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Research Article

The Use of Hazelnut Meal as a Substitute for Soybean Meal in the Diets of Rainbow Trout (*Oncorhynchus mykiss*)*

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Abstract: Hazelnut meal as a substitute for soybean meal in extruded feeds of rainbow trout was investigated. The performance of extruded feeds containing hazelnut meal as a substitute for 20% of soybean meal (Diet 2) and 30% of soybean meal (Diet 3) was compared to a nutritionally balanced control (Diet 1) (a commercial trout feed formulation). Each diet was fed to 3 replicate groups (initial BW: 36 ± 1.37 g; mean ± SD); the fish were fed the equivalent of 2% of their body weight, 2 times daily (0800 and 1600) for 64 days at 15 ± 0.11 °C under a natural photoperiod. There was no significant difference in weight gain between the control (Diet 1) and Diet 2. Diet 1 produced significantly higher weight gain than Diet 3. The carcass fat content of fish fed a fishmeal and soybean meal diet was significantly higher than that of fish fed the other diets. Weight gain, feed efficiency ratio, relative growth rate, and apparent net protein retention data showed that hazelnut meal had the potential to substitute 20% and 30% of soybean meal in extruded trout feeds.

Key Words: Hazelnut meal, trout, *Oncorhynchus mykiss*, growth, feed utilisation

Gökkuşağı Alabalığı (*Oncorhynchus mykiss*) Yemlerinde Soya Unu Yerine Fındık Ununun Kullanımı

Özet: Gökkuşağı alabalığı ekstrüde yemlerinde soya küspesi yerine fındık küspesinin kullanılabilirliği incelenmiştir. Dengeli bir şekilde hazırlanmış soya küspesi içeren ticari alabalık kontrol yemi (Diet 1) ve soya küspesi yerine % 20 oranında fındık küspesi içeren (Diet 2) ve % 30 oranında fındık küspesi içeren (Diet 3) yemler kullanılmıştır. Her bir yem, 3 grup 3 tekerrür halinde (başlangıç ağırlığı; 36 ± 1,37 g; ortalama ± S.D.), sıcaklığı ortalama 15 ± 0,11 ºC olan su ortamında tutulan balıklara toplam canlı ağırlıklarının % 2'si oranında günde iki kez saat 0800 ve 1600'da verilmiş ve doğal ışıklandırma uygulanan çalışma 64 gün sürmüştür. Kontrol yemi (Diet 1) ile Diet 2 arasında ağırlık artışı yönünden fark önemsiz bulunmuştur. Diet 1'deki ağırlık artışı Diet 3'teki ağırlık artışından önemli derecede yüksek bulunmuştur. Soya unu içeren yemle beslenen balıkların vücutlarındaki yağ oranı diğer yemlerle beslenen balıkların yağ oranına göre daha yüksek değerde bulunmuştur. Ağırlık artışı, yem değerlendirme oranı, spesifik büyüme oranı ve görünür net protein birikimi verileri ekstrüde alabalık yemlerinde soya küspesinin yerine % 20 ve % 30 oranında fındık küspesinin kullanılabileceğini göstermiştir.

Anahtar Sözcükler: Fındık unu, gökkuşağı glabalığı, *Oncorhynchus mykiss*, büyüme, yem tüketimi

Introduction

The protein component of fish feed is the most expensive portion and the most important dietary nutrient. There is an increasing demand for alternative protein sources in fish feeds (1). Many plant feedstuffs have already been used in the diets of marine and freshwater fish. Partially substituting fish meal with plant protein has been accomplished in some carnivorous fish (2,3). Generally, a combination of protein sources is a better and more efficient diet than a single protein source. Soybean products have been evaluated as alternative sources of plant protein and essential amino acids, although other plant and animal protein sources, such as poultry by-product meal, meat and bone meal, hempseed meal, and canola meal, have also been incorporated into practical feeds (4-7).

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Most plant protein sources have antinutritional ingredients due to lower protein content and deficiency in some essential amino acids (8,9). Many studies showed that antinutritional ingredients in salmon diets caused nutritional complications (10-13).

Hazelnut meal is a protein feedstuff with crude protein content just above 44% (14). There is no information on the growth of rainbow trout fed diets containing different concentrations of hazelnut meal, and its potential as a supplement in commercial diets is often neglected. Instead, soybean meal, which has extensive use in animal nutrition throughout the world, is currently being imported into Turkey as a supplement for commercial trout feed. In this study, we examined the feasibility of using hazelnut meal as a partial replacement for soybean meal in the diet of rainbow trout.

Materials and Methods

The experiment was conducted at a commercial trout farm, Akbalık A.Ş. Bafra, Samsun (lat 41°33′N, long 35°54′E), (Turkey) between June and August 2004 (total 64 days). Rainbow trout (*Oncorhynchus mykiss*) with an initial weight of 36 ± 7.11 g (mean ± SD) were randomly assigned to 9 concrete ponds, each containing 100 fish. Each pond (r = 1.5 m, h = 1.5 m) had a total volume of 10.6 m^3.

The fish were acclimatised to the experimental ponds and diets for 2 weeks prior to the start of the experiment. Freshwater (nitrite: 0 mg/l; nitrate: 1.2 mg/l; NH_3: 0.03 mg/l; pH: 7.6) with a temperature of 15 ± 0.11 °C was supplied to the ponds at a rate of 2 l min^{-1}. Temperature was measured daily and oxygen in the outlet was measured once a week to ensure a minimum level of 7 mg l^{-1}.

Three diets containing fish meal as the major protein source were prepared. The chemical composition of the hazelnut meal is presented in Table 1 (14). While Diet 1 was the control diet (0% hazelnut meal), Diets 2 and 3 were formulated to contain either a 20% or 30% replacement of soybean meal with hazelnut meal. All diets were adequately supplemented with free amino acids. Table 2 shows the formulation, proximate composition, and essential and semi-essential amino acid composition of the 3 diets. All 3 diets were prepared to be isonitrogenous, isolipidic, and isoenergetic. The 3 diets were formulated to meet the nutritional requirements of rainbow trout (15).

Table 1. The chemical composition of the hazelnut meal.

Ingredients	%
Dry matter	91.27
Crude protein	43
Crude fat	3.01
Crude ash	5.98
Crude cellulose	7.84
Nitrogen-free extracts	31.44
Essential amino acids	
Arginine	4.53
Histidine	1.07
Isoleucine	1.80
Leucine	2.77
Lysine	0.99
Methionine	0.15
Phenylalanine	1.21
Threonine	0.95
Valine	1.58
Non-essential amino acids	
Tyrosine	0.88

The fish were fed the equivalent of 2% of their body weight, 2 times daily (at 0800 and 1600) for 64 days. The fish were fed slowly with small amounts by hand. The appetites of the fish were watched carefully to avoid wasting any food.

Live weights of all the fish were recorded at the beginning and end of the experiment. Interim weight measurements were obtained every 2 weeks by weighing 30 randomly selected fish per tank (30 fish × 3 replicates = 90 fish per treatment) to monitor growth.

The approximate compositions of the diets were analysed at the Bağcı Gıda ve Yem San. Tic. Ltd. Laboratory. Fish carcasses were analysed according to AOAC [Association of Official Analytical Chemists] guidelines (16) at the nutrition laboratory of the Sinop Fisheries Faculty, Ondokuz Mayıs University. At the beginning of the experiment, 10 fish were randomly selected and individually analysed for approximate composition. At the end of the study, 5 fish were taken randomly from each pond (15 per treatment) for carcass analyses.

Dry matter was determined by drying to a constant weight at 105 °C. Nitrogen was determined using a micro-kjeldahl technique and protein content was

Table 2. Formulation, approximate composition, and essential and non-essential amino acid composition (g/100 g diet) of the experimental diets.

Diet	1	2	3
Ingredients (%)			
Fish meal	44	44	43
Defatted soybean meal	25.50	5.50	-
Hazelnut meal (defatted)	-	20	30
Fish oil	15.24	15.15	15.09
Wheat flour	10	10	6.91
Wheat gluten	2.26	2.35	2
Vitamins and minerals[a]	3	3	3
Proximate composition of diets by analysis of feed			
Crude protein (%)	44.4	43.9	44
Crude fat (%)	19.8	19.8	19.7
Ash (%)	11.4	9.6	8.9
Dry matter (%)	92.6	93	93.2
Gross energy (kJ/g)[b]	20.6	19.6	19
Essential and non-essential amino acid composition (g/100 g diet)			
Arginine	2.58	1.89	1.61
Histidine	1.08	0.83	0.73
Isoleucine	2.11	1.63	1.42
Leucine	3.32	2.68	2.38
Lysine	3.02	2.46	2.22
Methionine	1.05	1.03	1.01
Cystine	0.49	0.37	0.31
Phenylalanine	1.89	1.38	1.17
Threonine	1.73	1.41	1.26
Tryptophan	0.53	0.41	0.36
Valine	2.27	1.81	1.60

[a]Added to supply an excess of vitamin and mineral requirements for salmonids (15)
[b]Calculated according to 23.6 kJ/g protein, 39.5 kJ/g lipid and 17 kJ/g NFE.

calculated from nitrogen (N) content by multiplying by 6.25. Lipid was determined by extracting the residue with 40-60 °C petroleum ether for 8 h in a Soxhlet apparatus. The approximate analyses of the carcasses were performed before initiation and after termination of the experiment.

One-way analysis of variance (ANOVA) was used to test the effects of the diets. Levels of significance were determined using Tukey's HSD test, with significance being set at $P < 0.05$.

Results

There were significant differences in body moisture, crude protein (CP), crude fat, and ash among the fish fed the 3 different diets (Table 3). Fish fed with Diets 1 and 2 had significantly lower moisture and ash. Fish fed Diet 1 had higher body fat compared to fish fed Diets 2 and 3. Fish fed Diet 3 had significantly lower body CP than fish fed Diet 2.

Growth data are presented in Table 4. At the end of the 64 days of the growth trial of the rainbow trout fed

Table 3. Approximate composition (%wet weight) of rainbow trout.* Each value is the mean (± S.E.M.) of the 3 replicates. Initial group (mean ± SD; n = 10): 24.52 ± 0.56% dry matter; 16.8 ± 0.5% crude protein; 4.65 ± 0.18% crude lipid; 1.32 ± 0.04 ash.

Parameter		Diet		
	Initial	Diet 1	Diet 2	Diet 3
Moisture	75.5 ± 0.5	74.3 ± 0.04[a]	74.3 ± 0.08[a]	74.7 ± 0.07[b]
Crude protein	16.8 ± 0.5	18.4 ± 0.12[ab]	18.8 ± 0.1[a]	18.1 ± 0.11[b]
Crude lipid	4.6 ± 0.2	5.6 ± 0.04[a]	5.22 ± 0.04[b]	5.22 ± 0.03[b]
Gross energy (kJ/g)[1]	5.8	6.6 ± 0.01[a]	6.5 ± 0.01[a]	6.3 ± 0.01[b]
Ash	1.3 ± 0.04	1.28 ± 0.01[a]	1.21 ± 0.01[b]	1.5 ± 0.01[c]

*Values not sharing the same superscript letters within the same row are significantly different ($P < 0.05$).
[1]Calculated according to 23.6 kJ/g protein, 39.5 kJ/g lipid, and 17 kJ/g NFE.

each of the 3 diets, mean individual body weight ranged from 128 to 141 g, with significant differences observed between those fed Diets 1 and 3. There were no significant differences between the 3 groups in relative growth rate or specific growth rates. Survival was 100% for all treatments.

The feed performance data are presented in Table 5. There were no significant differences between the 3 diets in feed efficiency, protein efficiency ratio, daily dry protein intake, daily dry energy intake, and apparent net protein retention.

Discussion

In contrast to hazelnut meal, there is more information available on the use of other plant feedstuffs in feeds for salmonids. Peas (17,18), lupin (17,19), faba beans (17,18), rapeseed, canola (19,20), and others (21-23) have been used in trout feeds. A significant amount of research has been conducted on the replacement of fishmeal with soybean meal as a protein source in fish feeds for rainbow trout (21-24).

This is the first known study on the replacement of soybean meal by hazelnut meal in rainbow trout. Results of this study showed that hazelnut meal could replace 20% and 30% of dietary soybean meal without growth-suppressing effects on specific growth rate, relative growth rate, feed efficiency, and survival. Fish fed the Diet 1 had higher weight gain (Table 4) than fish fed Diets 2 and 3. The amino acid compositions of the 3 diets were similar (Table 2); these concentrations exceeded published requirement estimates for the experimental species. It is likely that the lower weight gain observed in the fish fed hazelnut meal diets may have been the result of lower consumption of those diets (Table 5). Plant meals contain various antinutritional factors of which trypsin inhibitors are of particular concern (24,25). Extrusion reduces the efficacy of the majority of these (26,27). A major problem in the use of plant meals is their relatively low protein content, which prevents them

Table 4. Growth performance of rainbow trout fed hazelnut meal diets as substitutes for soybean meal diets.

	Initial BW (g)	Final BW (g)	Relative growth rate (%)[1]	Specific growth rate (%/day)[2]
Diet 1	36.4 ± 1.69	141.9 ± 8.11[a]	291 ± 40.22[a]	2.12 ± 0.16[a]
Diet 2	36.5 ± 1.22	134.2 ± 2.23[ab]	268 ± 15.3[a]	2.04 ± 0.06[a]
Diet 3	35.3 ± 1.32	128.6 ± 2.03[b]	265 ± 8.00[a]	2.02 ± 0.03[a]

Values are means ± SD. Values not sharing the same superscript letter in the same column are significantly different ($P < 0.05$).
[1] Expressed as 100 × (final BW - initial BW)/initial BW
[2] Expressed as 100 × (ln final BW - ln initial BW)/days

Table 5. Feed performance of rainbow trout fed hazelnut meal diets as substitutes for soybean meal diets.

	Feed efficiency (%)[1]	Protein efficiency ratio (%)[2]	Daily protein intake (g/fish)[3]	Daily dry energy intake (kcal/fish)[4]	Apparent net protein retention (%)[5]
Diet 1	1.49 ± 0.13[a]	3.14 ± 0.3[a]	0.49 ± 0.03[a]	22.84 ± 1.27[a]	59 ± 4.66[a]
Diet 2	1.38 ± 0.03[a]	2.96 ± 0.06[a]	0.48 ± 0.006[a]	21.72 ± 0.31[a]	56.3 ± 1.42[a]
Diet 3	1.35 ± 0.02[a]	2.83 ± 0.03[a]	0.48 ± 0.06[a]	20.55 ± 0.43[a]	52.1 ± 0.29[a]

Values are means ± S.D. Values not sharing the same superscript letter in the same column are significantly different ($P < 0.05$).

[1] Expressed as 100 × (final BW - initial BW)/dry feed intake.

[2] Expressed as (final BW - initial BW)/protein intake.

[3] Expressed as (daily dry protein consumption/100)

[4] Expressed as (daily dry feed intake × gross energy in feed)

[5] Expressed as 100 [((final BW × final protein in fish) – (initial BW × initial protein in fish))/((total feed intake/n*) × protein in feed)].

*n = number of fish in treatment.

from being used commercially as ingredients in salmon feeds, which are typically formulated to contain relatively high protein and oil content (5). In addition, plant meals containing carbohydrates may have harmful effects on Atlantic salmon performance (28).

Fish fed hazelnut meal diets gained less weight than those fed the soybean meal diet (Diet 1), although the differences were not statistically significant between Diets 1 and 2. The growth rate and feed efficiency (Tables 4 and 5) of the trout fed soybean meal and hazelnut meal in this study were close to the results obtained in previous experiments (5,29-31). While the growth rate, PER, and feed efficiency results we observed were higher than those reported by Thiessen et al. (29), they were lower than the findings published by Vielma et al. (12). Some earlier studies of rainbow trout suggested that the major problem connected with poor growth of fish fed fishmeal-free, plant-protein-based diets is caused by poor feed intake (30,31); however, the present study showed that hazelnut meal diets had no negative effects on growth rate or feed efficiency (Tables 4 and 5).

Smith et al. (32), working with rainbow trout, fed either fishmeal-based or plant protein-based feeds and did not find any differences in organoleptic quality or flesh acceptability. Kaushik et al. (6) did not find any major effects of total replacement of fishmeal by a soybean protein concentrate. Aoki et al. (33) did not find any difference in fish quality between red sea bream fed with or without fishmeal as the dietary protein source. In this study, we obtained a significant increase in fat content in Diet 1. This consequently resulted in a similar increase in body energy content. The high fat and daily dry energy intake values in this group clearly suggested that there was increased lipogenesis with higher levels of soybean meal, without any effects on apparent net protein retention. Indeed, daily protein intake, protein efficiency ratio, energy intake, and apparent net protein retention did not vary among the groups.

Additional research may prove useful; however, it is clear that rainbow trout can efficiently use hazelnut meal as a source of nutrients. Based on the ingredients, a change to the current formulations to include hazelnut meal could reduce the proportion of soybean meal, opening a new market for hazelnut meal and helping this new aquaculture industry grow. Use of hazelnut meal in commercial rainbow trout feeds will depend on the availability and cost of each protein source.

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