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The Role of Genetics in Fish Breeding and Its Impact on Production and Meat Quality

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Abstract
Over the past 25 years, advances in biotechnology have enabled scientists to create animals that have been genetically modified (GM) for use in agriculture and medicine. The bulk of GM fish and animals are still in the research stage. In order to produce high-quality fish stocks and satisfy the rising worldwide demand for seafood, fish breeding is essential to the aquaculture sector. The business has undergone a revolution because to the use of genetics in fish breeding, which has improved desired features including growth rate, illness resistance, and environmental adaptation. The concepts and uses of genetics in fish breeding are summarized with an emphasis on the main methods and tactics used to accomplish the desired genetic advancements. Understanding genetic diversity, heritability, and connections is essential to understanding the principles of fish breeding. Breeders can find people with better features by using genetic variation as the foundation for selection. Heritability calculates the percentage of phenotypic diversity under the control of genes and sheds light on the possibility of genetic advancement. Breeders can better grasp the connections between various features and the likelihood of simultaneous selection using genetic correlations.

Keywords: Genetically modified, fish breeding, heritability, genetic diversity

Introduction

Genetics plays a significant role in fish breeding and has a profound impact on production and meat quality. Through selective breeding, desirable traits can be enhanced, leading to improved growth rates, disease resistance, and overall productivity in fish farming. Additionally, genetics influences various aspects of meat quality, including texture, flavor, color, and nutritional composition (1). Most fish breeding businesses view their growth rate as the main attribute that has to be enhanced in their breeding program. When a farm operates with a biomass quota, the increasing growth rate is anticipated to boost farm profit by cutting production time, which is the case, for instance, for salmon farms in Norway, boosting yearly production and returns. However, raising the need for breeding strategies that lessen these consequences, livestock and fish production affects the surroundings. The environmental effects of genetic enhancement of characteristics in cattle and fish production have previously been the subject (2). For human nutrition, fish is an essential source of protein from animals. Analysis of quality can increase the marketability of aquaculture products since excellent meat quality is linked to a healthy animal. Therefore, understanding how muscle characteristics impact fish flesh quality might be crucial for the aquaculture sector (3).

The majority of the minerals, proteins, and lipids, as well as their quantities and compositions, have been the focus of examinations of fish meat thus far. Additionally, there

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are initiatives to use genetic studies to improve product quality and production. However, because to the significant species variety of fish, the fundamental techniques used to assess the quality of flesh in mammals and birds are still not standardized (4). Several characteristics can be used to describe meat quality. In the manufacturing sector, these comprise the preparation, sensory, sanitary, and toxicological criteria and nutritional-physiological value. The customer, on the other hand, bases their judgment of quality on subjective factors, including freshness, appearance, odor, fragrance, and taste. Customers stress texture, firmness, juiciness, moisture, water-holding capacity, drip loss or cook loss, pH value, and colour as additional objectively verifiable parameters. The dryness, chewiness, and juiciness of the texture are three key quality indicators for fresh fish (5). The age of the fish was not taken into account because it is unimportant for sale. It is widely recognized that fish when fully grown, convert food into fat storage in addition to protein synthesis. Fish in aquaculture, as well as our previously utilized fish, was employed after they reached market size for profit reasons. The percids were older than the salmonids because of the more challenging breeding and rearing conditions, higher price class and matching weight class that European perch and pikeperch are marketed in, and other factors (6). For 40% to 50% of the fish consumed globally between 2010 and 2014, fish for human consumption was sourced from fish and fishery products, important source of proteins and essential minerals for human health. Fish provides higher quality protein, minerals, and vital fatty acids, particularly polyunsaturated fatty acids, than farm animals do (7).

The study (8) mentioned genetic advancements for salmon and trout aquaculture with a focus on the Chilean experience as the goal of this endeavor. They concentrate on the country's breeding programs' execution, the establishment of breeding objectives, the findings about genetic factors, the reaction to the selection, and the integration of genomics. Prospects and difficulties in study and development, climate change, genotype-by-environment conversations, and the proof of the financial value of breeding programs are also discussed. The article (9) suggests improving the methods and use of these additions for practical and environmentally friendly aquaculture, it is essential to comprehend the way in which herbal supplements and their derivatives work mechanistically. The precise information on the method of action of herbal supplements when taken orally in aqua feed has been elucidated by gene-related investigations. The possible effects of medicinal plants on aquatic creatures' behaviours have been discussed in several review studies. However, the research paper focuses on the gene expression associated with growth and immunological responses after investigations were done on aquatic animals given nutritional, medicinal plants. To prevent future inbreeding, the article (10) advised assessing how selection processes affect genetic diversity. Molecular genetics indicators, such as the fixation index (FST), linkage disequilibrium (LD), effective population size, and inbreeding coefficient derived from runs of homozygosity (ROH), were used to analyze Oncorhynchus mykiss experimental or commercial lines.

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The study (11) included the creation of techniques to harvest enough sperm from a variety of salmonid species, scaling up the techniques for high-volume sperm cryopreservation and high-volume sperm thawing, and improving Oocytes are fertilized artificially by a large quantity of frozen/thawed sperm. After cryopreservation and liquid nitrogen storage, in order to further lessen the risk of sperm infection and its transmission to offspring, technologies must be included in hatchery practice with specific care. The article (12) suggested a blockchain-based fish farm infrastructure to guarantee the accuracy of agricultural data. Fish producers will be able to save the enormous amounts of irreversible agricultural data in the system's safe storage thanks to its architectural design. Numerous processes in the fish farm are carried out automatically utilizing smart contracts to reduce the risk of errors or misuse. A proof of concept built on top of the recommended architecture using the Hyperledger Fabric blockchain in conjunction with an outdated fish farm system. The study (13) advised highlighting the potential application of curcumin, curcumin nanoparticles, and curcumin nanospheres in the monogastric feeding of ruminants, poultry, and fish. Think the review offers a clear perception of how curcumin, curcumin nanoparticles, and curcumin nanospheres will develop and how they will be used in monogastric farm animal, poultry, and fish feeding. The article (14) analyzed the concepts, emerging trends, and current use of e-tongue and e-noses for assessing the quality of meat and fish. An array of chemometric techniques has been crucial in using these instruments for quick quantitative, qualitative, and predictive investigation of some physical qualities, chemical properties, storability, and the authenticity of meat and fish. The article (15) suggested a general overview of sensory analysis as it is used in aquaculture, which produces goods for the market. Applying a precise strategy that considers the customer is the key potential that scientometrics might present to the aquaculture business.

Food products from fish

The major focus in fish research has been improving overall growth, mostly through using transgenic generated from fish that boost the synthesis of growth hormones. The species that have previously been utilized commercially in tilapia and salmonid fish are two examples of aquaculture. Using GM technology, several additional species have also been modified to grow more quickly. Different species experience different relative growth rates. They can be as little as a doubling of fish that are about 100 times heavier at the same age as the rough prototype. Another new method of boosting meat output targeted the development of "double muscling" in rainbow trout using transgenes expressing follistatin, which inhibits myostatin and results in two layers of muscle.

Fish have undergone GM alteration to boost their growth rate. Still, they have also undergone modifications to substantially expand in size, which may change how markets use the animal and improve feed conversion efficiency. The last one might impact the environment since it allows for the production of more meat while consuming less feed. This is crucial for animals like salmon, which depend on fish protein from the ocean for nutrition. An increase in feed conversion of about 10% has been seen in Coho salmon. In the comparison of the growth-GM and non-GM salmon hits really different from the market size and their maturity age

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shown in figure (1). The capacity of carnivorous fish to better use carbohydrates or endogenously manufacture necessary chemicals like vitamin C has also been modified.

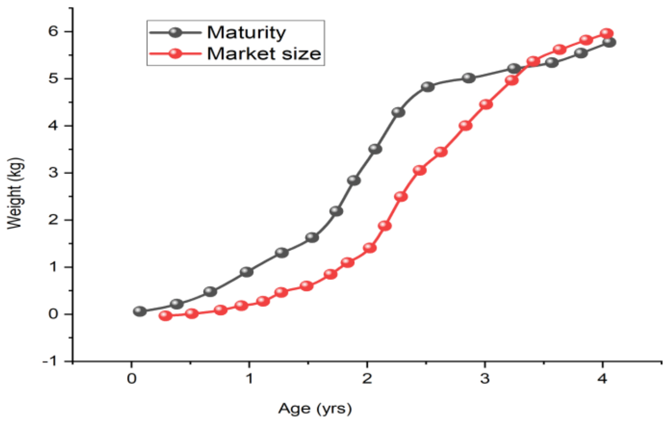

Figure (1): Comparison of growth-GM and non-GM salmon

Due to the frequent transmission of infectious diseases amongst individual fish kept in large numbers, intensive fish farming places a high priority on the development of disease resistance. Although it doesn't directly increase meat production, it could unintentionally do so by enhancing survival or by facilitating the maintenance of denser populations of fish. After infection with Aeromonas bacteria and Grass Carp Hemorrhage virus, grass carp were given a transgene encoding for human lactoferrin, which almost doubled their lifespan compared to control fish. Without affecting the growth rate, cecropin increased channel catfish's defense against harmful bacteria by 2–4. The injection of plasmid DNA into the muscle of an animal may also protect against viral infections. In Table (1) contain the target traits in fish breeding.

Table (1): Overview of the genes in fish used in food production

Fish	Growth	GH	Fish
	Health	Follistatin	Fish
		Cecropin	Insect
		Lactoferrin	Human
		Lysozyme	Fish
	Envir.tolerance	Antifreeze	Fish
		GH	Fish

By increasing the variety of conditions in which animals may be raised, the output can also be increased. Introducing genes from teleost fishes that code for antifreeze proteins is one method of this type. This would enable aquaculture to develop farther north or south than a species' typical range. For instance, Arctic fish farms may raise Atlantic salmon. Similarly, freshwater fish bred to tolerate saltwater may be raised in the ocean. Again, due to the relationship between size and salt tolerance, growth hormone transgenic salmonids may frequently be introduced to saltwater at a younger age.

Role of genetics in fish breeding

Selective Breeding

Selective breeding entails selecting particular people who possess desired qualities and mating them to produce offspring with those traits. Aqua culturists can increase production efficiency and total profitability by choosing fish with greater growth rates, feed conversion efficiency, and disease resistance.

Growth and Production

Enhancing fish species' development rates is the goal of genetic enhancement initiatives in order to increase productivity. Aquaculturists may quickly produce bigger, market-ready fish by choosing and breeding animals with better growth potential. In the growth rate of fish production in aquculture and capture contain at least square growth rate percentage between the year of (1981-2020) are shown in figure (2).

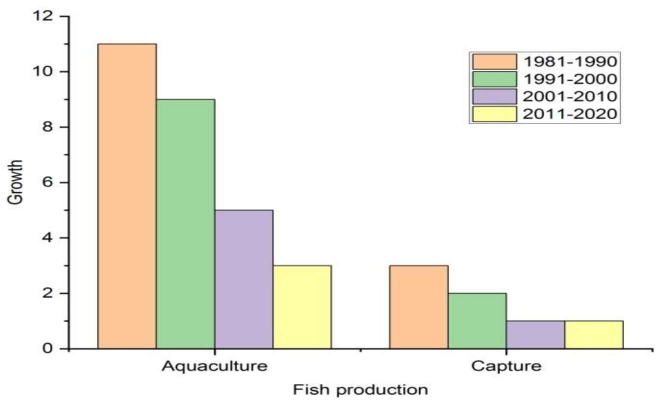

Figure (2): Growth of fish production

Disease Resistance

The resilience of fish to many illnesses and infections is influenced by genetic factors. Breeding programs aim on discovering and selecting people with natural resistance or tolerance to certain illnesses, hence minimizing the danger of outbreaks and the need for disease management treatments such as antibiotics or pesticides. Disease-resistant fish breeds support aquaculture methods that are more ecologically responsible and sustainable.

Meat Quality

Fish flesh quality is substantially influenced by genetics. Genetic characteristics have an impact on texture, flavour, colour, fat content, and nutritional makeup. Programs for selective breeding might focus on features like enhanced flesh hardness, a desired fat composition, and superior flavour that enhance meat quality. Producers can better serve customer preferences and increase market competitiveness by breeding fish with improved characteristics related to meat quality.

Reduced Environmental Impact

Fish aquaculture can lessen its negative effects on the environment by using selective breeding. Aquaculturists can reduce the quantity of feed needed to generate a unit of fish biomass by breeding fish with enhanced feed conversion efficiency. As a result, there is less waste produced, less contamination of the environment, and better resource management.

Genetic Markers and DNA Technologies

Recent developments in genetic science have made it possible to identify genetic markers linked to desirable fish features. Breeding programs can be more accurate and effective because to DNA-based technologies like marker-assisted selection (MAS) and genomic selection. Breeders can speed up the breeding process and find individuals with greater genetic potential with the use of these technologies.

Discussion

The ability to select and spread desirable features has transformed aquaculture methods because of genetic improvements in fish breeding. Production efficiency has significantly increased as a result of this. Aquaculturists can achieve quicker and more uniform growth, cutting down on time needed to reach market size by selecting breeding fish with higher growth rates. Optimizing resource use and increasing production yield, improves the economic viability of fish farming. Furthermore, fish disease resistance is greatly influenced by heredity. Diverse illnesses can affect aquaculture, and outbreaks can cause large financial losses. Breeders can create fish strains with greater resistance or tolerance to certain infections by using genetic selection for disease resistance. This encourages more sustainable and ecologically friendly aquaculture methods by reducing the need for antibiotics and other drugs to treat diseases. When it comes to meat quality, genetics significantly influences various aspects. Texture, flavor, color, fat content, and nutritional composition are all influenced by genetic factors. Through selective breeding, fish with improved meat quality attributes can be produced, catering to consumer preferences and market demands. For example, breeding programs can target traits such as firmer flesh, optimal fat composition, and superior taste, ensuring a consistent and high-quality product for consumers.

DNA-based technologies have developed into useful tools for accelerating and enhancing the breeding process. Breeders may more precisely choose people with higher genetic potential because to the identification of genetic markers linked to desirable qualities. Breeders may decide on breeding partners with more certainty thanks to genomic selection and marker-assisted selection (MAS), which improves the efficacy and efficiency of selective breeding operations. Despite the fact that nutrition, environment, and management practices also have an impact on production and meat quality, it is important to note that genetics plays a significant role in fish breeding. Optimal husbandry practices, including appropriate nutrition, water quality management, and disease prevention measures, work in concert with genetic improvements to achieve the desired results.

Conclusion

Most GM animals used to produce food and feed are still in the research stage, and only a small number have received final clearance. Fish breeding relies heavily on genetics to enable the selection and breeding of fish with desirable features. Traditional breeding practices have been integrated with cutting-edge molecular technologies and genomic tools, revolutionizing the sector and enabling faster genetic advancements in fish populations. The cultivation of better fish varieties and sustainable aquaculture show great promise for meeting the expanding demand for seafood on a worldwide scale. This is made possible by ongoing developments in genetics and breeding technology.

References

[1] Chu, Y.I., Wang, C.M., Park, J.C. and Lader, P.F., 2020. Review of cage and containment tank designs for offshore fish farming. Aquaculture, 519, p.734928.

[2] Besson, M., Komen, H., Rose, G. and Vandeputte, M., 2020. The genetic correlation between feed conversion ratio and growth rate affects the design of a breeding program for more sustainable fish production. Genetics Selection Evolution, 52, pp.1-10.

[3] Komolka, K., Bochert, R., Franz, G.P., Kaya, Y., Pfuhl, R. and Grunow, B., 2020. Determination and comparison of physical meat quality parameters of percidae and salmonidae in aquaculture. Foods, 9(4), p.388.

[4] Arnaudova, M., Brunner, T.A. and Götze, F., 2022. Examination of students' willingness to change behaviour regarding meat consumption. Meat Science, 184, p.108695.

[5] Kong, W., Huang, S., Yang, Z., Shi, F., Feng, Y. and Khatoon, Z., 2020. Fish feed quality is a key factor in impacting aquaculture water environment: evidence from incubator experiments. Scientific reports, 10(1), p.187.

[6] Kang, B., Vitule, J.R., Li, S., Shuai, F., Huang, L., Huang, X., Fang, J., Shi, X., Zhu, Y., Xu, D. and Yan, Y., 2023. Introduction of non-native fish for aquaculture in China: A systematic review. Reviews in Aquaculture, 15(2), pp.676-703.

[7] Baldissera, M.D., Souza, C.F., Zeppenfeld, C.C., Velho, M.C., Klein, B., Abbad, L.B., Ourique, A.F., Wagner, R., Da Silva, A.S. and Baldisserotto, B., 2020. Dietary supplementation with nerolidol nanospheres improves growth, antioxidant status and fillet fatty acid profiles in Nile tilapia: Benefits of nanotechnology for fish health and meat quality. Aquaculture, 516, p.734635.

[8] Lhorente, J.P., Araneda, M., Neira, R. and Yáñez, J.M., 2019. Advances in genetic improvement for salmon and trout aquaculture: the Chilean situation and prospects. Reviews in Aquaculture, 11(2), pp.340-353.

[9] Ahmadifar, E., Pourmohammadi Fallah, H., Yousefi, M., Dawood, M.A., Hoseinifar, S.H., Adineh, H., Yilmaz, S., Paolucci, M. and Doan, H.V., 2021. The gene regulatory roles of herbal extracts on the growth, immune system, and reproduction of fish. Animals, 11(8), p.2167.

[10] D'ambrosio, J., Phocas, F., Haffray, P., Bestin, A., Brard-Fudulea, S., Poncet, C., Quillet, E., Dechamp, N., Fraslin, C., Charles, M. and Dupont-Nivet, M., 2019. Genome-wide estimates

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of genetic diversity, inbreeding and effective size of experimental and commercial rainbow trout lines undergoing selective breeding. Genetics Selection Evolution, 51(1), pp.1-15.

[11] Judycka, S., Nynca, J. and Ciereszko, A., 2019. Opportunities and challenges related to the implementation of sperm cryopreservation into breeding of salmonid fishes. Theriogenology, 132, pp.12-21.

[12] Hang, L., Ullah, I. and Kim, D.H., 2020. A secure fish farm platform based on blockchain for agriculture data integrity. Computers and Electronics in Agriculture, 170, p.105251.

[13] Moniruzzaman, M. and Min, T., 2020. Curcumin, curcumin nanoparticles and curcumin nanospheres: A review on their pharmacodynamics based on monogastric farm animal, poultry and fish nutrition. Pharmaceutics, 12(5), p.447.

[14] Zaukuu, J.L.Z., Bazar, G., Gillay, Z. and Kovacs, Z., 2020. Emerging trends of advanced sensor based instruments for meat, poultry and fish quality–a review. Critical Reviews in Food Science and Nutrition, 60(20), pp.3443-3460.

[15] Calanche, J.B., Beltran, J.A. and Hernandez Arias, A.J., 2020. Aquaculture and sensometrics: The need to evaluate sensory attributes and the consumers' preferences. Reviews in Aquaculture, 12(2), pp.805-821.