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USING OF TOMATO AND POTATO BY-PRODUCTS AS PARTIAL REPLACEMENTS FOR SOYBEAN MEAL AND YELLOW CORN IN PRACTICAL DIETS FOR THE COMMON CARP, *Cyprinus carpio*

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SUMMARY

Two experiments were conducted, in the first experiment six experimental diets were formulated to contain 0 to 50% replacing levels of soybean meal (SBM) by tomato by-product meal (TBM) in 10% increments and in the second experiment another six experimental diets were formulated to contain also 0 to 50% replacing levels of yellow corn (YC) by potato by-product meal (PBM) in 10% increments. All experimental diets of the two experiments were isonitrogenous (30% CP) and isocaloric (3300 Kcal ME/kg diet) and P/E ratio of 90 mg protein/kcal (ME) and each diet was fed to two replicates of fish groups (20 fish for each replicate).

Results of the first experiment showed that, replacement of SBM by TBM up to 30% significantly improved final fish body weight (BW). Increasing the replacing levels of SBM by TBM up to 50% improved weight gain (WG), specific growth rate (SGR), feed conversion ratio (FCR) and protein efficiency ratio (PER). Results of carcass traits indicated that fish group fed diet TBM10 gained the higher values of dress-out and flesh and the lower percentage of by-products, while the replacement of 50% of SBM by TBM released the lower percentages of dress-out and flesh and the higher percentage of by-products of common carp compared with the control group. Replacing of SBM by TBM up to 40% insignificantly increased the moisture percentages of carp bodies, while the higher replacing level (50%) significantly increased the moisture and significantly decreased the fat content of carp bodies. Fish fed the TBM30 diet gained the higher protein content and the lower ash content of carp bodies, whereas, fish fed diet TBM50 gained the lower protein content and the higher ash contents.

Results of the second experiment showed that the higher replacing level (50%) significantly decreased BW, WG and SGR and significantly improved FCR and PER. Incorporation of PBM in carp diets as a replacement of YC at the high levels (40 and 50%) significantly decreased the percentages of dress-out and flesh. Also, increasing the inclusion level of PBM in carp diets significantly increased by-products percentage of carp carcasses. Increasing the replacing levels of YC by PBM in carp diets at the highest replacing level (50%) significantly decreased the protein content of fish body and the opposite trend was observed for ash content. Compared to the control group, all replacing levels of YC by PBM significantly decreased fat content of fish body.

Replacing 50% of SBM by TBM in carp diets reduces feed costs by 10.93% while replacing 50% of YC by PBM reduced feed costs by 9.41%.

Keywords: *tomato by-product meal, potato by-product meal, diets, common carp, growth performance*

INTRODUCTION

In Egypt, it is commonly known that, there is an observed shortage in the traditional feedstuffs rather than the continuous increase in their prices from time to time. Also, the high costs and/or fluctuating quality of soybean meal (the principle plant protein in fish diets) lead to identify alternative untraditional low price by-products that could be used in fish diets. Hassanen (1991) demonstrated that, the Nile catfish (*Clarias lazera*) was able to utilize a diet containing 66% unconventional protein supplement (tomato, brewers dried grain and bean haulms).

Tomato waste is one of the canning wastes that evaluated by many workers (Khadzhinikolova and Tomasyan, 1983 and 1984; Hassanen, 1986; Hassanen *et al.*, 1995; El-Shamma *et al.*, 1997 and Saad, 1998). The processing of tomatoes yields several by-products such as seeds and peels, which are mostly classified as tomato pomace, tomato seed meal, tomato seed cake and tomato seed oil. The total waste produced from tomato from world production was estimated roughly to be 3.7 million tons/year (FAO, 1991). According to the information released by "Kaha" and "Edfina" companies, the two companies produce not less than 1080 tons of tomato waste/year (Saad, 1998).

In Egypt, the yield of potatoes crop was 1984013 tons in 1999 and the waste was determined by 12.2% (Ghazalah *et al.*, 2002). The metabolizable energy content of PBM is 3.2 kcal/g, which is comparable with that of corn being 3.47 kcal/g (NRC, 1993). Potato processing is a very specialized field, which cannot be described briefly. The potato processing industry produces several products and by-products. The main aspects are dealing with the following; peeling potatoes for processing, processing of potato chips, frozen French fries, dehydrated mashed potatoes as granules or fläks and potato starch flour. Potato waste meal (potatoes, potato pulp and peeling) is a product produced by drying and grinding of culls of potatoes, potato trimming, pulp, peeling and off-colour parts of French fries and potato chips.

The present study aimed to investigate the possibility of using the low price tomato and potato by-products as unconventional protein and energy sources instead of the high price common sources, soybean meal (SBM) and yellow corn (YC) in carp diets.

MATERIALS AND METHODS

The experimental work of the present study was carried out at the Laboratory of Fish Nutrition, Faculty of Agriculture, Moshtohor, Zagazig University (Banha branch). Two experiments were conducted to evaluate the effect of partially replacing of SBM protein by tomato by-product meal (TBM) (First experiment) and replacing of YC by potato by-product meal (PBM) (Second experiment) on growth performance, feed utilization, carcass traits and proximate analysis of common carp.

Tomato by-product was obtained from Kaha factory, located in Kaha, Kalubia Governorate while potato by-product was obtained from chippsy factory, 10th of Ramadan City. Tomato and potato by-products were sun-dried and the resulting residues were ground to meal and incorporated in the experimental diets after the chemical analysis.

Six experimental diets were formulated to contain 0 to 50% (10% increment) TBM as a partial replacement of SBM protein (First experiment). Another six experimental diets were also formulated by the same substitution levels (0 to 50%) but contained PBM (Second experiment) as a partial replacement of YC. Composition and proximate analysis of the experimental diets used in the two experiments are presented in Tables (1 and 2). Twelve rectangular aquaria 100 × 40 × 50 cm (200 liter for each) were used in each experiment (2 replicates for each treatment), and each aquarium was stocked with 20 fish. The average body weights were 2.98±0.14 and 2.84±0.20g for fish used in the first and the second experiments, respectively. Fish were given the pelleted diets (3 mm in diameter) at a daily rate of 4% of total biomass during the experimental period, 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 from 1 July to 30 September 2002).

A chromic oxide marker was included in all experimental diets (of the two experiments) at a rate of 0.5%. During the last three weeks of each experiment, fish provided the diets and feces were collected daily from each tank as described by Hajen *et al.*, (1993). Diets and collected feces were dried to a constant weight. Proximate analysis of the diets and feces were conducted in duplicates for dry matter (DM) crude protein (CP), ether extract (EE), crude fiber (CF) and ash. Chromic oxide levels were determined in diets and feces (Fenton and Fenton, 1979) and apparent digestibility coefficients for DM, CP, EE and NFE were calculated according to NRC (1993) using the following equation:

Nutrient digestibility =
100-100 [% marker in diet / % marker in fecesX % nutrient in diet / % nutrient in faeces].

Records of live body weight (g) and body length (cm) of individual fish were measured at the start and the end of the two experiments for each aquarium. Growth performance and feed utilization parameters were calculated as follows:

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

Where:- Ln = the natural log, W_1 = initial fish weight; W_2 = 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, five fish were randomly sampled from each aquarium and slaughtered. The weight of flesh, carcass and total by-products were recorded. All carcass components were measured according to Lovell (1981). Another five fish were also chosen at random and exposed to the proximate analysis of whole fish body according to the methods of AOAC (1990).

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

$Y_{ijk} = \mu + R_i + \alpha_j + E_{ijk}$

Where, Y_{ijk} = the observation on the ijkth fish eaten the jth diet for the ith replicate; μ = overall mean, R_i = the effect of ith replicate; α_j = the effect of jth diet and E_{ijk} = random error.

RESULTS AND DISCUSSION

Results of feeding common carp, *Cyprinus carpio* on the different

Table (1): Composition and proximate analysis of the experimental diets (First experiment).

Ingredients, %	Diets					
	TBM0	TBM10	TBM20	TBM30	TBM40	TBM50
Fish meal (65%)	28	28	28	28	28	28
Soybean meal (40%)	20	18	16	14	12	10
Yellow corn	45	43	41	39	37	35
Tomato by-product	0	4	8	12	16	20
Corn oil	2	2	2	2	2	2
Cr_2O_3	0.5	0.5	0.5	0.5	0.5	0.5
Bone meal	1.5	1.5	1.5	1.5	1.5	1.5
Vit. & min. mixture[1]	3	3	3	3	3	3
Sum	100	100	100	100	100	100
Proximate analysis, %	(Determined on DM basis)					
Moisture	5.71	5.14	5.11	4.99	5.27	4.80
CP	30.05	30.02	30.09	30.50	30.03	30.10
EE	4.80	4.90	4.95	4.83	4.96	5.50
CF	9.50	9.66	10.03	10.29	10.68	11.00
Ash	10.13	10.61	10.88	10.76	10.91	11.23
NFE[2]	45.52	44.81	44.05	43.62	43.42	42.17
ME (Kcal/kg diet)[3]	3349	3332	3313	3306	3289	3294
P/E ratio	89.74	90.10	90.82	92.26	91.30	91.38

Table (2): Composition and proximate analysis of the experimental diets (Second experiment).

Ingredients, %	Diets					
	PBM0	PBM10	PBM20	PBM30	PBM40	PBM50
Fish meal (65%)	28	28	28	28	28	28
Soybean meal (40%)	20	20	20	20	20	20
Yellow corn	45.0	40.5	36.0	31.5	27.0	22.5
Potato by-product	0	4.5	9.0	13.5	18.0	22.5
Corn oil	2	2	2	2	2	2
Vit.& min. mixture[1]	3	3	3	3	3	3
Bone meal	1.5	1.5	1.5	1.5	1.5	1.5
Cr_2O_3	0.5	0.5	0.5	0.5	0.5	0.5
Sum	100	100	100	100	100	100
Proximate analysis, %	(Determined on dry matter basis)					
Moisture	5.03	5.28	5.58	5.80	5.34	5.70
CP	30.11	30.14	30.17	30.40	30.32	30.25
EE	4.69	4.77	4.19	4.56	4.82	4.96
CF	9.45	9.87	10.20	9.88	9.39	9.65
Ash	8.79	9.03	8.97	9.11	9.56	9.87
NFE[2]	46.96	46.19	46.47	46.05	45.91	45.27
ME (Kcal/kg diet)[3]	3393	3374	3336	3363	3377	3363
P/E ratio	88.71	89.33	90.44	90.40	89.78	89.95

[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; B_1, 0.4 g; Riboflavin, 1.6 g; B_6, 0.6 g, B_{12}, 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] Calculated based on kilocalorie values of 4.50 g^{-1} protein, 8.51 g^{-1} lipid and 3.49 g^{-1} NFE (Jauncey, 1982).

experimental diets containing the different levels of tomato or potato by-products during the experimental period are going to be discussed under three points: a) proximate analysis of tomato and potato by-products, b) effect of tomato or potato by-products on nutrients digestibility of different experimental diets, and c) effect of tomato or potato by-products on growth performance, feed utilization, carcass and proximate analysis of whole body of common carp, *Cyprinus carpio.*

First Experiment:

a) Proximate analysis of TBM:

Proximate analysis of TBM and SBM are presented in Table (3). As described in this table, the high protein content (20.13%) of TBM indicate the possibility of incorporation of this cheap industrial by-product in fish diets as a replacement of the high coast SBM, moreover EE content in TBM is high compared to that in SBM being 7.92 and 2.31%, respectively. Alicata *et al.*, (1988) found that, tomato waste contained 22.0 CP, 32.8 CF and 19.5% EE. El-Sayed (1994) demonstrated that, percentages of chemical composition of tomato by-product were 93.96 DM, 16.11 CP, 5.49 EE, 44.18 CF, 28.73 NFE, and 5.49 ash. Also, Hassanen (1986) reported that, the proximate analysis of tomato pulp was 95.61 DM, 24.38 CP, 6.43 EE, 25.94 CF, 31.50 NFE and 7.30% ash.

b) Nutrients digestibility:

Apparent digestibility coefficient (ADC) for different nutrients of experimental diets are presented in Table (4). As shown in this table, ADC for DM ranged between 70.65 and 72.83% with insignificant differences between experimental diets attributed to replacing levels of 0 to 50% of SBM by TBM and the same trend was also observed for EE. Similar results were obtained by Saad (1998) who found that, DM digestibility of diets fed to carp, *Cyprinus carpio*, was higher for the diet contained 11.25% TBM (50% substitution of SBM by TBM) followed by the diet contained 5.63% TBM (25% substitution of SBM by TBM) and the differences between the experimental diets were not significant. Recently, Soltan (2002) reported that, increasing the replacing level of SBM by TBM up to 70% had no significant effect on the ADC of DM and EE for tilapia fish but the higher replacing level (80%) significantly decreased the ADC for DM and EE.

With respect to CP, it is clear that ADC lie in three clusters, the first one includes the three diets (TBM0, TBM10 and TBM20), the second cluster includes another two diets (TBM30 and TBM40) and the third one includes the experimental diet TBM50. Statistical analysis indicated that, the differences between the first and the third clusters were significant ($P<0.05$), while the differences between the second and each of the first and the third clusters were not significant. Therefore we can conclude that, replacing up to 40% of SBM by TBM did not significantly changed ADC for CP but the higher replacing level (50%) significantly decreased ADC for CP and the same trend was also observed for the ADC of NFE. This pattern was also reported by Soltan (2002) with Nile tilapia, *O. niloticus*.

c) Growth performance:

Average initial BW of common carp, *Cyprinus carpio* ranged between 2.94±0.26 and 3.07±0.26 g with insignificant differences between fish groups (Table 5) indicating the random distribution of fish among the different experimental treatments. Final BW ranged between 24.83±0.83 and 28.82±0.83 g and the differences in BW among the different treatments were significant ($P<0.01$). The highest BW was recorded for the TBM20 treatment when 20% of SBM was replaced by

Table (3): Proximate analysis of TBM compared to SBM.

Item (%)	TBM	SBM
DM	91.72±2.14	91.00±1.50
CP	20.13±0.11	40.21±0.23
EE	7.92±0.33	2.31±0.26
CF	29.33±0.41	6.50±0.32
Ash	11.11±0.10	6.16±0.27
NFE	31.51±0.10	44.82±0.45

Table (4): Apparent digestibility coefficients (%) for different nutrients of experimental diets contained TBM as a replacement of SBM in carp diets.

Diets	DM	CP	EE	NFE
TBM0	71.60±1.54	75.15±2.11 a	91.66±2.55	80.62±1.77 ab
TBM10	70.80±1.54	76.11±2.11 a	91.00±2.55	83.49±1.77 a
TBM20	70.80±1.54	76.78±2.11 a	90.12±2.55	82.24±1.77 ab
TBM30	70.65±1.54	73.10±2.11 ab	92.00±2.55	83.66±1.77 a
TBM40	72.83±1.54	74.66±2.11 ab	91.00±2.55	84.55±1.77 a
TBM50	71.55±1.54	70.65±2.11 b	92.54±2.55	79.55±1.77 b
Probability	>0.05	<0.05	>0.05	<0.05

Means with the same letter in each column are not significantly different (P<0.05)

Table (5): Least square means and standard errors for the effect of replacing levels of SBM by TBM on growth performance and feed utilization of common carp.

Diets	Body weight (g)		Body length (cm)		Weight gain (g/fish)	Specific growth rate	Feed utilization		
	Initial	Final	Initial	Final			(FI)/fish (g)	FCR	PER
TBM0	3.1 ±0.3	24.8 ±0.8 b	4.6 ±0.2	9.1 ±0.3	21.8 ±0.1 b	2.3 ±0.01 c	46.0 ±0.1 e	2.1 ±0.02a	1.6 ±0.01 b
TBM10	2.9 ±0.3	28.2 ±0.8 a	4.4 ±0.2	9.1 ±0.3	25.3 ±0.1 a	2.5. ±0.01 a	48.8 ±0.1 d	1.9 ±0.02b	1.7 ±0.01 a
TBM20	3.0 ±0.3	28.8 ±0.8 a	4.1 ±0.2	9.5 ±0.3	22.8 ±0.1 ab	2.5 ±0.01 a	52.6 ±0.1 a	2.0 ±0.02a	1.6 ±0.01 ab
TBM30	3.0 ±0.3	27.3 ±0.8 a	4.1 ±0.2	9.2 ±0.3	24.3 ±0.1 a	2.5 ±0.01a	51.9 ±0.1 b	2.1 ±0.02a	1.5 ±0.01 b
TBM40	3.0 ±0.3	25.7 ±0.8 b	4.1 ±0.2	9.5 ±0.3	22.7 ±0.1 b	2.4 ±0.01 b	49.3 ±0.1 c	2.2 ±0.02a	1.5 ±0.01 b
TBM50	3.0 ±0.3	25.4 ±0.8 b	4.1 ±0.2	9.5 ±0.3	21.4 ±0.1 b	2.4 ±0.01 b	45.2 ±0.1 f	2.0 ±0.02a	1.6 ±0.01 ab
P*	>0.05	<0.01	>0.05	>0.05	<0.001	<0.001	<0.001	<0.001	<0.001

*Probability

TBM and the lowest BW was shown by the control group (TBM0). Moreover, results in Table (5) indicated that, the lower replacing levels (10 and 20%) released the higher BW compared to the control and the differences were significant. However, the higher replacing levels (30, 40 and 50%) showed higher BW values than the control but with no significant differences, indicating the possibility of replacing SBM by TBM up to 50% with improvement in BW of common carp, *Cyprinus carpio*. Saad (1998) reported that, BW of common carp (after 147 days) reached 50.63, 42.81, 35.58 and 17.74 g for fish groups fed the diets contained 0, 25, 50 and 100% of SBM replaced by TBM and the differences between these means were significant (P<0.05).

As shown in Table (5) BL of carp at either the start or the end of the experiment was not significantly different. The longest fish bodies were recorded for fish fed diets TBM40 and TBM50 (40 and 50% of SBM replaced by TBM) compared to other diets. These results are resemblance to those obtained by Soltan (2002), who found that BL of Nile tilapia, *O. niloticus* was not significantly affected by increasing the replacing level of SBM by TBM up to 70% while the higher replacing level (80%) significantly decreased BL.

With regard to WG, results in Table (5) showed that the higher WG (25.27 g) was recorded by fish fed diet TBM10 where 10% of SBM was replaced by TBM, while the lower WG (21.42 g) was obtained by fish fed the TBM50 diet and the differences were significant. However, the partial replacement of SBM by TBM at 20, 40, 50% levels in carp diets had no significant effect on WG as compared with that of the control group. These results are in agreement with those obtained by Soltan (2002) who found that, WG of *O. niloticus* insignificantly increased until the replacing level of SBM by TEM reached to 50%, after this level (50%), WG was significantly decreased. Khadzhinikolova and Tomasyan (1984), concluded that partial or complete replacement of sunflower meal by tomato waste showed an improvement in WG of carp fish. On the other hand, Saad (1998) found that, WG of common carp, *Cyprinus carpio* was significantly decreased with increasing the replacing levels of SBM by TBM form 0 to 25, 50 and 100%.

As shown in Table (5), the higher SGR value (2.51) was obtained with fish fed the diets contained 10 and 20% of TBM and the lowest one (2.32) was obtained with fish fed the control diet. Statistical analysis of data (Table, 5) also showed that, SGR values lie in three clusters, the first one included the control diet, the second one contained the three diets with 10, 20 and 30% and the third cluster included the two diets contained 40 and 50% of SBM replaced by TBM and the differences between SGR of the three clusters were significant (P<0.001) indicating the possibility of replacing up to 50% of SBM by TBM in carp diets with an improvement in SGR of fish. These results agreed also with those observed by Saad (1998) who detected insignificant differences in SGR of tilapia fish when 44.40% of dietary SBM was replaced by TBM.

It is noteworthy that, increasing the replacing level of SBM by TBM up to 50% in carp diets had no adverse effect on all growth parameters (BL, WG, and SGR) and this indicated the possibility of replacing 50% of SBM by TBM in carp diets to reduce the feed costs.

d) Feed utilization:

As described in Table (5), FI in the present experiment increased significantly with increasing the replacing levels of SBM by TBM up to

40% and these results indicated the improvement of growth parameters gained by fish fed the diets contained TBM. The higher FI (52.60 g/fish) was recorded for fish fed the diet TBM20 where 20% of SBM was replaced by TBM and the lower one (45.20 g/fish) was obtained for fish fed the diet TBM50.

Results in Table (5) indicated that, increasing the replacing level of SBM by TBM from 0 to 10% in carp diets, *Cyprinus carpio* significantly improved FCR and PER values, whereas, the higher replacing levels (20 to 50%, with an increment of 10%) had no significant adverse effect on the FCR and PER ones of carp fish (compared with FCR of the control). These results indicate the possibility of replacing SBM by TBM up to 50% with no adverse effect on FCR and PER values. These results are in complete accordance with those obtained by Soltan (2002) who cleared that increasing the levels of TBM as a replacement of SBM in tilapia diets up to 50% had no significant effect on neither FCR nor PER values. Also, Khadzhinikolova and Tomasyan (1984) found that, carp fish fed a control diet containing sunflower meal partially or completely replaced by tomato waste showed an improved feed efficiency values.

e) Carcass and proximate analysis:

As described in Table (6), the higher dress-out and flesh percentages were obtained by fish group fed diet TBM10 and the lower percentages of these components were recorded for fish fed diet TBM50, moreover, the higher replacing levels (40 or 50%) significantly decreased the dress-out and flesh percentages. In this respect, Saad (1998) found that, dressing percentages for carp carcasses were 51.79, 54.22, 56.86 and 48.02% for control, 25, 50 and 100% replacing levels of SBM by TBM in carp diets, respectively.

The higher by-product percentages were recorded by the fish groups fed diets, TBM40 and TBM50 and the differences due to replacing of SBM by TBM effects were significant ($P<0.001$).

Results in Table (6) showed that, as the inclusion level of TBM in the experimental diets increased the percentage of moisture in whole fish insignificantly increased up to the replacing levels of SBM by TBM reached to 40% but the higher replacing level (50%) significantly increased the moisture content of carp bodies and a reverse trend was observed for fat content of carp bodies. Similar results were reported by Saad (1998) who found that the addition of TBM at low levels (25% substitution) significantly ($P<0.05$) decreased the fat content of carp carcasses ($P<0.01$).

Data presented in Table (6) showed also that fish fed the experimental diet TBM30 gained the higher (52.15%) protein and the lower (6.79%) ash contents whereas, fish fed the experimental diet TBM50 gained the lower (48.13%) protein content and the higher (9.99%) ash percentage. The differences in percentages of protein and ash were significant.

Second Experiment:

a) Proximate analysis of PBM:

Proximate analysis of PBM and YC are presented in Table (7). As described in this table, PBM contained reasonable amount of NFE (64.08%) which is an indicator for its potential value as a source of energy, moreover, EE (3.6%) and CP (8.02%) are nearly similar to those determined in YC (4.01% EE and 7.80% CP). Proximate analysis for PBM in the present experiment is relatively similar to that obtained by Ghazalah *et al.*, (2002) except for EE. They found that, PBM contained 7.94% CP, 9.5% CF, 3.55% ash and 29.60% EE. Similarly, El-Tawil (2001) showed that

Table (6): Least square means and standard errors for the effect of replacing levels of SBM by TBM on carcass traits and proximate analysis of common carp.

Diets	Carcass traits (%)			Proximate analysis (whole fish body), %			
	Dress-out	Flesh	By-products	Moisture	Protein	Fat	Ash
TBM0	57.3±0.6 b	43.1±0.6	51.4±0.7 b	71.9±0.6 b	49.8±1.7 a	40.6±0.9 a	8.5±0.2 ab
TBM10	59.3±0.6 a	46.9±0.6	47.5±0.7 c	73.6±0.6 b	49.5±1.7 a	40.6±0.9 a	8.1±0.2 ab
TBM20	57.0±0.6 b	45.2±0.6	49.6±0.7 b	72.1±0.6 b	48.5±1.7 b	40.2±0.9 a	8.5±0.2 ab
TBM30	56.5±0.6bc	43.3±0.6	50.7±0.7 b	73.5±0.6 b	52.2±1.7 a	39.9±0.9 a	6.8±0.2 b
TBM40	54.9±0.6cd	40.0±0.6	54.1±0.7 a	71.9±0.6 b	49.0±1.7 a	39.8±0.9 a	7.1±0.2 ab
TBM50	53.3±0.6 d	38.3±0.6	55.2±0.7 a	76.3±0.6 a	48.1±1.7 b	37.7±0.9 b	10.0±0.2 a
P*	<0.001	<0.001	<0.001	<0.001	<0.05	<0.001	<0.001

* Probability

Means with the same letter in each column are not significantly different

Table (7): Proximate analysis of PBM compared to YC.

Item (%)	PBM	YC
DM	94.12±2.14	92.00±1.51
CP	8.02±0.11	7.80±0.26
EE	3.60±0.15	4.01±0.31
CF	18.13±0.51	3.10±0.16
Ash	6.17±0.21	3.03±0.19
NFE	64.08±0.11	82.06±1.10

Table (8): Apparent digestibility coefficients (%) for different nutrients of experimental diets contained PBM as replacement of YC in carp diets.

Diets	DM	CP	EE	NFE
PBM0	85.14±2.33	80.11±1.00 a	90.16±2.17 a	65.23±2.01 a
PBM10	86.11±2.33	79.24±1.00 a	92.15±2.17 a	62.18±2.01 ab
PBM20	84.22±2.33	79.26±1.00 a	90.22±2.17 a	61.37±2.01 ab
PBM30	86.40±2.33	77.15±1.00 ab	89.17±2.17 ab	60.78±2.01 ab
PBM40	86.40±2.33	74.54±1.00 b	92.14±2.17 a	61.25±2.01 ab
PBM50	87.44±2.33	73.35±1.00 b	85.12±2.17 b	57.78±2.01 b
Probability	P>0.05	P<0.05	P<0.05	P<0.05

Means with the same letter in each column are not significantly different potato waste contained 8% CP, 6% EE, 4% CF and 4% ash. Results of proximate analysis of PBM indicated the possibility of incorporation of this industrial by-product as energy source in carp diets as a replacement of YC but the level of replacement will depend on the availability of its nutrients for fish.

b) Nutrients digestibility:

As shown in table (8), ADC for DM was not significantly affected when the replacing level of YC by PBM increased from 10 to 50% as compared to that of the control diet. However, replacement of 40% and 50% of YC by PBM significantly ($P<0.05$) decreased ADC for CP and the replacement level of 50% significantly ($P<0.05$) decreased the ADC of EE and NFE values.

In this respect, Ufodike and Matty (1988) found that, inclusion of potato waste in diets of mirror carp (*Cyprinus carpio* L.) fingerlings increased the digestibility of carbohydrate from 45% in corn to 53% in diets containing potato waste. With Nile tilapia, *O. niloticus*, Soltan (2002) reported that, ADC for DM did not significantly differ when the replacing level of YC by PBM increased from 10 to 80% as compared to those of the control diet. However, replacement of 40% decreased ADC for CP and the replacement level of 50% significantly decreased the ADC of EE and NFE.

c) Growth performance:

Results of table (9) indicated that increasing the replacing level of YC by PBM from 0 to 40% had no significant effect on BW, WG and SGR but the higher replacing level (50%) significantly ($P<0.05$, $P<0.01$ or $P<0.001$) decreased these growth parameters. In agreement with these results, Soltan (2002) found that replacing 40% of YC by PBM in Nile tilapia diets had no effect on fish BW but the higher inclusion levels of PBM (50-80%) significantly ($P<0.001$) decreased the final BW, WG and SGR. Ghazalah *et al*., (2002) reported the same results. They found that, replacing 25 or 50% of YC with PBM did not significantly changed BW, WG and SGR of Nile tilapia, *O. niloticus*. On the other hand, Shouqi *et al*., (1997) concluded that, as dietary potato protein concentrate increased from 0 to 51% in rainbow trout (*Oncorhynchus mykiss*) diets, final BW and SGR significantly decreased and mortality increased. With respect to BL, results of Table (9) showed that, fish fed the control diet recorded the longest fish bodies however fish group fed diet TBM50 recorded the shortest ones. Generally, PBM contains considerably less of each amino acid compared to YC and it is limiting with respect to methionine, cystine, arginine and the aromatic amino acids (El-Tawil, 2001). For this reason, it is suggested that, the higher replacing level (50%) of YC by PBM decreased growth parameters for common carp, *C. carpio*.

d) Feed utilization:

Results of FI (Table 9) indicated that fish fed the control diet (PBM0) exhibited the highest FI compared to those fed the other experimental diets and fish fed the PBM50 diet recorded the lowest FI. It was noticed that the lower replacing levels of YC by PBM up to 30% had no significant effect on FI but the higher replacing levels (40 and 50%) significantly ($P<0.05$) decreased the FI for carp fish. Soltan (2002) and Ghazalah et al., (2002) with Nile tilapia, *O. niloticus*, reported that, replacing levels of YC by PBM up to 50% did not significantly affect FI.

With regard to FCR and PER, results of Table (9) showed that, the best ratios of FCR and PER (1.91 and 1.73, respectively) were obtained by fish fed the PBM40 diet (40% of YC replaced by PBM). Compared to the control group, all replacing levels of YC by PBM from 10 to 50% in carp diets improved the

Table (9): Least square means and standard errors for the effect of replacing levels of YC by PBM on growth performance and feed utilization of common carp.

Diets	Body weight (g)		Body length (cm)		Weight gain (g/fish)	Specific growth rate	Feed utilization		
	Initial	Final	Initial	Final			FI/fish (g)	FCR	PER
TBM0	2.9 ±0.3	24.8 ±1.3 a	3.7 ±0.2	9.9 ±0.3 a	21.9 ±0.5 a	2.4 ±0.01 a	50.0 ±0.4 a	2.3 ±0.01 a	1.5 ±0.03 c
TBM10	2.9 ±0.3	26.1 ±1.3 a	3.5 ±0.2	8.6 ±0.3 ab	23.1 ±0.5 a	2.4 ±0.01 a	45.0 ±0.4 ab	1.9 ±0.01 b	1.7 ±0.03 a
TBM20	3.0 ±0.3	26.0 ±1.3 a	3.7 ±0.2	8.3 ±0.3 b	23.0 ±0.5 a	2.4 ±0.01 a	48.5 ±0.4 ab	2.1 ±0.01 ab	1.6 ±0.03b
TBM30	2.9 ±0.3	24.9 ±1.3 a	3.5 ±0.2	8.3 ±0.3 b	22.0 ±0.5 a	2.4 ±0.01 a	46.5 ±0.4 ab	2.1 ±0.01 ab	1.6 ±0.03b
TBM40	2.8 ±0.3	24.5 ±1.3 a	3.3 ±0.2	8.6 ±0.3 ab	21.7 ±0.5 a	2.4 ±0.01 a	41.3 ±0.4 b	1.9 ±0.01 b	1.7 ±0.03 a
TBM50	2.5 ±0.3	20.6 ±1.3b	3.5 ±0.2	8.3 ±0.3 b	18.1 ±0.5 b	2.3 ±0.01 b	39.3 ±0.4 b	2.2 ±0.01 ab	1.5 ±0.03b
P*	>0.05	<0.05	>0.05	<0.05	<0.01	<0.001	<0.001	<0.001	<0.01

* **Probability**

Table (10): Least square means and standard errors for the effect of replacing levels of YC by PBM on carcass traits and proximate analysis of common carp.

Diets	Carcass traits (%)			Proximate analysis (whole fish body), %			
	Dress-out	Flesh	By-products	Moisture	Protein	Fat	Ash
TBM0	57.3±0.7a	42.6±0.7 a	51.4±0.7 c	74.6±0.6	54.6±1.7	38.7±1.1a	6.4±0.9
TBM10	56.2±0.7a	42.8±0.7 a	52.8±0.7 b	73.4±0.6	54.9±1.7	34.5±1.1	8.7±0.9
TBM20	56.5±0.7a	40.7±0.7 a	52.7±0.7 b	74.0±0.6	52.7±1.7	34.6±1.1	8.5±0.9
TBM30	55.7±0.7a	40.0±0.7 a	54.3±0.7 ab	73.8±0.6	50.5±1.7	33.4±1.1	8.5±0.9
TBM40	53.3±0.7b	38.0±0.7 b	55.6±0.7 ab	73.9±0.6	51.3±1.7	34.2±1.1	8.8±0.9
TBM50	51.9±0.7b	38.4±0.7 b	56.3±0.7 a	73.1±0.6	47.5±1.7	33.1±1.1	9.5±0.9
Probability	P<0.001	P<0.001	P<0.001	P>0.05	P<0.05	P<0.01	P<0.05

Means with the same letter in each column are not significantly different

FCR and PER values. These results are in agreement with those obtained by Ghazalah *et al.*, (2002) who found no significant differences in FCR and PER when YC was replaced by PBM up to 50% in Nile tilapia, *O. niloticus* diets. Shouqi *et al.*, (1997) concluded that, as dietary potato protein concentrate increased in rainbow trout (*Oncorhynchus mykiss*) diets from 0 to 51%, FCR values were significantly decreased (improved).

Generally, results obtained in the present study showed that, partial replacement of YC by PBM in carp diets up to 50% improved both the FCR and PER and this indicated the possibility of incorporating the lowest price PBM as a partial replacement of the high price YC in carp diets with an improvement in feed utilization parameters.

e) Carcass and proximate analysis:

As described in Table (10), replacing YC by PBM up to 30 did not significantly affected the percentages of dress-out and flesh in carp carcass, while the percentage of by-products increased significantly (P<0.001) with increasing the replacing levels of YC by PBM in carp diets, however, diet PBM50 released the highest (56.34) percentage of by-products compared to the control diet which recorded the lowest value (51.42%). In this respect, Soltan (2002) found that, replacing YC by PBM up to 40 and 70% did not significantly affected the percentages of dress-out and flesh in tilapia carcass.

Results of proximate analysis of whole body of common carp (Table 10) indicated that moisture percentage ranged between 73.11 and 74.58% with no significant differences between the experimental groups. The higher protein content of fish bodies was obtained in fish fed the experimental diets, PBM0 and PBM10 followed (in descending order) by that of fish fed PBM20, PBM40 and PBM30 diets with no significant differences between these values, indicating that, increasing substitution levels of YC by PBM up to 40% in carp diets had no significant effect on protein content of fish bodies while the higher level of substitution (50%) significantly decreased protein content of carp fish bodies. However, a reverse trend was observed for ash content. These results are relatively similar to those obtained by Soltan (2002) who found that increasing the inclusion level of PBM up to 50% in tilapia diets did not significantly changed the protein content but the higher inclusion levels (60, 70 or 80%) significantly decreased protein and ash contents of tilapia bodies. Shouqi *et al.*, (1997) reported that, CP content of the fish decreased (P<0.05) as dietary potato protein concentrate increased from 0 to 51% in rainbow trout (*Oncorhynchus mykiss*) diets. Also, Xie and Jokumsen (1997) cleared that, incorporation of potato protein concentrate in diets of rainbow trout significantly increased ash contents of fish body.

With regard to fat content, results in Table (10) showed that, the higher fat content (38.68%) of fish bodies was obtained by the control group (PBM0) and all the substitution levels of YC by PBM significantly (P<0.01) decreased fat content of fish bodies. These results are in agreement with those of Shouqi *et al.*, (1997) who found that, fat content of the fish body decreased (P<0.05) as dietary potato protein concentrate increased from 0 to 51% in rainbow trout (*Oncorhynchus mykiss*) diets. Also, Xie and Jokumsen (1997) reported that, incorporation of potato protein concentrate in diets for rainbow trout significantly decreased fat content of fish body.

Economical Efficiency:

The current investigation highlights the potential of using TBM for partial

Table (11): Feed costs (LE) for producing one kg WG by fish fed the experimental diets.

TBM						
Diets	**Costs, LE/ ton**	**Relative to control (%)**	**Decrease in feed cost (%)**	**FCR**	**Feed costs, LE/kg WG**	**Relative to control (%)**
TBM0	1647	100	0.00	2.11	3.48	100
TBM10	1611	97.81	2.19	1.93	3.11	89.37
TBM20	1575	95.63	4.37	2.04	3.21	92.24
TBM30	1539	93.44	6.56	2.14	3.29	94.54
TBM40	1503	91.26	8.74	2.17	3.26	93.68
TBM50	1467	89.07	10.93	2.02	2.96	85.00
PBM						
Diets	**Costs, LE/ton**	**Relative to control (%)**	**Decrease in Feed costs (%)**	**FCR**	**Feed costs, LE/kg WG**	**Relative to control (%)**
PBM0	1646.8	100	0.00	2.28	3.75	100
PBM10	1615.8	98.12	1.88	1.94	3.13	83.47
PBM20	1584.8	96.24	3.76	2.11	3.34	89.07
PBM30	1553.8	94.35	5.65	2.11	3.28	87.47
PBM40	1522.8	92.47	7.53	1.91	2.91	77.60
PBM50	1491.8	90.59	9.41	2.17	3.24	86.40

Table (12): Local market price (LE/ton) for feed ingredients used for formulating the experimental diets at the start of the experiment (June, 2002).

Ingredients	Price, LE / ton
Fish meal	3000
SBM	1200
YC	800
TBM	100
PBM	110
Bone meal	450
Vegetable oil	2500
Vit. & Min. mixture	5000

replacement of SBM and PBM for partial replacement of YC in common carp diets. Generally, results of the present study showed the possibility of replacing of SBM by TBM up to 50% (first experiment) and YC by PBM up to 50% (Second experiment) with no adverse effect on growth performance and feed utilization.

Feed cost is considered to be the highest recurrent cost in aquaculture, often ranging from 30 to 60%, depending on the intensity of the operation. Any reduction in feed costs either through diet development, improved husbandry or other direct or indirect means is therefore decreased the total production investment and increased the net return (Collins and Delmendo, 1979; Green; 1992 and De Silva and Anderson, 1995). All other costs are almost constant, therefore, the feeding costs required to produce one kg gain in weight could be used to compare the economical efficiency of different experimental treatments.

As shown in Tables (11 and 12), feed costs (LE/ton) decreased gradually with increasing substitution level of SBM by TBM. Data presented in the same table showed that, increasing substitution level of SBM by TBM at 10, 20, 30, 40 and 50% decreased feed costs by 2.19, 4.37, 6.56, 8.74 and 10.93%, respectively. Compared to the control diet, feed costs (LE/kg WG) decreased for all substitution levels of SBM by TBM and the experimental diet TBM50 released the lowest feed costs (LE/kg WG) while the control diet (TBM0) released the highest one. In conclusion, replacing 50% of SBM by TBM reduced feeding costs by 10.93%.

With regard to PBM, results in Table (11) showed that, replacing YC by PBM up to 50% reduced feeding costs (LE / ton) gradually from 1646.8 to 1491.8 LE. Also data in Table (11) showed that, increasing the replacing level of YC by PBM at 10, 20, 30, 40 and 50% decreased feed costs by 1.88, 3.76, 5.65, 7.53 and 9.41%, respectively. Compared to the control diet, feed costs (LE / kg WG) decreased for all substitution levels of YC by PBM and the experimental diet PBM40 released the lowest feed costs (LE/kg WG) while control diet (TBM0) released the highest one. Accordingly, replacing 50% of YC by PBM in carp diets reduce feeding costs by 9.41%.

REFERENCES

Alicata, M.L., A. Bonanuo, P. Glaccone, G. Leto and D. Battaglia (1988): Use of tomato skins and seeds in the feeding of male rabbits. Rivista di congili, Coltura 25(1):33-36. [C.F. Nut. Abst. and rev., 58:472, 1988].

AOAC (1990): Association of Official Analytical Chemists. Official Methods of Analysis. 15th Ed. Published by the North Nineteen St. Auite 210 Arlingth, Virginia 2220/USA.

Collins, R.A. and M.N. Delmendo (1979): Comparative economics of aquaculture in cages, raceways and enclosures. In: Advance in aquaculture, England, Fishing News Books.

De Silva, S. S. and T.A. Anderson (1995): Fish nutrition in aquaculture. CHAPMAN edaw & HALL, London.

El-Sayed, A.M. (1994): Nutritive value evaluation of some crops, vegetable and fruit residues. M.Sc. Thesis, Fac. Agric., Cairo University.

El-Shamma, A.A., A.H. Saiman, M.H. Al-Ashabb, A.S. Ahmed and I.S. Tchyad (1997): The use of tomato processing wastes as a partial replacement for maize diets of common carp, *Cyprinus carpio* L. Dirasat. Agric. Sci., 24:69-72.

El-Tawil, M.E. (2001): Studies on some nutritional and managerial trials to improve the growth capacity of broiler chickens. M.Sc. Thesis, Fac. Agric., Zagazig University.

FAO (1991): Production year book, Vol. 44. Food and Agricultural Organization of the United Nations, Rome.

Fenton, T.W. and M. Fenton (1979): An improved procedure for the determination of chromic oxide in feed and feces. Can. J. Anim. Sci., 59:631-634.

Ghazalah, A.A., I.A. Gomaa and H. D. Tonsy (2002): The use of date stone meal (DSM) and potato by-product meal (PBM) as non-conventional energy feed sources in Nile tilapia (*Oreochromis niloticus*) diets. The 1st Scientific Conference of the Egyptian Aquaculture Society, El-Arish, North Sinai, Egypt, 13-15 December, 2002.

Green, B.W. (1992): Substitution of organic manure for pelleted feed in tilapia production. Aquaculture, 101:213-222.

Hajen, W.E., D.A. Higgs, R.M. Beames and B.S. Dosanjh (1993): Digestibility of various feedstuffs by post-juvenile chinook salmon (*Oncorhynchus ishawytscha*) in sea water: I. Validation to technique. Aquaculture, 112:321-332.

Hassanen, G.D.I. (1986): Studies on some appropriate rations for reared fishes in Egyptian fish farms. Ph.D. Thesis, Fac. of Agric., Monofia University. Egypt.

Hassanen, G.D.I. (1991): The utilization of some unconventional protein by Nile catfish (*Clarias lazera*). J. Egypt. Ger. Soc. Zool., 6:49-62.

Hassanen, G.D.I., M.A. Sherif, H.A. Hashem and M.A. Hanfy (1995): Utilization of some fermented waste food as a protein source in pelleted feeds for Nile tilapia (*Oreochromis niloticus*) fingerlings. Proc. 5th Sci. Conf. Animal Nutrition, 1: 427-435, Ismailya, 12-15, December 1995.

Khadzhinikolova, L. and K.H. Tomasyan (1983): Tomato and pepper waste as fodder in fish farming. Ribno-Stopanstvo, 28:10-12.

Khadzhinikolova, L. and K.H. Tomasyan (1984): Tomato waste for feeding carp up to one year old. Ribno-Stopanstvo, 30:20-21.

Lovell, R.T. (1981): Laboratory manual for fish feed analysis and fish nutrition studies. Auburn Univ., Alabama.

NRC (1993): Nutrient requirements of fish. National Academy Press, Washington D.C.

Saad, F.A. (1998): Some studies on fish nutrition. M. Sc. Thesis, Fac. Veterinary Medicine, Moshtohor, Zagazig University (Banha branch).

SAS (1996): SAS Procedure Guide "version 6.12 Ed". SAS Institute Inc., Cary, NC, USA.

Shouqi, X., A. Jokumsen and X. Sq (1997): Replacement of fish meal by potato protein concentrate in diets for rainbow trout, Oncorhynchus mykiss (Walbaum): growth, feed utilization and body composition. Aquaculture Nutrition, 3:65-69.

Soltan, M.A. (2002): Using of tomato and potato by-products as non-conventional ingredients in Nile tilapia, *Oreochromis niloticus* diets. Annals of Agric. Sci., Moshtohor, 40(4):2081-2096.

Ufodike, E.B.C. and A.G. Matty (1988): Growth responses and nutrient digestibility in mirror carp (*Cyprinus carpio*) fed different levels of cassava and rice. Aquaculture, 31:41-50.

Xie, S. and A. Jokumsen (1997): Incorporation of potato protein concentrate in diets for rainbow trout: effect on feed intake, growth and feed utilization. Aquaculture Nutrition, 3(4):223-226.

إستخدام مخلفات تصنيع الطماطم و البطاطس كإحلال جزئى لكسب فول الصويا و الذرة الصفراء فى العلائق التطبيقية لأسماك المبروك العادى.

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أقيمت تجربتان، إستخدمت فى التجربة الأولى ٦ علائق تجريبية احتوت على نسب متزايدة من مخلفات تصنيع الطماطم (صفر إلى ٥٠%) كبديل لكسب فول الصويا، و فى التجربة الثانية تم أيضا تكوين ٦ علائق تجريبية احتوت على نسب متزايدة من مخلفات تصنيع البطاطس (الشيبسى) كبديل للذرة الصفراء بنسب تراوحت بين صفر إلى ٥٠% (بفاصل ١٠%)، و كانت علائق التجربتين متماثلة فى محتواها من البروتين (٣٠% بروتين خام) و الطاقة (٣٣٠٠ كيلو كالورى طاقة ممثلة/كجم عليقة)، و كانت نسبة البروتين إلى الطاقة بها ٩٠ ملجم بروتين / كيلو كالورى (طاقة ممثلة). و كانت أهم النتائج المتحصل عليها ما يلى:

أظهرت نتائج التجربة الأولى أن إحلال مخلفات تصنيع الطماطم محل كسب فول الصويا بنسبة وصلت إلى ٥٠% أدى إلى تحسين مقدار الزيادة فى الوزن و معدل النمو و كذلك معدل تحويل الغذاء و كفاءة البروتين. و قد أعطت العليقة المحتوية على ١٠% من مخلفات الطماطم أعلى تقدير للذبيحة و اللحم و أقل نسبة من المخلفات الغير مأكولة بينما أظهرت العليقة المحتوية على ٥٠% نتائج عكسية لهذه المقاييس. و قد أدت الزيادة التدريجية من صفر إلى ٥٠% من مخلفات الطماطم إلى زيادة معنوية فى نسبة الرطوبة و نقص معنوى فى محتوى الدهن كما أظهرت نتائج التحليل الكيميائى لجسم السمكة أن العليقة التى تم فيها الإحلال بنسبة ٣٠% من مخلفات الطماطم قد أدت إلى الحصول على أعلى نسبة للبروتين و أقل نسبة للرماد فى جسم السمكة، بينما أظهرت العليقة التى وصلت نسبة الإحلال بها إلى ٥٠% إلى نتائج عكسية لهذه المقاييس.

أظهرت نتائج التجربة الثانية أن إحلال مخلفات تصنيع البطاطس (الشيبسى) محل الذرة الصفراء بنسبة ٥٠% إلى نقص معنوى لمعظم صفات النمو (وزن الجسم و الزيادة فى وزن الجسم و معدل النمو)، و إلى تحسن معدل تحويل الغذاء و كذلك تحسن كفاءة تحويل البروتين. بينما أدت نسبة الإحلال المرتفعة (٤٠-٥٠%) إلى خفض معنوى فى نسب الذبيحة و اللحم. كما أدت زيادة نسب الإحلال تدريجيا بمخلفات الشيبسى إلى زيادة معنوية فى نسبة الأجزاء الغير مأكولة من السمكة. و قد أدى زيادة نسبة الإحلال إلى ٥٠% بالشيبسى إلى خفض معنوى فى نسبة البروتين، أما العكس فقد حدث مع نسبة الرماد. كما أظهرت نتائج التحليل الكيميائى لجسم السمكة أن جميع نسب الإحلال (٠ – ٥٠%) قد أدت إلى خفض نسبة الدهن معنويا فى جسم السمكة.

من الناحية الإقتصادية وجد أن إحلال ٥٠% من بروتين كسب فول الصويا بمخلفات تصنيع الطماطم قد أدى إلى توفير ١٠,٩٣% من تكاليف التغذية، كما أن إحلال ٥٠% من الذرة الصفراء بمخلفات تصنيع البطاطس فى العليقة قد أدى إلى تخفيض تكاليف التغذية بنسبة ٩,٤١%.