Effects of dietary olive pomace meal levels on growth performance, feed utilization and bio-economic analysis of juvenile tilapia 
(Tilapia zillii)

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Abstract
The aim of this study was to evaluate the effects of replacing wheat meal with olive pomace meal (at 10%, 20% and 30% ratios) on growth performance, feed utilization and bio-economic analysis of Tilapia zillii. The trial was performed by using four groups and three replications: 10 fish per/aquariums were fed with experimental diets for 45 days. The results of the research did not show any statistically significant differences in the growth parameter among the fish groups that were fed with or without the olive pomace (p>0.05). The use of 20% olive pomace meal diet showed similarities with control group growth performance and specific growth rate results. The best feed conversion ratio was observed in the control group while in the other groups it increased with increasing of olive pomace meal in diets (p>0.05). There place of 10% olive pomace meal in diets showed similarities with the control group on in terms of feed conversion ratio. On the other hand, the feeding costs of the olive pomace groups were found higher than the control fish group. In conclusion, specific proportions of olive pomace meal may be used as an alternative raw source in Tilapia zillii juvenile diet.

Keywords: Tilapia zillii, olive pomace, growth performance, feed efficiency, bio-economic analysis

1. Introduction
Aquaculture sustainability is dependent, in part, upon feed costs in that expensive feed production causes costly feed. Among animal based protein sources the most commonly used is fish meal due to its high protein content amino acid balance and high digestibility (B.D. GLENCROSS & al. [1]). The most expensive feed ingredient is fish meal because of fisheries dependent availability issues. In recent years decline in fish stocks and the increased consumption of fish in human diets have promoted the search for alternative protein sources T. AKIYAMA & al. [2], consequently researchers have focused on replacing fish meal with vegetable protein sources (P. GOMEZ-REQUENI & al. [3]; M.D. HERNANDEZ & al. [4]; Ö. YILDIRIM & al [5]). Plant protein sources should be nutritionally balanced, environmental friendly, cost efficient and readily available. All Mediterranean countries produce large amounts of olive oil products and related pomace (I.S. ARVANITOYANNIS & al.[6]) e.g. in 2013/2014 180.000 tons of olive oil were estimated in Turkey (IOOC, [7]). Olive by-products which remain after the extraction of olive oil called pirina in Turkey can be used in animal feeds. 15-22 kg olive oil and 35-45 kg olive pomace meal were obtained from 100 kg olive (E. KURTULUŞ, [8]).
Tilapia is the second most important species after carp for the aquaculture industry in the world (FAO [9]). Tilapia needs 28-50% protein in their diets for optimum growth (S. Shiau [10]). Tilapia is an omnivorous fish species that can consume a variety of industrial wastes (N.A. Al-Asgah [11]). M.O.A. El-Gendy [12] reported no adverse effects when 25% soybean meal was replaced with broad bean leaves, cucumber and squash in tilapia diets. Further, N.A. Al-Asgah [11] demonstrated that olive pomace meal can be substituted for wheat meal in Nile tilapia (*Oreochromis niloticus*) diets up to 25%. Some earlier studies have shown promising results on the utilization of olive by-products for feeding ruminants (A. Mohebbifar & al. [13]). However, only limited information is available on the use of olive pomace meal in fish diets.

The aim of this study was to evaluate the effects on growth performance, feed evaluation and bio-economic analysis when replacing wheat meal with olive pomace meal as the raw material in practical diets for *Tilapia zillii* juveniles.

2. Materials and Methods

Olive pomace meal which contains 8.28% crude protein and 9.2% crude lipid was obtained from a local olive oil factory. A total of 120 *Tilapia zillii* with about 3.95±0.02 g initial body weight were captured from Köyceğiz Lake, Muğla, using a small hand net in one hour. Fish were held in circular tanks for 15 days to adapt to the new rearing conditions. Then ten fish were weighed and distributed into twelve aquariums of 84 L (35 cm x 45 cm x 60 cm) in a recirculation fresh water system equipped with aeration and filtration systems. Water temperature ranged from 21.2° C to 25.9° C (average 23.5). Fish were kept under a constant photoperiod (12 h light/ 12 h dark). Three replications per treatment were performed. Four diets (isonitrogenic and isocaloric, 35% CP and 9% CL) were formulated using commercial ingredients (Table 1). The dry ingredients weighed were carefully mixed with a laboratory food mixer. The mixtures were primed with water to yield a suitable pulp. Wet diets were made into 2 mm pellet size and dried at 40 °C in a drying cabinet. The diets were stored at -20°C until usage. During the first week fish were fed by hand to satiety five times a day with 8% of their body weight and 6% during the second, third and other weeks for 45 days.

<table>
<thead>
<tr>
<th>Ingredients (%)</th>
<th>Control</th>
<th>10% OWM</th>
<th>20% OWM</th>
<th>30% OWM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish meal</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Olive pomace meal (OWM)</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Corn gluten</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Wheat meal</td>
<td>45.5</td>
<td>36.5</td>
<td>27.5</td>
<td>18.1</td>
</tr>
<tr>
<td>Fish oil</td>
<td>2.5</td>
<td>2</td>
<td>1.5</td>
<td>1.2</td>
</tr>
<tr>
<td>Vegetable oil</td>
<td>2.5</td>
<td>2</td>
<td>1.5</td>
<td>1.2</td>
</tr>
<tr>
<td>Vitamin</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Mineral</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Antioxidant</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**Chemical analyses (% dry matter)**

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>10% OWM</th>
<th>20% OWM</th>
<th>30% OWM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude protein</td>
<td>35.45</td>
<td>35.23</td>
<td>35.03</td>
<td>34.88</td>
</tr>
<tr>
<td>Crude lipid</td>
<td>9.04</td>
<td>8.76</td>
<td>8.57</td>
<td>8.77</td>
</tr>
<tr>
<td>Crude ash</td>
<td>5.03</td>
<td>6.35</td>
<td>7.56</td>
<td>9.04</td>
</tr>
</tbody>
</table>
Data on weight gain were collected on days 15, 30 and 45 after the start of experiment. Growth performance of tilapia fed with different olive pomace meal level diets was considered by calculating relative growth rate (RGR %), specific growth rate (SGR % day⁻¹) and feed conversion rate (FCR).

\[
\text{RGR} \, (\%) = \frac{\text{final weight (g)} - \text{initial weight (g)}}{\text{initial weight (g)}} \times 100
\]
\[
\text{SGR} \, (\% \text{ day}^{-1}) = \frac{\ln \text{final weight (g)} - \ln \text{initial weight (g)}}{\text{days}} \times 100
\]
\[
\text{FCR} = \frac{\text{feed intake (g)}}{\text{weight gain (g)}}
\]

Statistical analysis included one-way analysis of variance (ANOVA) and Tukey’s multiple significant difference tests using the software program (Minitab 16 for windows). Differences were regarded as significant when p<0.05 level.

3. Results and Discussion

Experimental diets well accepted by the fish. All groups increased weight during the experiment. Result about fish growth performance (RGR), feed conversion ratio (FCR) and specific growth rate (SGR) is shown in Table 2. Final weight, FCR, and SGR were affected by the increase of olive pomace meal in diets (p>0.05).

Table 2 Growth performance of *Tilapia zillii* juveniles fed diets with different levels of olive pomace meal for 45 days culture period

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Control</th>
<th>10% OWM</th>
<th>20% OWM</th>
<th>30% OWM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial weight (g)</td>
<td>3.94±0.00</td>
<td>3.95±0.02</td>
<td>3.94±0.02</td>
<td>3.96±0.03</td>
</tr>
<tr>
<td>Final weight (g)</td>
<td>5.38±0.69a</td>
<td>4.95±0.12a</td>
<td>5.28±0.05a</td>
<td>5.11±0.25a</td>
</tr>
<tr>
<td>RGR %</td>
<td>36.38±17.6a</td>
<td>25.22±3.51a</td>
<td>34.08±0.83a</td>
<td>28.91±6.15a</td>
</tr>
<tr>
<td>FCR</td>
<td>6.03±0.54a</td>
<td>6.97±1.31a</td>
<td>7.40±0.34a</td>
<td>8.07±1.17a</td>
</tr>
<tr>
<td>SGR</td>
<td>0.68±0.29a</td>
<td>0.50±0.06a</td>
<td>0.65±0.01a</td>
<td>0.56±0.11a</td>
</tr>
</tbody>
</table>

Values with different superscripts in the same row are significantly different (p<0.05)

As expected the cost of diets was decreased with the increase of dietary olive pomace meal level. Overall the profit values in the control groups were higher than the all groups (Table 3).

Level of acceptance/rejection by fish is a common problem associated with the use of vegetable protein sources as an alternative foodstuff in fish diets (S.M. RODRIGUEZ & al. [14]). In the present experiment, all diets were accepted by fish using olive pomace meal in fish diets did not affect palatability of the diets. The present study agreed with N.A. AL-ASGAH [11] who said that olive pomace meal can be used as a substitute to wheat meal up to level 25% in the Nile tilapia diets without negative effects on growth performance and feed utilization. The increase of olive waste in tilapia diets increased the overall crude fiber contents of the diets which could be attributed to the higher crude fiber content of olive waste (39.62%). The increase in dietary fiber content might have affected the overall digestibility of the fish diets that could be held responsible for reduction in growth performance and efficiency of feed utilization. V. VIYAKRAN & al. [15] reported that low lysine and methionine contents within vegetable protein sources affected fish growth and feed efficiency adversely. C. NASOPOULOU & al. [16] reported significant poor feed conversion ratios and
Effects of dietary olive pomace meal levels on growth performance, feed utilization and bio-economic analysis of juvenile tilapia (*Tilapia zillii*).

Low specific growth rate in sea bass when using olive pomace meal and olive waste oil instead of fish meal and oil in the diets. The lack of growth performance could be attributed to the metabolic capacities of sea bass. A. POLAT [17] studied the effects of supplementing soybean meal-based diets with methionine in *Tilapia zillii* diets and reported that 0.5% methionine supplement resulted in higher growth performance. In a similar vein, (E. RABAYA & al. [18]; A.Z. MEHREZ & MOUSA, [19]; A. MOHEBBIFAR & al. [13]) reported that the inclusion of olive waste product was possible in ruminants e.g. rabbits and broiler chicken diets at levels of 7.5 - 25%. In addition, A.A. GHAZALAH & A.A. EL-SHAAT [20] declared that olive kernel meal can be used in rabbit diet up to 50%. Conversely, B. MIOC & al. [21] reported that high levels (30%) of olive cake addition decreased the final weight of lambs. A. DAL BOSCO & al. [22] recommended the use of olive pomace in rabbit diets to improve growth performance and meat quality. Also in Iranian fat-tailed sheep diets olive pulp silage can be used up to 70% with 30% alfalfa hay without any negative effects (Z. FARAJI & al. [23]). M.A. ADEWOLU [24] conducted a study with *Tilapia zillii* fingerlings to determine the potential of sweet potato leaf meal in diets and reported that sweet potato leaf meal can be used as a potential protein source up to 15% level without stressed growth performance. *Azollapinnata* (25%) can be used instead of fish meal in *Tilapia zillii* diets (M. ABDEL-TAWWAB [25]). Vegetable protein sources with an antinutritional factor might depress growth performance and feed utilization (Ö. YILDIRIM & al. [5]). Poultry by-product meal can be used up to 50% instead of fish meal in *Tilapia zillii* diets (Ö. YILDIRIM & al. [5]). Ö. YILDIRIM & al. [5] reported that with suitable processing methods poultry by-products can replace diets 100%. In this study tilapia were captured in nature. Therefore growth parameters may be affected adversely by increasing olive pomace meal in diets. Results of this study showed that the inclusion of 10% and 30% of olive pomace product meal produced poorer growth performance and feed evaluation compared to the inclusion of 20% olive pomace meal. In contrast, J.W. HERTRAMPF & F. PIEDAD-PASCUAL [26] noted that the inclusion rate of olive pulp should not exceed 10%.

### Table 3 Bio-economic analyses of *Tilapia zillii* juveniles fed diets with different levels of olive pomace meal for 45 days culture period

<table>
<thead>
<tr>
<th>Groups</th>
<th>Cost of feed (USD/kg)</th>
<th>Cost of fish (USD/kg)</th>
<th>Feeding cost (USD/kg)</th>
<th>Profit (USD)</th>
<th>Feed cost as % of fish cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.67</td>
<td>6</td>
<td>4.70</td>
<td>2.30</td>
<td>67.34</td>
</tr>
<tr>
<td>10% OWM</td>
<td>0.64</td>
<td>6</td>
<td>5.23</td>
<td>1.77</td>
<td>74.35</td>
</tr>
<tr>
<td>20% OWM</td>
<td>0.62</td>
<td>6</td>
<td>5.40</td>
<td>1.60</td>
<td>76.47</td>
</tr>
<tr>
<td>30% OWM</td>
<td>0.60</td>
<td>6</td>
<td>5.73</td>
<td>1.27</td>
<td>80.70</td>
</tr>
</tbody>
</table>

Feeding cost ($) = FCR × cost of feed ($) ; Profit ($) = Cost of fish ($) – feeding cost ($) ; Feed cost as % of fish cost = (feeding cost ($) / cost of fish ($) ) × 100

Regarding economic efficiency of experimental diets, the reduction or increase in cost of diets are related to olive pomace meal levels in the diet. The profit and feed costs as percent of profit values in the present study were also lower than those reported for marine species diets by M. YIGIT & al. [27]. However, I. OKUMUŞ & M.D. MAZLUM [28] informed that profits from the feed provided maximum, and minimum final weights were very close. These differences could be attributed to the difference between the FCR values in the treatments.
Bio-economic analysis of feeds displayed that feeding cost and percentage feed cost over fish cost with olive pomace groups were higher than control. However, fish fed with or without the olive pomace meals among the groups on the growth parameter did not differ statistically significant (p>0.05).

4. Conclusions
In the results of this study show that dietary olive pomace meal could replace wheat meal 20% levels in Tilapia zillii juvenile diets without any adverse effects on growth performance and feed evaluation. When olive pomace meal used as feed ingredients in tilapia diets that may help to develop cost effective fish feeds. Dietary olive pomace meals are natural by-products available inexpensively and not genetically modified throughout the year. Further investigations are necessary to examine dietary contribution rates in cultured fish.

References
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