The effect of mechanization on the growth and nutritional indicators of dual-purpose rainbow trout culture farms in Markazi Province, Iran

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Abstract

This research was aimed to investigate the effect of mechanization on the growth and nutritional indices of dual-purpose rainbow trout farms in the Markazi province (Iran). 5 cities with high production capacity and pools numbers were selected in cooperation and according to the provincial fisheries. The experts were sent to the farms to prepare necessary documents, complete the questionnaire regarding the existing and active mechanization equipment and the technologies used, the production in the farm, the type of food consumed, the factory producing the feed, type of feeding (automatic, manual), use of feed dispensers, the same size of fish to avoid competition and the dominance of larger fish during feeding, the condition and method of food storage. Growth and nutrition indicators of farms were determined. some mechanization equipments of farms included as aeration tower (90%), drum filter (23.33%), Feed storage equipped with a fan (30%), pallet in the feed store (66.67%), sediment pool (53.33%) and grading (76.67%), respectively. Mechanization and the type of food had effect on the growth process of fish, and the improvement of nutritional management, the use of resources more efficiently with the optimization and correct selection of the type, amount, method of feeding increases the economic productivity of dual-purpose rainbow trout culture ponds in the Markazi province. This study showed that various variables such as the amount of production, quantity and quality of food, health management, density, fish weight, implementing fishing patterns, construction of a sediment collection pool, fish grading, proper storage in optimal and hygienic conditions on pallets, installation of aerators and installation mesh in the windows in the feed store, periodic testing of the physico-chemical and microbial parameters of the water, can be effective in the farm's performance.

Keywords: Mechanization, Agricultural dual-purpose fields, Feeding, Markazi Province

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Introduction

Restrictions on fishing and the lack of access to some potential water resources have led to the maximum use of available resources in aquaculture (Aubin *et al.*, 2006). Mechanization of fish farms mainly includes feeding, water distribution and replacement, aeration, water quality monitoring systems and other activities such as electrical equipments, security camera, administrative management, etc. Mechanization reduces labor and feed costs in fish farms and increases productivity in fish farms along with reducing water pollution through effective management of fish farms and creates another revolution in aquaculture (Asadujjaman and Chowdhury, 2019).

Considering that the average age of agricultural workers is increasing in many parts of the world, fishery productions are facing the problem of labor shortage and aquaculture methods need urgent change. The smart fish farm increases the amount of dissolved oxygen in the water, optimizes nutrition, reduces the incidence of diseases and provides accurate harvesting of the catch through the thinking of replacing humans with machines to realize sustainable and green aquaculture (Wang *et al.*, 2021). Food is vital for the growth, health and reproduction of fish and plays an important role in salmon farming, which includes about 60-70% of production costs. The quality of feed directly affects the quality of water, because part of the feed received by fish is returned to the environment as metabolites or by-products of metabolites (Thorpe and Cho, 1995).

Since trout farming in a semi-arid country like Iran, targets the highest quality water resources attention should be paid to the responsible development of aquaculture (as opposed to purely economic development) by using advanced systems and mechanization, not only in optimizing Water consumption in this area and increasing the quantity and quality of fish production, but it also minimizes the environmental risks and ensures the sustainability of production (Hafezieh and Mateenfar, 2013). The best method is that the distribution of feed should be performed until reaching a level close to satiation (Bureau *et al.*, 2006). Feed quality directly affects water quality because part of the feed received by fish is returned to the environment as metabolites or by-products of metabolites (Thorpe and Cho, 1995).

The amount of cold-water fish culture in the country in 2014 was 140,244 tons, which increased to 190,287 tons in 2019. Also, the amount of cold-water fish culture in Markazi Province in 2014 was 1889 tons, which increased to 5144 tons in 2019 (Ghorbanzadeh and Nazari, 2021). A significant part of the production of this province is carried out in dual-purpose agricultural farms, and since integrated management was not applied to these farms, the province's fisheries management instituted a plan to benefit from the mechanization of these farms. Overfeeding, underfeeding, fish diseases and residual feed waste are the most important challenges that rainbow trout farmers will face during fish feeding operations, which can lead to economic challenges (Qadeem Khan *et al.,* 2016).

Feeding fish with the right feed containing the required nutrients, taking into account the light and temperature factors, feeding the fish with the right amount of feed and choosing the right feeding method is necessary to achieve the desired results of the growth performance and increase the weight and length of the fish (Alyshbaev, 2013). Also, having knowledge about the nutritional requirements, feeding behavior and eating habits of different species is essential for preparing formulated feeds in the field using local good quality food ingredients (Haridas *et al.,* 2019). In order to achieve maximum production with high economic efficiency, it is necessary to comply with the standards of nutritional management, health, biosecurity principles and proper storage methods to maintain the nutritional quality of fish feed. Feed should be properly stored under hygienic conditions to prevent any type of contamination and spoilage (Haridas *et al.,* 2019). Fiordelmondo *et al.* (2020) reviewed the improvement of water quality in culturing rainbow trout using the type of feeding and nutritional management in a period of 10 years (2009-2019) and concluded that due to the decrease in the values of physical and chemical parameters of water reviewed in 2010 compared to 2009, the use of extruded food is a suitable method in feed processing and is more suitable for preserving the environment. Qadeem Khan *et al.* (2016) concluded that suitable habitat and feeding containers, standard water quality and food protein play an important role in growth of cultured rainbow trout. Clontz (1991) while emphasizing the selection of the appropriate size of the pellet according to the size of the smallest fish in the pond and the fair distribution of feed to be available to all fish, stated that the use of automatic feeders for farms with a capacity of less than 50 tons per year is not economical. Also, when feeding fish daily based on the size of the fish, it is better to supply the amount of food needed for 7 days to the fish in 5 days and consider the last 2 days as rest days for the fish and the fish farmer. Lee (1995) reviewed the automatic control systems of aquaculture and the design criteria for their implementation in the United States and stated that the use of intelligent automation systems in aquaculture brings farm products closer to the market, increases the control of the culture environment, and reduces losses, reduces environmental risks by reducing waste water output, reduces production costs and improves product quality. Tokmechi *et al.* (2013) concluded that the combined use of vitamin C and *Lactobacillus rhamnosus* improves final weight, the percentage of body weight gain, specific growth rate and immune responses of rainbow trout.

Farahani *et al.* (2015) stated that the use of mechanical devices and new mechanization methods for water recirculation plays an important role in increasing production efficiency. In such a way, the water exiting from culture ponds can be pumped back to the ponds by the pump engine after removing its waste and suspended materials and aerating and compensating the lost oxygen and increasing the capacity of keeping fish in the pond. Khoshakhlagh and Kiyani (1999) concluded that water flow rates and temperature have a significant effect on salmon production. Davies *et al.* (2008) quantitatively investigated the mechanization of fish farms in Rivers State, Nigeria, and found that the installation of air pumps to boost dissolved oxygen levels significantly increased fish stocking rates from the usual 30 fish per square meter to 150-200 fish per square meter. This research was conducted to study the effect of mechanization and the type and amount of feed consumed in improving the growth and nutritional indicators of dual-purpose agricultural farms for cold water fish culture in the Markazi province of Iran.

Materials and methods

This study has been concluded in 30 dual purpose fish farms from 5 cities of Markazi Province, namely Farahan (6 farms-numbers1 to 6), Arak (11 farms-numbers 7 and 21 to 30), Khondab (3 farms-numbers 15 to 17), Shazand (7 farms-numbers8 to14) and Khomein (3 farms-numbers 18 to 20). During the field study, registration of existing and active mechanization equipment and technologies used and actual production in the farm, amount of feed consumed, food conversion ratio, type of food consumed (feed manufacturing company), primary and final weight, the type of feeder (automatic, manual), the use of feed dispensers, the way to store the food materials was done in the form of a questionnaire. Also, some growth and nutritional factors such as body weight gain, (Bekcan *et al.,* 2006), specific growth rate (Hevroy *et al*., 2005), and condition factor (Helland *et al.*, 1996) were determined based on the following formulas:

FCR= $(\text{dry food fed(g)})/(\text{wet weight gain(g)})$

body weight gain = the average weight at the end of the period in grams- The average weight at the beginning of the period in grams

percentage of weight gain=Weight at the end of the period in grams ÷ (weight at the beginning of the period in grams - weight at the end of the period in grams) × 100

specific growth rate=Time ÷ (natural logarithm of the weight at the beginning of the period in grams - natural logarithm of the weight at the end of the period in grams) × 100

condition factor= (weight in grams ÷total length in centimeters) ^{3}×100

Results

Equipment and mechanization tools used in the studied farms are given in Table 1. Also, some nutritional indices in the studied farms are shown in Table 2.

Table 1: equipment and mechanization tools used in the studied farms.

farm No.	Sedimentation pool	Food factory	Feeding intervals (days)	Sorting	The presence of pallets in the feed store	aerator in the feed store	drum filter	No. of air conditioner	Air tower	Hand-made mechanical feeder
1	-	21 Beyza	7	-	-	+	-	8	+	-
2	+	Faradaneh	10	+	+	-	-	8	+	-
3	+	faradaneh	10	+	-	+	-	12	+	-
4	-	mazandaran	10	+	+	-	-	9	+	-
5	+	mazandaran	7	-	+	+	+	10	-	-
6	-	21 Beyza	10	+	+	-	-	8	+	-
7	-	21 Beyza	20	+	+	-	-	12	+	-
8	-	21 Beyza, Faradaneh	10	+	+	-	+	3	-	-
9	+	Beta	8	+	+	-	-	15	+	-
10	-	faradaneh	10	+	+	+	-	18	+	-
11	-	faradaneh	15	+	+	-	-	10	+	-
12	+	faradaneh	7	+	+	+	+	11	+	-
13	-	mazandaran	15	+	-	-	+	3	+	-
14	-	mazandaran	10	+	+	-	-	15	+	-
15	+	faradaneh	15	+	-	-	-	9	+	+
16	+	faradaneh	10	-	-	-	+	7	+	-
17	+	faradaneh	15	-	+	+	-	6	+	-
18	+	21 Beyza	8	-	-	-	-	17	-	-
19	+	21 Beyza	15	-	-	-	-	4	+	-
20	+	Kyimiagaran, faradaneh	15	+	+	+	+	8	+	-
21	+	Beta	15	-	+	+	-	5	+	-
22	+	faradaneh	7	+	+	-	-	23	+	-
23	-	faradaneh	12	+	-	-	-	13	+	-
24	-	faradaneh	8	+	+	-	-	6	+	-
25	-	faradaneh	7	+	+	-	-	12	+	-
26	+	Kymiagaran, 21 Beyza	12	+	+	+	-	12	+	-
27	+	faradaneh	۱۵	+	-	-	-	۲۰	+	-
28	-	21 Beyza	۷	+	+	-	-	۱۱	+	-
29	+	faradaneh	۷	+	-	-	+	۱۷	+	-
30	-	faradaneh	۱۵	+	+	-	-	۱۳	+	+

The values of FCR of selected farms (n=30) showed that farms 1 and 24 had the highest (1.34) and farms 13, 15, 16, 20, 21, 23, 25 and 29 had the lowest (1) value, which showed the appropriate FCR in the studied farms. Examining the amounts of production and feed consumption of the selected farms showed that the highest (70 tons) production amount in farm 27 and the lowest (4 tons) production amount in farm 13, as well as the highest (80 tons) and the lowest (4 tons) consumed feed were related to farms 27 and 13 have been registered.

The condition factor of the farms showed that farm 17 had the highest (2.437) and farm 3 (1.076) had the lowest value. The specific growth rate of the studied farms showed that farm 19 had the highest (0.4382) and farm 23 (0.1819) had the lowest specific growth rate. Also, the effective growth of the farms showed that farm 19 had the highest (0.146) and farm 17 (0.058) had the lowest value of the effective growth rate. In the studied farms, farm 25 had the highest (1485) and farm 19 had the lowest (299g) average weight gain in the period.

Table 2: Some nutritional indices in the studied farms.

farm No.	Initial release weight (g)	Final harvest weight (g)	Amount of food consumed (tons)	Production amount (tons)	FCR	CF	SGR	Mean weight gain (g)
1	7	700	20	21	1.34	1.286	0.266	693
2	5	900	14	13	1.10	1.296	0.267	895
3	15	60	33	30	1.28	1.076	0.301	993
4	35	1500	20	18.5	1.26	1.172	0.199	1465
5	1	1000	30	18.5	1.10	1.284	0.399	999
6	6	850	17.5	30	1.17	1.289	0.308	842
7	18	700	20	20	1.14	1.286	0.211	682
8	10	750	25	22	1.14	1.284	0.249	740
9	35	1000	50	40	1.32	1.284	0.194	965
10	1	900	50	45	1.11	1.296	0.314	899
11	3	750	17	17	1.10	1.284	0.321	747
12	0.6	800	60	50	1.20	1.288	0.273	799
13	1	1000	4	4	1.00	1.284	0.369	999
14	30	1200	16	18	1.10	1.120	0.207	1170
15	22	1500	30	30	1.00	1.200	0.196	1478
16	2	1000	11	11	1.00	1.284	0.321	998
17	10	1000	12	13	1.01	2.437	0.175	990
18	2	800	8	7	1.14	1.288	0.348	798
19	1	300	3.5	3.2	1.09	1.243	0.438	299
20	1	800	5	5	1.00	1.288	0.386	799
21	1	80	5.7	6	1.00	1.185	0.403	595
22	1	700	36	35	1.05	1.286	0.302	699
23	50	1500	18	20	1.00	1.165	0.182	1450
24	2	650	6.5	6	1.34	1.283	0.316	648
25	15	1500	27	26.5	1.00	1.172	0.242	1485
26	16	800	15	15	1.08	1.288	0.202	784
27	1	1200	80	70	1.20	1.120	0.372	1199
28	340	850	7	6	1.17	1.289	0.091	510
29	1	800	44	40	1.00	1.228	0.370	799
30	1	700	35	32	1.22	1.222	0.287	699

In the studied farms, the FCR range were between 1 to 1.34. In total, farms with high production had a higher food conversion ratio than farms with low production. In the cities of Khomein and Khondab, due to the uniformity of the feed manufacturing companies, the quality of the feeds was uniform and there was a better nutritional management. The difference in the way of nutritional management in the farms in terms of production management, workers' skills, feeding intervals, feeding speed and the use of food rations with different feed companies and as a result different qualities of food to be consumed, which doubles the need for nutrition management training in the farms.

Among the 30 studied farms, only two farms in Khondab (Farm 15) and Arak (Farm 30) cities were equipped with hand-made mechanical feeder instead of manual feeding, which is equivalent to 6.7% of the surveyed farms. Considering that in Khondab, the food conversion ratio with manual and mechanized feeding was 1, and in Arak city, manual feeding and the use of a food sprayer did not have a significant difference in the food conversion ratio, therefore, despite the reduction in labor costs, the use of a mechanical food sprayer in the cities of Khondab (Farm15) and Arak (Farm 30), has not had a significant positive effect on the food conversion ratio. In total, 90% of the farms had an aeration tower, 23.33% of the farms had a drum filter, 30% had a fan in the feed store, 66.67% had a pallet in the feed store, and 53.33% had a sediment pool. Also, grading was done only in 76.67% of the studied farms.

Discussion

Having knowledge about the nutritional requirements, feeding behavior and feeding habits of different species is necessary to prepare formulated feeds in the field using local quality food ingredients. In order to achieve maximum production with high economic efficiency, it is necessary to observe preventing excessive feeding or underfeeding, observing the correct amount of feeding and feeding at the right time of the day. The amount of feeding, feeding time and frequency of feeding depends on the stage of growth and body weight of the fish, as well as the provision of favorable environmental conditions such as temperature, dissolved oxygen, etc. To calculate the amount of feeding, it is necessary to correctly estimate the weight of the fish. Fish grow faster in the first days and should be fed at frequent intervals to support their metabolic activity and overall growth. Also, compliance with health standards, principles of biosecurity and appropriate storage methods are very necessary to maintain the nutritional quality of fish feed. Feed should be properly stored under hygienic conditions to prevent any type of contamination and spoilage (Haridas *et al.*, 2019).

Providing food according to the natural needs of the fish reduces stress and improves the health of the fish and reduces their aggressive behavior during manual feeding, which leads to less ammonia production and less oxygen consumption, and ultimately improves the food conversion ratio. In order for farmed trout to enjoy their living conditions during the farming period, it is necessary to control and monitor environmental indicators, disease control, feed management, stress control, skills and training should be under control at all times (Soltani *et al.*, 2018).

In the 30 studied farms, manual feeding was often used to feed rainbow trout, and only two farms (6.67%) had mechanized feeders, which, despite the reduction in labor costs, the use of mechanized feeders did not affect the food conversion rate of the farms. 20 farms had pallets in the feed store, and in 23 farms regular grading was done. Physical, chemical and microbial factors of water were not measured in any of the farms.

The feed store of only 9 farms (30%) was equipped with ventilators. Only 16 farms had sedimentation ponds and 7 farms (23.33%) enjoyed drum filter. According to the conducted field survey, it is suggested to do the following to improve the nutritional management of the surveyed farms: the construction of an active and appropriate disinfection pond, the existence of a written program for disinfection and washing between and within the period, performing disinfection operations on the effluent, the provision of safe and healthy food from factories under veterinary supervision, the storage of food and medicine in a suitable and hygienic condition on the pallet. Installing a suitable net on all windows and air inlets and outlets to prevent the entry of birds, rodents and insects, testing the physico-chemical and microbial parameters of water at least once a year, installing medicine storage, creating facilities for washing and disinfecting vehicles entering the complex, optimizing the health management of the farm, using food sprinklers and drum filters, installing ventilation systems in fee stores, preventing the accumulation of additional equipment and used and worn out items in the complex, installing air jets in the shape of a round clock and creating flow in stagnant areas, or modifying the structure of the pool, the specificity of the tools and equipment used in each pool, modifying the feeding method , grading, modifying the growth structure of plants around the pool and changing the type of feed consumed in older ages, installing a quarantine or release and Sedimentation pool, aligning water pipes in a way to prevent water stagnation in the pipe and biofilm production, installation of ponds to collect the effluent of the pools. Treating the effluent, not keeping koi fish and other animals next to the rainbow trout, building a disinfection pond at the entrance of the farm, installing a disinfection pond at the entrance of the farm, Placing death wells or carcass incinerators, modifying the water circulation system in the pools to prevent the accumulation of suspended particles, reducing the density of the herd so that they do not become dense at higher weights, or reducing the density of fish and if the necessity of installing shade in the farm, buying uniform fry and not mixing different weights, considering that hand-made mechanized feeders are used, feeding only covers the middle part of the pool, and it is better to do supplemental manual feeding as well.

It is also recommended to fill disinfection pools with disinfectant, use separate devices for each pool. Avoid of excessive feeding to the fishes and be sure of the feeder to fully consume the given foods, use of proper feeding system, step production, correct feeding method (to prevent food waste), use of sedimentation ponds to remove waste and feed residue in order to Preventing the decomposition of these materials and permanently removing these materials from the system, installing the drum filter right at the pumping station and reducing the suspended solids in the water by correcting the feeding management, using a resident expert in the farm and controlling all the quality and quantity of water and fish health by an expert and recording daily events in the relevant office, replacing the use of splashes in fish ponds, mechanically removing algae and controlling them with suitable algaecide measures, installing wooden pallet for food store and use feed from the previous to the new date, to employ a resident health technical officer and to hold supplementary training courses for managers, workers and technical officials of the farms of the province.

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References

Alyshbaev, A., 2013. Feeding level effect on the growth of rainbow trout (*Onchorynchus mykiss*) fingerlings. Pro Gradu Thesis. Faculty of Science and Forestry, Department of Biology, University of Eastern Finland. 40 P.

Asadujjaman, M.D. and Chowdhury, M.T.H., 2019. Fish farm mechanization: revolution in aquaculture. Chapter in book: National Fish Week 2019 Compendium (in Bangla) (pp. 79-83). Publisher: DoF.2020. National Fish Week 2019 Compendium (in Bangla). Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh.160P.

Aubin, J., Papatryphon, E., Van der Werf, H.M.G., Petit, J. and Morvan, Y.M., 2006. Characterization of the environmental impact of a turbot (*Scophthalmus maximus*) recirculating production system using Life Cycle Assessment. *Aquaculture*, 261(**4**), 1259–1268. DOI:10.1016/j.aquaculture.2006.09.008.

Bekcan, S., Dogankaya, L. and cakirogollari, G.C., 2006. Growth and body composition of European catfish (*Silurus glanis*) fed diet containing different percentages of protein. *journal of Aquaculture- Bamidgeh*, 58(**2**), 137-142. DOI: 10.46989/001c.20430.

Bureau, D.P., Hua, K., Cho, C.Y., 2006. Effect of feeding level on growth and nutrient deposition in rainbow trout (*Oncorhynchus mykiss* Walbaum) growing from 150 to 600 g. *Aquaculture Research*, 37, 1090–1098.DOI:10.1111/j.1365-2109.2006.01532.x.

Clontz, G.W., 1991. Manual for rainbow trout production on the mily –owned farm. Nelson and Sons, Inc., 118 West 4800 South, Murray, Utah 84107, *The Manufacturers of Nelson's Sterling Silver Cup Fish Feeds*, 70P.

Davies, R.M., Davies, O.A., Inko-Tariah, M.B. and Bekibele, D.O., 2008. The mechanization of fish farms in Rivers State, Nigeria. *World Applied Sciences Journal*, 3(**6**), 926-929.

Farahani, R. Shirazi, J. Khoshkho, Zh. Azimi Esk Shahr, M. Asadi, H. Saidi, D., 2015. Trout culture Guide, Agricultural Research, Education and Extension organization. Iranian Fisheries Research Institute, 200P, ISBN: 8-288-978-964-520. [In Persian]

Fiordelmondo, E., Enrico Magi, G., Mariotti, F., Bakiu, R. and Roncarati, A., 2020. Improvement of the Water Quality in Rainbow Trout Farming by Means of the Feeding Type and Management over 10 Years (2009–2019). *Animals*, 10, 1541. DOI:10.3390/ani10091541.

Ghorbanzadeh, R.A., Nazari, S., 2021. Statistical Yearbook of Iranian Fisheries 1394-1399- Iranian Fisheries Organization. Vice President of Planning and Resource Management. Planning and budget office. *Planning and Statistics Department*, 64P. [In Persian]

Hafezieh, M. and Mateenfar, A., 2013. Considerations of nutrition and mechanization of rainbow trout breeding in Iran, the second national conference on the development and breeding of cellar fish, Kurd city, Iran. pp.129-135. [In Persian]

Haridas, H., Saravanan, K., Praveenraj, J., Sontakke, R., Gladston, Y., Ajina, S.M., Deepitha, R., Streepriya Prakasasn, Kiruba Sankar, R., and Roy, D., 2019. Training manual on freshwater ornamental fish breeding and aqua scaping techniques. ICAR-CIARI, Port Blair, India, 39P.

Helland, S.J., Grisdale, B. and Nerland, S., 1996. A simple method for the measurement of daily feed intake of groups of fish in tanks. Aquaculture, 139,157-163. DOI:10.1016/0044-8486(95)01145-5

Hevroy, E.M., Espe, M., Waagbo, R., Sandness, K., Rund, M. and Hemer, G.I., 2005. Nutrition utilization in Atlantic salmon (*Salmo salar*) fed increased level of fish protein hydrolysate during a period of fast growth. *Aquaculture Nutrition* 11, 301-313. DOI:10.1111/j.1365-2095. 2005.00357.x.

Khoshakhlagh, R. and Kiyani, M., 1999. Investigating factors affecting the production of cold-water fish in Chahar Mahal and Bakhtiari province, *Journal of Agricultural Economics and Development*, 7, 28. [In Persian]

Lee, P.G., 1995. A Review of Automated Control Systems for Aquaculture and Design Criteria for Their Implementation. *Aquacultural Engineering*, 14, 3, pp. 205-227. DOI:10.1016/0144-8609(94)00002-I.

Qadeem Khan, Y., Ur Rehman, H., Naeem, M., Ahmad, M., 2016. Artificial feed for rainbow trout (*Oncorhynchus mykiss*) in district Swat Khyber Pakhtunkhwa, Pakistan. *Journal of Entomology and Zoology Studies*; 4(**5**), 155-158.

Soltani, M., Mirzargar, S.S., Nematollahi, M.A., Seidgar, M., 2018. Fish Health. Translation of the second edition. Tehran University Publications. 352 P. [In Persian]

Thorpe, J.E., Cho, C.Y., 1995. Minimizing waste through bio energetically and behaviorally based feeding strategies. *Water Science and Technology*, 31, 29–40. DOI:10.1016/0273-1223(95)00424-L.

Tokmechi, A., Shamsi, H., Meshkini, S., Delshad, R., Ghasemi Mughanjooghi, A., 2013. Improvement of growth indices and some immune response parameters of rainbow trout by using Vitamin C and probiotic *Lactobacillus rhamnosus*. *Scientific Journal of Iranian Fisheries*, 21, 3, pp. 13-22. [In Persian]

Wang, C., Li, Zh., Wang, T., Xu, X., Zhang, X. and Li, D., 2021. Intelligent fish farm-the future of Aquaculture. *Aquaculture International*, 29, 2681-2711. https://doi.org/10.1007/s10499-021-00773-8. DOI: 10.1007/s10499-021-00773-8.