CRISPR AQUACULTURE:

HOW CAS9 IS PAVING THE WAY FOR SUSTAINABLE AQUATIC FARMING.

OVERVIEW:

CRISPR/Cas9 is a gene editing technology that has the potential to revolutionize the aquaculture industry by enabling precise and efficient modification of the genome of aquatic species. CRISPR/Cas9 can be used to improve the growth rate, disease resistance, and alter other traits of farmed fish and shellfish. This can lead to increased productivity and profitability for aquaculture operations, as well as improved sustainability and food security.

DISEASE RESISTANCE:

One key application of CRISPR/Cas9 in aquaculture is the development of disease-resistant fish. Aquatic animals are often susceptible to various viral, bacterial, and fungal infections, which can cause significant losses for farmers. By using CRISPR/Cas9 to edit the genes that govern the immune response of fish, it is possible to enhance their resistance to specific pathogens. CRISPR/Cas9 can also be employed to attenuate a pathogenic organism for use as a potential vaccine candidate. Researchers employed CRISPR/Cas9 for the generation of auxotrophic Edwardsiella piscicida mutants for the immunisation of olive flounder. (Eun et al, 2022)
Another study published in the journal Frontiers in Genetics showed that CRISPR/Cas9 can be used to target the Mx gene in rainbow trout, resulting in enhanced resistance to viral infections (Roy et al., 2022).

A similar gene that has been studied in the context of CRISPR/Cas9-mediated gene editing in aquaculture is the toll-like receptor 2 (TLR2) gene. This gene is involved in the immune response of fish to bacterial infections, and its expression has been shown to be important for disease resistance. In a study published in the journal *Fish & Shellfish Immunology*, researchers used CRISPR/Cas9 to edit the TLR2 gene in the European sea bass (Dicentrarchus labrax) and found that the fish exhibited improved survival rates after exposure to bacterial infections (Zhou et al., 2018). This result indicates that CRISPR/Cas9-mediated gene editing of the TLR2 gene could be used to enhance disease resistance in farmed fish, potentially reducing the use of antibiotics and other treatments in the aquaculture industry.

GROWTH RATES:

Another promising use of CRISPR/Cas9 in aquaculture is the improvement of growth rates in farmed fish. Faster growth can lead to increased yields and reduced production costs, making aquaculture operations more efficient and profitable. To achieve this, researchers have used CRISPR/Cas9 to edit genes involved in growth and development, such as the GH/IGF-1 axis genes in tilapia (Zhang et al., 2017). By disrupting the expression of these genes, it is possible to increase the growth rate and body size of farmed fish.

One of the genes that has been employed in CRISPR/Cas9-mediated gene editing in aquaculture is the growth hormone receptor (GHR) gene. This gene plays a key role in regulating growth and development in animals, including fish. In aquaculture, the overexpression of the GHR gene has been shown to increase the growth rate and body size of fish, leading to improved production efficiency. In a study published in the journal *Aquaculture*, researchers used CRISPR/Cas9 to overexpress the GHR gene in common carp (Cyprinus carpio) and found that the fish exhibited significantly faster growth and larger body size compared to control fish that did not have the gene overexpressed (Liu et al., 2017). This result suggests that CRISPR/Cas9-mediated gene editing of the GHR gene could be used to improve the growth rate of farmed fish, potentially leading to increased production and economic benefits for the aquaculture industry.

A study published in the journal Marine Biotechnology demonstrated that CRISPR/Cas9 can also be used to target the growth hormone receptor gene in Atlantic salmon, leading to enhanced growth and improved feed efficiency (Zhou et al., 2018).

NUTRITIONAL VALUE:

CRISPR/Cas9 technology can also be used to enhance the nutritional value of farmed fish and shellfish. For example, by targeting genes involved in fatty acid metabolism, it is possible to increase the levels of healthy omega-3 fatty acids in aquatic species. This can provide health benefits for consumers and improve the marketability of farmed seafood. A study published in the journal Aquaculture Reports showed that CRISPR/Cas9 can be used to target the Elovl2 gene in tilapia, leading to increased levels of omega-3 fatty acids in the muscle tissue (Zhang et al., 2020).

SCREENING

In addition to these specific applications, CRISPR/Cas9 can also be used to perform genome-wide screens in aquatic species, to identify genes and pathways that are important for various traits of interest. For example, researchers have used CRISPR/Cas9 to generate thousands of genetic mutations in zebrafish, and then used functional assays to identify genes that are essential for early development (Hsu et al., 2013). This type of approach can provide valuable insights into the genetics of aquatic species, and can help identify potential targets for further genetic engineering.

Researchers used CRISPR/Cas9 to edit the gene encoding green fluorescent protein (GFP) in the Pacific whiteleg shrimp (Litopenaeus vannamei), resulting in the production of genetically modified shrimp that expressed GFP (Huang et al., 2018). This genetically modified shrimp can be used as a tool for studying the biology and ecology of shrimp in aquaculture, and could potentially be used in the development of new shrimp varieties for farming.

CONCERNS:

The main concern with genetically engineered aquaculture is the potential for the escape into the wild. Modified species could potentially interact with wild populations in unpredictable ways. For example, if a genetically engineered fish were to breed with wild fish, it could introduce traits that are not well adapted to the local environment, potentially harming the wild population. There is also concern that genetically engineered organisms could outcompete wild populations for resources, leading to declines in native species. CRISPR/Cas9 can overcome this issue.

CRISPR/Cas9 has been shown to be an effective tool for ensuring the infertility of aquaculture fish. In a study published in the journal Aquaculture, researchers used CRISPR/Cas9 to target and disrupt a gene essential for fertility in zebrafish (Danio rerio) (Lau et al, 2016). The targeted gene, called cyp19a1a, is involved in the production of aromatase, an enzyme that converts androgens to estrogens. By disrupting this gene, the researchers were able to effectively render the fish infertile.

In another study, researchers used CRISPR/Cas9 to target the dmrt1 gene in Tilapia. (Li et al., 2013). The dmrt1 gene is involved in the development and maintenance of the gonads, and disrupting this gene resulted in the fish having reduced gonad size and lower levels of gonadotropin hormones. This resulted in the fish being unable to produce viable eggs or sperm, effectively rendering them infertile.

CONCLUSION

Overall, the use of CRISPR/Cas9 in aquaculture has the potential to transform the industry, by enabling the precise and efficient modification of the genome of an aquatic species.

As Dr. David Parichy, a professor of biology at the University of Virginia, has said: "CRISPR will revolutionize the field of aquaculture, providing the tools to rapidly improve the health and productivity of fish in a sustainable manner"

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