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Effect of dietary phytoextracts supplementation on the chemical composition and fatty acid profile of rainbow trout (Oncorhynchus mykiss W.), cultivated in recirculation system

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Abstract. The present research aimed to examine the effect of dietary phytoextracts supplementation on the chemical composition and fatty acid profile in the meat of rainbow trout (Oncorhynchus mykiss W.), cultivated in a recirculation system. The fish were divided into 6 groups: one control (C) and five experimental groups in the food of which phytoextracts of curcumin (EC), paprika (EP), thyme (ET), oregano (EO) and garlic (EG) were added. The inclusion of phytoextracts had no significant effect on growth parameters of fish from EC, EP, ET, EO and EG groups (P>0.05). No statistical differences on water content, protein and lipids were observed in the meat of fish from the control and the experimental groups (P>0.05). Statistically significantly higher value of the dry matter was established in ET group in comparison with C, EC, EP, EO and EG groups (Ps<0.001). The values of ash were significantly lower in fish from all experimental groups compared to the control group. The inclusion of phytoextracts did not affect the fatty acid profile of fish from EP, EO and EG groups (P>0.05). Exceptions are EC and ET groups, which had the lowest value of C18:3 n-3 e-linolenic compared to those from the control group (Ps<0.05, Ps<0.001).

Keywords: rainbow trout, phytoextracts, chemical composition, fatty acid profile

Introduction

The rainbow trout (Oncorhynchus mykiss W.) is native species to areas of the Pacific Ocean in Asia and North America, which in relatively short time has been introduced into at least 45 countries and territories (Gabor et al., 2012). In a number of countries, including Bulgaria, experiments have been conducted with rainbow trout, cultivated in different types of ponds and recirculating systems (Farahi et al., 2010, 2010; Ahmadifar et al., 2011; Gabor et al., 2011; Zheliazkov, 2014).

Many countries have forbidden the use of antibiotics and chemicals, and refuse to import aquaculture products treated with them. Therefore, researchers are looking for methods to develop alternative dietary supplements such as herbs and plants that increase growth performance, health and immune system of cultured fish instead of the use of chemotherapeutic agents. There are reports which have documented the positive effects of herbs as appetizers and growth promoters in aquatic species (Syahidah et al., 2015). A number of researchers established higher weight gain in different fish species (including rainbow trout) as a result of the addition to extruded pellet plant extracts, such as garlic, oregano, paprika, thyme, curcumin, ginger, echinacea, etc. (Ahmadifar et al., 2011; Gabor et al., 2011; Jegede, 2012; Antache et al., 2013; Maniat et al., 2014; Mahmoud et al., 2017).

According to recent studies, fish lipids are a rich source of long chain n-3 polyunsaturated fatty acids, especially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). These fatty acids are considered to be some of the most important ingredients for human health, nutrition and disease prevention. The humans cannot synthesize the long chain n-3 PUFA and they receive them through the diet. The content of these fatty acids differs among species and it is not a constant. A number of factors such as size, age, reproductive cycle, salinity, temperature, diet, season and geographical location can influence the amount of n-3 PUFA (Kalyoncu et al., 2009).

The present research aimed to examine the effect of dietary phytoextracts supplementation on the chemical composition and fatty acid profile in the meat of rainbow trout (Oncorhynchus mykiss W.), cultivated in a recirculation system.

Material and methods

Experimental design

The rainbow trout used in this study were raised in concrete tanks with efficient water volume 0.8 m³, part of a recirculation system. Fish were divided into six groups of 20 fish each: one control (C) and five experimental groups whose feed was supplemented with curcumin (EC), paprika (EP), thyme (ET), oregano (EO) and garlic (EG). Each of the trial variants was with two replications. The trout were fed with extruded pellets produced by "Aqua garant" Co (Bulgaria), with pellet size 3mm, three times per day. The feed of the fish from the experimental groups was supplemented with 1% dry extract of the different spices, mentioned above. It was dissolved in 1ml distilled water and sprayed onto 100g feed one hour before feeding. The specimens from the control group (C) did not receive any phytoextracts. The nutritional content of the extruded feed for the different groups is presented in Table 1. The duration of the experiment was 80 days.

After the trial period, four fish of each group were randomly selected for evaluation of the chemical and fatty acid composition in the fillets. The experiment was conducted in accordance with the requirements of Regulation 201/11.12.2012 for minimum requirements for the protection and welfare of experimental animals and the requirements to sites for use, growth and/or their delivery.
Chemical composition

Meat samples were prepared according to AOAC (2006; method 983.18) and subjected to determination of water content (%) using air drying (AOAC, 1997; method 950.48). Crude protein content (%) was calculated by converting the nitrogen content, quantified by Kjeldahl’s method, using an automatic Kjeldahl system (Kjeltec 8400, FOSS, Sweden). Lipid content (%) was determined by the method of Soxhlet, using an automatic system (Soxtec 2050, FOSS, Sweden). Ash content (%) was investigated by incineration in a muffle furnace (MLW, Germany) at 550°C for 8h. Crucibles were brought about the room temperature and weighed.

Fatty acid composition

The determination of fatty acid composition (%) of the total lipids of the trout is carried out by the application of a gas chromatographic method, using a gas chromatograph HP 5890 II with a flame ionization detector, 60m a capillary column "DB - 23"; column temperature – 130°C (1 min), with change 6.5°C/min to 170°C, with change 3.0°C/min to 215°C (12 min) 40.0/min to 230°C (1 min), detector temperature 280°C; injector temperature – 270°C, gas holder – hydrogen (H₂), split: 1:50 and software Data Apex Clarity TM 2.4.1.93/2005.

Statistical evaluation

The results were statistically evaluated to determine the effect of the phytoextracts in the diet of trout on the chemical and fatty acid composition of the fillets. The statistical evaluation was performed using STATISTICA 6.0 software, t – test, independent by variables (StatSoft Inc., 2002).

Results

Growth performance

At the end of the trial, individual weight gain of fish from ET group was the highest -141.33±32.67g compared to those from the control and the other experimental groups by 9.03% (C), 9.98% (EC), 16.36% (EP), 2.53% (EO) and 2.12% (EG), but the differences between groups were statistically insignificant (P>0.05). Survival rates of fish from control and experimental groups were as follows: C – 90%, EC – 93%, EP – 83%, ET – 90%, EO – 93%, and EG – 88%. The value of this parameter is higher in fish from EC and EO by 3-10% from the one of specimens from the other groups.

Chemical composition

Lower water content was established in fish fed with pellets, added with thyme extract (ET), although the values of this parameter in fish from control and experimental groups were almost equal (P>0.05) (Table 2). The same tendency was observed in fish from control group and EC, ET, EO, EG groups concerning the protein content. Its value was the lowest in rainbow trout from EG group with no significant differences among groups (P>0.05). The addition of dietary phytoextract did not change significantly the lipid content in the meat of rainbow trout from the control and experimental groups. The lower lipid content was found in fish receiving curcumin extract, however the differences among groups were statistically insignificant (P>0.05). The inclusion of thyme extract influenced significantly the dry matter content. Its content in the fillets of fish from ET group was significantly higher vs that of control and experimental groups by 2.60% (C), 1.19% (EC), 4.79% (EP) 0.99% (EO) and 0.38% (EG) (P≤0.001).

Table 1. Nutritional content in the trout feed

<table>
<thead>
<tr>
<th>No.</th>
<th>Parameters</th>
<th>C</th>
<th>EC</th>
<th>EP</th>
<th>ET</th>
<th>EP</th>
<th>EG</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Crude protein, %</td>
<td>45.00</td>
<td>45.00</td>
<td>45.00</td>
<td>45.00</td>
<td>45.00</td>
<td>45.00</td>
</tr>
<tr>
<td>2</td>
<td>Crude fat, %</td>
<td>16.00</td>
<td>16.00</td>
<td>16.00</td>
<td>16.00</td>
<td>16.00</td>
<td>16.00</td>
</tr>
<tr>
<td>3</td>
<td>Crude fibre, %</td>
<td>2.40</td>
<td>2.40</td>
<td>2.40</td>
<td>2.40</td>
<td>2.40</td>
<td>2.40</td>
</tr>
<tr>
<td>4</td>
<td>Crude ash, %</td>
<td>8.00</td>
<td>8.00</td>
<td>8.00</td>
<td>8.00</td>
<td>8.00</td>
<td>8.00</td>
</tr>
<tr>
<td>5</td>
<td>Calcium, %</td>
<td>1.60</td>
<td>1.60</td>
<td>1.60</td>
<td>1.60</td>
<td>1.60</td>
<td>1.60</td>
</tr>
<tr>
<td>6</td>
<td>Phosphorus, %</td>
<td>1.20</td>
<td>1.20</td>
<td>1.20</td>
<td>1.20</td>
<td>1.20</td>
<td>1.20</td>
</tr>
<tr>
<td>7</td>
<td>Curcumin, %</td>
<td>-</td>
<td>1.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>Paprika, %</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>9</td>
<td>Thyme, %</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td>Oregano, %</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
<td>-</td>
</tr>
<tr>
<td>11</td>
<td>Garlic, %</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
</tr>
<tr>
<td>12</td>
<td>Metabolisable energy, MJ/kg</td>
<td>18.50</td>
<td>18.50</td>
<td>18.50</td>
<td>18.50</td>
<td>18.50</td>
<td>18.50</td>
</tr>
</tbody>
</table>

*C – control group; EC – group+curcumin; EP – group+paprika: ET – group+thyme; EO – group+oregano; EG group+garlic (EG);

**1 kg compound feed contains: vitamin A – 10000 IU; vitamin D3 – 1500 IU; vitamin E – 200 mg; vitamin C – 150 mg;

***1 kg compound feed contains: Fe – 62 mg; Mn – 26 mg; Cu – 5 mg; Zn – 103 mg; J – 2.6 mg; Se – 0.3 mg.
In the present study we observed significant decrease of ash content in fish from the experimental groups. In the fillets of rainbow trout from the experimental groups the ash content was lower than that of the control group by 10.45% (EC), 4.58% (EP), 8.80% (ET), 5.23% (EO) and 13.07% (EG) (Table 2).

**Fatty acid composition**

The fatty acid composition in the fillets of rainbow trout, cultivated in a recirculation system is presented in Table 3. The addition of phytoextract to the diet had no effect on the contents of C14:0 and C16:0 in the fish from the control and experimental groups (P>0.05). No significant influence was noticed on the content of C16:0 in the fillets of trouts from the control and the other groups and it was the lowest in EP group. No statistical differences in the content of C18:0 were observed in fish from C, EC, EP, ET, EO and EG groups (P>0.05). The inclusion of phytoextracts did not change the total content of the saturated fatty acids (SFA) in the meat of fish from the experimental groups (P>0.05).

**Table 2.** Chemical composition of the fillets of rainbow trout (*Oncorhynchus mykiss* W.), cultivated in a recirculation system

<table>
<thead>
<tr>
<th>Parameter</th>
<th>n</th>
<th>C ± SD</th>
<th>EC ± SD</th>
<th>EP ± SD</th>
<th>ET ± SD</th>
<th>EO ± SD</th>
<th>EG ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water, %</td>
<td>4</td>
<td>75.85±2.09</td>
<td>73.98±0.85</td>
<td>74.94±0.66</td>
<td>73.68±0.09</td>
<td>73.93±0.42</td>
<td>73.77±0.35</td>
</tr>
<tr>
<td>Protein, %</td>
<td>4</td>
<td>19.43±0.40</td>
<td>20.30±1.07</td>
<td>19.22±0.22</td>
<td>19.65±0.62</td>
<td>19.57±0.18</td>
<td>19.14±0.16</td>
</tr>
<tr>
<td>Lipids, %</td>
<td>4</td>
<td>4.70±0.44</td>
<td>4.35±0.20</td>
<td>4.39±0.45</td>
<td>5.30±0.74</td>
<td>5.06±0.23</td>
<td>5.77±0.20</td>
</tr>
<tr>
<td>Dry matter, %</td>
<td>4</td>
<td>25.65±0.03&lt;sup&gt;a&lt;/sup&gt;</td>
<td>26.02±0.85</td>
<td>25.07±0.66</td>
<td>26.33±0.09&lt;sup&gt;***&lt;/sup&gt;</td>
<td>26.07±0.42</td>
<td>26.23±0.35</td>
</tr>
<tr>
<td>Ash, %</td>
<td>4</td>
<td>1.53±0.01&lt;sup&gt;b,c,d&lt;/sup&gt;</td>
<td>1.37±0.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.46±0.01&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.38±0.03&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.45±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.33±0.01&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

*<sup>a</sup>C – control group; EC – group+curcumin; EP – group+paprika; ET – group+thyme; EO – group+oregano; EG group+garlic (EG);
*<sup>b</sup>**Values with same superscripts in the same row are significantly different, (P<0.05) ***P ≤ 0.001; **P ≤ 0.01; *P ≤ 0.05.

**Table 3.** Fatty acid composition of the fillets of rainbow trout (*Oncorhynchus mykiss* W.), cultivated in a recirculation system

<table>
<thead>
<tr>
<th>Fatty acids, %</th>
<th>n</th>
<th>C ± SD</th>
<th>EC ± SD</th>
<th>EP ± SD</th>
<th>ET ± SD</th>
<th>EO ± SD</th>
<th>EG ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>C14:0 Myristic</td>
<td>4</td>
<td>1.95±0.64</td>
<td>1.45±0.07</td>
<td>1.25±0.07</td>
<td>1.40±0.14</td>
<td>1.35±0.21</td>
<td>1.45±0.07</td>
</tr>
<tr>
<td>C16:0 Palmitic</td>
<td>4</td>
<td>15.75±2.19</td>
<td>13.45±0.49</td>
<td>12.60±0.14</td>
<td>13.35±0.92</td>
<td>14.15±1.06</td>
<td>13.15±1.48</td>
</tr>
<tr>
<td>C16:1 Palmoleic</td>
<td>4</td>
<td>2.35±0.49</td>
<td>1.90±0.14</td>
<td>1.80±0.14</td>
<td>2.00±0.28</td>
<td>1.85±0.07</td>
<td>2.10±0.28</td>
</tr>
<tr>
<td>C18:0 Stearic</td>
<td>4</td>
<td>3.85±0.49</td>
<td>3.75±0.21</td>
<td>3.65±0.07</td>
<td>3.60±0.00</td>
<td>4.30±0.71</td>
<td>3.60±0.42</td>
</tr>
<tr>
<td>C18:1 Oleic</td>
<td>4</td>
<td>48.8±0.13</td>
<td>51.25±1.91</td>
<td>51.90±0.57</td>
<td>49.95±1.91</td>
<td>51.15±0.92</td>
<td>50.10±2.12</td>
</tr>
<tr>
<td>C18:2 Linoleic</td>
<td>4</td>
<td>14.75±1.34</td>
<td>15.80±1.13</td>
<td>15.85±0.17</td>
<td>16.55±0.35</td>
<td>14.15±1.20</td>
<td>16.60±0.28</td>
</tr>
<tr>
<td>C18:3n-3-Linolenic</td>
<td>4</td>
<td>5.55±0.07&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.90±0.14&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.20±0.28</td>
<td>4.65±0.07&lt;sup&gt;***&lt;/sup&gt;</td>
<td>5.45±0.07</td>
<td>5.40±0.57</td>
</tr>
<tr>
<td>C20:2 Eicosadienoic</td>
<td>4</td>
<td>0.30±0.00</td>
<td>0.30±0.00</td>
<td>0.30±0.00</td>
<td>0.25±0.07</td>
<td>0.50±0.28</td>
<td>0.30±0.00</td>
</tr>
<tr>
<td>C20:3 Eicosatrienoic</td>
<td>4</td>
<td>0.60±0.14</td>
<td>0.65±0.07</td>
<td>0.65±0.07</td>
<td>0.80±0.00</td>
<td>0.80±0.14</td>
<td>0.55±0.07</td>
</tr>
<tr>
<td>C20:4 Arachidonic</td>
<td>4</td>
<td>0.40±0.00</td>
<td>0.50±0.12</td>
<td>0.50±0.00</td>
<td>0.60±0.00</td>
<td>0.50±0.12</td>
<td>0.40±0.00</td>
</tr>
<tr>
<td>C20:5 Eicosapentaenoic</td>
<td>4</td>
<td>0.70±0.00</td>
<td>0.80±0.28</td>
<td>0.80±0.00</td>
<td>0.75±0.07</td>
<td>0.45±0.35</td>
<td>0.85±0.21</td>
</tr>
<tr>
<td>C22:6 Docosahexaenoic</td>
<td>4</td>
<td>2.40±0.07</td>
<td>3.05±1.34</td>
<td>3.00±0.57</td>
<td>3.70±0.28</td>
<td>2.50±0.42</td>
<td>3.20±0.85</td>
</tr>
<tr>
<td>SFA</td>
<td>22.75±2.33</td>
<td>10.70±13.44</td>
<td>18.55±0.21</td>
<td>19.40±1.13</td>
<td>21.25±2.05</td>
<td>19.40±2.12</td>
<td></td>
</tr>
<tr>
<td>UFA</td>
<td>77.25±2.33</td>
<td>80.30±0.71</td>
<td>81.45±0.21</td>
<td>80.60±1.13</td>
<td>78.75±2.05</td>
<td>80.60±2.12</td>
<td></td>
</tr>
<tr>
<td>MUFA</td>
<td>51.80±0.57</td>
<td>53.70±2.12</td>
<td>54.30±0.71</td>
<td>52.50±1.56</td>
<td>53.55±0.78</td>
<td>52.75±2.33</td>
<td></td>
</tr>
<tr>
<td>PUFA</td>
<td>25.45±1.77</td>
<td>26.60±2.83</td>
<td>27.15±0.92</td>
<td>28.10±0.42</td>
<td>25.20±1.27</td>
<td>27.80±0.28</td>
<td></td>
</tr>
<tr>
<td>n-6</td>
<td>16.80±1.13</td>
<td>17.85±1.34</td>
<td>18.15±0.07</td>
<td>19.00±0.14</td>
<td>16.80±0.57</td>
<td>18.35±0.21</td>
<td></td>
</tr>
<tr>
<td>n-3</td>
<td>8.65±0.64</td>
<td>8.75±1.48</td>
<td>9.00±0.85</td>
<td>9.10±0.28</td>
<td>8.40±0.71</td>
<td>9.45±0.49</td>
<td></td>
</tr>
<tr>
<td>n-6/n-3 ratio</td>
<td>1.95±0.07</td>
<td>2.05±2.05</td>
<td>2.05±0.21</td>
<td>2.10±0.00</td>
<td>2.00±1.14</td>
<td>1.95±0.07</td>
<td></td>
</tr>
</tbody>
</table>

*<sup>a</sup>C – control group; EC – group+curcumin; EP – group+paprika; ET – group+thyme; EO – group+oregano; EG – group+garlic (EG);
*<sup>b</sup>**Values with same superscripts in the same row are significantly different, (P<0.05);
*<sup>c</sup>P ≤ 0.05, **P ≤ 0.001;
***SFA – Saturated fatty acids; UFA – Unsaturated fatty acids; MUFA – Monounsaturated fatty acids; PUFA – Polynsaturated fatty acids; n-6= ΣC18:2;C20:2;C20:3;C20:4; n-3= ΣC18:3n-3;C20:5;C22:6.
The phytoextract supplementation in the fish feed had no effect on the contents of C18:1 and C16:1 and the differences among the groups were insignificant \((P>0.05)\). The higher values of C18:1 were observed in EC, EP, ET, EO and EG groups. The content of C16:1 was the lowest in EP group. In the present study we observed a tendency of significant decrease in the content of C18:3n-3 in the meat of the experimental fish. The amount of linoleic acid of fish from the control group was significantly higher than those from EC and ET groups 13.26\% \((P \leq 0.05)\) and 19.35\% \((P \leq 0.001)\) respectively. The dietary phytoextracts supplementation led to insignificant differences between groups, concerning the content of C18:2. Nevertheless, the lowest value was observed in EO group and the highest in EP group.

No significant influence of the added phytoextracts was found on the content of C20:2 \((P>0.05)\) in the meat of rainbow trout. The lowest value was established in ET group and the highest in EO group. The inclusion of curcumin, paprika, thyme, oregano and garlic did not have significant effect on the content of C20:3. The lowest value of eicosapentaenoic acid was registered in EG group. The addition of phytoextracts had no influence on the amount of arachidonic acid and the differences between the groups were insignificant \((P>0.05)\). There were no significant differences between C and experimental groups, concerning the content of C20:5 and C22:6. The content of eicosapentaenoic acid was the lowest in EO group. No significant effect was observed on the total content of SFA in rainbow trout from C and experimental groups \((P>0.05)\). The content of SFA was higher in fish from C group.

The amounts of UFA were higher in the experimental groups, supplemented with curcumin, paprika, thyme, oregano and garlic extracts, with no differences between groups \((P>0.05)\).

The dietary phytoextracts supplementation led to insignificant effects between fish from the control and experimental groups in regards to the amounts of MUFA. However, the higher values of these fatty acids were established in EC, EP, ET, EO and EG groups \((P>0.05)\).

The influence of the added phytoextracts did not change the content of PUFA in the meat of fish from the experimental groups. However, the higher amounts of PUFA were found in fish from EC, EP, ET and EG groups, while in the control group and EO group the values were the same. The phytoextracts had no significant effect on the content of n-6 in the experimental groups. Its value was the highest in ET group, while the lowest was established in fish fed oregano extract. The amount of n-3 was the lowest in the EO and the highest in EG, but differences among groups were insignificant \((P>0.05)\). The analysis of experimental data showed that the inclusion of phytoextracts had no influence on the n-6/n-3 ratio. Its value was the highest in ET, EP, EC and EO groups, while in the control group and EG group the values were the same.

Discussion

Growth performance

The analysis of experimental data from the present research revealed that the inclusion of curcumin, paprika, thyme, oregano and garlic extracts in the diet did not change final weight and weight gain of the rainbow trouts from the experimental groups. Their values were not statistically different compared with those of fish from the control group \((P>0.05)\). Similar results were reported by Nya and Austin (2011) with different dietary garlic, oregano, ehnacea, ginger levels in the feed of trouts. Gabor et al. (2011) and Abraham and Ritu (2015) also observed no significant influence on the weight gain of rainbow trout \((Oncorhynchus mykiss)\) and African catfish \((Clarias gariepinus)\), receiving garlic supplemented feed. Similar results established Yılmaz et al. (2013) who studied the influence of thyme added in the diet of Oreochromis mossambicus. Pham et al. (2014) also found insignificant effect on the growth of \(Paralichthys olivaceus\) as a result from paprika supplemented feed.

Chemical composition

The analysis of experimental data showed that the addition of phytoextract had no significant influence on the water content in the meat of rainbow trout. This was confirmed by the results of Saleh et al. (2015) for \(Dicentrarchus labrax\) fed with garlic and Jiang et al. (2016) for \(Carassius auratus\) that received different curcumin levels. For the same results also reported Pham et al. (2014) having fed paprika to \(Paralichthys olivaceus\). Ahmadifar et al. (2011) also established insignificant effect on the water content in the meat of rainbow trout \((Oncorhynchus mykiss)\) that received feed supplemented with thymol-carvacrol.

Despite the insignificant differences on water content in the fillets of experimental fish, we established the lowest value of this parameter in ET group. Contrary to these results, Farahi et al. (2010) observed higher values of water content in the meat of rainbow trout \((Oncorhynchus mykiss)\) fed feed supplemented with different garlic levels. Antache et al. (2013) established that inclusion of thyme to the feed of Nile tilapia \((Oreochromis niloticus)\) also led to significantly higher water content. The results from the recent study were not in agreement with them.

In the present investigation the phytoextracts supplementation had no effect on the protein content and no significant differences among groups were observed \((P>0.05)\). However, its value was lower in fish from EG group compared to those from the control and the other experimental groups. On the contrary, other authors established significantly higher protein in the meat of \(Oncorhynchus mykiss\) and \(Dicentrarchus labrax\), fed with garlic (Farahi et al., 2010; Saleh et al., 2015). For the same results reported Hwang et al. (2013) having fed curcumin to \(Sebastes schlegeli\). The addition of thyme led to higher protein content in the meat of \(Dicentrarchus labrax\) (Yılmaz et al., 2012). This was confirmed by Maniat et al. (2014) for \(Mesopotamichthys sharpeyi\) that received feed enriched with paprika. According to Ahmadifar et al. (2011) the thymol-carvacrol supplementation influenced significantly the protein in the meat of \(Oncorhynchus mykiss\). On the contrary, other authors observed decrease of its content in the meat of different fish fed with oregano and thyme extracts (Gabor et al., 2011; Antache et al., 2013). The conclusions of the recent study were confirmed by Pham et al. (2014) who observed insignificant effect on the protein content in \(Paralichthys olivaceus\), fed with different paprika levels and Jiang et al. (2016) for \(Carassius auratus\) that received feed with curcumin extract.

No significant differences were observed between experimental groups, concerning the lipid content in the fillets of rainbow trout \((P>0.05)\). However, the lowest value of this parameter was established in EC group. Hwang et al. (2013) also determined lower lipid content in the meat of \(Sebastes schlegeli\) fed with 1.0%, 3.0% and 5.0% curcumin extract. On the contrary, Farahi et al. (2010) and Maniat et al. (2014) established significant decrease in the lipid content for \(Oncorhynchus mykiss\) and \(Mesopotamichthys sharpeyi\) fed with garlic and paprika. Similar results were reported by Gabor et al. (2011) for \(Oncorhynchus mykiss\), receiving feed enriched with oregano extract. According to Saleh et al. (2015) the
addition of garlic to the diet of *Dicentrarchus labrax* had no significant effect on the lipid content. For the same results reported Jiang et al. (2016) for *Carassius auratus* fed feed supplemented with different curcumin levels. This was also confirmed by results of other authors for different fish fed with feed enriched with thyme and paprika extracts (Yılmaz et al., 2012; Pham et al., 2014). The results from the recent study for insignificant effect on the lipid content as a results of phytoextracts supplementation in the diet of rainbow trout were confirmed by them.

The data from the present investigation revealed that the phytoextracts supplementation had a trend to increase the dry matter in the fillets of rainbow trout. Significantly higher value of this parameter was established in fish from ET group (P≤0.001). Gabor et al. (2011) also observed the highest dry matter in the meat of *Oncorhynchus mykiss*, receiving oregano extract. According to Mehrim et al. (2014) the garlic extract added to the diet of Oreochromis niloticus led to significant decrease of the dry matter. This was not in agreement with our results.

In the present research significant decrease of the ash content in the meat of fish from the experimental groups compared to control group was established. This was confirmed by the results of Mehrim et al. (2014) who investigated the influence of garlic supplementation on the diet of *Oreochromis niloticus*. Ahmadifar et al. (2011) reported the same results at different thymol-carvacrol levels in the feed of *Oncorhynchus mykiss*. On the contrary, Farahi et al. (2010) observed the highest amount of ash in *Oncorhynchus mykiss* as a result of added garlic in the feed. For the same also reported Hwang et al. (2013) who studied the effect of paprika supplementation on the ash content in the fillets of *Sebastes schlegeli*. The inclusion of thyme also tended to increase the ash content in *Oreochromis niloticus* (Antache et al., 2013). The results of the present investigation with rainbow trout disagreed with them.

**Fatty acid composition**

The phytoextracts supplementation to the diet of rainbow trout had no significant influence on the content of C14:0. However, tendency to decrease the amount of this fatty acid in the fillets of fish from the experimental groups as compared to control group was observed and its lowest values were established in EP group. On the contrary, Pham et al. (2014) having fed paprika to *Paralichthys olivaceus* observed insignificant differences in the content of C14:0. For the same results also reported Hwang et al. (2013) for *Sebastes schlegeli* fed with different curcumin levels. According to Lee et al. (2012), the supplementation of garlic led to statistically lower amount of C14:0 in the meat of *Acipenser ruthenus*. This was not in agreement with our results. The phytosupplement thyme and oregano added to the feed of rainbow trout had lower values of C14:0 as compared to those from the C group, but the differences between the groups were insignificant (P>0.05).

In the present investigation, the addition of phytoextracts had no effect on the content of C16:0. However, the lower amount of C16:0 was established in EP group compared to C, EC, ET, EO and EG groups. Lee et al. (2012) also established significantly lower value of C16:0 in the fillets of *Acipenser ruthenus* fed garlic supplemented feed. On the contrary to these results, Pham et al. (2014) reported relatively close values of palmitic acid in the meat of *Paralichthys olivaceus*, fed a diet enriched with paprika extract. This was confirmed by Hwang et al. (2013) who studied the effect of different curcumin levels to the diet of *Sebastes schlegeli* on its fatty acid composition.

The results of our study showed that the inclusion of phytoextracts in the diet of rainbow trout did not change the content of C18:0 (P>0.05). Nevertheless, the lowest values of stearic acid were found in ET and EG groups as compared to those from C, EC, EP and EO groups. This was confirmed by the results of Lee et al. (2012) who established significantly lower amount of C18:0 in the fillets of *Acipenser ruthenus*, receiving feed enriched with garlic. According to Hwang et al. (2013) the addition of 1.0% curcumin extract in the feed of *Sebastes schlegeli* also led to lower content of stearic acid. According to the experimental data from the present study the contents of C18:1 and C16:1 was not influenced by the added phytoextract in the feed of the experimental fish. Nevertheless, the amount of oleic acid in the fillets was the lowest in the control group compared to those from the experimental groups. Hwang et al. (2013) also found higher content of C18:1 in *Sebastes schlegeli* fed with extruded pellets, supplemented with 1.0% curcumin. Contrary to these results, Pham et al. (2014) having fed paprika to *Paralichthys olivaceus* affirmed its insignificant effect on the content of C18:1. The values of oleic acid tend to be higher in the fillets of trout from ET and EO.

The amount of C16:1 in the fillets of rainbow trout was the lowest in EP and EO groups compared to those from C, EC, ET and EG groups, with no statistical differences (P>0.05). The inclusion of different curcumin levels led to insignificant effect, concerning the content of palmitoleic acid in *Sebastes schlegeli* (Hwang et al., 2013). On the contrary, Pham et al. (2014) established significantly higher value of palmitoleic acid in the meat of *Paralichthys olivaceus* fed with paprika extract. No significant difference was observed in the contents of C18:2 in the fillets of rainbow trout (P>0.05). However, the lowest amount of linoleic acid was observed in EO group and fish from ET group had higher amount of C18:2.

Hwang et al. (2013) found equal value of C18:2 in the meat of *Sebastes schlegeli* fed a diet enriched with different curcumin levels as compared to those from the control group. According to Pham et al. (2014), the addition of paprika led to lower amount of linoleic acid in the fillets of *Paralichthys olivaceus*. This was not in agreement with the results of the recent study. On the contrary, Lee et al. (2012) reported the highest amount of C18:2 in *Acipenser ruthenus* fed with garlic.

Phyto supplements curcumin and thyme added to the feed of rainbow trout, led to significant decrease in the amount of linolenic acid (C18:3n-3). Contrary to our results, Lee et al. (2012) observed significantly higher amount of linolenic acid in the meat of *Acipenser ruthenus*, receiving garlic supplemented feed.

No significant influence was observed in regard to the content of eicosadienoic acid in the meat of fish from C and experimental group (P>0.05). This was confirmed by the results of Lee et al. (2012) having fed garlic to *Acipenser ruthenus* and Pham et al. (2014) for *Paralichthys olivaceus* fed with paprika extract. Hwang et al. (2013) also established insignificant effect on the amount of C20:2 in the meat of *Sebastes schlegeli*, receiving curcumin supplemented feed. Despite the insignificant differences among experimental groups (P>0.05), the value of C20:2 was found to be the lowest in ET group.

The dietary phytoextracts supplementation had no effect on the amount of eicosatetraenoic acid. Our results corresponded to those reported by Hwang et al. (2013) who investigated the influence of different curcumin levels on the fatty acid composition of *Sebastes schlegeli*. In the present investigation the content of C20:3 was the lowest and the differences between the groups were insignificant (P>0.05).

The phytoextracts included in the diet of rainbow trout did not influence significantly the content of C20:4. The results from our investigation showed that the content of C20:4 was higher in fish.
from ET, although the differences between the groups were insignificant (P>0.05).

The curcumin, paprika, thyme, oregano and garlic added in the feed had no effect on the content of C20:5 in the fillets. For the same results also reported Pham et al. (2014) who found the same values of C20:5 in Paralichthys olivaceus fed with paprika extract. The analysis of experimental data from the present investigation showed that the lowest content of eicosapentaenoic acid was established in EO group (P>0.05).

The amount of C22:6 was not influenced by the addition of phytoextracts in the feed of rainbow trout. This was confirmed by Hwang et al. (2013) for Sebastes schlegeli. Our results corresponded with them. On the contrary, Lee et al. (2012) established significantly higher amount of C22:6 in the fillets of Acipepsor ruthenus, fed garlic supplemented feed.

No significant influence of the added phytoextracts was established on the content of SFA in fillets of rainbow trout. For the same results also reported Hwang et al. (2013) for Sebastes schlegeli fed with different curcumin levels. The inclusion of phytoextracts to the diet of rainbow trout showed no influence on the content of UFA. The results of the present research showed that the addition of phytoextracts to the diet of rainbow trout tend to increase the amount of UFA, with no significant differences among the groups (P>0.05).

The amount of MUFA was not changed by the addition of phytoextracts. Despite the insignificant differences (P>0.05) between the experimental groups, we observed tendency to increase the content of MUFA in fish fed with extruded pellets, supplemented with curcumin, paprika, thyme, oregano and garlic extracts.

The content of PUFA was not affected by the phytoextracts supplementation. Similar results were established by Hwang et al. (2013) in fish fed with different curcumin levels.

Experimental data show that the inclusion of phytoextracts had no significant influence on the amount of n-6 in the fillets of trout. Hwang et al. (2013) found almost equal values of n-6 in Sebastes schlegelii having fed 2.0% and 3.0% curcumin. The addition of phytoextracts did not change the content of n-3 in the meat of experimental fish. This was confirmed by Hwang et al. (2013) for Sebastes schlegelii fed with curcumin. The results of our investigation showed that the lowest amount of n-3 was found in fish from EO group (P>0.05).

No significant differences were observed, concerning the n-6/n-3 ratio in fillets of rainbow trout (P>0.05). Despite that, the n-6/n-3 ratio tends to be higher in rainbow trout from all the experimental groups vs to that of individuals from the control group.

Conclusion

The addition of curcumin, paprika, thyme, oregano and garlic extracts to the diet had no significant influence on the growth performance of rainbow trout from the experimental groups. The phytoextract supplementation did not change the values of water, protein and lipid contents in fillets of experimental fish compared to those from the control group. Significantly higher dry matter in fish meat was established in rainbow trout from ET group as compared to values of this parameter of fish from the control (C) and the experimental groups (EC, EP, EO and EG). The dry matter content in the meat of the fish from ET group was 26.33±0.09%, significantly higher vs that of the control and the experimental groups by 2.80% (C), 1.19% (EC), 4.79% (EP) 0.99% (EO) and 0.38% (EG) (P≤0.001). The inclusion of feed additives led to significant decrease of ash content in the meat of the fish from all experimental groups when compared to those from non-supplemented trouts. Its content was lower than that of C group by 10.45% (EC), 4.58% (EP), 8.80% (ET), 5.23% (EO) and 13.07% (EG). The fatty acid profile of the fillets from rainbow trout was not influenced by the addition of curcumin, paprika, thyme, oregano and garlic extracts. The content of linolenic acid was lower in the meat of fish from EC and ET groups as compared to its amounts in specimens from C, EP, EO and EG groups. The amounts of this fatty acid of fish from C group was 5.55±0.07% and it was significantly higher than those from EC and ET groups. 13.26% (P ≤ 0.05) and 19.35% (P ≤ 0.001), respectively. However, this did not change the content of n-6/n-3 ratio in the fillets of trouts from all experimental variants.

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