significantly decreased lipids content of gilthead seabream, *Sparus aurata*. Fish fed the control diet contained the higher protein and ash contents compared to the other fish groups. Protein and ash contents of fish fed the diet SHCSM25 (25% of fish meal was replaced by SHCSM) did not significantly differ from those of the control fish group while the higher levels of substitution (50, 75 or 100%) significantly decreased each of protein and ash contents of fish.

Economical evaluation:

Calculation of the economical efficiency of the tested diets for the two experiments was based on the costs of feed because the other costs were equal for all studied treatments. As described in Tables (7 and 8) feed costs (LE) were the highest for the control diet and gradually decreased with increasing the replacing levels of each RCSM or SHCSM. These results indicate that incorporation of RCSM in tilapia diets reduced the total feed costs, which reflected directly on the total costs. However, all replacing levels of fish meal by RCSM (25, 50, 75 and 100%) adversely affected all growth and feed utilization parameters, but the incorporation of RCSM in tilapia diets seemed to be economic as incorporation of RCSM in tilapia diets sharply reduced feed costs by 12.73, 24.11, 35.16

and 46.67% for the replacing levels of 25, 50, 75 and 100%, respectively and the reduction in feed costs was easily observed for the feed costs per kg weight gain which decreased with increasing incorporation levels of RCSM in tilapia diets. Therefore, the recommended level of incorporation of RCSM in tilapia diets must depend on the final body weight required for marketing.

With regard to SHCSM, data of Table (7) also indicated that, replacing fish meal by SHCSM in an increasing levels of 25, 50, 75 and 100% decreased feed costs by 11.91, 22.47, 32.70 and 43.39%, respectively and this followed by decrease in feed costs per kg weight gain. Substitution of 50% of fish meal by SHCSM did not significantly affect growth and feed utilization and reduced feed costs by 22.47%.

Conclusion:

Based on the results obtained from the present study it could be concluded that incorporation of raw canola meal by all levels studied significantly adversed all growth performance and feed utilization parameters however these replacing levels reduced feed costs/kg weight gain. Soaking canola meal in 0.1% citric acid solution followed by heating treatment improved its nutritional value and could substitute up to 50% of fish meal in tilapia diets and this reduce feed costs by 22.47% without significant effect on growth performance. It is therefore worth to recommend treating canola meal before incorporation in fish diets to reduce their anti-nutritional factors and improve its nutritional value.

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Table (1 a): Composition and proximate analysis of the experimental diets (first experiment)

Ingredients	Diets				
	RCSM0	RCSM25	RCSM50	RCSM75	RCSM100
Fish meal (65%)	20	15	10	5	0
Yellow corn	31	28	27	27	23.3
Soybean meal (40%)	32	32	32	33	34
Raw canola meal	0	9.3	18.6	27.9	37.2
Wheat bran	10.5	10.2	6.9	1.6	0
Vegetable oil	3	2	2	2	2
Vit. & Min. Mixture[1]	3.5	3.5	3.5	3.5	3.5
Sum	100	100	100	100	100
Proximate analysis	*(determined on dry matter basis)*				
Dry matter (DM)	94.83	93.97	94.50	94.22	93.03
Crude protein (CP)	30.62	30.39	29.99	29.92	29.48
Ether extract (EE)	4.30	4.27	4.61	6.31	5.36
Crude fiber (CF)	10.26	9.74	9.75	11.37	11.00
Ash	10.12	9.27	10.74	10.72	11.32
NFE[2]	44.70	46.33	44.91	41.68	42.84
ME[3] (Kcal/kg diet)	2650.00	2623.40	2617.40	2644.00	2608.50
P/E ratio[4]	115.55	115.84	114.58	113.16	113.02

Table (1 b): Composition and proximate analysis of the experimental diets (second experiment)

Ingredients	Diets				
	SHCSM0	SHCSM25	SHCSM50	SHCSM75	SHCSM100
Fish meal (65%)	20	15	10	5	0
Yellow corn	31	28	27	27	23.3
Soybean meal (40%)	32	32	32	33	34
Heated canola meal	0	9.3	18.6	27.9	37.2
Wheat bran	10.5	10.2	6.9	1.6	0
Vegetable oil	3	2	2	2	2
Vit. & Min. Mixture[1]	3.5	3.5	3.5	3.5	3.5
Sum	100	100	100	100	100
Proximate analysis	*(determined on dry matter basis)*				
Dry matter (DM)	93.85	92.76	93.63	93.46	93.86
Crude protein (CP)	31.00	30.18	29.97	30.27	29.31
Ether extract (EE)	4.28	4.12	5.62	5.62	6.12
Crude fiber (CF)	7.72	8.02	10.99	10.32	11.25
Ash	10.00	10.21	10.17	11.54	11.33
NFE[2]	47.00	47.47	43.25	42.25	41.99
ME[3] (Kcal/kg diet)	2648.00	2620.40	2600.80	2650.00	2600.20
P/E ratio[4]	117.07	115.17	115.23	114.23	112.72

[1] Vitamin & mineral mixture/kg premix : Vitamin D_3, 0.8 million IU; A, 4.8 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 (NFE) =100-(CP+EE+CF+Ash)

[3] Metabolizable energy was calculated from ingredients based on **NRC (1993)** values for tilapia.

[4] Protein to energy ratio : mg protein/kcal ME.

Table (2): Proximate analysis of RCSM and SHCSM and essential amino acids content of CSM compared to fish meal.

Item	Chemical composition, %					
	DM	CP	EE	Ash	CF	NFE
Raw canola meal	95.22	35.15	1.42	6.15	8.12	49.16
Heated canola meal	94.45	35.00	1.59	7.60	7.10	48.71

Amino acids profile (g/100 g protein)

Amino acid	Requirements of Nile tilapia*	Fish male	Canola seed meal (CSM)
Lysine	5.12	5.80	5.79
Leucine	3.39	7.30	6.30
Isoleucine	3.11	4.30	3.40
Cystine	3.21**	0.90	0.82****
Methionine		2.40	1.46****
Phenylalanine	3.75***	4.00	4.40
Tyrosine	1.79	3.20	2.99
Threonine	3.75	3.60	4.92
Valine	2.80	5.40	4.96
Tryptophane	1.00	1.10	1.10
Histidine	1.72	2.50	2.90
Arginine	4.20	5.00	6.80

* Data resulting from growth experiments **(Santiago and Lovell, (1988)**
** Total sulphur amino acids (methionine + cystine) requirements is 3.21% of the protein.
***Total aromatic amino acids (phenylalanine + tyrosine) requirement is 5.54% of the protein
****Amino acids which could be deficient in the canola meal for Nile tilapia

Table (3): Effect of soaking on anti-nutritional factors content of canola seed meal (calculated on dry matter basis).

Item	Trypsin inhibitor %	Total polyphenolic %	Phytic acid %
Raw canola seed meal (RCSM)	0.13	0.70	5.10
Soaking in water (12 hrs)			
Anti-nutritional factors%	0.10	0.65	4.18
Reduction%	23.08	7.14	18.04
Soaking in citric acid (12 hrs)			
Anti-nutritional factors%	0.114	0.581	3.570
Reduction%	12.31	17.00	30.00

Table (4): Effect of soaking followed by heating on anti-nutritional factors content of canola seed meal (calculated on dry matter basis).

Item	Trypsin inhibitor %	Total polyphenolic %	Phytic acid %
Dry raw canola meal (RCSM)	0.13	0.70	5.10
Soaking in water (12 hrs) followed by heating			
Anti-nutritional factors%	0.026	0.217	1.887
Reduction%	80.00	69.00	63.00
Soaking in citric acid (12 hrs) followed by heating			
Anti-nutritional factors%	0.047	0.128	1.428
Reduction%	63.85	81.71	72.00

Table (5): Growth performance, feed utilization and proximate analysis of Nile tilapia as affected by replacing fish meal by RCSM (first experiment).

Item	No.	Experimental diets						
		RCSM0	RCSM25	RCSM50	RCSM75	RCSM100	±SE	Prob.
Growth performance								
Body weight (g)								
Initial	40	8.42	8.49	8.38	8.44	8.49	0.09	0.9007
Final	40	43.69 a	37.89 b	33.44 c	30.22 cd	28.71 d	0.21	0.0001
Body length (cm)								
Initial	40	8.01	7.96	7.88	7.90	7.86	0.03	0.9866
Final	40	13.12 a	12.58 b	12.59 b	11.67 c	11.55 c	0.16	0.0001
WG (g/fish)	2*	35.27 a	29.40 b	25.06 c	21.78 d	20.22 d	1.19	0.0368
SGR	2*	1.83 a	1.67 b	1.54 c	1.42 d	1.22 e	0.01	0.0001
Feed utilization								
FI (g/fish)	2*	59.80 a	52.33 b	50.90 b	48.50 bc	46.75 c	0.11	0.0001
FCR	2*	1.70 e	1.78 d	2.03 c	2.23 b	2.31 a	0.01	0.0001
PER	2*	1.93 a	1.85 b	1.64 c	1.50 d	1.47 d	0.01	0.0010
Proximate analysis of fish (%)								
Dry mater	8	24.21 b	24.74 b	24.20 b	27.20 a	27.14 a	0.24	0.0018
Protein	8	63.45 a	62.67 a	61.89 ab	61.63 ab	59.29 b	1.12	0.0171
Fat	8	17.34 c	17.63 c	19.78 bc	21.43 b	25.04 a	0.42	0.0002
Ash	8	17.30 b	18.23 a	17.42 b	14.46 c	14.39 c	0.25	0.0001

Means followed by the different letters in each row for each trait are significantly different (P<0.05).

* average of two aquaria (2 replicates)

Table (6): Growth performance, feed utilization and proximate analysis of Nile tilapia as affected by replacing fish meal by SHCSM (second experiment).

Item	No.	Experimental diets						
		SHCSM0	**SHCSM25**	**SHCSM50**	**SHCSM75**	**SHCSM100**	**±SE**	**Prob.**
Growth performance								
Body weight (g)								
Initial	40	8.29	8.27	8.24	8.16	8.30	1.74	0.9984
Final	40	44.43 a	46.86 a	41.65 a	32.79 b	29.34 b	1.61	0.0001
Body length (cm)								
Initial	40	7.94	7.91	7.86	7.82	7.92	0.69	0.9987
Final	40	13.17 a	13.63 a	13.32 a	11.81 b	11.56 b	0.42	0.0001
WG (g/fish)	2*	36.14 a	38.59 a	33.41 a	24.63 b	21.04 b	0.12	0.0001
SGR	2*	1.86 a	1.93 a	1.97 a	1.52 b	1.39 c	0.02	0.0011
Feed utilization								
FI (g/fish)	2*	59.80 a	60.00 a	56.43 a	52.43 b	44.30 b	0.83	0.0028
FCR	2*	1.65 b	1.55 b	1.69 b	2.13 a	2.11 a	0.04	0.0045
PER	2*	1.95 a	2.13 a	1.98 a	1.55 b	1.62 b	0.03	0.0031
Proximate analysis of fish (%)								
Dry mater	8	25.01 b	25.23 b	26.36 a	26.56 a	27.24 a	0.36	0.0042
Protein	8	65.11 a	64.13 a	63.21 b	62.95 b	58.10 c	1.14	0.0001
Fat	8	17.34 c	17.41 c	20.29 b	20.03 b	26.60 a	0.35	0.0001
Ash	8	16.71 a	16.05 a	14.22 b	14.71 b	13.39 c	0.10	0.0001

Means followed by the different letters in each row for each trait are significantly different ($P<0.05$).

* average of two aquaria (2 replicates)

Table (7): Feed costs (L.E) for producing one kg weight gain by fish fed the experimental diets.

Experimental diets	Costs (L.E)/ ton	Relative to control %	Decrease in feed cost (%)	FCR	Feed costs * (L.E)/kg Weight gain	Relative to control %
			Raw canola seed meal (RCSM)			
RCSM0	2832.0	100	0.00	1.70	4.81	100
RCSM25	2471.6	87.27	12.73	1.78	4.40	91.48
RCSM50	2149.1	75.89	24.11	2.03	4.36	90.64
RCSM75	1836.2	64.84	35.16	2.23	4.09	85.03
RCSM100	1510.3	53.33	46.67	2.31	3.49	72.56
			Treated canola seed meal (SHCSM)			
SHCSM0	2832.0	100	0.00	1.65	4.67	100
SHCSM25	2494.8	88.09	11.91	1.55	3.87	82.87
SHCSM50	2195.6	77.52	22.47	1.69	3.71	79.44
SHCSM75	1905.9	67.30	32.70	2.13	4.06	86.94
SHCSM100	1603.3	55.61	43.39	2.11	3.38	72.38

* Feed costs/kg weight gain = FCR × costs of kg feed.

Table (8): Local market price (L.E./ton) for feed ingredients used for formulating the experimental diets when the experiment was started.

Ingredients	Price (L.E.) / ton
Fish meal	7000
Yellow corn	1250
Soybean meal	1500
RCSM	750
SHCSM	1000
Wheat bran	900
Corn oil	4000
Vit. & Min. Mixture	10000

الملخص العربى

كفاءة إستخدام كسب بذرة الكانولا الخام والمعامل كبديل لمسحوق السمك فى علائق أسماك البلطى النيلى

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فى هذه الدراسة تم إجراء تجربتين لتقدير كفاءة إدخال كسب بذرة نبات الكانولا كبديل جزئى أو كلى فى علائق أسماك البلطى النيلى حيث تم إحلال مسحوق السمك فى التجربة الأولى بكسب بذرة نبات الكانولا الخام وفى التجربة الثانية تم إحلال مسحوق السمك بكسب بذرة نبات الكانولا المعامل (معاملة حرارية بعد النقع) وقد تم إدخال كسب الكانولا فى علائق التجربتين بنسب ٣٠ر٩ ، ٦٠ر١٨ ، ٩٠ر٢٧ و٢٠ر٣٧% لكى يحل محل ٢٥ ، ٥٠ ، ٧٥ ، ١٠٠% من مسحوق السمك فى علائق التجربتين على التوالى. وقد أظهرت نتائج التحليل الكيميائى لكسب بذرة الكانولا الخام احتوائه على مثبط التربسين والفينولات الكلية وحمض الفيتك بنسب ١٣ر٠ ، ٧٠ر٠ ، ١٠ر٥% على التوالى. كما وجد أن نقع بذور الكانولا فى الماء أو محلول ١ر٠% حمض ستريك لمدة ١٢ ساعة أدى إلى تناقص جميع العوامل المضادة للتغذية حيث أدت عملية النقع فى الماء لمدة ١٢ ساعة إلى تناقص نسب العوامل المضادة للتغذية بنسب 23ر08 ، ١٤ر٧ ، ٠٤ر١٨% وذلك بالنسبة لمثبط التربسين والفينولات الكلية وحمض الفيتك أما عملية النقع فى محلول حمض الستريك (١ر٠%) لمدة ١٢ ساعة فقد أدت إلى تناقص هذة المركبات بنسب ٣١ر١٢ ، ٠٠ر١٧ ، ٠٠ر٣٠% على التوالى. كما أظهرت النتائج أن تسخين كسب بذرة الكانولا (على درجة ١٠٠ درجة مئوية لمدة ٤٠ دقيقة) بعد عملية النقع فى الماء لمدة ١٢ ساعة قد أدى إلى تناقص مضادات التغذية بنسب ٠٠ر٨٠ ، ٠٠ر٦٩ ، ، ٠٠ر٦٣% فى حين أن التسخين بعد النقع فى محلول حمض الستريك قد أدى إلى نقص نسب محتوى الكسب من مثبط التربسين والفينولات الكلية وحمض الفيتك بنسب ٨٥ر٦٣ ، ٧١ر٨١ ، ٠٠ر٧٢% على التوالى.

أظهرت نتائج تجربة التغذية الأولى لأسماك البلطى أن إحلال مسحوق السمك بكسب بذرة الكانولا الخام بجميع نسب الاحلال قد أدى إلى انخفاض معنوى فى مقاييس صفات النمو (طول ووزن الجسم ــ الزيادة فى وزن الجسم ــ معدل النمو) كما لوحظ نفس الاتجاه بالنسبة للكفاءة الغذائية للعليقة حيث أدت جميع نسب الإحلال إلى إنخفاض فى الكفاءة التحويلية للغذاء وكمية الغذاء المأكول وكفاءة بروتين الغذاء.

وقد أظهرت نتائج التجربة الثانية أن إحلال مسحوق السمك بكسب بذرة الكانولا المعامل حتى ٥٠% لم يؤثر معنوياً على مقاييس صفات النمو والاستفادة من الغذاء أما نسب الاحلال الأعلى ٧٥ ، ١٠٠ % فقد أثرت تأثيراً سلبياً على صفات النمو والاستفادة من الغذاء.

من الناحية الاقتصادية وجد أن إحلال ٥٠% من مسحوق السمك بكسب بذرة الكانولا المعامل (بالنقع فى محلول حمض الستريك ثم التسخين) قد أدى إلى توفير ٤٧ر٢٢% من تكاليف التغذية دون أن يؤثر ذلك على صفات النمو والاستفادة من الغذاء.