FISH FEED AS A FACTOR AFFECTING AQUACULTURE IN LATVIA

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Abstract
Aquaculture in Latvia represents a minor economic sector, characterised by a limited number of enterprises, employees and overall turnover. However, recent years have seen growth in both production areas and output levels, indicating a promising potential for development in this field. Fish feed constitutes a significant portion of aquaculture expenses, accounting for 60-80% of total costs, making it a crucial factor influencing the industry. The purpose of the study is to determine the impact of fish feed in fish farms in Latvia. The study was carried out in different regions of Latvia, depending on the location of the aquaculture establishment. The data was collected through a partially structured interview using a questionnaire. The log-linear regression model was used to determine the relationship between all independent variables. The results showed that more than 90% of aquaculture farms were small farms and only 30% of the surveyed fish farmers use fish feed produced in Latvia on their farms. The study concluded that fish growers in Latvia face problems from the aspect of fish feed, which is influenced by the high feed price, co-operation opportunities among growers, feed logistics, as well as awareness of local fish feed from their producers. Alternative feed could become a possible solution to reduce the price of feed and buy it from local feed producers. Exploring alternative feed options may provide a feasible solution to lower feed prices while supporting local producers. Identifying issues related to aquaculture feed is essential for achieving efficient production and economic viability.
Keywords: aquaculture, fish feed, Latvia.

Introduction

Aquaculture in Latvia represents a minor economic sector, characterised by a limited number of enterprises, employees and overall turnover. However, recent years have seen growth in both production areas and output levels, indicating a promising potential for development in this field.

The impact of fish feed on aquaculture is a critical area of concern, largely due to the economic, environmental, and nutritional implications associated with various feed components. The overarching challenge is to develop sustainable feed alternatives that maintain or improve fish health and growth performance while minimising ecological footprints.

The dependency of aquaculture on traditional fishmeal and fish oil has become increasingly unsustainable. Aquaculture is recognised as the largest global consumer of these marine resources, accounting for approximately 70% of fishmeal and 73% of fish oil utilised (Lozano-Muñoz et al., 2022). This heavy reliance on wild-caught fish threatens both marine ecosystems and the future viability of aquaculture as a food source.

The increasing demand for fish is projected to rise from 50% currently to 62% by 2030, thus exacerbating this issue (Han et al., 2016). Sustainable solutions must therefore address these economic pressures and ecological concerns.

Various alternatives to conventional fish feed have emerged, including the use of plant proteins and insect meals. Studies show that diets incorporating alternative plant proteins, such as bioconverted vegetable waste, have resulted in improved growth rates and feed utilisation efficiency in aquaculture species (Azad & Lal, 2018; Arru et al., 2019). This shift towards plant-based feeds is viewed as a viable solution to meet the nutritional requirements of fish while alleviating pressure on fishmeal and fish oil markets.

Furthermore, the inclusion of insect meal has shown promise in improving economic sustainability within aquaculture, providing a low-cost, high-protein alternative (Arru et al., 2019). The introduction of these alternatives could help reduce feeding costs (Garg & Meena, 2023).

The nutritional quality of fish feed also plays a vital role in mitigating health issues and enhancing growth efficiency. The incorporation of biologically active substances and additives has been demonstrated to improve feed digestibility and fish immunity, potentially correcting nutritional deficiencies that can compromise fish health (Ponomarev et al., 2022; Syanya et al., 2023).

Moreover, understanding the impact of feeds on fish metabolism, particularly concerning the balance of essential amino acids, emphasises the need for tailored feeding strategies that align with the specific nutritional profiles of different fish species for optimal growth and health (Snellgrove & Alexander, 2011; Pratiwi & Zidni, 2023).

Additionally, recent studies suggest that utilising ingredients such as microalgae and fermented plant materials can yield highly nutritious feed options that support rapid fish growth while addressing sustainability concerns (MacLeod et al., 2020; Sarker et al., 2020). For instance, the application of microalgae-blend feeds has been noted to eliminate the need for fishmeal while improving growth outcomes in tilapia, showcasing both ecological and economic benefits (Sarker et al., 2020). In light of these findings, it is pivotal for the aquaculture sector to innovate and adopt sustainable feeding practices that support fish health and productivity while mitigating environmental impacts. Addressing the prevalent reliance on wild-caught marine resources through the integration of alternative protein sources and the optimisation of feed formulations can drive the aquaculture industry towards a more sustainable future.

Aquaculture is constrained by a number of challenges, including high feed costs, which account for 60–80%

of fish farming costs (Ragasa et al., 2018). In addition to high feed costs, other challenges include limited feed availability and poor feed and management practices, especially among smallholder farmers (Ragasa, 2018; Obwanga et al., 2018).

Fish require a high quality and balanced diet to grow as quickly as possible. Although imported feed is becoming more accessible, some countries are boosting investment in local feed production to capitalise on more affordable, locally sourced raw materials and improved access for fish farmers.

Research in aquaculture is essential for evaluating locally available feed ingredients, and expanding cost-effective local fish feed production is vital for the growth and sustainability of the industry. Quality feed at an affordable price will make fish farming more profitable for small entrepreneurs. Producing high quality and cost effective feed is a complex process that requires an understanding of the nutrient levels that optimise fish growth, survival and profitability.

Materials and Methods

The study was conducted from January to March 2025, with 40 fish farmers selected from various regions of Latvia. The regions represented included Kurzeme (15 farms), Zemgale (ten farms), Latgale (eight farms), Vidzeme (five farms), and Riga (two farms).

A semi-structured interview format with a questionnaire was used to collect data from Latvian fish farmers. The questionnaire includes some questions about fish culture, farm size, activity type, culture type, culture system, feed costs, used feed type, availability of feed, alternative feed types, place of origin of the feed, membership in a co-operative group, market information, the marketing channels and some economical parameters.

Data were analysed using SAS statistical software. The log-linear regression model was used to determine and quantify the relations between all the independent variables (fish growing experience years, the marketing channels, market information, membership in a co-operative group, fish farm size, culture type, activity type, culture system, labour cost, used feed type, availability of feed, alternative feed types, place of origin of the feed, transportation cost, total cost and feed cost (the dependent variable).

The log-linear regression model was formulated to assume a linear relationship between the log-dependent variable and log-explanatory variables, allowing for traditional estimation procedures (Gujarati, 2003).

The regression model in Equation 1 takes the following form:

$$InYi=\alpha+\beta 1InX1+\beta 2InX2+\beta 3InX3+\beta 4InX4+\beta 5InX5+\beta 6InX6+\beta 7InX7+\beta 8InX8+\beta 9InX9+\beta 10InX10+\beta 11InX11+\beta 12InX12+\beta 13InX13+\beta 14InX14+\beta 15InX15+\varepsilon \quad (1)$$

where:

α= intercept term, Y= value of feed cost, X1= experience (years), X2= marketing channels, X3= market information, X4= membership in a co-operative group, X5= farm size, X6= culture type, X7= activity type, X8= culture system, X9= labour cost, X10= fry price, X11= used feed type, X12= availability of feed, X13= alternative feed types, X14= place of origin of the feed, X15= transportation cost, βi= the explanatory variables coefficients, In= the natural logarithm and ε= error term (normally distributed with a mean of zero and constant variance).

Results and Discussion

Table 1 illustrates that over 75% of fish farmers have 21 years or more of experience in fish breeding, with 90% of fish farms categorised as small. Most popular fish farm growing method is freshwater ponds (80%). However, only 12% of the respondents produced fish in recirculation systems. The development of recirculation systems is important for the Latvian aquaculture industry, as recirculation systems cause less pollution to the environment and water.

Table 1

Distribution of the respondents based on socio-economic characteristics

Variable	***Category***	***N***	***%***
Experience (years)	Low (≤5)	3	7.50
	Medium (6-20)	6	15.0
	High (≥21)	31	77.5
Farm ownership	Owned	31	77.50
	Owned, rented	5	12.50
	Rented	4	10.00
Membership in co-operative group	Yes	20	50.00
	No	20	50.00
Access to market information	Yes	7	17.50
	No	33	82.50
Origin of fish feed	Latvia	12	30.00
	Other country	28	70.00
Co-operation in the procurement of feed	Yes	12	30.00
	No	28	70.00

Variable	*Category*	*N*	*%*
Farm size	Small	37	92.50
	Medium	2	5.00
	Large	1	2.50
Farm type	Freshwater ponds	32	80.00
	Recirculation system	5	12.50
	Basins	3	7.50
Feed type	Grains	25	62.50
	Extruded	4	10.00
	Combined	11	27.50
Business activity type	Aquaculture only	4	10.00
	Aquaculture, agriculture	31	77.50
	Other	5	12.50
Alternative protein source	Yes	20	50.00
	No	20	50.00
Culture system	Extensive	24	60.00
	Semi-intensive	6	15.00
	Intensive	10	25.00

About 77% of the respondents own their fish farm. About 91% of the respondents reported employing 10-15 workers on their farms. While 17% of the respondents lacked access to training and credit, only 83% reported limited access to market information. Half of the fish farmers were members of a cooperative group, and 74% sold their fish production directly from the farm. The predominant culture type among respondents was polyculture (76%), while 24% engaged solely in aquaculture activities. The extensive culture system was the most common production method, utilised by 60% of respondents. More than 60% of the fish farmers fed their fish with grains, while only 10% of the fish farmers used extruded feed. This also reflects the small number of recirculating farms using only this type of fish feed. Aquaculture is the only source of income for only 10% of the respondents, while 77% of the respondents engage in additional agricultural activities on their farms – cereal farming, beekeeping, forestry, etc. When asked whether fish farmers would be willing to use fish feed that has been produced in Latvia and offers higher protein content and lower price on their farms, only 50% said yes. This implies that fish farmers either rely on trusted feed producers or lack confidence in the quality and effectiveness of locally produced feed. 70% of the respondents would not be willing to participate in the purchase of fish feed in cooperation with other fish farmers, which shows that there are problems of cooperation in the aquaculture sector in Latvia. Half of the respondents were members of a Latvian aquaculture NGO, which shows that fish farmers are involved in policy making in the aquaculture sector.

Table 2

Fish feed related problems facing the fish culture farmers in Latvia

Problem	*Problem Severity**				*PFI***	*Score*
	FS	*FM*	*FL*	*FN*		
High feed price	105	5	0	0	325	1
Low protein content	99	7	4	0	315	2
High feed impact on environment	99	5	6	0	313	3
Lack of feed quality	45	15	21	29	186	4
High feed transportation cost	33	27	17	33	170	5
Lack of feed storage knowledge	25	20	28	37	143	6
Long feed delivery	26	7	7	70	99	7
Lack of Latvian feed marketing information	15	6	10	79	67	8
Incomplete Latvian fish feed	15	6	10	79	67	9
Underdeveloped cooperation in feed procurement	15	6	10	79	67	10

Note:* FS: numbers of fish farmers facing a severe problem, FM: numbers of fish farmers facing a moderate problem, FL: numbers of fish farmers facing a little problem, and FN: numbers of fish farmers facing no problem.

** PFI (Problem Facing Index) = 3 × FS + 2 × FM + 1 × FL + 0 × FN.

According to Table 2, the fish culture farmers identified 20 significant challenges. A total of 105 out of 110 farmers regarded high feed prices as a critical issue. The rise in feed costs is attributed to ingredient imports and fluctuations in foreign currency exchange rates. Problems faced by the fish culture farmers were categorised based on severity: severe, moderate, little, and none, assigned scores of 3, 2, 1, and 0, respectively. The Problem Facing Index (PFI) was calculated using the formula:

$$\text{Problem Facing Index (PFI)} = 3 \times FS + 2 \times FM + 1 \times FL + 0 \times FN \quad (2)$$

where:
FS = quantity of fish farmers facing a severe problem,
FM = quantity of fish farmers facing a moderate problem,
FL = quantity of fish farmers facing a little problem,
FN = quantity of fish farmers facing no problem.
As shown in Table 2, the most important problems in the Latvian aquaculture sector are the high price of fish feed, the low protein content of fish feed, and the environmental impact of the feed. The opportunities for cooperation in fish feed procurement and the insufficiency of locally produced fish feed in Latvia for meeting consumption needs were identified as less significant issues. Since only 30% of the respondents purchase fish feed in Latvia, this suggests that the quality of the feed is insufficient to attract the interest of other fish farmers.

Conclusions

1. Aquaculture serves as a vital source of fish, providing an alternative to the diminishing natural ecosystems. It also plays a crucial role in enhancing the social and economic status of fish farmers, thereby alleviating poverty and improving their living conditions. It is therefore necessary to promote the development of aquaculture.
2. The cost of fish feed in Latvian fish farms accounts for 60–80% of the total expenses of the enterprise. This indicates the need to explore economically viable alternatives that utilise food industry by-products to reduce fish feed costs, replace protein in fish feed, and support the circular economy.
3. Only 30% of fish farmers surveyed use fish feed produced in Latvia on their farms. Latvian fish feed producers need to stimulate the interest of local fish farmers in Latvian production and identify the needs of potential customers.
4. The study concludes that fish farmers in Latvia encounter challenges related to fish feed, driven by high feed prices, low protein content, opportunities for farmer cooperation, feed logistics, and awareness of locally produced fish feed.
5. Identifying feed problems in aquaculture is necessary for efficient production and economic returns, and is essential for the development of sustainable aquaculture.

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