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Detection of Freshness of Fish using Machine Learning Techniques on Vyas Municipality, Nepal

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Abstract: ***The historical narrative of the fish trade is well-document in various sources. However, the concerning prevalence of fish traders vending spoiled fish poses a significant threat to human health, prompting specific research inquiries. The study aimed to address key questions: What quality of healthy fish do traders sell? How effective are their fish storage methods? What's the duration between fish purchase and consumer access? The study objectives were devised to uncover a actual condition of the fish on sale, assess storage practices, and determine the selling timeline. To achieve these aims, the study employed the EfficientNetB1 machine learning model, chosen for its simplicity and high accuracy. Five fish shops and traders from wards 1,2,3 and 4 in Damauli, the primary city of Vyas Municipality in Nepal, were selected for investigation. Results from five main city shops in Damauli revealed that only 26% of the fish were deemed healthy, while a concerning 74% were identified as rotten. Similarly, within the sample, 44% of the fish were healthy, while 56% were spoiled. This study unveiled that fish were being sold even up to 15 days post-purchase, employing ice packs, refrigeration, and potentially chemicals for storage. These findings highlight the urgent need for ongoing monitoring by relevant stakeholders and local government entities to address this issue effectively.***

Keyword: Machine Learning, Freshness, Rotten, Efficient NetB1, Health.

1. INTRODUCTION

Fish serves as a crucial protein source essential for human sustenance worldwide. However, if fish is consumed in an unfit stage, it can significantly impact human well-being. Fish tends to spoil

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rapidly, prompting fishermen to employ diverse chemicals, ice packs and refrigeration methods to prolong its freshness. Despite appearances suggesting otherwise, fish kept for extended periods can still deteriorate. Utilizing machine learning facilitates the identification of imperceptible issues. This research integrates new technology to address these concerns.

During the early 13th century, Shinran, a renowned Buddhist priest, advocated for the consumption of fish due to its nutritional benefits. This advocacy led to an increased consumption of fish among the Japanese population and spurred growth in the fish trading industry. However, the commercialization of fish notably surged in the mid-17th century, coinciding with the rise of a monetary economy and the heightened activity of merchants involved local commodity shipments. The progression continued with significant developments in marine transportation: an eastern route linking japan Sea coasts to Tokyo opened in 1771, while in 1772, western routes between Japan Sea coast and Osaka, the Higaki Kaisen route, and the Taru Kaisen route connecting Osaka and Tokyo were established. This developments, coupled with government policies emphasizing commercialization, catalyzed widespread commercialization in Japan during modern times[1][2].

Fish production has rapidly grown within the agricultural sector of Nepal, with ethic and indigenous communities actively participating in fisheries. Nowadays, it has become a lucrative venture. To gather information about fish and fish-related products, both online and printed sources, such as articles, journals, and official reports, were consulted and examined. The trend in fish production in Nepal is on the rise, with Mrigal carp being the most produced fish at 29.2 percent. Nepal predominantly imports fish and fish products from India, China, and Bangladesh, while its fish and fish product exports are minimal. The increasing number of individuals engaging in fish farming in ponds and lakes has led to an upsurge in fish and fish product production. Consequently, the nation is progressing towards achieving self-sufficiency in fish production[3].

The study revealed that the majority of farmers (86.76%) considered fish farming as their primary occupation, and it proved to be profitable endeavor, boasting an average productivity of 5.53 metric tons per hectare per year and a benefit-cost ratio of 1.37. While most farmers practiced carp polyculture, a few respondents also engaged in monoculture and integrated fish farming. The fish produced in the area were distributed across various markets, including local markets, adjacent districts, and more distance markets. Traders played a significant role in this distribution, with 59.65% of the total being sold to wholesalers, 30.49% to retailers, and 9.87% directly to consumers. Common means of transportation included bicycles, motorbike, and pickup vans[4].

The significance of the fish industry is evident, yet there are disparities among those involved While fish traders' express contentment, consumers struggle to access healthy fish. The transit time from India to Nepal, roughly 10 days, leads to a concerning issue: by the time fish reaches consumers via traders, it has typically spoiled. Despite efforts to preserve fish using ice packs and refrigerator, it still spoils, appearing normal but being unsuitable for consumption. Shopkeepers note that Indian-imported fish lasts longer than Nepali fish, which spoils within 2 days. However,

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consumers and shops report Indian fish as acceptable. Understanding the chemicals present in Indian fish is crucial, prompting the need for a dedicated study. Prior to investigating the chemicals used, it's essential to assess the ratio of healthy versus rotten fish to address this concerning issue. Consuming fish tainted with metals poses severe health risk such as renal failure, liver and kidney damage, cardiovascular aliments, neurogenic and carcinogenic effects, and weakened immune systems. Different fish and shellfish species may carry bio toxins leading to various types of poisoning: ciguatera fish poisoning, Scombroid fish poisoning, rudder fish poisoning[5], Tetrad toxin of puffer fish poisoning in humans. Seeking immediate medical help upon symptom onset is is crucial to counter fish poisoning. Avoiding consumption of fish roes and organs, as well as those caught during algal blooms and periods of global warming, is advised as a preventive measure against poisoning or spoiling[6].

This research formulates several inquiries, with specific questions aimed at uncovering the truth behind the intended objective. Among these questions, the research sought to determine whether the fish being sold by fishmongers as healthy are indeed safe for consumption Additionally, it aimed to assess the state of the fish stock.

The primary goals of this research focus on determining the edibility of fish sold in Damauli, the primary city of Vyas Municipality, and its surrounding areas. The specific aims include assessing the quality disparity between healthy and spoiled fish and evaluating the effectiveness of fish storage methods. The ascertain the fish's condition, the research intends to utilize image processing through a machine learning-based system that has been developed for this purpose.

The research area has been narrowed down for simplification purposes. Specifically, this study focuses on examining the organized fish shops in Damauli, the main city of Vyas Municipality, along with the residences in wards 1,2,3 and 4, and the fish sold by local fishmongers. The study involved capturing images of the eye parts of 20 fish from each of the 5 fish shops and collecting images of fish sold by 5 selected fishmongers, 10 fro each, who cater to toll and customer households. These collected photos underwent identification using image processing techniques. The research utilized the EfficientNetB1 machine learning model. Additionally, the investigation delved into studying the fish storage methods employed by the sampled fish shops and businesses. This research will greatly help an underdeveloped country like Nepal. It also inspires new researchers in this place where modern research methods are less used. Caution can be taken when using the fish that people in this area have been consuming. The findings of this study will inspire to research other places like Damauli. It is hoped that this research will make an important contribution in helping to identify the serious problems caused by rotting fish, which looks normal.

2. RELATED WORKS

Monthly monitoring of water quality parameters, including temperature, dissolved oxygen, pH and total hardness, was conducted. Water temperature and total hardness levels were diminished during

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the months of November to January in the bell, which posed challenges for the fish. Histopathological examination revealed that sampled fishes were normal in September and October, with reduced pathological signs in February and march. Eels, both clinically and pathologically, were found to be more affected in December and January. The reduced temperature and total hardness likely played a role in the occurrence of clinical and pathological changes in fish during this period. Furthermore, the evidence suggested that the fishes were affected by EUS, as demonstrated by the development of fungal granulomas in the skin, muscles, and kidneys[7].

The size of ice crystals does not necessarily serve as the sole indicator of frozen fish meat quality, as the meat tissue can reabsorb water during the thawing process unless prior damage from protein denaturation has occurred. The quality is significantly influenced by the salting conditions, which affect both the muscle's water retention capacity and ice crystal size. similarly, a product with denatured protein gel, the size of ice crystals cloud plays a critical role in determining quality, as the protein gel, the size of ice crystals could play a critical role in determining quality, as the protein gel does not absorb thawed water adequately[8].

The primary aim of this study is to assess the freshness of papayas and watermelons by monitoring their post-harvest CO_2 release, water vapor release, and O_2 absorption. The were divided into three weight categories and subjected to testing on four specific days: the day of harvest, three days after harvesting, one week after harvesting, and two weeks after harvesting. These tests aimed to track changes in three key factors, namely CO_2 levels, and humidity. To capture these changes, a setup was implemented with CO_2, O_2, and Humidity sensors. The data collected from these sensors was then utilized to train a machine learning model specifically a Keras Sequential Model. This model takes inputs such as the type of fruit, its weight, and the difference in oxygen and water vapor concentrations after 45 minutes. The accuracy of this developed model was found to be 98%, indicating its reliability. The analysis results suggested that the rate of O_2 absorption gradually increases post-harvest, while water vapor release gradually decreases. It is recommended to employ sensors with higher sensitivity to ensure more precise and accurate result[9].

3. METHODOLOGY

The research method makes the study goal-oriented. In this research work, to make the study highly effective, first of all, the problems of the study area have been collected. Research design has been prepared after selecting the collected problems. Although the design is ready, the methods of data collection have been prepared. The collected data has been analyzed. A report has been prepared and documentation has been done at the end. In this research used mixed method.

3.1 The Conceptual Framework

Various elements have been recognized to enhance the freshness fish.

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Table 1

Main Factors	Scale and inquiries
Image of fish	Using machine learning to distinguish between healthy and rotten fish image.
Storage of fish	To find out how they have stocked fish.
Time to sell (Storing duration)	.To find out how long the bought fish is being sold.
Place of Purchase	Place to buy fish
Sell quantity per day	To find out how many fish are sold on average each day.

3.2 Research Design

In order to organize the research, the problems were studied at the beginning. Like storing fish for a long time, selling rotten fish and using pesticides on fish. Similarly, necessary materials like computer, camera, Python programming language etc. were prepared. This is how the model was developed like EfficientNetB1. Similarly, training and validation was done for validation. After validation was successful, necessary data was collected such as photos of fish and various opinion surveys were conducted. The given diagram is research design.

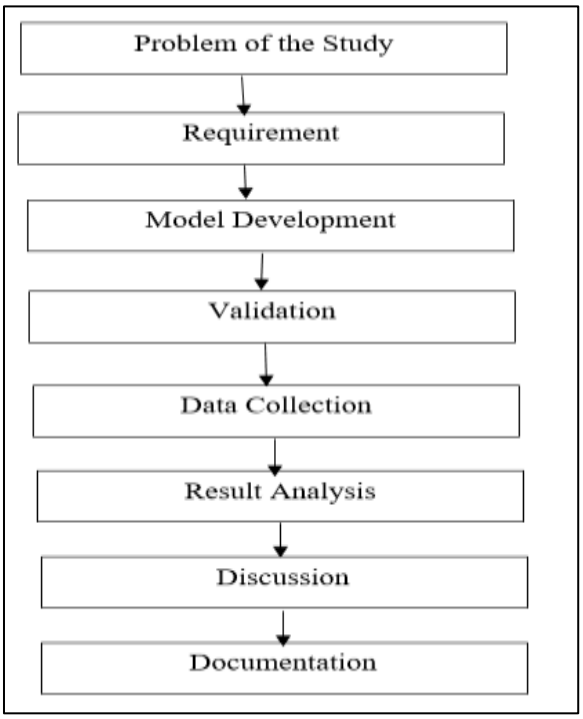


Fig. 1

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3.3 Requirement

Software Requirement

- Operating System: Windows 11
- Google Colab with python libraries

Hardware Requirement

- Processor: Intel Core ™i5
- Hard Disk: 500 GB
- RAM: 8 GB

3.4 Model Development

EfficientNetB1

EfficientNetB1 is a part of a family of convolutional neural network architecture called EfficientNets. These models are known for their efficiency in terms of accuracy and computational resources. EfficientNetB1 specifically refers to a variant of the EfficientNet architecture, with B1 indicating its relative size within the family. EfficientNetB1 is one of the smaller versions in the EfficientNet series. it's designed to be computationally efficient while still offering good performance on various computer vision tasks, such as image classification, object detection, and segmentation. By scalling the network architecture in a principled way, EfficientNetB1 aims to achieve better performance than similarly size models while requiring fewer computational resource, making attractive for applications where resource constraints are a concern[10][11].

3.5 Data Collection

Data plays a crucial role in thesis writing as it is the backbone of any research work. Data provides evidence to support the hypothesis, research question or objectives of the research. The study utilized the Kaggle dataset, downloading its information and employing machine learning techniques for validation. This dataset encompasses 2000 distinct fish photos. The primary data source for this study comprises image capturing fish available for sale and storage. Distinguishing fresh from spoiled fish relies on visual cues, prompting the use of high-resolution cameras for image capture. Fish sample from multiple shops within the research area were collected for analysis. To align with the study's goals and inquiries, distinct questionnaires were administered to the fish vendors, further advancing the research process.

3.6 Area and Population

This study focused on four fish vendors situated in the Damauli market within Vyas Municipality Nepal, the primary urban center Tanahun district. Nine individuals engaged in fish vending were randomly selected for participation. Questionnaires were administered and photographs capturing the fish sold by these vendors were promptly gathered during the interactions.

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3.7 Machine Learning Algorithm

EfficientNetB1 operates on the principles of compound scaling, where the model's depth, width and resolution are scaled in a balanced manner to achieve better performance without significantly increasing computational cost.

- Compound Scaling: EfficientNet models use compound scaling to balance the model's depth (number of layers), width (number of channels or heuristic that considers how each aspect affects the model's performance and computational cost.
- Base Architecture: The backbone of EfficientNetB1 is built upon a combination of mobile inverted bottleneck convolutional layers, which consists depthwise and pointwise convolutions along with squeeze-and-excitation blocks. These layers help in capturing complex patterns in the data efficiently.
- Depthwise Separable Convolutions: EfficientNet models use depthwise separable convolutionals, which split standard convolutions into depthwise convolutions (operating independently on each channel) and pointwise convolutions (mixing information across channels). This approach reduces computation by reducing the number of parameters and operations.
- Squeeze-and-Excitation blocks: Squeeze-and-Excitation blocks, integrated within the MBConv layers, help the model to better capture interdependencies between channels by adaptively recalibrating channel-wise feature responses. This mechanism enhances the model's representational power.
- Efficient Scaling: The model scaling process involves determining the optimal balance of depth, width, and resolution. By scaling these factors together, the model adapts to different resource constraints while maximizing performance.
- Transfer Learning and Fine-Tuning: EfficientNetB1, like many deep learning models, benefits from transfer learning. Pretrained versions of EfficientNetB1 on large-scale dataset can be fine-tuned on specific tasks with smaller datasets, leveraging learned features and adapting to new data.

EfficientNetB1's architecture and scaling methodology allow it to achieve competitive performance on various computer vision tasks while being relatively more efficient in terms of computational requirements compared to many other models.

3.8 Validation

In this research, the machine learning model underwent training and testing using Kaggle dataset, split into a 7:3 ratios for training and testing, respectively, across 15 epochs. The analysis revealed notable outcomes. The diagram illustrates optimal performance seen at the 15th epoch concerning training and validation loss, while the 11th epoch showcased the highest accuracy in both training and validation.

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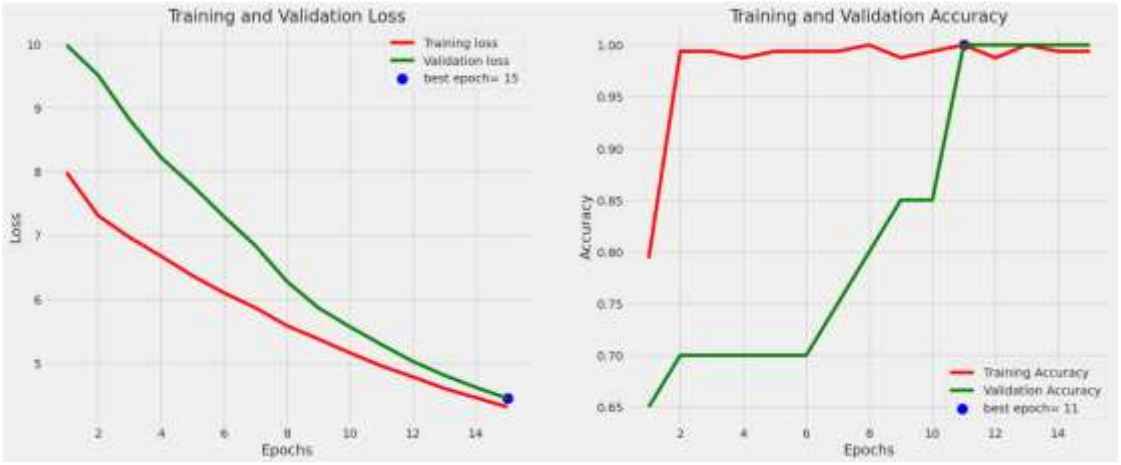


Fig. 2

The confusion matrix for this test is detailed below, and the findings derived from this evaluation are outlined accordingly.

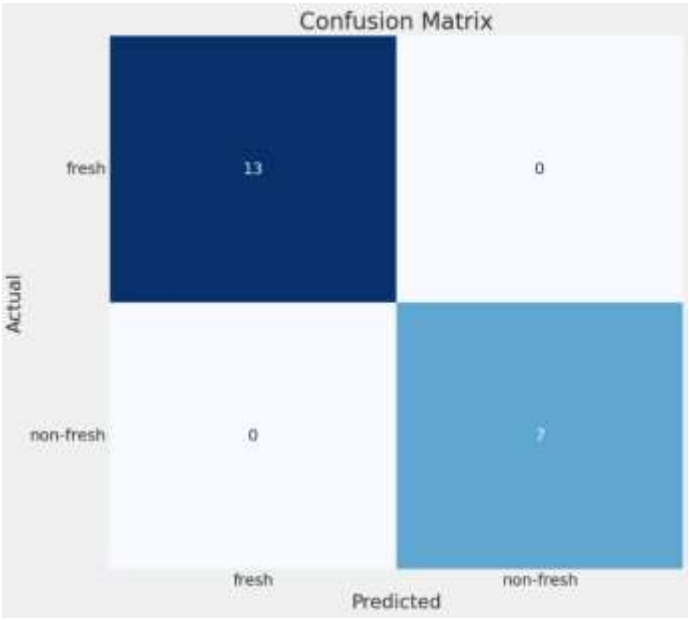


Fig. 3

Table 2

Types of Fish	Precision	Recall	F1-Score	Accuracy
Fresh	100%	100%	100%	100%
Non-Fresh	100%	100%	100%	100%

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The analysis indicates an exemplary performance across the board for both "Fresh" and "Non-Fresh" fish types based on various evaluation metrics:

Precision
Precision is a metric used in classification to assess the accuracy of positive predictions made by a model. It measures the proportion of correctly predicted positive instances out of all instances predicted as positive by the model. A high precision indicates that when the model predicts a positive result, it's likely to be correct.

$$\text{Recall} = \frac{True\ Positives}{True\ Positives+False\ Positive}$$

100% for both Fresh and Non-Fresh types implies that all items labeled as Fresh or Non-fresh were correct in their classification.

Recall
Recall, in the context of classification models and evaluation matric, measure the ability of a model to correctly identify all relevant instances or items from a particular class. It is also known as sensitive true positive rate. In simple terms, recall answers the question: "Of all the relevant items in the dataset, how many were correctly predicted by the model?"

$$\text{Recall} = \frac{True\ Positives}{True\ Positives+False\ Negative}$$

Also at 100% for both categories suggests that the model identified all actual instances of Fresh and Non-Fresh fish.

F1-Score
The F1-score is a metric that combine both precision and recall into a signal value. It's particularly useful when dealing with imbalanced classes or situations were both precision and recall are important but need to be balanced.

$$\text{F1-score} = 2X\ \frac{Precision\ X\ Recall}{Precision+Recall}$$

Achieving 100% for both categories implies a perfect balance between precision and recall.
Accuracy: The accuracy of 100% signifies that the model's overall classification performance was flawless for both Fresh and Non-Fresh fish types.

This data suggests that the model's predictions were entirely accurate for the given classes, showing a highly reliable performance in distinguishing between Fresh and Non-Fresh fish samples.

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4. RESULTS AND DISCUSSION

During the study of fish shops in the area and the collection of samples, it was discovered that only 179 out of 700 fish quality standard across all shops. The remaining 521 fish were damaged. The specific breakdown is outlined in the subsequent table.

Table 3

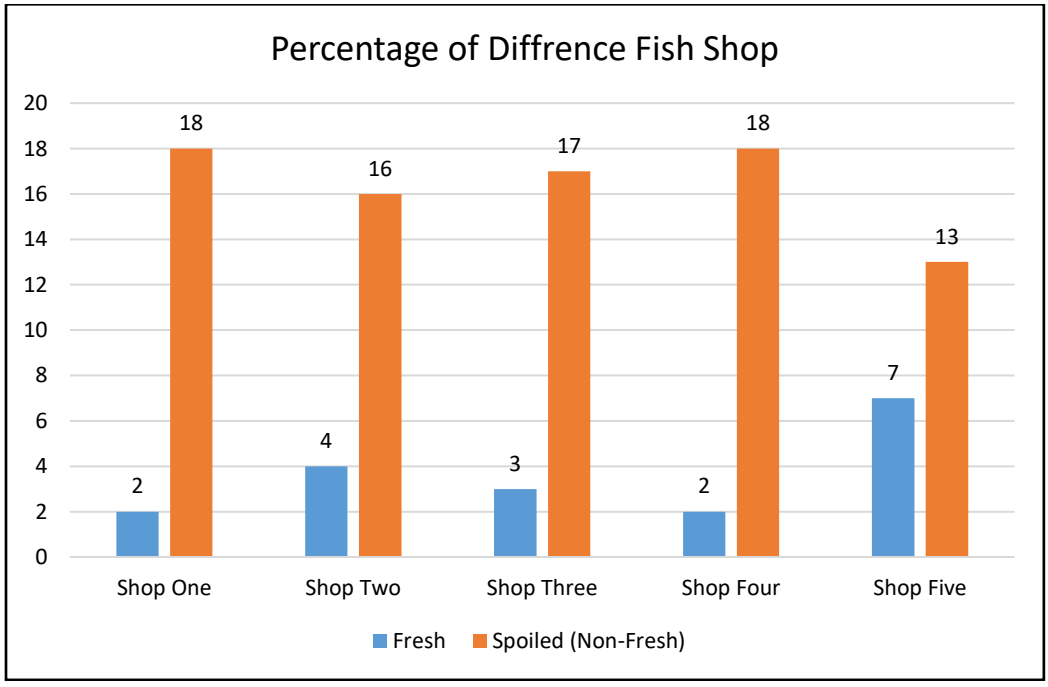
Date	Fish Shop	Total Sample	Fresh		Spoiled (Non-Fresh)	
May 1, 2023	1	20	2	10%	18	90%
	2	20	4	20%	16	80%
	3	20	3	15%	17	85%
	4	20	2	10%	18	90%
	5	20	7	35%	13	65%
June 1, 2023	1	20	4	20%	16	80%
	2	20	6	30%	14	70%
	3	20	5	25%	15	75%
	4	20	4	20%	16	80%
	5	20	9	45%	11	55%
July 1, 2023	1	20	3	15%	17	85%
	2	20	5	25%	15	75%
	3	20	4	20%	16	80%
	4	20	3	15%	17	85%
	5	20	8	40%	12	60%
August 1, 2023	1	20	5	25%	15	75%
	2	20	7	35%	13	65%
	3	20	6	30%	14	70%
	4	20	5	25%	15	75%
	5	20	10	50%	10	50%
September 1, 2023	1	20	7	35%	13	65%
	2	20	9	45%	11	55%
	3	20	8	40%	12	60%
	4	20	7	35%	13	65%
	5	20	12	60%	8	40%
October 1, 2023	1	20	4	20%	16	80%
	2	20	2	10%	18	90%

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	3	20	1	5%	19	95%
	4	20	3	15%	17	85%
	5	20	5	25%	15	75%
November 1, 2023	1	20	3	15%	17	85%
	2	20	2	10%	18	90%
	3	20	4	20%	16	80%
	4	20	5	25%	15	75%
	5	20	5	25%	15	75%
Total Sample		700	179	26%	521	74%
Maximum			12		19	
Minimum			1		8	
Average			5.11		14.89	

The given diagram is comparative analysis of fish condition.



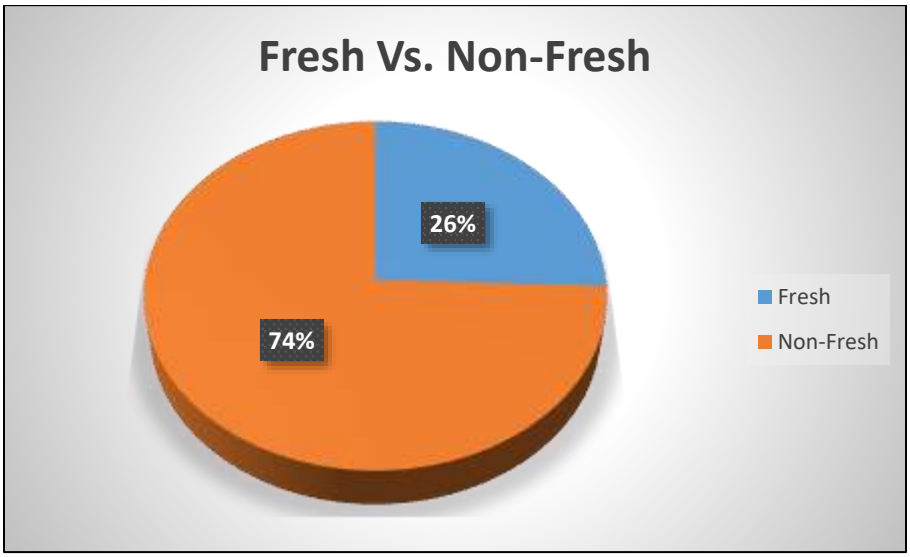
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Based on the report received during the research, the fish used in this area were found to be healthy. It has been found that rotten fish is being sold in 5 shops of Damauli and from the study of itinerant

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traders. Only 26% of fresh fish were found in Damauli's fish shop and 74% of fish were found to be non-fresh.



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Storing process of Fish

Table. 4

Fish Shop	Place of Purchase	Store	Time To sell	Sell Quantity per Day
1	India	Freeze / Ice Pack	About 1 week	About 15 KG
2	India / Nepal	Freeze / Ice Pack	About 10 Days	About 12 KG
3	India	Ice Pack	About 5 Days	About 15 KG
4	India / Nepal	Freeze / Ice Pack	About 9 Days	About 5 KG
5	India	Freeze / Ice Pack	About 10 Days	About 14 KG

Our home town, of the fish vendors selling in the village, 5 out of the total 350 fish were identified, with a majority being spoiled. Upon examining the 50 fish, 14 were deemed suitable for consumption, while the remaining 197 were spoiled and unsuitable for consumption. Detail result are given table.

Table 5

Date	Fish Shop	Total Sample	Fresh		Spoiled (Non-Fresh)	
May 1, 2023	1	10	2	20%	8	80%
	2	10	4	40%	6	60%

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	3	10	7	70%	3	30%
	4	10	0	0%	10	100%
	5	10	1	10%	9	90%
June 1, 2023	1	10	4	40%	6	60%
	2	10	6	60%	4	40%
	3	10	9	90%	1	10%
	4	10	2	20%	8	80%
	5	10	3	30%	7	70%
July 1, 2023	1	10	3	30%	7	70%
	2	10	5	50%	5	50%
	3	10	8	80%	2	20%
	4	10	1	10%	9	90%
	5	10	2	20%	8	80%
August 1, 2023	1	10	5	50%	5	50%
	2	10	7	70%	3	30%
	3	10	8	80%	2	20%
	4	10	3	30%	7	70%
	5	10	4	40%	6	60%
September 1, 2023	1	10	7	70%	3	30%
	2	10	9	90%	1	10%
	3	10	8	80%	2	20%
	4	10	5	50%	5	50%
	5	10	6	60%	4	40%
October 1, 2023	1	10	4	40%	6	60%
	2	10	2	20%	8	80%
	3	10	1	10%	9	90%
	4	10	3	30%	7	70%
	5	10	5	50%	5	50%
November 1, 2023	1	10	3	30%	7	70%
	2	10	2	20%	8	80%
	3	10	4	40%	6	60%
	4	10	5	50%	5	50%
	5	10	5	50%	5	50%
Total Sample		350	153	44%	197	28%
Maximum			9		10	

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Minimum		0		1	
Average		4.37		5.63	

Comparative analysis of Fresh fish and non-fresh fish are given by diagram first studies.

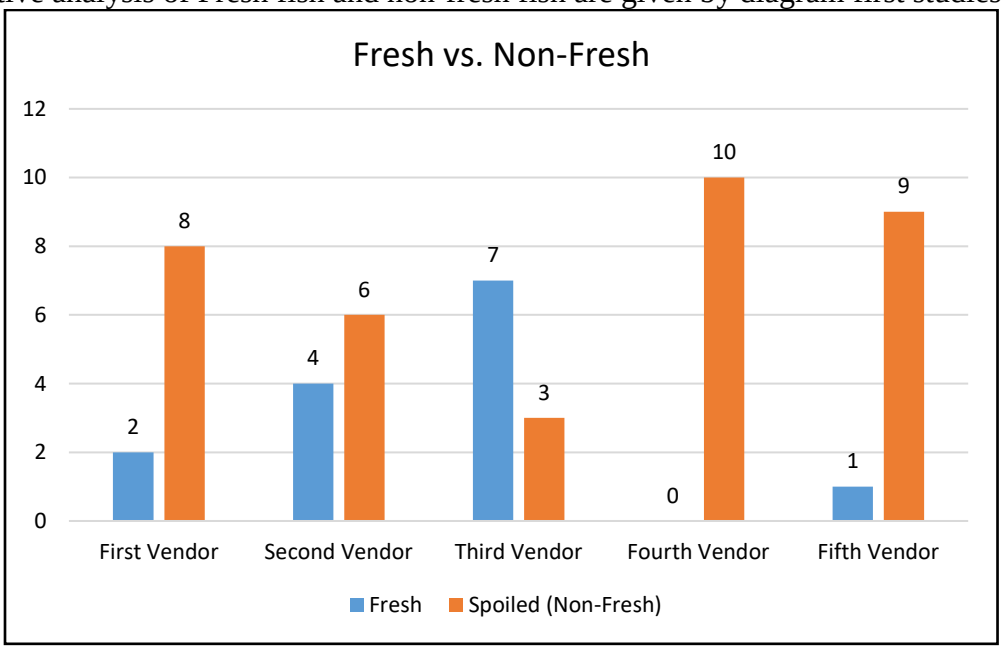
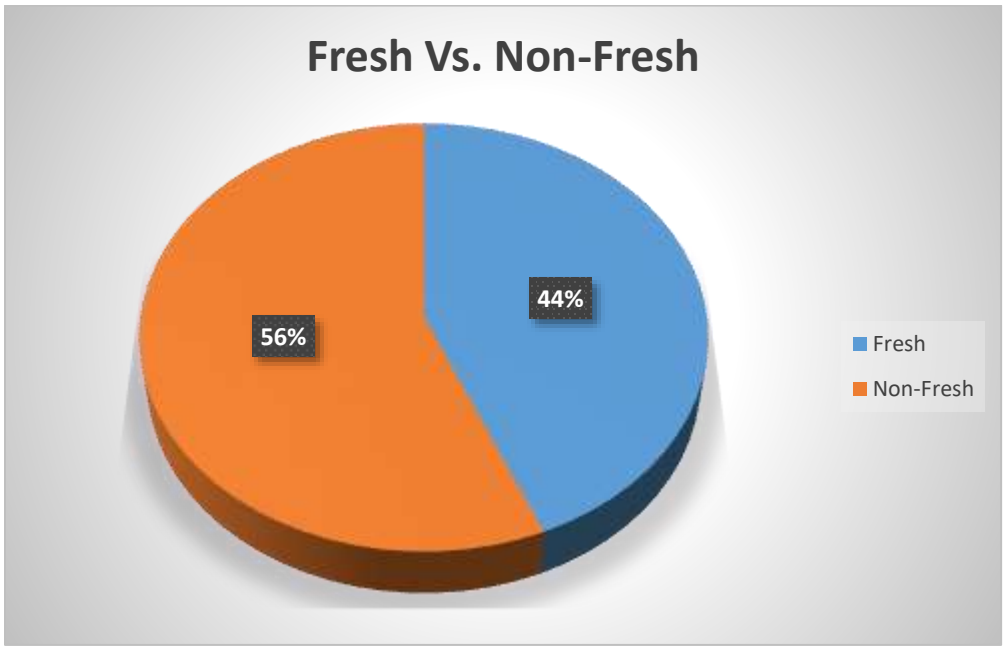


Fig. 6

Similarly, 44% of fresh fish and 56% of non-fresh fish were found in the fish examination of the itinerant fish traders.

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Storing Process of the Fish

Fish Shop	Place of Purchase	Store	Time To sell	Sell Quantity per Day
1	Local River	Chemical	About 3 Days	About 5 KG
2	India	Ice Pack	About 4 Days	About 6 KG
3	India	Ice Pack	About 5 Days	About 8 KG
4	Nepal	Freeze / Ice Pack	About 6 Days	About 4 KG
5	India	Freeze / Ice Pack	About 8 Days	About 9 KG

Fish stands as a crucial element in ensuring human well-being, but the concern over the quality of available fish prompted an investigation into the reality of the situation outlined in this paper. Spanning from May 1st, 2023, to November 1st, seven months of research have been scrutinized to reveal a disconcerting truth. Shockingly, none of the shops surveyed had 100% clean fish, with only a mere 26% meeting healthy standards. Alarmingly, 74% of the fish analyzed were found to pose serious health risks. Delving deeper, Mobile fish businesses exhibited 44% offering clean fish, while 56% provided rotten ones. This scenario might extend beyond this area, indicating potential widespread trading of compromised fish. Numerous traders were discovered sourcing fish from India, where the transit time to reach consumers ranged from 4 days upon arrival to this place, extending up to 7 to 15 days. Despite efforts to preserve fish quality through ice packs and refrigeration, a noticeable odor and evidence of spoilage persisted even in fish without a

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discernible smell. Traders' claims about India first's prolonged freshness hinted at possible chemical treatments. This prompts the urgency for local authorities to investigate further. The local government must consider a thorough examination of this matter, urging closer monitoring of fish traders. Equally vital is educating fish consumers about the hazards associated with using spoiled fish. Additional research into the fish's condition is imperative, accompanied by seeking guidance from local authorities for necessary intervention strategies.

5. CONCLUSION

The fish trade boasts a long-standing global history, yet its susceptibility to quick spoilage remains a challenge. Market observations revealed the sale of apparently fresh-looking but ultimately rotten fish due to prolonged storage and improper handling practices in fish shops emitting unpleasant odors. In response to these issues, the research necessitated leveraging machine learning techniques to study fish photos, a pivotal step in advancing the investigation. This method allowed for a comprehensive examination of various fish aspects, utilizing collected images to assess fish conditions efficiently. The analysis of received reports concluded that only a minimal quantity of edible fish was available.

The local government's involvement becomes imperative in addressing this concern. Vigilant oversight in required in fish trader establishments, while consumers need enlightenment about the risk associated with using spoiled fish. Further in-depth studies on fish conditions are warranted, urging the local government to provide guidance and recommendations for an essential intervention program.

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