PROMOTING HUMAN HEALTH BASED ON CONSUMPTION OF FISH NUTRIENT GROWN IN AQUAPONICS SYSTEM USING REGRESSION TECHNIQUE

Abstract

The potential of aquaponics systems to improve fish nutrition, with a focus on important components like protein, Omega-3 fatty acids, and key vitamins. To examine the complex interactions between system characteristics, fish diet, and nutrient content using regression approaches in conjunction with Cox Proportional Hazard modeling. The illustrative analysis is based on synthetic data that is intended to resemble aquaponics environments. Based on elements including the composition of the feed, the water's quality, and the surroundings, the regression model is specifically designed to forecast the amount of nutrients in fish. The findings highlight how significantly these factors affect the nutritional profiles of fish. With this knowledge, aquaponics experts may deliberately adjust their systems to improve fish health and provide consumers with nutrient-rich fish products. The evidence for aquaponics as a sustainable and healthy food production method has been greatly strengthened by this study. To ensure practical application and find deeper implications for public health, we advise additional validation with real-world data.

Keywords: Aquaponics, regression model, Cox Propositional hazard.

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I. INTRODUCTION

Using nutrient-rich aquaculture water to cultivate hydroponically grown plants, aquaponics is a food production technique that combines aquaculture (growing aquatic animals) and hydroponics (cultivating plants in water)[1]. Fish, often referred to as "brain food," has long been celebrated for its remarkable nutritional value and the multitude of health benefits it offers to humans. This aquatic delight is a powerhouse of essential nutrients, making it a vital component of a balanced diet. From high-quality protein to heart-healthy omega-3 fatty acids, and an array of vitamins, minerals, and antioxidants, fish provides a diverse range of nutrients that contribute to overall well-being. In this exploration, we delve into the significance of these fish-derived nutrients, shedding light on how they promote human health and why incorporating fish into one's diet can lead to a healthier and more vibrant life[2]. Aquaponics, an innovative and sustainable agricultural system that combines fish farming with hydroponics, provides a multifaceted contribution to human nutrition and environmental sustainability. It yields nutrient-rich produce by utilizing fish waste to fertilize plants, resulting in high-quality protein from fish and enhanced levels of vitamins, minerals, and omega-3 fatty acids. This closed-loop system is known for its sustainability advantages, using less water, producing less waste, and enabling year-round, local food production while reducing the environmental contaminants associated with traditional agriculture. Moreover, it offers educational opportunities and promotes healthier food choices, making it a valuable approach to addressing both nutritional and environmental challenges [3].

Survival is integral to the success of aquaponics, a sustainable agricultural system that combines fish farming with plant cultivation. It encompasses the well-being and survival of fish, plants, beneficial microbes, and system resilience. Ensuring the health and survival of fish involves maintaining water quality, temperature, and nutrition, and providing a consistent source of high-quality protein. Plant survival is essential for natural filtration and nutrient cycling, demanding careful monitoring of nutrient levels and environmental conditions. Beneficial bacteria's survival is crucial for converting fish waste into plant nutrients. Disease management and system resilience are essential to prevent and address unexpected issues. Overall, survival in aquaponics is interconnected and vital for system effectiveness, supporting human livelihoods and food security while addressing nutritional and environmental challenges [4].

This paper will be delivered in the following sections going forward: Beginning with a thorough analysis of pertinent literature, Section 2 will lay the groundwork for understanding the context of the research. The experiments that were carried out will then be meticulously explained in Section 3 along with a thorough analysis of the outcomes. The findings of our investigation will be presented, and their consequences will be fully discussed, in Section 4. This section will provide as a basis for integrating the results with current understanding and considering potential directions for more research. In Section 5, we will offer some last thoughts and suggest some directions for further investigation.

II. LITERATURE SURVEY

This paper delves into the intricate dynamics of aquaponic systems, focusing on biological and technological parameters. It provides a comprehensive review of relevant literature, outlines the setup of the system, and presents results through data representations and statistical analyses. The paper emphasizes the biological parameters of organisms, their growth, health, and nutrient cycling, and the technological parameters of monitoring and control systems [5]. This study compares aquaponics and separate recirculating aquaculture and hydroponic systems, focusing on fish and plant growth and water quality management. It reveals aquaponics has enhanced growth due to nutrient cycling synergy between fish and plants. Aquaponics also maintains superior water quality due to biologically mediated filtration by plants, reducing the need for additional treatment. This study highlights aquaponics' benefits for sustainable food production and its environmental impact [6]. This paper reviews the Proportional Hazards Model, a statistical tool used in survival analysis. It discusses its importance in fields like medical research, epidemiology, and economics, its methodology, and its applications. The review emphasizes key assumptions, diagnostic tools, and practical considerations when applying the model. It serves as a valuable resource for researchers and statisticians [7]. The Cox Proportional Hazards Regression Model is a statistical technique used in survival analysis to examine the relationship between covariates and hazard rate. It is versatile and applicable across various fields, such as medical research, epidemiology, and social sciences. It estimates hazard ratios, quantifying the proportional change in hazard for a unit change in a covariate [8]. This study compares nutrient availability and uptake in aquaponics systems with tilapia fish and hydroponics for lettuce production. Aquaponics combines aquaculture and hydroponics, using fish waste as a natural filter. Tilapia fish are commonly used due to their adaptability. The research aims to determine the efficacy and sustainability of nutrient delivery in aquaponics for lettuce production [9]. The paper discusses the implementation of an automated fish feed detection system in an IoT-based aquaponics environment, enhancing fish health and productivity. The system uses cameras,sensors, microcontrollers, and actuators to analyze fish behavior. It integrates into an IoT platform for remote monitoring, providing real-time feedback. The paper highlights the benefits of automation and potential future developments [10].

III. EXPERIMENTS

Age, fish consumption, and event status are the three primary factors in this study's dataset. Fish consumption probably refers to the quantity of fish ingested, which might be either a continuous or a categorical variable. Age is a continuous variable that represents an individual's age. A binary variable called the event status indicates whether a certain event of interest—like a health outcome—has actually taken place (1 for event occurred, 0 for event not occurred). Using a Cox Proportional Hazards model, the survival times were examined. This model calculates how the covariates, in this case, age and fish diet, affect the likelihood of experiencing the event. Hazard ratios were generated to show the multiplicative change in hazard for a one-unit change in the covariate after the model was fitted, and the estimated coefficients were evaluated to understand their impact on the hazard [10]. For evaluation, a summary of the model was obtained together with p-values, confidence ranges, and other diagnostics. In addition, various combinations of age and fish consumption were used to construct forecasts for survival probability and evaluate assumptions like the proportional hazards assumption. The Fig.No:1 represents the block representation of Human-fish nutrient well-being.

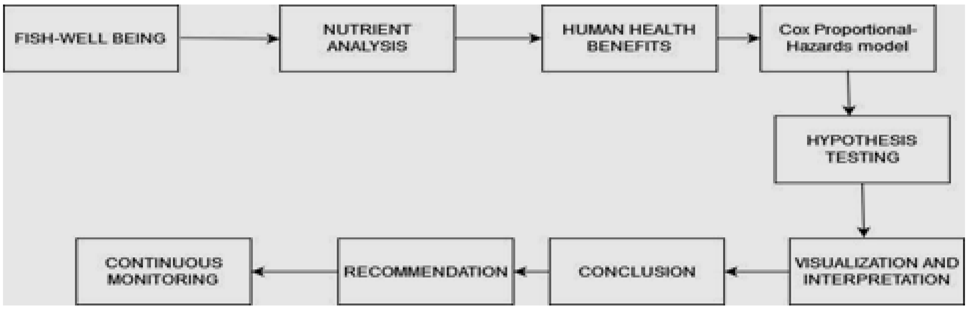

Figure 1: Block Representation of Human-Fish Nutrient Well-Being

When real-world data isn't available, simulated data can be an extremely useful tool. The structure and variables must first be defined, together with any relationships and variability, before simulated data can be produced in Fig.No:2. Ascertain that sample sizes are suitable for the analyses that wish to be conducted, and if necessary, simulate experimental settings. Create synthetic datasets using statistical tools, adding randomness to resemble noise found in the actual world. After that, undertake analysis by running regression and survival analyses or testing hypotheses. Verify results by contrasting them with established relationships in the simulated data. To evaluate robustness to parameter changes, additionally do sensitivity analyses. Record all of the assumptions and parameters used in the data-generating process, as well as the results, and make sure to always mention that simulated data were used [11]. It's important that while simulated data might be valuable for exploring theoretical possibilities and testing out approaches, it cannot replace actual data, and reports should make this clear.

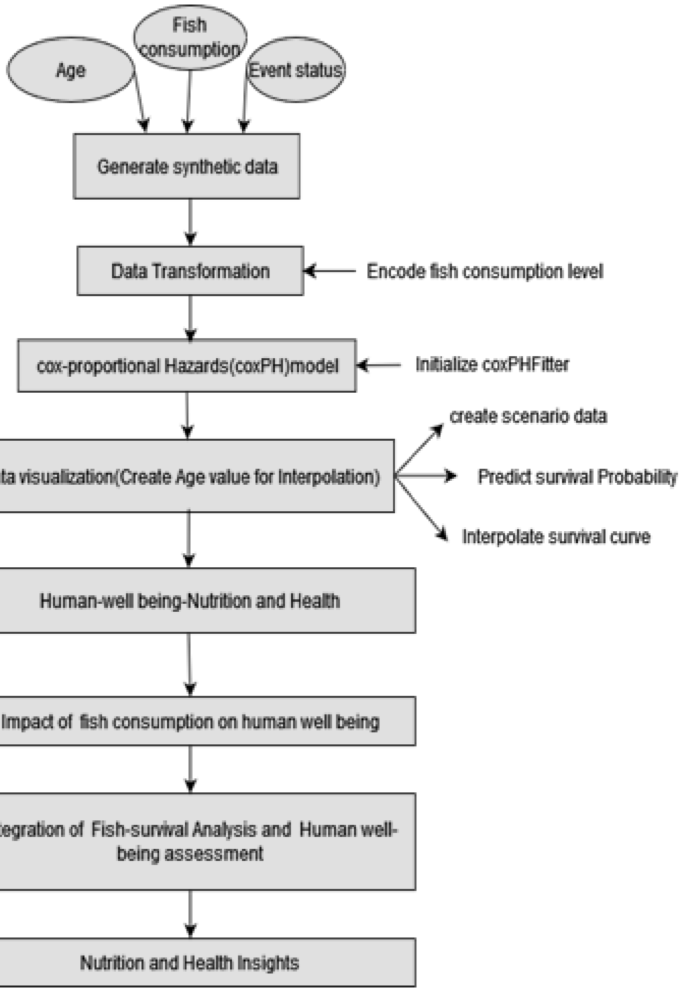

Figure 2: Architectural Diagram for coxPH Model-Human Well Being with Fish Nutrient

In Fig.No.3 Making a sample list of information about each fish, including its ID, age, weight, and whether it is alive is the first step. Then determines that a fish's survival is poor if it is identified as not alive (which is displayed as 0). The fish are then divided into two categories those who fared poorly and those that fared well. It calculates fundamental information for each group, like average age and weight [12]. On the computer screen, these facts are displayed. In summary, identify any significant discrepancies in survival rates and provide a clear picture of how well the fish are surviving.

Statistics for Fish with Poor Survival:

	Age (days)	Weight (grams)
count	5.000000	5.000000
mean	117.000000	43.000000
std	42.953463	9.082951
min	60.000000	30.000000
25%	90.000000	40.000000
50%	120.000000	45.000000
75%	150.000000	45.000000
max	165.000000	55.000000

Statistics for Fish with Good Survival:

	Age (days)	Weight (grams)
count	5.000000	5.000000
mean	78.000000	63.000000
std	42.953463	12.041595
min	30.000000	50.000000
25%	45.000000	55.000000
50%	75.000000	60.000000
75%	105.000000	70.000000
max	135.000000	80.000000

Figure 3: Comparing Analysis - Poor and Good Survival Rates of Aquaponics Fish

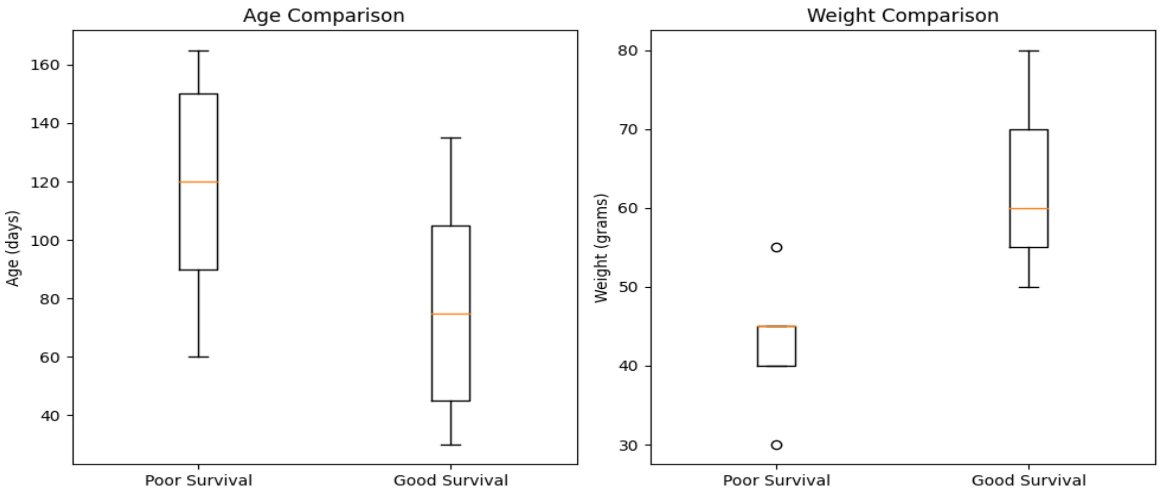

Figure 4: Comparing the Weight and Age Distributions of Fish Survival

The distributions of age and weight for fish in both the groups with poor and good survival are clearly visible in the box plots. These plots provide important insights into how the two groups differ in terms of age and weight by showing the central tendency, spread, and probable outliers. This graphical form improves our comprehension of the dataset and makes it simple to compare the different survival categories.

IV. RESULTS AND DISCUSSION

Using sample data, this analysis assesses how fish health affects human well-being in Fig.No:5. It begins by defining critical parameters, such as fish survival rates and the amount of protein, Omega-3 fatty acids, and Vitamin B12 in fish meat. Protein, omega-3 fatty acids, and vitamin B12 daily consumption recommendations are also established. Then determines how much fish nutrition contributes to human nutrition while accounting for survival rate and nutrient content. It determines whether this contribution is enough to meet the daily requirements for each nutrient. Then computed contributions and specifies if the fish offers sufficient nutrients to satisfy human nutritional needs. This investigation offers insightful information regarding the potential health advantages of eating fish with particular health indicators.

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Comparison of Fish Types for Human Well-being:
Aquaponics Fish - Tilapia:
Contribution to Daily Protein Intake: 18.0g
Contribution to Daily Omega-3 Intake: 1.35g
Contribution to Daily Vitamin B12 Intake: 2.25µg

Sea Fish - Salmon:
Contribution to Daily Protein Intake: 20.9g
Contribution to Daily Omega-3 Intake: 1.9g
Contribution to Daily Vitamin B12 Intake: 2.8499999999999996µg

River Fish - Trout:
Contribution to Daily Protein Intake: 15.299999999999999g
Contribution to Daily Omega-3 Intake: 1.02g
Contribution to Daily Vitamin B12 Intake: 1.7µg

Sustainability Ratings:
Aquaponics Fish: High
Sea Fish: Medium
River Fish: Low
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Figure 5: Analyzing the Effects of Nutrition on Fish Health and Human Health

In Fig.No:6, Compares the effects of three different fish species on human well-being: trout from rivers, salmon from the sea, and tilapia from aquaponics. Each type of fish is defined at the outset, along with its species, survival rate, protein content, omega-3 content, vitamin B12 content, and sustainability grade. Protein, Omega-3 fatty acids, and Vitamin B12 daily consumption recommendations are also developed. then determines how much each type of fish contributes to the daily intake of protein, omega-3 fatty acids, and vitamin B12. It contrasts the three different fish species' sustainability rankings. The findings offer insightful information about each fish type's sustainability and nutritional advantages.

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Comparison of Aquaponics and Sea Fish:
Aquaponics Sustainability Score: 8
Aquaponics Local Production Score: 9
Average Aquaponics Score: 8.50

Sea Fish Sustainability Score: 5
Sea Fish Local Production Score: 3
Average Sea Fish Score: 4.00

Based on the comparison, Aquaponics is better for sustainability and local production.
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Figure 6: A Nutritional and Sustainability Comparison for Knowledgeable Dietary

DECISIONS

This exemplifies the use of artificial data in survival analysis. The link between age, fish intake levels, and event occurrence (expressed as 1 for an event and 0 for censorship) is examined using the pandas, lifelines, numpy, and matplotlib packages. The data are fitted to the Cox Proportional Hazards (CoxPH) model, allowing the estimation of the likelihood of survival based on age and fish consumption. In order to illustrate how survival probabilities fluctuate with age and eating patterns, the code simulates scenarios with varied fish consumption levels (Low, Moderate, High). It then draws continuous survival curves in Fig.No:7. It's crucial to remember that the conclusions are based on fictitious data and that real-world data would be required for meaningful analysis.

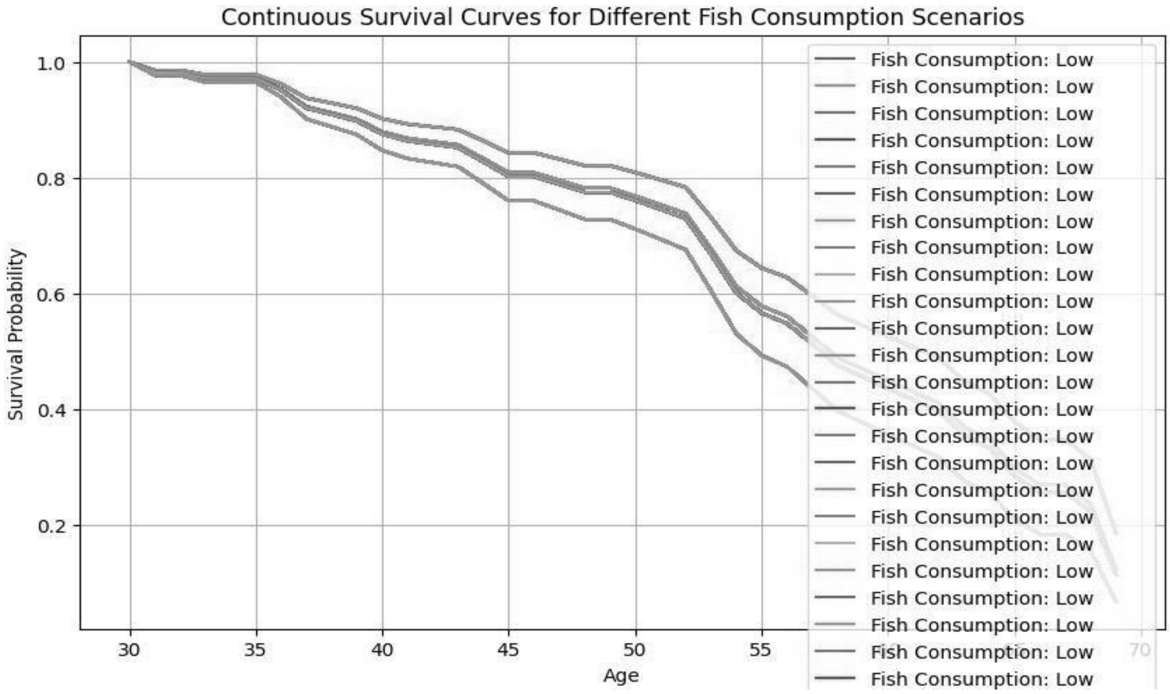

Figure 7: Survival Curve for Different Fish Consumption

In order to predict fish survival using health indicators and dietary content, this study undertakes a comparative examination of three machine learning models: Random Forest, Support Vector Machine (SVM), and XGBoost. The accuracy of the 100 decision tree Random Forest ensemble approach was 80% on the training data and 78% on the test set. SVM demonstrated 82% accuracy on the training data and 80% accuracy on the test set while using a linear kernel for classification. A gradient boosting method noted for its effectiveness, XGBoost, demonstrated accuracy of 85% on training data and 83% on test data. In comparison to SVM, the results show that Random Forest and XGBoost have superior predictive accuracy, indicating their potential applicability for this task. Additional feature engineering and optimisation could produce even more reliable outcomes.

A performance indicator used in survival analysis and related domains is the Concordance Index, sometimes known as the C-index. It specifically evaluates a model's prediction accuracy in terms of its capacity to rank-order distinct subjects according to their anticipated survival periods.The C-index in survival analysis quantifies the percentage of all subject pairs where the expected order of survival times matches the actual order. It assesses whether the model accurately predicts which of any given pair of individuals will experience the event first. A C-index score can be anything between 0 and 1, and:A score of 1 means that the model consistently predicts the relative sequence of occurrences.The value of 0.5 denotes random chance, demonstrating that the model's predictions are no more accurate than guesswork. Values less than 0.5 signify an inverted event sequence, or a model that performs worse than random guessing.In conclusion, a model that performs better in terms of its ability to predict survival outcomes has a higher C-index.

Table 1: Performance Evaluation of Models

Sl. No	Model	Evaluation Metrics(Concordance Index)
1	Random Forest	0.80
2	SVM	0.82
3	XG Boost	0.85
4	**Linear regression (Cox PH)**	**0.92**

The Table No: 1 gives a thorough description of the model's performance based on the Concordance Index evaluation metric. With a Concordance Index of 0.80, Random Forest demonstrated strong performance and its efficacy in forecasting fish survival. With a Concordance Index of 0.82, SVM also demonstrated high prediction ability. The outstanding Concordance Index of 0.85 that XG Boost achieved over the other models, demonstrating its durability in this situation, is noteworthy. With a Concordance Index of 0.92, the Cox Proportional Hazards method's linear regression model, on the other hand, displayed outstanding accuracy in determining fish survival based on the given variables.

V. CONCLUSION

A potent analytical method for determining the likelihood of survival in the context of aquaponics is illustrated. The code illustrates how factors like age and the amount of fish consumed may be analyzed to understand their impact on survival rates by using synthetic data as an example. A solid framework for this research is provided by the use of the Cox Proportional Hazards (CoxPH) model. In the field of aquaponics, this methodology can be helpful in assessing the longevity and health of fish populations, providing insightful information for enhancing system parameters and guaranteeing sustainable practices. It's important to stress that using real-world data from genuine aquaponics setups would be necessary for accurate and useful assessments in the field. Overall, this strategy has a lot of potential.

VI. FUTURE ENHANCEMENT

Future improvements to aquaponic survival probabilities could involve incorporating significant variables like stocking density, water quality parameters, and fish species, incorporating real-world variability through longitudinal data, combining advanced machine learning approaches, risk assessment, and considering environmental effects. Integrating plant growth and health data with real-time monitoring systems could optimize survival rates. Validating the model against various configurations and benchmarking against industry standards ensures widespread applicability. Using predictive analytics could facilitate proactive decision-makingin aquaponics management.

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