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The Effects of Dietary Turnip (*Brassica rapa*) and Biofuel Algae on Growth and Chemical Composition in Rainbow Trout (*Oncorhynchus mykiss*) Juveniles

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Abstract

The present study was conducted to investigate the supplemental effects of the turnip (*Brassica rapa*) and its extracts and algae powder on growth performance and body composition of rainbow trout juveniles (0.67±0.01 g). For this purpose, 7 casein-gelatin based semi purified diets were formulated to be isonitrogenous and isocaloric to contain turnip meal, its extracts (with water and methanol) and the powder of after extraction as well as algae powder. The diets were supplemented with 15% wheat flour (diet 1, control), 15% turnip meal of Turkish origin (diet 2), water extract from U.S. turnip (diet 3), methanol extract from Turkish turnip (diet 4), powder of Turkish turnip after extraction (diet 5), 15% turnip meal of U.S. origin (diet 6) and 15% biofuel algae powder (diet 7). After 4 week feeding trial, the fish fed diet 7 had significantly lower growth than those fed the other 6 experimental diets ($P<0.05$). Among the fish fed dietary turnip or its extracts, there was no significant difference in growth and survival ($P>0.05$). However, turnip supplementation tended to increase growth in comparison to control diet. Food conversion ratio (FCR) and protein efficiency ratio (PER) were significantly higher in fish fed diets with turnip and its extract than those fed the biofuel algae and control diets. Our study indicated that turnip seems to have a growth enhancing effects in juvenile rainbow trout. This positive effect might be connected with some phytochemicals, which is reported as antioxidant and health promoting properties of turnip. Further studies are needed to disclose the effect of dietary turnip on rainbow trout.

Keywords: Turnip (*Brassica rapa*), feed, growth, rainbow trout.

Diyetlere İlave Edilen Şalgam (*Brassica rapa*) ve Yosun Ununun Gökkuşağı Alabalığı (*Oncorhynchus mykiss*) Yavrularının Büyüme ve Kimyasal Kompozisyonlarına Etkileri

Özet

Bu çalışma yavru gökkuşağı alabalıkları (0,67±0,01) diyetlerine katılan şalgam (*Brassica rapa*) ve eksraktları ile yosun ununun olumlu etkilerini belirlemek amacıyla yapılmıştır. Bunun için 7 adet kazein-jelatin tabanlı enerji ve besin değerleri ayarlanmış şalgam unu, ektraktları (su ve metanol), ektraksiyon sonrası toz hali ve yosun unu ile yarı saf diyetler hazırlanmıştır. Diyetler %15 buğday unu (diyet 1, control), %15 Türkiye orijinli şalgam unu (diyet 2), Amerika orijinli su eksraktı (diyet 3), Türkiye orijinli metanol ekstraktı (diyet 4), Türkiye orijinli eksraktsiyon sonrası tozu (diyet 5), %15 Amerika orijinli şalgam unu (diyet 6) ve %15 lik alg unu (diyet 7) ilavesiyle hazırlanmıştır. Dört haftalık besleme süresi sonunda 7 numaralı diyetle beslenen balıklarda büyüme diğer 6 diyetle beslenenlere göre önemli seviyede düşük çıkmıştır ($P<0,05$). Şalgam ve onun eksraktlarının kullanıldığı diyetlerdeki büyüme ve yaşama oranları bakımından önemli bir fark çıkmamıştır ($P>0,05$). Yem değerlendirme (FCR) ve protein etkinlik değerleri (PER) şalgam ve ektsraktları katılan gruplarda yosun unu ve kontrol grubuna göre önemli seviyede yüksek çıkmıştır. Çalışmamız, şalgam unu takviyesinin alabalık yavrularında büyümeyi teşvik etme eğiliminde olduğunu göstermektedir. Şalgam ununun alabalıklar üzerindeki pozitif etkilerinin daha iyi anlaşılması için detaylı çalışmaların yapılması gerekmektedir.

Anahtar Kelimeler: Şalgam (*Brassica rapa*), yem, büyüme, gökkuşağı alabalığı.

Introduction

Replacement of fish meal by ingredients of plant or animal origin in aquatic animal feeds has been the constant objective of numerous recent nutritional studies because of the rising cost and uncertain availability of fish meal (Higgs *et al*., 1985; Sugiura *et al*., 2000; Lee *et al*., 2001; Yamamoto *et al*,. 2002 Kaushik *et al*., 1995; Refstie *et al*., 2000; Stone *et al.*, 2005; Barrows *et al.*, 2007). However, these sources show differences, particularly in protein levels, amino acid profile, energy concentration and mineral content with respect to fish meal. Furthermore vegetable by-products may also contain one or more anti-nutritional factors (ANFs) with adverse effects on both nutritional value and fish health and growth performance. However, plant based foods contain significant amounts of bioactive non nutritive compounds, which provide desirable health benefits beyond basic nutrition. This association is often attributed to the antioxidant phytochemicals, namely phenolic compounds and organic acids (Liu, 2003; Silva *et al*., 2004). The most common plant products for fish diets are now derived from soya beans (Gomes *et al.*, 1995; Kaushik *et al.*, 1995) and from other plant sources particularly legumes (Watanabe *et al*., 1993). But there is no information about the potential use of turnip meal in fish diets.

Turnip (*Brassica rapa*) is a root vegetable that is grown in all Europe, Asia and America and available all year-round. It is known that white turnip (*Brassica rapa)* is a root vegetable commonly grown in low temperature climates world wide. Small, tender varieties are grown for human consumption, while larger varieties are grown as feed for livestock. Turnip is one of the oldest cultivated vegetable that has been used for human consumption since prehistoric times (Liang *et al*., 2006). This plant is especially popular in Europe and Turkey, particularly in its cold regions. Because it grows well in cold climates and after harvesting it can be stored several months without any deformation. Therefore, turnip with the other crops is a unique supply of vegetable during the winter. The brassicaceae family has a wide range of crops; some of them like *Brassica rapa* has economic significance because it is a diet used throughout the world (Sasaki and Takahashi, 2002).

In many countries, turnip is widely consumed for its leaves and roots. In addition to leaves and roots, flower buds are also eaten mixed with other vegetable. The other edible parts of turnip are consumed boiled, being used in the preparation of soups and stews. The turnip juice is greatly appreciated in Turkey. Brassica family is also known to contain so many photochemicals and organic acids such as phenolic and malic acids which exhibit strong antioxidant capacity, and some aromatic compounds which increase the immune system in the human body.

In aquaculture there is a problem, especially in early life stage of fish that diet consumption is low because of palatability or flavor. Therefore, it is very important to increase the feed consumption for fish health and growth and it can be managed only by improving the palatability of diets (Lee *et al*., 2004).

Protein concentration of turnip changes between 10-12 % and it has high carbohydrate level as well as the other phytochemicals. High carbohydrate in feed ingredients could be used for energy and protein can be used for growth in this circumstance, which is economically beneficial in aquaculture producers. It is expected that turnip meal can be used as a feed attractant which increases feed intake and growth performance in rainbow juveniles. In this study, turnip meal was extracted with water and methanol and these extracts were supplemented into semi purified diet, and their effects on growth and chemical composition of rainbow trout juveniles were tested.

Materials and Methods

Extraction Procedure

For extraction from the turnip, 33 g Turkish turnip meal (cultivated in Erzurum province) was extracted in 600 mL pure water at room temperature on the magnetic mixer during the 24 hours. The mixture was filtered with 0.45 micron paper filter and the meal was used for further methanol extraction. Same procedure was applied to methanol extraction, then liquid and meal parts were separated and freeze dried. The Turkish turnip meal after extraction with methanol was used for dietary supplementation. With respect to U.S. turnip, only water extraction was performed using the same procedure above and only liquid part was used in the diet. Extracts were weighed and the amount corresponding to 15% of the whole turnip meal was added to the diet.

Experimental Diets

Seven casein-gelatin based semi purified diets were for formulated to be isonitrogenous and isocaloric to contain the turnip meal, two extracts of turnip meal and biofuel algae (Table 1). The seven diets were supplemented with 15% wheat flour (diet 1, control), 15% Turkish turnip meal (diet 2), water extract from U.S. turnip (diet 3), methanol extract from Turkish turnip (diet 4), powder of Turkish turnip after extraction (diet 5), 15% U.S. turnip (diet 6) and 15% biofuel algae (Algamaxx, Independence Bio-Products, Dublin, OH, USA) (diet 7). Water and methanol extracts were added to be equivalent to that contain a 15% portion of turnip meal, and wheat flour was used as the filler. Five percent of soluble fish protein concentrate (CPSP 90, Sopropeche S.A., Bolulogne-Sur-Mer, France) was used to secure the palatability of semi purified diets. After dough formation with distilled water, the diets were cold pelleted into 3 mm diameter size then freeze-dried to have less moisture, crushed into desirable particle size (0.8-1 mm) and stored at -20°C until used. Daily feed amount during the experimental period was between 3-3.5% of total biomass. Turnips and biofuel algae used as dietary supplementation varied in their proximate and mineral contents (Table 2) and it was reflected by the composition of experimental diets (Table 3).

Table 1. Composition (%) of the seven experimental diets fed to rainbow trout

Ingredients	Diets						
	1	2	3	4	5	6	7
Casein (vitamin free)[a]	40.00	40.00	40.00	40.00	40.00	40.00	40.00
Gelatin[a]	8.00	8.00	8.00	8.00	8.00	8.00	8.00
L-Arg[a]	0.50	0.50	0.50	0.50	0.50	0.50	0.50
L-Met[a]	0.40	0.40	0.40	0.40	0.40	0.40	0.40
L-Lys[a]	0.80	0.80	0.80	0.80	0.80	0.80	0.80
CPSP[b]	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Dextrin	9.10	9.10	9.10	9.10	9.10	9.10	9.10
Wheat flour	15.00		7.00	12.30	10.70	0.00	0.00
Turnip meal (Turkey)		15.00					
Turnip meal extract (H_2O)			8.00				
Turnip meal extract (MeOH)				2.70			
Turnip meal post extract					4.00		
Turnip meal (USA)						15.00	
Biofuel algae[c]							15.00
Cod liver oil	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Soy-lecithin	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Vitamin mixture[d]	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Mineral mixture[e]	3.00	3.00	3.00	3.00	3.00	3.00	3.00
CMC[f]	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Stay-C 35[g]	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Choline cloride	0.17	0.17	0.17	0.17	0.17	0.17	0.17

[a]ICN Biomedicals, Costa Mesa, CA
[b]Concentrate of fish soluble protein (CPSP 90: crude protein, 82-84% WW; crude lipid, 9-13% WW), Sopropêche S.A., Boulogne-sur-mer, France.
[c]Algamaxx, Independence Bio-Products, Dublin, OH, USA
[d]Roche Performance Premix (Hoffman-La Roche, Inc., Nutley, New Jersey), composition per g of the vitamin mixture: vitamin A, 2645.50 IU; vitamin D_3, 220.46 IU; vitamin E, 44.09 IU; Vitamin B_{12}, 13 g; riboflavin, 13.23 mg; niacin, 61.73 mg; D-pantothenic acid, 22.05 mg; menadione, 1.32 mg; folic acid, 1.76 mg; pyridoxine, 4.42 mg; thiamin, 7.95 mg; D-biotin, 0.31 mg.
[e]Bernhart Tomarelli salt mixture (ICN Pharmaceuticals, Costa Mesa, CA), composition (g/100g): calcium carbonate, 2.1; calcium phosphate dibasic, 73.5; citric acid, 0.227; cupric citrate, 0.046; ferric citrate (16 to 17% Fe), 0.558; magnesium oxide, 2.5; manganese citrate, 0.835; potassium iodide, 0.001; potassium phosphate dibasic, 8.1; potassium oxide, 6.8; sodium chloride, 3.06; sodium phosphate, 2.14; and zinc citrate, 0.133. Five milligrams of Se in the form of sodium selenite was added per kilogram of the salt mixture.
[f]Carboximetilecellulose.
[g]Vitamin C (DSM Nutritional Products, Basel, Switzerland).

Table 2. Proximate and mineral composition of turnip and biofuel algae

Ingredients	Turkish turnip	U.S. turnip	Biofuel algea
Crude protein (%)	9.97	11.67	15.3
Ash (%)	8.76	11.31	6.95
P (µg/g)	2906	5358	4313
K (µg/g)	26285	32239	2189
Ca (µg/g)	4310	3719	40776
Mg (µg/g)	1308	1366	1679
Al (µg/g)	57.1	38.4	1659
Cu (µg/g)	21.6	10.96	16
Fe (µg/g)	79.6	63.7	2159
Mn (µg/g)	10.3	13.5	309
Na (µg/g)	564	1866	701
Zn (µg/g)	33.57	24.94	299

Fish and Feeding Trial

Rainbow trout (*Oncorhynchus mykiss*) juveniles (average weight 0.67±0.01 g) were randomly distributed into 21 tanks at a density of 30 fish per tanks in 3 replicates, where three tanks were randomly assigned to each diet. Each experimental diet was fed at feeding rates ranging from 3.5% of fish weight at the beginning to 3% at the end of the feeding trial. Feeding rate was adjusted to the actual fish biomass in each treatment. Fish were fed three times a day in semi resirculating system equipped with 50 L plastic tanks and bio filtration was used to secure stable condition. Water flow was 1 L/min for each tank. Supplemental aeration was also provided to maintain dissolved oxygen level near saturation. The temperature of the water changed between 21.2-22.7ºC during the 4 week feeding trial. Diurnal

Table 3. Proximate and mineral composition of experimental diets

Ingredients	Diets						
	1	2	3	4	5	6	7
Crude protein (%)	58.71	59.52	55.74	56.73	56.79	54.87	57.35
Crude lipid (%)	15.09	14.95	15.08	15.12	15.03	14.89	15.11
Ash (%)	5.03	5.06	5.92	5.53	5.07	5.93	13.21
P (µg/g)	8102	7808	8925	8738	8992	9514	9692
K (µg/g)	3082	6211	7937	2997	3958	8211	3147
Ca (µg/g)	5097	5004	5347	5501	5926	5820	10895
Mg (µg/g	277	402	433	279	389	436	632
Cu (µg/g)	42	292	44	17	38	31	51
Fe (µg/g)	91	112	82	144	88	116	5510
Mn (µg/g)	88	83	87	92	93	91	157
Na (µg/g)	2371	2222	2550	2409	2357	2553	2478
Zn (µg/g)	41	108	45	38	48	43	115

light/dark cycle was controlled at 13:11 h. The biomass was weighted every 2 weeks to adjust the feeding rate.

Calculated Growth Parameters and Analysis

After four week feeding trial, all fish were weighed and percent weight gain (body weight gain x 100/ initial body weight), specific growth rate {[(Ln final weight-Ln initial weight) x 100] / days), feed conversation ratio (dry feed fed/body weight gain]), protein efficiency ratio (body weight gain/protein fed} were calculated.

The whole body proximate and mineral compositions were analysed according to the standard procedures (AOAC, 1995; Watson and Isac, 1990). Nine fish per tank were used for body proximate and mineral composition analysis. Dietary and whole-body lipids were extracted according to the procedure of Folch *et al*. (1957). After extraction, whole body lipids were separated into polar (phospholipids) and neutral (mostly triglycerides) lipids using Sep-Pak silica cartridges (Waters, Milford, MA, USA). The mobile phases were chloroform and methanol for neutral and phospholipids, respectively (Juaneda and Rocquelin, 1985).

Statistical Analysis

Results were expressed as Mean±SD (n=3). Data were subjected to one-way ANOVA and subsequent comparison of Means by Duncan's multiple range test. Percentage data were arcsin transformed prior to statistical analysis. Differences were considered statistically significant at $P<0.05$.

Results

At the end of the feeding trial, dietary supplementation had significant effect on growth performance (Table 4) and body chemical composition (Table 5) in rainbow trout juveniles ($P<0.05$). Fish fed diet 7 exhibited significantly lower growth than those fed the other 6 experimental diets. Although there were no significant differences among the fish fed the other experimental diets, the weight gain in fish fed diets with turnip supplementation tended to increase in comparison to those on control diet Dietary treatments did not influence survival. Feed conversation and protein efficiency ratio were significantly influenced by dietary treatments ($P<0.05$). Fish fed diet 6 had the lowest FCR and the highest PER. Turkish turnip and its extract showed better FCR and PER than those fed the control diet. Whole body protein was significantly higher in fish fed diets 2 and 3 than those fed the other 5 experimental diets.

Dietary supplementation had significant effect on whole body total lipid content as well as neutral lipid (NL) and phospholipids (PL) ratios of total lipids ($P<0.05$). Initial fish had significantly lower whole body total lipid content and NL ratio than those fed 7 experimental diets ($P<0.05$). Among the fish fed experimental diets, fish fed diets 1, 4 and 5 had the highest and fish fed diet 2 had the lowest total lipid amounts in their body. NL ratio was the highest in fish fed diets 1 and 7 and the lowest in those fed diets 2 and 3 (Table 5).

Discussion

Major attention has been given to the potential of soybean meals as protein source in feeds for salmonid fish (Hardy 1995; Adelizi *et al*., 1998; Olli and Krogdahl, 1995). On the other hand, less attention has been paid to other plant sources because of their low level of protein content and presence of antinutritional factors (Francis *et al*., 2001).

To the best of our knowledge, the present study is the first work which is investigating the effect of dietary turnip on the growth and body chemical composition in fish. Earlier studies showed that maca meal supplementation into a semi-purified diet could improve the palatability of the diet and thence increase food intake, growth and feed utilization in rainbow trout juveniles (Dabrowski *et al*., 2003; Lee

Table 4. Growth performance and survival of rainbow trout fed the four experimental diets. Means with different superscript letters in a row are significantly different (P<0.05)

	Diets						
	1	2	3	4	5	6	7
Final weight (g)	2.04 ± 0.20^{ab}	2.10 ± 0.12^{a}	2.29 ± 0.22^{a}	2.26 ± 0.12^{a}	2.19 ± 0.26^{a}	2.32 ± 0.05^{a}	1.73 ± 0.14^{b}
Weight gain (%)	305.09 ± 31.26^{a}	325.12 ± 17.66^{a}	341.62 ± 33.59^{a}	337.37 ± 19.34^{a}	327.01 ± 40.08^{a}	346.82 ± 8.44^{a}	258.54 ± 21.4^{b}
SGR[1] (%/day)	4.65 ± 0.25^{a}	4.82 ± 0.14^{a}	4.94 ± 0.24^{a}	4.91 ± 0.14^{a}	4.83 ± 0.31^{a}	4.99 ± 0.06^{a}	4.25 ± 0.19^{b}
Survival (%)	91.66±5.77	95±5	90±8.66	91.66±7.63	85±15	91.66±2.88	96.66±5.77
FCR[2]	0.63 ± 0.01^{b}	0.61 ± 0.05^{bc}	0.62 ± 0.01^{bc}	0.61 ± 0.01^{bc}	0.62 ± 0.01^{b}	0.59 ± 0.05^{c}	0.67 ± 0.04^{a}
PER[3]	3.16 ± 0.05^{b}	3.25 ± 0.05^{ab}	3.2 ± 0.07^{b}	3.24 ± 0.07^{ab}	3.18 ± 0.07^{b}	3.38 ± 0.05^{a}	2.98 ± 0.18^{c}

[1]Spesific growth rate, [2]Food conversion ratio, [3]Protein efficiency ratio

Table 5. Proximate and mineral composition (% of dry matter) of whole body of rainbow trout. Means with different superscript letters in a row are significantly different (P< 0.05)

	Diets							
	Initial	1	2	3	4	5	6	7
Crude protein (%)	68.69 ± 4.2^{a}	58.62 ± 3.8^{cde}	60.64 ± 4.1^{b}	59.83 ± 3.9^{b}	57.78 ± 2.6^{de}	56.98 ± 2.4^{e}	59.39 ± 3.1^{bc}	59.08 ± 3.2^{bcd}
Lipid (%)	3.16 ± 0.1^{d}	7.30 ± 0.38^{a}	6.40 ± 0.23^{c}	6.5 ± 0.24^{bc}	7.46 ± 0.21^{a}	7.55 ± 0.83^{a}	6.55 ± 0.33^{bc}	7.0 ± 0.30^{ab}
NL (%)	62.80 ± 1.4^{d}	84.39 ± 0.57^{a}	82.05 ± 1.48^{c}	82.53 ± 0.74^{c}	83.90 ± 0.54^{ab}	84.10 ± 0.63^{ab}	82.94 ± 0.58^{bc}	84.51 ± 1.47^{a}
PL (%)	37.19 ± 1.4^{a}	15.60 ± 0.57^{d}	17.94 ± 1.48^{b}	17.46 ± 0.74^{b}	16.09 ± 0.54^{cd}	15.89 ± 0.63^{cd}	17.05 ± 0.58^{bc}	15.48 ± 1.47^{d}
Ash (%)	13.66 ± 0.56^{a}	9.47 ± 0.56^{de}	9.93 ± 0.01^{bcd}	10.53 ± 0.05^{b}	9.12 ± 0.28^{e}	9.85 ± 0.25^{cd}	10.47 ± 0.45^{bc}	9.88 ± 0.38^{cd}
P (μg/g)	19169 ± 35^{a}	13625 ± 47^{cd}	14316 ± 310^{c}	15567 ± 695^{b}	13022 ± 338^{d}	13999 ± 586^{cd}	15988 ± 954^{b}	13858 ± 722^{cd}
K (μg/g)	17520 ± 42^{a}	11627 ± 55^{bc}	12865 ± 750^{b}	12349 ± 925^{b}	10757 ± 453^{c}	10850 ± 861^{c}	12336 ± 951^{b}	11509 ± 369^{bc}
Ca (μg/g)	22310 ± 75^{a}	14525 ± 934^{d}	15415 ± 487^{cd}	17358 ± 148^{bc}	12979 ± 130^{e}	15009 ± 129^{d}	18519 ± 132^{b}	14625 ± 201^{d}
Mg (μg/g)	1447 ± 24^{a}	853 ± 52^{cd}	981 ± 36^{bc}	939 ± 89^{bc}	791 ± 47^{d}	877 ± 87^{bcd}	996 ± 81^{b}	947 ± 27^{bc}
S (μg/g)	8788 ± 14^{a}	6514 ± 165^{bc}	6526 ± 277^{bc}	6498 ± 230^{bc}	6268 ± 106^{bc}	6229 ± 103^{c}	6488 ± 379^{bc}	6858 ± 571^{b}
Bo (μg/g)	56.18 ± 1.2^{a}	12.31 ± 5.2^{b}	15.83 ± 7.8^{b}	8.92 ± 7.4^{b}	6.96 ± 2.5^{b}	13.14 ± 3.3^{b}	12.51 ± 6.3^{b}	10.42 ± 7.4^{b}
Cu (μg/g)	3.64 ± 0.9^{b}	8.96 ± 2.8^{b}	18.25 ± 0.1^{a}	6.91 ± 2.1^{b}	7.59 ± 0.7^{b}	5.55 ± 1.7^{b}	10.31 ± 1.6^{ab}	19.25 ± 4.5^{a}
Fe (μg/g)	86.81 ± 1.3^{b}	55.26 ± 13.8^{b}	43.36 ± 5.5^{b}	45.71 ± 7.9^{b}	43.54 ± 2.1^{b}	41.57 ± 4.3^{b}	51.80 ± 7.4^{b}	282.76 ± 73.8^{a}
Mn (μg/g)	6.56 ± 2.1^{f}	21.04 ± 2.7^{b}	14.7 ± 1.7^{cd}	16.37 ± 0.8^{c}	25.82 ± 1.5^{a}	15.59 ± 0.9^{c}	12.47 ± 0.7^{de}	11.74 ± 0.8^{e}
Na (μg/g)	6564 ± 25^{a}	4130 ± 329^{b}	4048 ± 215^{b}	3797 ± 304^{b}	3846 ± 242^{b}	3675 ± 400^{b}	3847 ± 317^{b}	4185 ± 828^{b}
Zn (μg/g)	294.24 ± 1.2^{a}	150.9 ± 2.6^{a}	162.17 ± 12.4^{a}	167.45 ± 4.1^{a}	146.76 ± 5.2^{a}	154.55 ± 4.3^{a}	168.29 ± 10.8^{a}	159.88 ± 9^{a}

et al., 2004; Lee *et al*., 2005). The higher growth performance recorded in these studies was mainly attributed to the attractants present in the maca meal, which caused a significant increase in feed intake. In our study, all experimental fish were fed at the same rate, therefore the effect of food intake, which would possibly be increased by dietary turnip, on growth was clouded. However, dietary turnip supplementation tended to increase growth in rainbow trout juveniles although there was no significant difference in comparison to control diet. As there was no depletion in growth and survival in fish fed diet with turnip supplementation, turnip meal and its extracts can be used safely in juvenile rainbow trout diets. The palatability and flavour are very important in fish feeding. Especially the palatability increase feed intake, growth and feed utilization at the first stage of exogenous feeding period in rainbow trout (Dabrowski *et al*., 2003; Lee *et al*., 2004, 2005). Turnip roots contain high concentration of health promoting gluconasturtiin and glucosinolates (Krumbein *et al*., 2005) and these chemicals as well as other phytochemicals present in turnip could have positive effect in the case of *ad libitum* feeding of fish by increasing the feed intake. Fernandes *et al*. (2007) stated that turnip may be an easily accessible dietary source of biologically active compounds and phenolics and organic acids profiles of turnip samples can be different depending on the geographic origins. In our study the U.S. turnip diet tended to have better growth.

Several researches suggested possible fruit and vegetable supplementation in fish diets due to the limited source of fish meal (Rumsey, 1993; Özoğul *et al*., 2006). Phytochemicals provided by the supplementation of fish diets with plant sources were reported to stimulate growth hormone and increase resistance against disease or stress (Li *et al*., 2001), increase fertilization, immunostimulation, anabolism and balances hormones (Shumin *et al*., 2007; Gonzales *et al*., 2004; Oshima *et al*., 2003).

In conclusion, the results of the current study suggest that turnip seems to have a growth enhancing effects in juvenile rainbow trout. This positive effect might be connected with some phytochemicals, which is reported as antioxidant and health promoting properties of turnip. On the other hand, the restricted feeding rate clouded the possible increasing feed intake in fish fed diet with turnip supplementation thence possible increasing growth. The antioxidative capacity of turnips and its extracts should be further analyzed and feeding trial with *ad libitum* feeding regime should be applied in further studies to disclose the effect of dietary turnip on growth performance in rainbow trout.

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