Iran. J. Ichthyol. (2025) 12(1): 39-45
P-ISSN: 2383-1561; E-ISSN: 2383-0964

ORIGINAL ARTICLE

Comparing on substitution of soybean meal for fish meal on Persian sturgeon (*Acipenser persicus*) and Goldfish (*Carassius auratus*)

Tahereh BAGHERI[1,2*], Toktam BAGHERI[3]

[1]Inland Waters Aquatics Resources Research Center, Iranian Fisheries Sciences Research Institute (IFSRI), Agricultural Research, Education and Extension Organization (AREEO) Gorgan, Iran.
[2]Offshore Fisheries Research Center, Iranian Fisheries Science Research Institute (IFSRI), Agricultural Research Educations and Extension Organization (AREEO), Chabahar, Iran.
[3]Department of Food Hygiene and Quality Control, Faculty of Veterinary Medicine. University of Tehran, Tehran, Iran.

Correspondence
bagheri1360@gmail.com

Article history:
Accepted 12 January 2024

Abstract
For investigating the capacity of soybean meal to be used as a diet's primary protein ingredients, two trial diets designed on two species with discriminate feeding habit (Persian sturgeon, *Acipenser persicus*, as carnivorous and Goldfish, *Carassius auratus*, as omnivorous. Diets prepared according to each species specified nutritional requirements. Surprisingly, the results of soybean meal inclusion in Gold fish diets showed better weight gain and specific growth rate. There were no significant differences among treatments in the case of condition factor and food conversion rate of Goldfish. In contrast, soybean meal could not be used efficiently by Persian sturgeon, even if partly used and phosphorous met with microbial phytase incorporation. Well growing of an omnivorous species throughout soybean inclusion in diet would be a promising achievement for designing a more efficient and cheaper diet in the future.

Keywords: Growth, Diet, Substitution, Feeding habit

INTRODUCTION

Aquaculture industry has been developing as one of the main aquatic food-supplying sectors in the world (FAO 2018). So, it is not surprising if this industry comes up with some challenges and determinative issues related to the food production (Ma et al. 2020, Liu et al. 2020). For preparing aquaculture foods, protein source of diets is the most important and cost demanding ingredient (Watanabe 2002; Wang et al. 2023). Fish meal is usually used as protein ingredient, which is limited, expensive and unpredictable source, so aquaculture industry has been searching for more sustainable and cheaper protein sources (Bagheri et al. 2013). Soybean meal is a high protein source with a relatively well-balanced amino acid profile, which made it an acceptable substitution for fish meal (Ma et al. 2020). Nevertheless, they contain compounds that influence the fish health and growth (Imanpoor & Bagheri 2011; Tan et al. 2019; Liu et al. 2020). Iranian native species, Persian sturgeon, *Acipenser persicus*, stocks are endangered and its production through farming is essential. Moreover, preparing diets satisfying good health and profitable farming process is inevitable. In addition, Goldfish is an omnivorous fish which used as an omnivorous model species in aquaculture food industry research (Ishibashi & Iwasaki 2015). In the following, we conducted a study and evaluate the consequences of soybean inclusion according to the fish nutritional status of Gold fish as well as Persian sturgeon and compare them to attain an achievement for a suitable diet with cost effective ingredients.

MATERIAL AND METHOD

Preparing trial diet for Persian sturgeon and Goldfish: Since Acipenser is a carnivorous species; two diets were prepared based on its protein requirement as well as fish meal and soy bean meal composition. The latter was experimental diet in which partly soybean meal replaced and supplemented to compensate and alleviate the limitations within soybean meal. These supplements include: phosphorous, magnesium, and phytase (Table 1).

Table 1. Formulation of reference and the experimental diets as dried weight.

	Persian sturgeon Content (g kg^{-1} diet)		Goldfish Content (g kg^{-1} diet)	
Ingredients	Reference diet	Experimental diet	Reference diet	Experimental diet
Fish meal	550	218	500	0
Soybean meal	0	500	0	500
Milk powder	150	150	123.5	237.5
Wheat flour	170	0	310	146
Fish oil	30	40	40	90
Soybean oil	50	40	0	0
Methionine	12.5	14.5	2	2
Lysin	15	15	2	2
Vitamin mineral premix	20	20	20	20
Mold inhibitor	2.5	2.5	2.5	2.5
Phosphorous	0	6	0	0
Magnesium	0	0.5	0	0
Phytase	0	0.2	0	0

On the other hand, Goldfish is an omnivorous species, so satisfying its protein requirement is less strict. Based on nutritional requirement and favorite ingredients with fish meal and complete soybean meal replacement, trial diets prepared (Table 1).

Experimental rearing condition: Persian sturgeon juveniles (average weight: 352.07±5.51 g) and Gold fish (average weight: 11.8±01g) were acclimatized to be reared and fed with experimental diets for a period of 2 weeks. For setting experiment, 400-l fiberglass aquariums in an indoor facility prepared for fish to be stocked. Every group was fed for a 10-week with experimental diet. Feeding trial ran in triplicates at a rate of 3% of body weight (Mohseni et al. 2007; Yanar et al. 2008). Each tank aerated with air stone to supply sufficient dissolved oxygen during the trial. For keeping water quality of each aquarium in a favorable condition, 80% volume of water replaced along with daily siphoning to remove uneaten feed and feces. For more exact calculation of FE, SGR, and CF, Uneaten feed dried, weighted, and subtracted (Lim & Lee 2008).

Analyzing proximate composition of the experimental diets: All diets prepared to satisfy fish protein requirement and available ingredients with fair composition. For comparing soybean meal efficiency over fish meal, fish meal diets for both species considered as reference diet and the diet replaced by soy bean meal considered as experimental diet. Both reference and replace diets contain equal composition of protein, fat and carbohydrate (table 2).

For analyzing proximate composition of experimental diets, samples dried at 110 ◦C in an oven for 24 h. Crude protein, Crude fat and the ash contents determined by the methods respectively includes: Kjeldahl method (Total Kjeldahl Nitrogen×6.25), soxhlet extraction method using petroleum ether (boiling point 60˚C) in the electro-thermal soxhlet and incineration in a muffle furnace at 550 ◦C for 24 h (AOAC 1990).

Sampling for growth assessment: The amount of food for each treatment adjusted every 14 days. Upon experiment ended, feeding stopped for one day, and then fish took from each tank, anesthetized and weighted for growth evaluation. In order to analyze nutrient composition of each sample, fish killed by a sudden sharp stroke on its head. Muscle prepared through evisceration, skinning and vertebrate removing.

Samples kept in freezer (-20˚C) until further analysis (Imanpour & Bagheri 2011). Growth performances calculated according to the following formula (1, 2, 3 & 4) for assessing food efficiency on fish production (Bagheri et al. 2008; Imanpoor & Bagheri 2011; Mastorakia et al. 2020).

1. Weight Gain (WG, %)= 100 × [(final bodyweight - initial body weight) (initial body weight)$^{-1}$]

Iran. J. Ichthyol. (2025) 12(1): 39-45

Table 2. Proximate composition of reference and the experimental diets (presented as dried matter (DM)).

	Persian sturgeon Reference diet	Persian sturgeon Experimental diet	Goldfish Reference diet	Goldfish Experimental diet
Dry Matter (DM)%	891.8	904.5	903.1	913.8
In DM (%)				
Crude protein	426.1	433.2	403	404.6
Crude fat	84.6	84.3	90.3	91.2
Ash	78	72	78	76

Table 3. Mean initial and final weight of Persian sturgeon and Goldfish influenced by different diets.

	Persian sturgeon Reference diet	Persian sturgeon Experimental diet	Goldfish Reference diet	Goldfish Experimental diet
Initial body weight(g)	352.9±5	358.60±0.7	10.1±0.01	10±0.01
Final body weight(g)	681.04±38.36	511.75±70.48	14.9±0.2	17.95±0.3

2. Feed efficiency (FE)= [body weight gain × (feed supply)$^{-1}$]
3. Specific growth rate (SGR, %)= 100 × [Ln (final weight) - Ln (initial weight)] (duration)$^{-1}$
4. Condition factor (CF)= 100 × [body weight (g) × (body length, cm)$^{-3}$]

RESULTS

All diets analyzed for revealing their nutritional composition and expressed in table 2. Initial and final weight of each is shown in table 3. Growth performances evaluated through calculating some parameters relate to the fish feeding condition. They include weight gain (WG), feed efficiency (FE), specific growth rate (SGR), and condition factor (CF), which are shown in Figures 1, 2 and 3.There was no apparent different performance of diet acceptance among experimental diets throughout the feeding trial. In addition, mortality was not recorded during trial operation. In Persian sturgeon, results showed that there was no improvement in FE, SGR, and CF in fish fed diet containing soybean meal as protein source, even if diet supplemented (Fig. 2). In contrast to Persian sturgeon, Gold fish fed diet in which soybean meal completely replaced, performed obviously better growth in weight gain (WG), feed efficiency (FE), specific growth rate (SGR), and condition factor (CF) (Figs. 1 & 3). The proximate carcass composition showed no difference in lipid as well as moisture content (Figs. 4 & 5). Although, protein content of Persian sturgeon influenced. (Fig. 4).

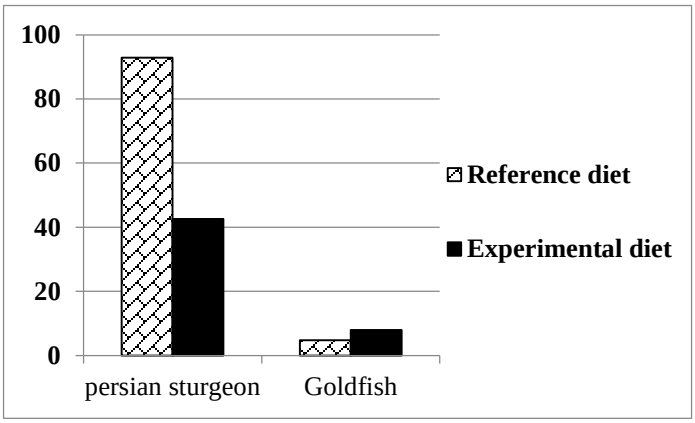

Fig.1. Weight gain of Persian sturgeon and Gold fish after feeding with experimental and reference diets.

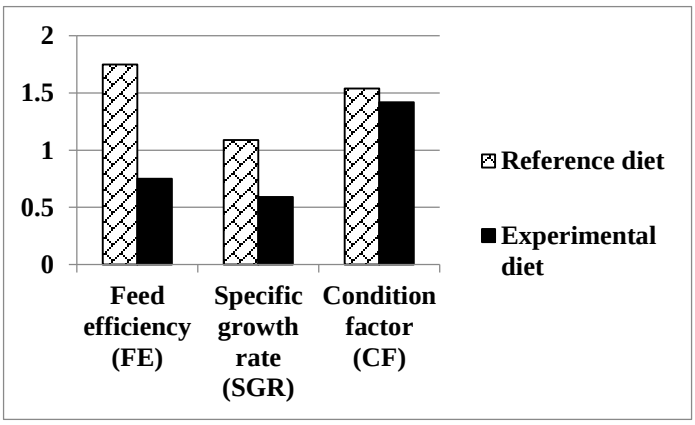

Fig.2. Comparing Growth performances of Persian sturgeon and Gold fish after feeding with experimental and reference diets.

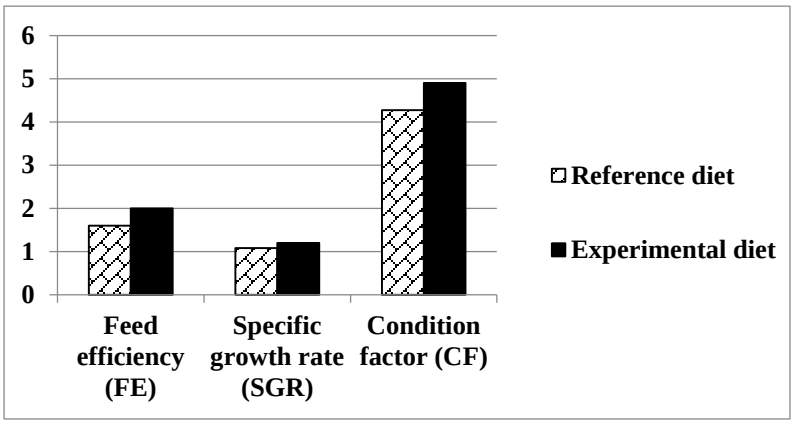

Fig.3. Comparing Growth performances of Persian sturgeon and Gold fish after feeding with experimental and reference diets.

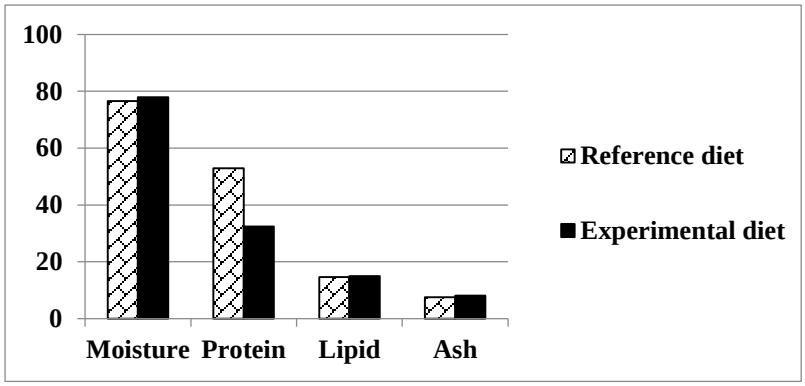

Fig.4. Carcass composition of Persian sturgeon fed Experimental and reference diets.

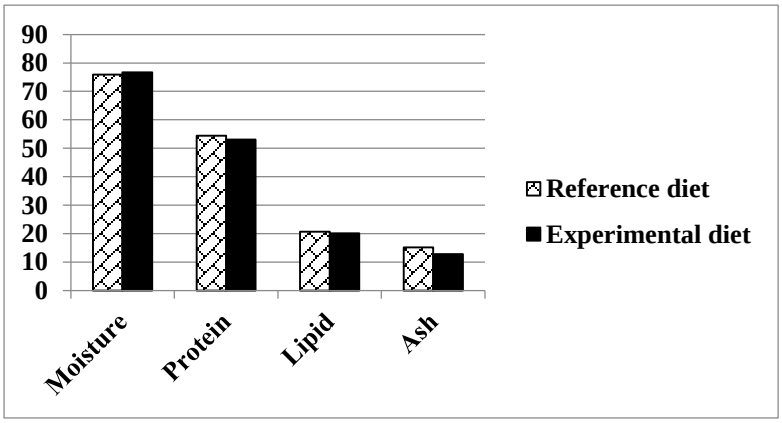

Fig.5. Carcass composition of Goldfish fed Experimental and reference diets.

DISCUSSION

In this feeding trial, fish meal revealed more efficiency for Persian sturgeon growth and soybean meal diet did not resulted in growth enhancement, even if diets supplemented with minerals and phytase for compensating soybean meal deficiency. The probable reason might be disability of fish to digest amino acid contents of soybean meal, which limits digestive tract to absorb soybean protein efficiently, compare to the fish meal (Mohseni et al. 2007; Liu et al. 2008).

Replacing diet with new source protein ingredients could disturb the microbiota and reduce its diversity (Duan et al. 2022). Well balancing of intestinal microbiota is accepted as one reason for better growth in fish (Apper et al. 2016). Intestinal microbiota also might be prevalence by bacteria which are responsible for inflammatory reactions.

This cause changes in gut membrane structure and mucosal secretion, which lead to lower growth rate. What's more, Soybean meal contains high fibers which are rich in indigestible cellulose and inhibit full digestion and nutrient absorption of diet (Duan et al. 2022). In fact, high crude fiber is a negative issue for ingredients to be applied for carnivorous fish (Zhou et al. 2011).

Unlike Persian sturgeon, Gold fish showed growth enhancement as a result of feeding with diets replaced fish meal completely by soybean meal. Soybean meal contains substances named phytoestrogens, which include three main groups: isoflavone, coumestans and lignans. It has biologically estrogen-like effects and can act as estrogen agonists. Since phytoestrogen has a similar structure of estrogen hormones, it can have synergism effect on growth mechanisms. Phytoestrogens can act as an antioxidant agent and improve health condition as well (Zhou et al. 2015). Therefore, better growth of Gold fish might be related to the phytoestrogen content of soybean. In the case of Persian sturgeon, it is assumed that the advantages of soybean phytoestrogen are less than disadvantages of its antinutrient compounds.

The whole body composition in both species showed no significant affect through feeding with experimental diets. This is similar to the studies on other species and it seems that main source nutrition contents of diet are not determinative factor reflecting in body composition (Zhang et al. 2023). On the other hand, body composition appeared to be affected by protein source of diet in some other research (Liang et al., 2017; Armando et al. 2016). This might be claimed that body composition is affected by several complicated factors, feeding period should be longer for affecting on nutritional composition of animal for instance.

The findings from the study revealed that fish meal replacement in fish diets is strongly influenced by fish species instead of supplementation or other processing to prepare fish nutritional requirements. Indeed, these findings suggest that fish meal replacement by soybean meal could not be always a helpful solution for cost reduction in all fish husbandry operation.

ACKNOWLEDGEMENTS

The authors would like to thanks to all who contributed to this research.

REFERENCES

Apper, E.; Weissman, D.; Respondek, F.; Guyonvarch, A.; Baron, F.; Boisot, P.; Rodiles, A. & Merrifield, D.L. 2016. Hydrolysed wheat gluten as part of a diet based on animal and plant proteins supports good growth performance of Asian seabass (*Lates calcarifer*), without impairing intestinal morphology or microbiota. Aquaculture 453: 40-48.

AOAC, 1990. In: Helrich, W. (Ed.), Official Methods of Analysis of the Association of Official Analytical Chemists, vol. 1, 15th ed. Association of Official Analytical Chemists, Washington, DC.

Armando, G.O., Kissinger, K.R. & Trushenski, J.T. 2016. Evaluation of fish meal and fish oil replacement by soybean protein and algal meal from *Schizochytrium limacinum* in diets for giant grouper *Epinephelus lanceolatus*. Aquaculture 452: 1-8.

Bagheri, T.; Imanpoor, M.R. & Jafari, V. 2014. Effects of diets containing genistein and diadzein in a long-term study on sex steroid dynamics of goldfish (*Carassius auratus*). Toxicology and Industrial Health 30(2): 132-140.

Bagheri, T.; Imanpoor, M.R.; Jafari, V. & Bennetau-Pelissero, C. 2013. Reproductive impairment and endocrine disruption in goldfish by feeding diets containing soybean meal. Animal Reproduction Science 139: 136– 144.

Duan, Z.; Zhang, C.; Huang, L.; Lan, Q.; Hu, J.; Li, X. & Leng, X. 2022. An evaluation of replacing fish meal with fermented soybean meal in diet of hybrid snakehead (*Channa argus*× *Channa maculata*): growth, nutrient utilization, serum biochemical indices, intestinal histology, and microbial community. Aquaculture Nutrition 2022(1); 2964779.

FAO, 2018. FISHSTAT Plus, Universal Software for Fishery Statistical Time Series. United Nations Food

and Agriculture Organization, Rome. Electronic webpage.

Ishibashi, T. & Iwasaki, H. 2015. Breeding-Back of Goldfish as a Practice that Mediates Between Experimental Biology and Aesthetics. In Recent Advances in Natural Computing: Selected Results from the IWNC 7 Symposium (pp. 123-130). Springer Japan.

Imanpoor, M.R. & Bagheri, T. 2012. Effects of replacing fish meal by soybean meal along with supplementing phosphorus and magnesium in diet on growth performance of Persian sturgeon, *Acipenser persicus*. Fish Physiology and Biochemistry 38: 521-528.

Liang, X.F.; Hu, L.; Dong, Y.C.; Wu, X.F.; Qin, Y.C.; Zheng, Y.H.; Shi, D.D. & Xue, M. 2017. Substitution of fish meal by fermented soybean meal affects the growth performance and flesh quality of Japanese seabass (*Lateolabrax japonicus*). Animal Feed Science and Technology 229: 1-12.

Lim, S.J. & Lee, K.J. 2008. Supplemental iron and phosphorous increase dietary inclusion of cottonseed meal and soybean meal in olive flounder (*Paralichthys olivaceus*). Aquaculture Nutrition 14: 423-430

Liu, H.; Wu, X.; Zhao, W.; Xue, M.; Guo, L.; Zheng, Y. & Yu, Y. 2008. Nutrient digestibility coefficients of selected protein sources for juvenile Siberian sturgeon (*Acipenser baeri* Brandt), compared by two chromic oxide analysis methods. Aquaculture Nutrition 15(6): 650-656.

Liu, X.; Han, B.; Xu, J.; Zhu, J.; Hu, J.; Wan, W. & Miao, S. 2020. Replacement of fishmeal with soybean meal affects the growth performance, digestive enzymes, intestinal microbiota and immunity of *Carassius auratus* gibelio♀ ϧ *Cyprinus carpio*♂. Aquaculture Reports 18: 100472.

Ma, Y.; Xu, C.; Li, M.; Hanyi, C.; Ye, R.; Zhang, G.; Xie, D.; Ning, L.; Wang, S.; Sun, L.; Wang, Y. & Li, Y.2020. Diet with a high proportion replacement of fishmeal by terrestrial compound protein displayed better farming income and environmental benefits in the carnivorous marine teleost (*Trachinotus ovatus*) Aquaculture Reports 18: 100449.

Mohseni, M.; Sajjadi, M. & Pourkazemi, M. 2007. Growth performance and body composition of sub-yearling Persian sturgeon, (*Acipenser persicus*, Borodin, 1897), fed different dietary protein and lipid levels. Journal of Applied Ichthyology 23(3): 204-208.

Tan, C.; Zhou, H.; Wang, X.; Mai, K. & He, G. 2019. Resveratrol attenuates oxidative stress and inflammatory response in turbot fed with soybean meal based diet. Fish & Shellfish Immunology 91: 130-135.

Wang, X.; Luo, H.; Wang, D.; Zheng, Y.; Zhu, W.; Zhang, W.; Chen, Z.; Chen, X. & Shao, J. 2023. Partial Substitution of Fish Meal with Soy Protein Concentrate on Growth, Liver Health, Intestinal Morphology, and Microbiota in Juvenile Large Yellow Croaker (*Larimichthys crocea*). Aquaculture Nutrition 1: 3706709.

Watanabe, T. 2002. Strategies for further development of aquatic feeds. Fisheries Science. 68: 242–252.

Yanar, M.; Erçen, Z.; Hunt, A.Ö. & Büyükçapar, H.M. 2008. The use of alfalfa, Medicago sativa as a natural carotenoid source in diets of goldfish, *Carassius auratus*. Aquaculture. 284(1-4): 196-200

Zhang, Q.; Li, F.; Guo, M.; Qin, M.; Wang, J.; Yu, H.; Xu, J.; Liu, Y. & Tong, T. 2023. Growth Performance, Antioxidant and Immunity CapacityWere Significantly Affected by Feeding Fermented Soybean Meal in Juvenile Coho Salmon (*Oncorhynchus kisutch*). Animals 13: 945.

Zhou, F.; Song, W.; Shao, Q.; Peng, X.; Xiao, J.; Hua, Y.; Owari, B. N.; Zhang, T. & Ng, W-K. 2011. Partial replacement of fish meal by fermented soybean meal in diets for black sea bream, *Acanthopagrus schlegelii*, juveniles. Journal of the World Aquaculture Society 42(2): 184-197.

Zhou, C.; Lin, H.; Huang, Z.; Wang, J.; Wang, Y. & Yu, W. 2015. Effects of dietary soybean isoflavones on non-specific immune responses and hepatic antioxidant abilities and mRNA expression of two heat shock proteins (HSPs) in juvenile golden pompano *Trachinotus ovatus* under pH stress. Fish & Shellfish Immunology 47(2): 1043-1053.

Iran. J. Ichthyol. (2025) 12(1):39-45
P-ISSN: 2383-1561; E-ISSN: 2383-0964
http://www.ijichthyol.org

doi: 10.22034/iji.v12i1.1049

مقاله کامل

مقایسه جایگزینی پودر سویا به‌جای پودر ماهی در ماهی خاویاری ایرانی (*Acipenser persicus*) و ماهی قرمز (*Carassius auratus*)

طاهره باقری[۱،۲*]، تکتم باقری[۳]

[۱]مرکز تحقیقات ذخایر آبزیان آب‌های داخلی، موسسه تحقیقات علوم شیلاتی کشور، سازمان تحقیقات، آموزش و ترویج کشاورزی، گرگان، ایران.
[۲]مرکز تحقیقات شیلات آب‌های دور، موسسه تحقیقات علوم شیلاتی کشور، سازمان تحقیقات، آموزش و ترویج کشاورزی، چابهار، ایران.
[۳]گروه بهداشت و کنترل مواد غذایی، دانشکده دامپزشکی، دانشگاه تهران، تهران، ایران.

چکیده: با هدف بررسی امکان استفاده از پودر سویا به‌عنوان منبع پروتئینی جیره، دو جیره آزمایشی بر روی دو گونه با عادت غذایی متمایز طراحی شد: قره‌برون (*Acipenser persicus*)، به‌عنوان گونه گوشتخوار و ماهی قرمز (*Carassius auratus*) به‌عنوان همه‌چیزخوار. جیره‌های غذایی برای هر گونه براساس نیازهای تغذیه‌ای تهیه شد. نتایج گنجاندن پودر سویا در جیره ماهی طلایی افزایش وزن و سرعت رشد ویژه را نشان داد. تفاوت معنی‌داری بین تیمارها در مورد فاکتور وضعیت و ضریب تبدیل غذای در ماهی طلایی وجود نداشت. برعکس، نتایج نشان داد که پودر سویا نمی‌تواند به‌طور مؤثر توسط قره‌برون استفاده شود، حتی اگر بخشی از آن جایگزین شود و آنزیم فیتاز نیز در جیره اضافه گردد. رشد یک گونه همه‌چیزخوار با گنجاندن پودر سویا در جیره غذایی، دستاورد امیدوارکننده‌ای برای طراحی یک جیره غذایی کارآمدتر و ارزان‌تر در آینده خواهد بود.

کلمات‌کلیدی: رشد، سرعت رشد ویژه، جایگزینی، عادت غذایی