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Comparative Studies on Combined Effects of Some Plant Remnants on the Growth Performance and Immune Response of Fish

Raky Fakhry Attalla*, Susan Hassan Fadda
Fish Nutrition Department, National Institute of Oceanography and Fisheries, Cairo, Egypt-11516.
*Corresponding author E-mail address: rakyniof(at)yahoo.com, Tel: + 201229569595

Abstract— *This study were designate to evaluate some plant residues (peduncles and calyces) of three plant fruits which eaten daily as the main favorite dish represented in tomato, pepper and eggplant and compare the effects of these secondary plant resources on tilapia performance, feed utilization and immune response system. Test diets (40.25±0.15 % protein and 406.10 Kcal) as follow: eggplant residue (ER), pepper residue (PR), and tomato residue (TR) 2% from each besides to the control (0 % additives). Nile tilapia fry reared in 12 glass aquaria (70 liter each), were fed with 3% daily feeding rate, two times a day, through 10 weeks. Results of the trials were promising in all trends for all the three used additives and the best were cleared in the enhancement of the immunity indicators like plasma total protein (PTP) and serum immunoglobulin (IgM & IgD), also the performance as growth, digestibility or feed efficiency ratios like food conversion and protein utilization. These plant remnants contain many important compounds that are found in the origin fruit, but may be in lower proportions. From this perspective, we hopefully to shed more light on these remnants by increasing of studies, for using this wastes in feeding fish, which may contribute to reduce environmental pollution, and enhance economical profits.*

Keywords— *Pepper calyces, Tomato residues, Eggplant by-products, Tilapia growth and biochemical parameters, Immunity indicators.*

I. Introduction

Past decades have a notable global expansion of Nile tilapia farming in more than hundred Asian and African countries [1]. The *Oreochromis niloticus* is one of the dominant species of world aquaculture especially in Egypt [2]. Global tilapia production increasing annually by 13.5% [3]. A great efforts for use alternative plant sources to replace the expensive conventional ingredients to reduce feed costs and enhancing the productive yield of the fish [4]. The use of inexpensive natural feed sources, considered the main targets for fish nutritionists. A large quantity of residues is generated by the processing industry of fresh-cut fruits [5].

Currently, people have interest in producing the food which contain a huge nutritional value, bioactive compounds and antioxidant components, such as fruits and vegetables.

Many scientists stated that a positive relation between the consumption of fruits and vegetables and a reduction in the mortality rate due to dangerous diseases, and aging. This is because that, these foods are considered rich source of nutritional components, like vitamins, minerals, phenolics, antioxidants, fiber, and other biotic compounds [6-7-8- 9].

Daily, great amounts of plant wastes are generated as a result of fruit and vegetable production, industrial uses, and commercial, home and local consumption around the world. All of these remnants consist mostly of unutilized plant tissues such as peels, husks, leaves, calyxes and seeds or products outside of quality parameters [8,10].

These byproducts are usually discarded as waste in landfill sites, giving rise to serious environmental complications and economic expenses [11,12]. These plant tissues consist mainly of the sepals (calyces) stems (peduncles), these parts of the fruit remaining, can be using as a source of bioactive, and includes metabolites of great interest as the phenolic compounds [13,14].

Cost-effective and environmentally friendly reuse is one of the main target to be decreased food loss and waste due to processing from local facilities [15].

There is no person who does not know the green salad dish, which often contains from 5-7 varieties of vegetables of different colors such as cucumbers, tomatoes, peppers, lettuce, and others, which is not absent from Egyptian table.

Family Solanaceae includes; pepper, eggplant and tomato. Pepper (*Capsicum annum* L) is known for its high nutritional value [16]. Pepper used as a food in Africa and other countries of the world [17]. Genus Capsicum contains 200 variety species which ranged from very hot chilies to sweet bell peppers. Capsaicin is a fat soluble, colorless, odorless and flavorless compound [18].

Pepper peduncle is the part of the crop that attaches it to the main stem of the plant and discarded as waste [19].

Tomato, *Solanum lycopersicum* L, contains minerals, vitamins, proteins, essential amino acids, monounsaturated fatty acids, lycopene carotenoids, β-carotenoids and phytosterols [20]. About a third of tomatoes yield is processed and gives considerable amounts of remnants, known as tomato pomace or by-products, representing 2-10% of the whole fresh tomato [21,22]. More than 80% of harvested tomato have the calyx attached to the peduncle which attached by the plant and fruit. The calyx is firmly connect to the fruit [23]. Tomato pomace is a mixture of tomato peel, seeds and some amounts of pulp which remain after processing [21]. It is using as animal feed [24]. Tomato pomace are rich in fiber and lycopene, dietary fiber has different beneficial properties, and the seeds are rich in unsaturated fatty acids [25].

Eggplant (*Solanum melongena* L.) is a common vegetable which rich in antioxidants [26], Eggplant fruit differ in their pulp size, shape, and color. Eggplant residues consist of peel and calyx, are generated in substantial amounts by industrial

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food processing usually discarded as remnants without further utilization. However, studies have demonstrated that these by-products are superb sources of bioactive components. Therefore, the disposal of eggplant wastes represents a tremendous loss of valuable materials [12]. There are by-products (peduncles and calyces) of tomato, pepper, and eggplant which are neglected required to more attention. So, in our current study, we are trying to exploit leftover these vegetables and fruits that are found almost daily in the Egyptian household. Hence, these residues can be processed in an environmental friendly and energy-saving manner and used in fish feed.

II. MATERIALS AND METHODS

2.1. Plant material preparation

The by-products of eggplant (ER), *Solanum melongena*, pepper (PR), *Capsicum annum*, and tomato (TR), *Solanum lycopersicum* L., were obtained from the local market. These plant residues are constituted by calyces and peduncles. The by-products of the three plants were collected and weighed, squashed then sun-dried and powdered and packed in plastic bags.

2.2. Diets formulation

Four treatment diets (40.25% CP) were used as follow: eggplant (ER), pepper (PR) and tomato (TR) residues, 2% of each, besides to control (without additives), diet formula and proximate composition shown in Table (1).

2.3. Fish and Experimental design

The evaluation was performed with Nile tilapia, *Oreochromis niloticus*, fry which were held under optimal conditions for a week before the onset of the growth trials. Fries with initial body weight 2.21±0.08, were randomly distributed and reared in 12 glass aquaria (70-L) each, which stocked with 20 fry per aquarium. The water were partially changed day after day. The fish were fed three times a day at 9am, 12 and 3pm and weighed biweekly.

2.4. Water quality

Physicochemical measurements includes; ammonia, pH, water temperature and the dissolved oxygen were measured through the 70 days for the glass aquaria.

2.5. Growth performance

The fish samples were randomly collected biweekly to investigate the growth parameters that were calculated according to [27] as the following equations:
Average weight gain (AWG, g /fish) = [final body weight (g) - initial body weight (g)];
daily weight gain, (DWG, g /fish /day) = [AWG (g) / Experimental period (days)];
Specific growth rate (SGR, %g/day) = 100x (Ln final weight - Ln initial weight) / time intervals (day).

2.6. Feed utilization ratios

Food conversion (FCR) = feed intake (g) / body weight gain (g);
Protein efficiency (PER) = gain in weight (g) / protein intake in feed (g);
Protein productive value (PPV, %) =100 [protein gain in fish (g) / protein intake in feed (g)].

TABLE 1. Formulation and proximate analysis of the test diets.

Ingredients	Experimental diets			
	Control	ER	PR	TR
Fishmeal	21	21	21	21
Soybean meal	50	50	50	50
Corn gluten meal	7	7	7	7
Wheat bran	20	20	20	20
Fish oil	1	1	1	1
Premix[1]	1	1	1	1
Cr_2O_3	0.5	0.5	0.5	0.5
Additive dried	0	2	2	2
Chemical composition				
Dry matter	90.39	89.00	89.21	88.79
Crude protein	40.25	39.66	39.59	39.61
Ether extract	4.05	4.21	4.19	4.15
Ash	8.35	8.46	8.34	8.46
Crude fiber	5.88	6.22	6.13	6.14
NFE[2]	30.87	30.45	30.96	30.43
Gross energy[3] (Kcal)	406.10	415.98	417.12	414.72

1- One kg premix contained:
Vitamins:- 48×10^5 I.U (A), 6×10^2 mg (B_6), 20 mg (Biotin), 8×10^5 I.U. (D_3), 144 mg (E), 400 mg (B_1), 1600 mg (B_2), 4×10^3 mg (Pantothenic acid), 4 mg (B_{12}), 4×10^2 mg (Niacin), 2×10^5 mg (Choline chloride), and 400 mg (folic acid).
Minerals:- 12×10^3 mg Iron, 16×10^3 mg Manganese, 12×10^2 mg Copper, 120 mg Iodine, 80 mg Cobalt, 40 mg Selenium, and 16×10^3 mg Zinc.
2-, Nitrogen free extract = DM - (CP + Ash + CF + EE).
3- Gross energy = 5.7× g protein +9.4× g fat +4.1× (g NFE + g fiber), [28].

2.7. Flesh Condition indicators.

The normality of the fish body growth, were measured using the formula of [29]**:** condition factor (CF) =W/ L^3 × 100, where W is wet weight (g) of the tested fish and L is the length in centimeter, where Hepato-somatic (HSI) and gastro-somatic (GSI) were calculated as equation by [30,31], HIS = 100 × liver weight [g] / total body weight [g], and GSI = 100 × gut weight [g] / total body weight [g].

2.8. Digestibility

Apparent protein digestibility (APD), was measured by using [32,33]. Fish final weight was recorded, then the digestion trial was started where the uneaten diet and feces were collected once daily for 15 days by siphoning. Feces were collected separately then filtered and dried at 60ºC and stored for determined the chemical composition. Crude protein contents of the diets and feces were determined. Feces were analyzed separately to determine their respective values of dry matter and CP.

2.9. Biochemical studies

2.9.1. Plant materials analysis:

Samples of the additives were analyzed for crude protein (CP), ether extract (EE), crude fiber (CF), ash and minerals using the [34] reference methods.

2.9.1.1. Assessment of the main vitamins in byproducts

a. Ascorbic acid determination

Samples (1.0 g of each) were extracted in 4% oxalic acid, and the solution was brought to 100 ml (V1 ml) and

centrifuged at 4032 xg for 10 min. Then, 5 ml of the supernatant was mixed with10 ml of 4% oxalic acid; then the solution was titrated against the dye (V2 ml).
Ascorbic acid (mg/100g) = 0.5mg/V1 ml ×V2/5 ml ×100 ml/sample weight (1g) ×100 [35].

b. Determination of vitamins

The essential vitamins A, E, k and B were measured in the Central lab. of Agricultural Ministry, Dokki, Giza.

2.9.1.2. Amino and fatty acids profiles

Fatty acid and amino acid compositions of the three residues were assessed by using the methods recommended in the studies of [36,37].

2.9.2. Carcass analysis:

At the end of the experiment, five samples were taken randomly and analyzed for adjusting the moisture oven-dried (at 85ºC till constant weight), crude protein using Kjeldahl, total lipids by the method of ether extraction, and the total ash (550ºC / 6 hours) by [34].

2.9.3. Liver health signal:

At the end of the trial, liver samples of 10 fish were taken randomly from the aquaria, then liver tissues were homogenized by 5 ml distilled and Liver glycogen was measured (g/100 g fresh tissue) using the method by [38].

Hepatic glycogen= (absorbance sample/absorbance standard) ×conc. of standard × (V. of dil. factor/ Wt. of tissues).

Total liver protein was extracted by homogenization in trichloroacetic acid, then centrifuged (1008 x*g*), and the hepatic protein content was determined as described by [39], using the following formula:

Hepatic protein= (absorbance sample/absorbance standard) × Conc. of standard ×(V. of dil. factor/ Wt. of tissues).

The samples of 0.5 g of liver were preserved in a 2:1 mix of chloroform/ methanol for posterior lipid class analysis [40] then the liver lipid content was detected as [41].

Hepatic lipid= (Absorbance sample/Absorbance standard) x Conc. of standard × (V. of dil. factor/ Wt. of tissues).

2.10. Physiological status:

Blood samples (0.5-1 ml blood), at the end of the investigation periods, were taken randomly from 5 fish/ aquarium, by puncture of the caudal vein, using the heparinized syringes for some plasma parameters, and syringes without anticoagulant for obtained serum, which was separated by centrifuging at 3000 RPM for 10 min [42]. Plasma were subjected to measuring plasma protein (PTP) according to [43]. The immunoglobulin's (IgM and IgD) were assessed according to [44].

2.11. Data statistical analysis

The data were subjected to analysis of variance (ANOVA) using general linear models (GLM) procedure, the software used was SPSS (Version 16.0) [45]. Duncan's multiple range tests by [46] was used to compare between means of the control and treated groups, the model of analysis was as follows:

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

Where: μ = the overall mean; T_i = the effect of treatment; E_{ij} = the random error.

III. Results and Discussion

3.1. Water quality

Physico-chemical data for rearing water were revealed that, water temperature (28.3 ± 1.1 °C), dissolved oxygen (6.18 ± 0.4 mg/L), pH (6.9 ± 0.1) and total ammonia (0.035 ± 0.01 mg/L). All the water parameters are within normal range for rearing tilapia, with a controlled photoperiod (12 h light: 12 h dark) through the experimental period.

3.2. Proximate composition of the three remnants

The dry matter content in the three examined by-products (calyces and peduncles) were recorded 21.44%, 12.04%, and 33.3% for eggplant, pepper and tomato respectively (Table 2). Also, were recorded high values of ash and crude fiber (Fig.1), hence, these products considered a good source of crude fiber and total ash in fish diet. Dried peppers (*Capsicum annum)* contain 13.4% moisture, 12.8% protein, 11.9% fat, 56.2% carbohydrate, 22.5% fiber, and 5.7% ash. Also, reported that fiber is the major compound of tomato pomace on a dry matter basis at 25.4–50.0% and conclude that, other components ranged between 15.4% and 23.7% for total protein, 5.4% and 20.5% total fat, and 4.4% and 6.8% mineral content [47,48]. The dry matter content in eggplant calyx was recorded 21.52 %, while recorded 7.8- 9.1% in eggplant fruit (raw) in different cultivars according to [49].

TABLE 2. Chemical composition of the three examined byproducts.

	ER	PR	TR
Moisture	$78.56^{b}\pm2.83$	$87.96^{a}\pm1.61$	$66.70^{c}\pm2.47$
DM	$21.44^{b}\pm1.94$	$12.04^{c}\pm0.46$	$33.3^{a}\pm2.32$
Protein	$10.50^{a}\pm0.63$	$7.35^{b}\pm0.42$	$7.81^{b}\pm0.14$
Lipid	$12.52^{a}\pm0.24$	$11.21^{b}\pm0.11$	$9.60^{c}\pm0.96$
Ash	$14.12^{a}\pm1.7$	$8.05^{b}\pm0.33$	$14.91^{a}\pm2.03$
Fiber	$23.0^{a}\pm2.30$	$18.50^{c}\pm1.03$	$19.2^{b}\pm2.01$
Carbohydrate	$39.86^{c}\pm2.53$	$54.89^{a}\pm2.45$	$48.48^{b}\pm2.61$

Mean values in the same row with different letters, are significantly different ($P < 0.05$).

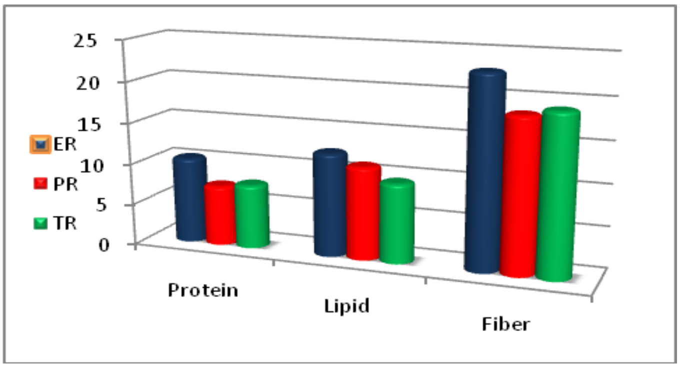

Fig. 1. Chemical composition of the three plant remnants.

3.3. Minerals and vitamins in the three additives.

Eggplant, pepper and tomato by-products (Table 3 & Fig. 2) contains a considerable contents of vitamin C, A, E, K and B [50,51,20]. The differences between the results may due to the variety of the plant species and culture condition. Raky *et*

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al. [5] stated that pineapple by-products contains 24.22 - 29.14 mg/100g vitamin C.

TABLE 3. of vitamins contents of the three plant byproducts

Vitamins	ER	PR	TR
Vit. C (mg/100g)	16.35	21.6	17.52
Vit. K (µg/100g)	3.5	7.4	7.9
Vit. B6 (mg/100g)	0.184	0.224	0.180
Vit. A (µg/100g)	33.80	68.30	42.30
Vit. E (mg/100g)	0.32	0.37	0.54

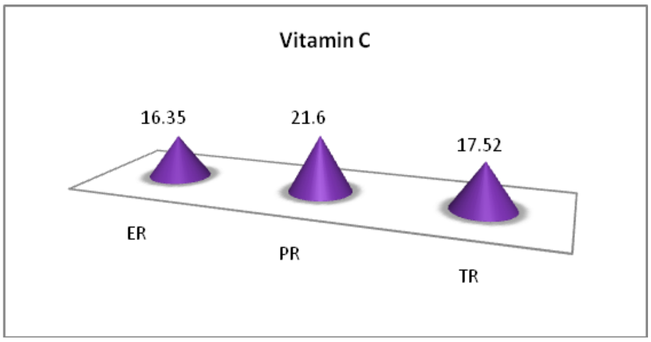

Fig. 2. Vitamin C level of the three residues.

The present results (Table 4), cleared that eggplant, pepper and tomato residues contain a considerable amount of some essential minerals for fish health and growth (Fig.3&4). Potassium was the most abundant element in the three residues, similar with [52,53,51].

Eggplant calyx extract contained minerals and vitamins that higher than the edible part, these minerals are important and useful food supporting the immunity of the body. Studies prove that the some combination elements (phosphorus, potassium and vitamin C) in sufficient amounts for the body, they act as analgesic. Eggplant remnants has a very important sources from these minerals for millions of people and can be an alternative to the mineral deficiency [54,51]. Present study cleared the high value of these vitamins or minerals and how it could protect from certain diseases.

Although there are a little studies describing the mineral content in tomato, pepper and eggplant fruits, there is not enough information about the mineral and vitamins content in tomato, pepper and eggplant calyces and peduncles.

It should be noted that the waste tissues of the three studied residues are considered the best source of antioxidant agents, which can neutralize different free radicals and other reactive oxygen species [55]. Total phenolic compounds from the by-products of eggplant, pepper and tomato were higher than that obtained from the own fruits [54,51].

3.4. Fatty acids in three calyces

Table (5), showed the value of the fatty acid content of the three byproducts and recorded that eggplant residues has highest content of poly-unsaturated fatty acids followed by pepper by-products, while tomato calyces contains highest level of monounsaturated fatty acid Fig. 5 (a ,b). Generally, all residues contains high levels of polyunsaturated fatty acid group, which consists of high level of ω-6 acids (18:2n-6) as shown in Table (5&6) [52,56,53,57].

TABLE. 4. Mineral concentrates (mg/100g) in the three by-products

Concentrate (mg/100g)	ER	PR	TR
Phosphorus	140.0	45.0	41.0
Magnesium	140.0	19.0	39.3
Potassium	712.0	250.0	318.0
Sodium	90.0	30.0	61.1
Iron	4.23	0.74	2.92
Zinc	1.16	0.33	0.17
Manganese	0.43	0.12	0.15
Calcium	157.0	19.0	24.7
Copper	0.28	0.35	0.21
Total	1245.1	364.54	487.55

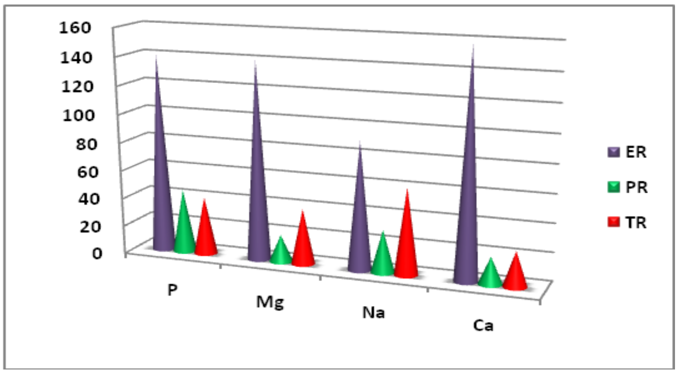

Fig. 3. Main mineral concentrates in the three plant residues.

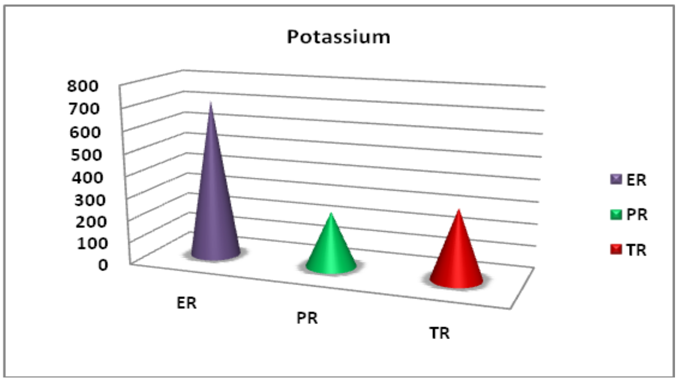

Fig. 4. Potassium concentrate in the three plant by-products.

TABLE 5. Fatty acids groups in the three examined plant remnants

Fatty Acid groups	ER	PR	TR
Total - Saturated	204.11	216.80	190.23
Total-monounsaturated	203.94	203.5	208.21
Total -polyunsaturated	611.89	572.2	489.53
Ω3	98.71	89.2	64.5
Ω6	364.2	341.2	301.45

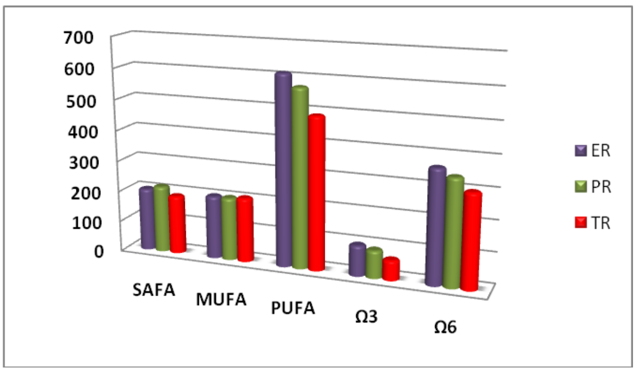

Fig. 5a. Fatty acid groups of the three plant by-products

TABLE 6. Profile of PUFA the three by-products

PUFA content	ER	PR	TR
18:00	46.75	38.2	20.1
18:1n-9	86.22	88.4	89.20
18:1n-7	7.54	7.3	8.11
18:2n-6	364.2	341.2	301.45
18:3n-3	98.71	89.2	64.5
20:00	4.74	4.22	3.02
20:1n-9	0.61	0.7	0.7
22:00	3.12	3.01	2.45

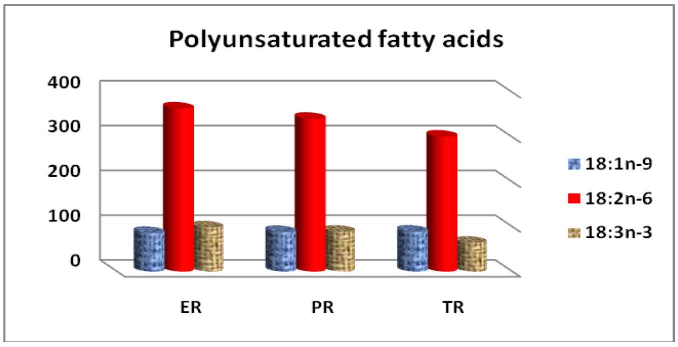

Fig. 5b. Comparison between the dominant PUFAs in the three remnants.

3.5. Amino acids profile of the three by-products.

The present results (Table 7) cleared that the tested residues contains a considerable levels of essential amino acids, where eggplant was the best values (Fig. 6). Glutamic acid was the predominant non-essential amino acid in the three by products [52,53,57].

TABLE 7. Amino acids concentration of three test byproducts.

Amino acids	ER	PR	TR
Tryptophan	0.012	0.01	0.01
Threonine	0.041	0.04	0.03
Isolucine	0.050	0.02	0.02
Leucine	0.061	0.04	0.03
Lysin	0.052	0.04	0.03
Methionine	0.015	0.01	0.01
Cystine	0.015	0.01	0.01
Phenylalanine	0.040	0.09	0.03
Tyrosine	0.031	0.01	0.01
Valine	0.050	0.04	0.02
Arginine	0.061	0.03	0.02
Histidine	0.022	0.01	0.02
Alanine	0.051	0.04	0.03
Aspartic acid	0.163	0.21	0.14
Glutamic acid	0.192	0.19	0.43
Total	0.856	0.79	0.83

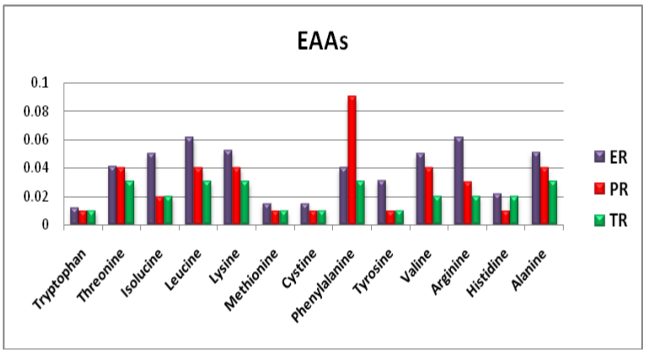

Fig. 6. Essential amino acids profile

3.6. Growth indicators of the test fish fed the additives

Present data (Table 8) showed a distinguished growth performance (FW, WG and DWG) for the fish treated with the three byproducts (ER, PR & TR) more than the control one, the best values were detected for those fed ER (Fig. 7&8). These results may be due to its superb content of bioactive compounds [12]. The data recorded the highest SGR, SR and CF for the three test fish groups especially those fed on ER. Regarding the fish body condition and survival rates (Table 8), the present results proved that it was improved to feed the fish with test diets compared to the control one [58,5].

We hope that those who are interested in health benefit from the eggplant calyces, and do not neglecting them due to richness with nutritional characters [51].

TABLE 8. the growth performance.

Parameters	Experimental diets			
	Control	ER	PR	TR
Initial weight	2.05±0.14	2.04±0.16	2.07±0.19	2.07±0.16
Initial length	$3.03^{a}\pm0.10$	$2.85^{c}\pm0.09$	$3.01^{a}\pm0.13$	$2.96^{b}\pm0.09$
Final weight (FW)	$11.03^{d}\pm1.61$	$13.11^{a}\pm2.04$	$12.44^{b}\pm1.43$	$11.35^{c}\pm1.70$
Final length (FL)	$9.04^{a}\pm1.21$	$8.85^{b}\pm1.32$	$8.91^{b}\pm1.24$	$9.05^{a}\pm1.40$
Condition factor (CF)	$1.49^{d}\pm0.03$	$1.89^{a}\pm0.03$	$1.76^{b}\pm0.05$	$1.53^{c}\pm0.05$
Weight gain (WG)	$8.98^{d}\pm 0.97$	$11.07^{a}\pm1.03$	$10.37^{b}\pm1.06$	$9.28^{c}\pm1.01$
Daily wt. gain (DWG)	$0.128^{c}\pm0.01$	$0.158^{a}\pm0.02$	$0.148^{b}\pm0.01$	$0.133^{c}\pm0.01$
Specific growth SGR	$2.40^{c}\pm0.10$	$2.66^{a}\pm0.09$	$2.56^{b}\pm0.11$	$2.43^{c}\pm0.06$
Survival (SR %)	85	90	90	85

Mean values in the same row with different letters, are significantly different ($P < 0.05$).

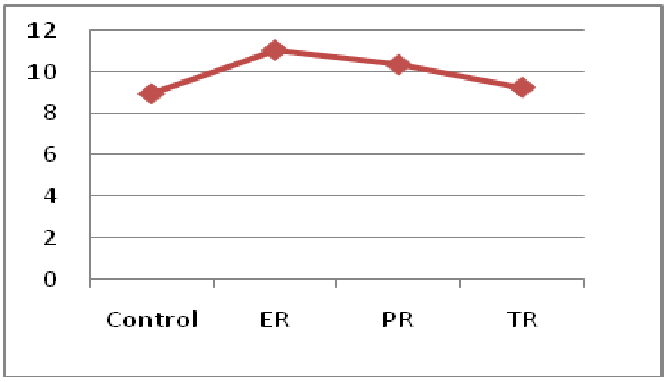

Fig. 7. Mean weight gain of examined fish

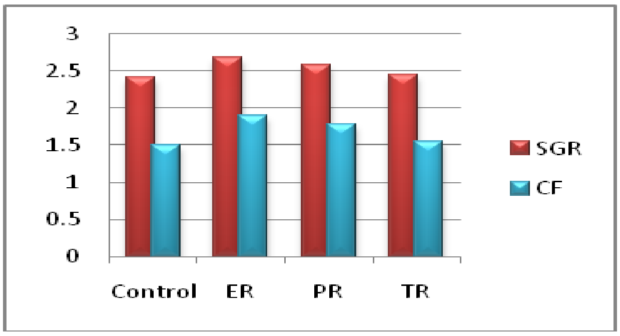

Fig. 8. Specific growth rate and condition factor.

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3.7. Feed retained and digestibility rates

Present results as cleared in Table (9), the best FCR were observed for the fish fed ER additive accompanied with the best PER (Fig. 9) PPV and APD (Fig.10). The digestibility (APD) depends on feed intake and fiber content which increase intestine movement then increase digestibility. Those results may due to the considerable amounts of dietary fibers in present residues, which improved the digestibility, promoting growth performance and feed utilization of the test fish [5].

TABLE 9. The Feed utilized parameters for the three test tilapia fry.

Parameters	Experimental diets			
	Control	ER	PR	TR
FCR	1.13^{a}±0.04	1.05^{b}±0.01	1.08^{b}±0.02	1.12^{a}±0.03
PER	2.43^{d}±0.03	2.69^{a}±0.02	2.62^{b}±0.03	2.51^{c}±0.04
PPV	36.0^{d}±1.61	44.27^{a}±2.04	42.44^{b}±1.43	39.68^{c}±1.70
APD	75.91^{c}±1.21	78.46^{a}±1.32	77.73^{b}±1.24	78.05^{ab}±1.40

Mean values in the same row with different letters, are significantly different ($P < 0.05$).

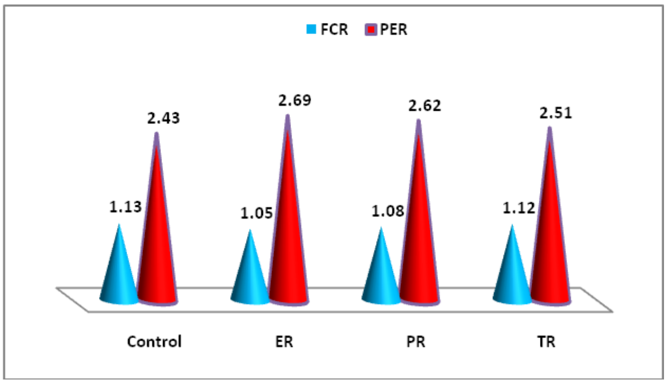

Fig. 9. Feed utilization ratios.

[59,58,60,5] stated that even though, fibers do not supply nutrients to the body, they are essential in the fish diet because fibers promote the health benefits by the use of plant by-products and which are considered a good food ingredient. Insoluble fiber helps to promote regularity and maintain digestive system health.

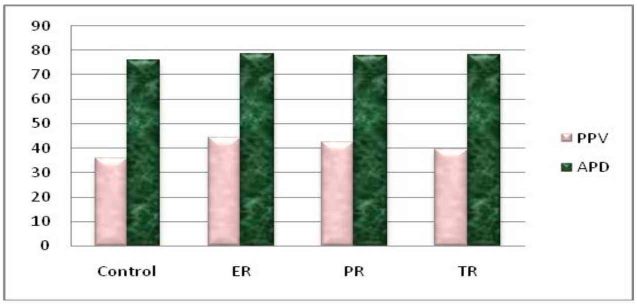

Fig. 10. Protein efficiency and digestibility.

3.8. Fish body composition

Table (10) showed that fish carcass composition were enhanced for those fed the three additives compared with the control one. The highest protein content was recorded for the fish fed ER followed by those fed PR, which accompanied with lower lipid content (Fig. 11). These results may be owing to the abundant of amino acid in these wastes [58,5]. Eggplant residues contain a good amount of protein, that they may be necessary in functional food compositions, even though fruits and vegetables are a poor source of fat.

The present trials resulted that dry matter and ash content were increased for those fed ER and TR. High mineral content in the examined by-products may increase the mineral in fish muscles. [35] stated that the high amount of mineral in fish diet improves the mineralization of body.

TABLE 10. Chemical composition of fish fed on the three additives.

Parameters	Experimental diets			
	Control	ER	PR	TR
DM	25.93^{d}±2.03	27.55^{a}±2.04	27.16^{bc}±1.94	26.91^{c}±1.88
Protein	57.13^{d}±1.95	59.65^{a}±2.01	59.56^{b}±1.84	58.81^{c}±2.11
Lipid	15.30^{a}±0.83	14.63^{d}±0.65	14.90^{c}±1.00	15.14^{b}±0.84
Ash	16.60^{c}±1.21	16.93^{a}±1.32	16.63^{bc}±1.24	16.74^{b}±1.40
NFE	10.97^{a}±0.65	8.79^{d}±0.71	8.91^{c}±0.35	9.31^{b}±0.62
Moisture	74.07^{a}±2.13	72.45^{d}±2.35	72.84^{c}±1.95	73.09^{b}±2.11

Mean values in the same row with different letters, are significantly different ($P < 0.05$).

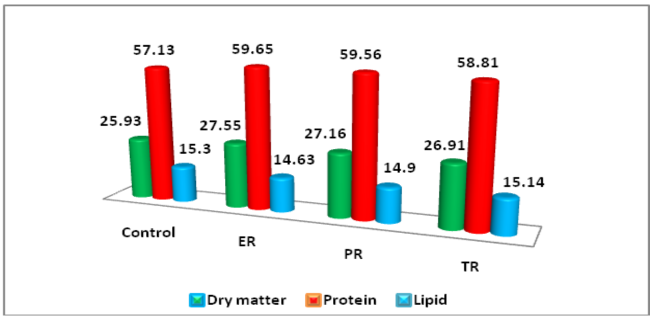

Fig. 11. Carcass composition of the fish fed the three remnants.

3.9. Liver metabolites

Present data were shown in table (11), the liver metabolites, (protein and glycogen) were improved through the three test diets comparing by control fish group, at the same time hepatic lipids were detected the optimum values (Fig. 12). [60,5] recorded an increasing trend for liver protein and glycogen, while hepatic lipids showed an opposite trend.

TABLE 11. Fish hepatic metabolites.(g/ 100g)

Parameters	Experimental diets			
	Control	ER	PR	TR
Hepatic protein (Hp)	17.21^{d}±0.14	18.45^{a}±0.16	17.85^{c}±0.19	18.13^{b}±0.16
Hepatic lipid (Hl)	10.85^{a}±0.10	9.37^{c}±0.09	9.65^{bc}±0.13	9.82^{b}±0.09
Hepatic glycogen (Hg)	1.70^{c}±0.02	1.87^{b}±0.04	1.74^{c}±0.03	2.04^{a}±0.01

Mean values in the same row with different letters, are significantly different ($P < 0.05$).

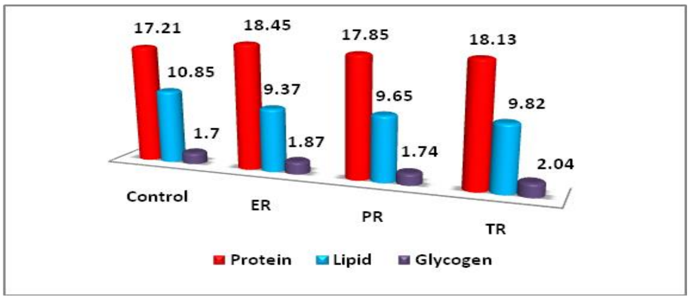

Fig. 12. Liver composition of experimental fish

3.10. Physiological exponents measures

Table (12) clarifies that immunoglobulin (IgM & IgD) and plasma total protein (PTP) revealed better results for the fish groups fed the three additives 2% (Fig. 13&14) than those fed the control groups ($p<0.05$). These results may be owing to the presence of abundant amounts of the phenolics, minerals, vitamins (C, E, B), and amino acids in the current residues [52,53,57].

Family Solanaceae includes; pepper, eggplant and tomato, well known by its high contents of bioactive compounds and great antioxidant effect, and it is among the most popular of fresh vegetables worldwide due to its nutritional value, used not only medicinally but also as a globally food [17,16]. It is interesting that the total phenolics obtained from the by-products of eggplant, pepper and tomato were higher than that determined in the own fruits.

Optimal levels of blood serum proteins improving immune response of fish, and at high level of them provides a strong response [61,62]. Our study cleared a significant increase in plasma proteins, that may be depends on the increasing digestibility of dietary protein [63].

TABLE 12. Biochemical blood parameters

Parameters	Experimental diets			
	Control	ER	PR	TR
PTP	$3.29^{c}\pm0.04$	$4.45^{a}\pm0.04$	$3.85^{b}\pm0.02$	$4.15^{ab}\pm0.05$
IgM	$9.23^{a}\pm0.10$	$8.27^{bc}\pm1.20$	$8.03^{c}\pm1.13$	$8.51^{b}\pm1.09$
IgD	$134.71^{c}\pm2.61$	$142.71^{a}\pm2.04$	$139.86^{b}\pm2.43$	$139.85^{b}\pm3.70$

Mean values in the same row with different letters, are significantly different ($P < 0.05$).

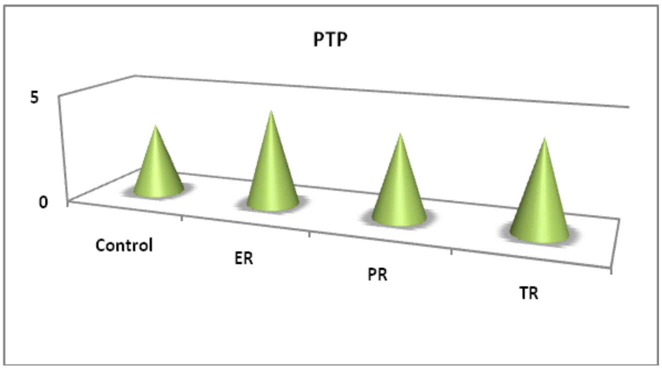

Fig. 13. Plasma total protein of fish.

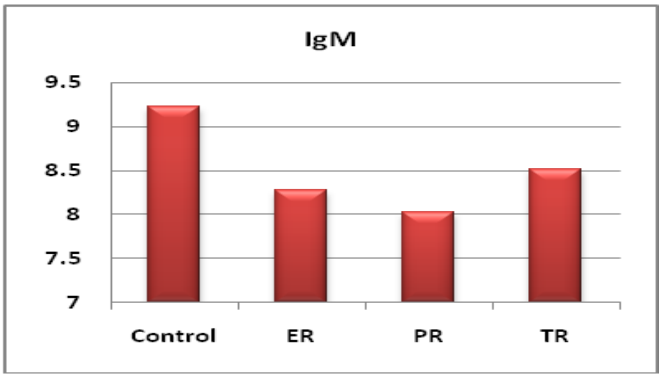

Fig. 14, a. Immune response of test fish.

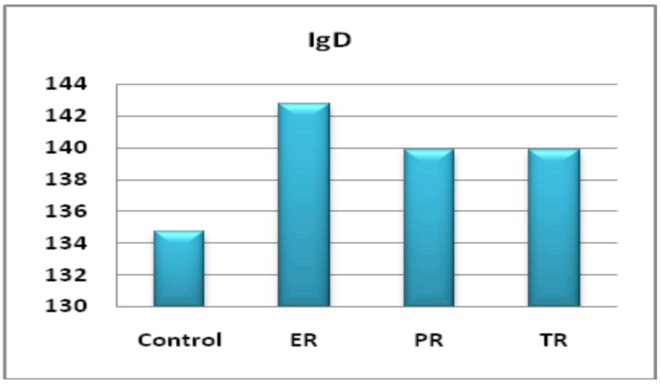

Fig. 14, b. Immune response of test fish.

IV. CONCLUSION AND RECOMMENDATIONS

The data of the current study indicate the possibility of reusing the eggplant, pepper and tomato wastes as additives in enhancement. This would, in turn, reduce the aquaculture feed cost and solve the environmental problem from accumulating residues. We are not sure to get such a special opportunity tilapia feed for obtaining the best quality of fish body and to enhancement fish production. More studies on these residues are required for the sake of fish production and health quality easily without more information by further researches.

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