A REAL TIME NON-DESTRUCTIVE AUGMENTED REALITY BASED MOBILE APPLICATION FOR ASSURING THE QUALITY OF RAW MEAT ITEMS

BY

2125110012 **Ayesha Munawar**
2125110018 **Ghania Shahzad**
2125110046 **Raeesa Asif**
2125110056 **Shifa Zahra**

SUPERVISOR
Dr. Mariam Nosheen
Assistant Professor

Signature: _____

Committee Member 1:

Signature: _____

Committee Member 2:

Signature: _____

Committee Member 3:

Signature: _____

DEPARTMENT OF COMPUTER SCIENCE
LAHORE COLLEGE FOR WOMEN UNIVERSITY LAHORE

ABSTRACT

Meat quality is tightly related to human life. It is the most critical aspect for consumers to consider when purchasing such items. Few consumers are even willing to pay a higher price to guarantee the quality of meat. Developing countries (i.e. Pakistan) where majority consumers are below the poverty line cannot be able to afford meat items regularly. Moreover, lack of education, inadequate implementation of laws makes it difficult for them to estimate the quality of such expensive product.

The variability of raw meat items quality is one of the factors effecting the estimation of its quality. Currently destructive and non-destructive approaches have been adopted. These techniques uses sensory approach, laboratory equipment, human and machine resources that need time and human effort. To reduce the cost and enhance the portability of these techniques. The proposed idea will provide a mobile application that will assure the quality of raw meat items by using computer vision and deep learning techniques. A customized dataset will be used to train and test the proposed models.

The tentative modules of the proposed solution are mobile app manager, image processing, raw meat item type classification, raw meat quality classification, raw meat quality assurance estimation and augmented reality based report generation.

The proposed application will not only facilitate its consumer but also help the food authorities to measure raw meat quality anywhere anytime.

Table of Contents

1. INTRODUCTION

The technological advancements in food industry and growing trends of economy, changes the consumption concepts of raw meat items [1]. Today it is available in many categories such as poultry, livestock, seafood etc [2].

According to **Figure 1** the global statistics of meat consumption over past few years that people consume it in their daily routine life for fulfilling their nutritional needs [3]. According to the Organization for Economic Co-operation and Development (OECD) meat consumption is expected to increase per person to 35.5 kg by the end of year 2024. The demand for quality meat items not only enhances the life style of their consumer's health but also facilitate them economically [4].

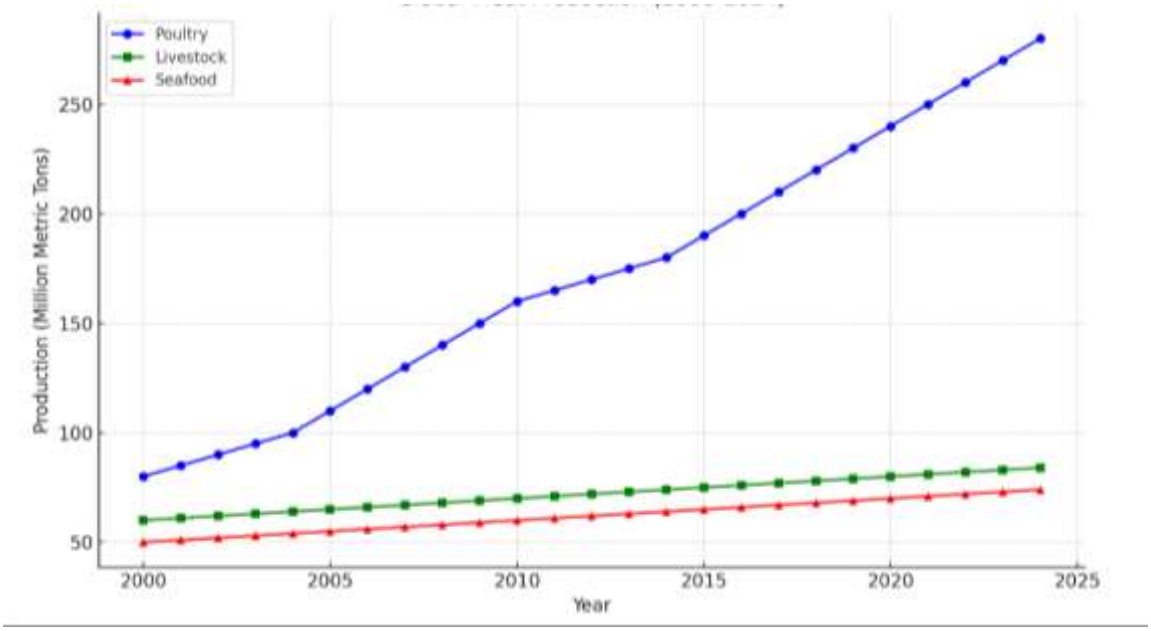

Figure 1: Global Meat Consumption Statistics (2000-2024) [1]

The quality of meat items are directly related to the survival and development of human beings, and it is the most critical aspect for consumers to consider when purchasing such

items. Few consumers are even willing to pay a higher price to guarantee the quality of meat .Developing countries (i.e. Pakistan) where majority consumers are below the poverty line cannot be able to afford meat items regularly.

Moreover, lack of education, inadequate implementation of laws makes it difficult for them to estimate the quality of such expensive product.

(a) Sample image of Livestock (i.e. Raw Beef)

(**b)** Sample image of Poultry (i.e. Raw Chicken)

(c) Sample image of seafood (i.e. Raw fish)

Figure 2: Raw Meat Items Sample images a) Livestock, b) Poultry and c) Seafood

The variability of raw meat items quality is one of the factors effecting the estimation of its quality. Currently two approaches have been used for estimating raw meat items quality [5]. First is destructive and second is non-destructive. In destructive approach meat quality has been measured using chemical component in laboratory based environment. This approach of estimating quality is much expensive as they require high human resources

and machines [1]. Moreover after the analysis the meat item get destroyed and cannot be able to use for consumption. This approach also utilizes lengthy analysis which needs more than two to three days that is difficult for consumers to adopt [6].

In non-destructive approach traditionally spectroscopy, colorimetric and sensory based techniques have been used for estimating the physiological and biological feature of raw meat items. It is also a laboratory based evaluation which is more expensive and need expert resources for estimation. To overcome the above gaps an AI based mobile application is proposed for real time raw meat quality estimation by using non-destructive technique [8] .

This document is further decomposed into nine sections. In the Section 1 of the proposal an introduction will be presented. Section 2 presented the literature review of research. Section 3 explains the proposed project problem statement. Proposed project objectives are presented in Section 4. In Section 5 proposed project scope is presented. The methodology of proposed project is explain in Section 6.The proposed solution is presented in Section 7. Implementation technologies are explain in Section 8. At the end Section 9 presents the proposed projects plan in the form of GANTT chart.

2. LITERATURE REVIEW

The literature review of the proposed project is divided into two phases. In first phase review of the previous real time based solutions will be done which is presented in **Table1**. In second phase the current software solutions available for the subject study have been received and presented in **Table2**

TABLE 1: Review of raw meat quality assurance tools, techniques and methodologies.

Author /Year	Proposed idea domain	Proposed solution	Types of raw meat items	Microorganisms Indicators	Quality features	Sampling approach	Proposed methodology	Proposed technique	Proposed tool	Hardware capture	Dataset			Testing Environment
											Type	No of instances	Acquisition source	
Xiao Hong Wu , 2024 [1]	Food science	Integrated system that employs various non-destructive detection techniques	Beef , Poultry Lamb, Mutton pork	Physiological Morphological, sensory	Color, tenderness, texture, pH levels, fat content, protein, smell, taste	Non destructive	Machine Learning , AL	Spectroscopic , Imaging Techniques Machine vision, electronic nose	Spectrometers (NIR, Raman Infrared cameras, gas sensors	Spectrometer, digital camera	Thermal images	100	Customized data set	Real time
Eric Zhou ,2024 [2]	Meat science	Fluorescence-based prototype device	Beef	Physiological , Morphological	Color, marbling, pH level, Collagen Content, Oxidative State of Myoglobin	Non destructive	Machine Learning	Auto fluorescence imaging	Prototype device using 3D nm LED and CMOS camera	CMOS Camera	Spectral image	200-300	Beef samples from a meat supplier	Laboratory

Philip Donald C. Sanchez,2022 [3]	Food science	Quantification and Visualization of Meat Quality	Pork, Beef	Physiological, Morphological	Color, tenderness, texture, pH levels ,fat content, Biogenic Amine Content, Oxidation (Lipid and Protein) protein	Non destructive	Machine Learning, Deep Learning	Hyperspectral Imaging (HSI), Spectral Data Acquisition	hyperspectral camera	Camera, Spectrograph, Illumination units	Hyperspectral images.	150	Customized	Laboratory
Kyung Jo, 2024 [4]	Food science	Assessment report	Beef, Pork, Poultry	Physiological Morphological	Appearance, size, tenderness color , marbling pH levels, water-holding capacity, and oxidation	Non-destructive	Machine Learning	Hyperspectral Imaging	HSI spectrometer	Camera	3D Hyperspectral Image	200	Public repositories	Real time
Valeriy Zaytsev, 2024 [5]	Food sciences	e-nose based on semiconductor metal oxide gas sensors, RGB	Beef, pork, poultry, lamb.	Brochothrix, Pseudomonas, Acinetobacter, Flavobacterium,	Spoilage-related gases, **C**olor changes	Non-destructive	Machine Learning	Volatile compound analysis, RGB imaging	e-nose, computer Vision (RGB), mass spectrometry, machin	Sensor RGB cameras	Multi sensor data	335	Online	Laboratory

		computer vision							e learning					
Marcin Wegner,2024 [6]	Agricultural science	Guidline	guinea fowl	Physicochemical, physiological	Protein fat content, Collagen, salt content, pH, Tenderness, Springiness, Gumminess, hardness,	Destructive	NIR, Electrical Conductivity, Colorimetry, Texture Profile Analysis, Warner-Bratzler Shear Force Test	NIR Analyzer, Electrical Conductivity Probe	Near-Infrared Spectroscopy (NIR)	Food Scan Analyzer, CX-701 pH Meter, LF-Star CPU Probe, TA.XT Plus Texture Analyze , Electric Meat Grinde	Meat sample	10 male guinea fowl 10 female guinea fowl	Customized	Laboratory
Bukola M. Adenuga, 2025 [7]	Food Industry	Use of DNA-based methods (PCR)	Red deer meat	Physiological	High nutritional value, low fat, high protein, low heavy metals	Non destructive	Deep learning	Real-time PCR	SYBR Green PCR assay for species-specific	PCR instruments, DNA extraction, amplification tools	Review Articles, Published Research Papers	Multiple samples from 3 countries (Poland, Portugal, Spain)	Online	Laboratory

									identification					
Stefaan De Smet ,2024 [8]	Public Health and Meat Safety	Evaluation of sustainable meat production	Beef, Pork, Poultry	Physiological	High protein, vitamins	Non destructive	Machine learning	Environmental modeling	Food analysis software	Spectrophotometer, Environmental monitoring devices	Online database	200	National health surveys	Laboratory
Zhe Sha, Weiqing Lan 2024 [9]	Food science and technology	Development of Colorimetric freshness indicators (CFIs)	seafood(fish, shellfish)	Morphological, physiological	pH, color freshness, spoilage , color ,odour	Non destructive	Deep Learning	Colorimetric technique	Colorimetric freshness indicators (CFIs)	Sensors, spectrophotometer	Images	Above 400	Experiments in labs	Laboratory
Linyu Zhang ,2023 [10]	Food Bioscience	Intelligent detection technologies	Beef, Pork, Chicken, Fish, Lamb	Physiological, Morphological	Color, texture , odor , pH level ,water activity , fat content	Non-destructive	Artificial Intelligence, Machine Learning	Spectroscopic, Electromagnetic, Biosensors	Spectrometer, Smart biosensors	NIR Spectrometer, Hyperspectral cameras, biosensors	Spectral images	Not mentioned	Customized	Real-time
Poonguzhali Elan	Food Safety	Automated system that utilizes	Beef, Poultry , Pork, Fish	Physiological	Color, texture , odor , tenderness	Non-destructive	CNN model	ConvNet-18 and ConvNet-24 CNN	Imaging devices , CNN	Cameras, AI processors,	Image data, Spectral data	Variable	Meat processing facilities, abattoirs,	Real time

govan, 2024 [11]		shallow (CNNs) to assess the quality						models, Ensemble models	framework	Spectrometers			retail distribution centers	
Benjamin W.B. Holman ,2021 [12]	Food science	Guidelines for Meat Quality Assessment	Beef , Sheep	Physiological	Tenderness, color, juiciness, flavor,	Destructive	Laboratory assessments with sensory evaluations	Colorimeter, Texture analyzer,	-	pH Meter, Hedonic Scales, Drying Apparatus	Raw meat sample	200	Customized	Laboratory
Dwi Agustina Kurniawati, 2024 [13]	Halal supply chain optimization	Automated spoilage detection model	Chicken, Beef, Pork	physiological	Freshness, Tenderness, pH, Color	Non-destructive	Deep learning AI, CNN	Convolutional Neural Networks	Imaging Devices	Sensors, Cameras	Image Dataset	5,000+ Images	Halal food logistics	Laboratory
Viorica Bulgaru, 2022 [14]	Food science	Evaluating the aging process	Beef (dry-aged)	Physiological	Tenderness, juiciness, flavor, color, moisture content	Destructive	Physicochemical tests (moisture, fat conten), sensory tests	Moisture content, texture analysis	Texture Analyzer, Colorimeter, pH meter	Incubators for aging room	Structured dataset	Multiple samples at stages (e.g., 3, 7, 14, 28 days)	Customized	Laboratory

Kudzai N. Ngongoni, 2025 [15]	Food Processing	Acacia mearnsii bark extracts	Beef patties	Reactive oxygen species	Oxidative deterioration, shelf-life	Destructive	Literature review, case studies	DPPH, TBARS assays	Analytical tools	Quantitative data	images	20 instances	Lab extracted	Laboratory
Zhe Shao, 2024 [16]	Food science	Application of CFIs to detect freshness and spoilage	Aquatic products	Spoilage bacteria	Freshness, spoilage indicators	Non destructive	Machine learning	Colorimetric freshness indicator (CFI) deployment	Green extraction tools	Experimental samples	Experimental data	100+ samples	Samples sourced from storage experiments	laboratory
Yuandaong,2024 [17]	Food industry	Real-time quality monitoring	Chilled beef	Physiological	Fresh , slightly spoiled	Non - destructive	Deep Learning, Machine Learning	CSA, camera , scanner, Colorimetric sensor array, camera, scanner	CNN, t-SNE, HCA, PCA	Camera, sensors	Images	400+	Online	Real time
BirkanBuyukarikan,2024	Food Safety , healthcare	To classify beef quality , reduce waste and	Fresh half, Fresh spoiled	Physiological	Color, texture, PH level , Marbling ,	Non destructive	Deep learning, frameworks	DNN (Deep Neural Network, CNN,	Digital cameras	Google Cloud Platform	Images	2266 RGB images of beef	Experiments available in lab	Real time

[18]		improve food safety			Fat color, odur			LSTM, Bi-LSTM (Bidirectional LSTM)		Digital cameras				
Gongshuai, 2024 [19]	Food science, analytical technology	Rapid Evaporative Ionization Mass Spectrometry (REIMS), Support Vector Machines (SVM) , Gradient Boosting Machines (GBM)	Beef	Physiological, morphological	pH, Moisture Content, Texture , color, Cut Type ,chemical composition	Non destructive	Machine learning , Data Science , Mass Spectrometry (MS) , Cloud Computing	Imaging, Machine Vision	REIMS Device (Rapid Evaporative Ionization Mass Spectrometry)	Mass Spectrometer, Digital cameras , Mobile or Handheld Devices (for portable testing	Images	100	Develop a system that accurately identifies and distinguishes b/w correctly and incorrectly labeled beef cuts	Real time
N. Berdusco,2024 [20]	Food science	Integrating AR for sensory evaluation, safety inspections, traceability	Food items	Sensor, physiological	Sensory quality, freshness, safety	Systematic literature review , industry data collection	Systematic review and analysis of AR technology in food	food quality analysis	AR devices, sensors, mobile AR applications	AR sensors, 3D cameras	Literature review, Review Articles	50+	Public academic databases , industry reports	laboratory

In above analysis, 20% are destructive which need 100% laboratory environment and 80% are non-destructive. Quality factors of physiological are 90%, morphological are 87% and sensory are 45%.

Table 2: Review of software based solution for estimating the quality assurance of meat items.

Tool	**Cost**	**Features**	**Device**
Raman Spectroscope [1]	Paid	Chemical Composition, Moisture Content, Foreign Object Detection:	Hyperspectral Imaging (HSI) Systems, X-ray Imaging Systems
Strenuous [2]	Paid	Color, marbling ,pH level, Collagen Content, Oxidative State of Myoglobin	CMOS Camera
Hyperspectral Imaging (HSI), Magnetic Resonance Imaging (MRI), Raman Spectroscopy [3]	Paid	Color, tenderness, texture, pH levels ,fat content, Biogenic Amine Content, Oxidation (Lipid and Protein) protein	Hyperspectral Imaging (HSI), Spectral Data Acquisition

Raman Spectroscopy [4]	Paid	Appearance, size, tenderness color, marbling pH levels, water-holding capacity, oxidation	Camera, 3D Hyper spectral Image
Sensor RGB [5]	Unpaid	Spoilage-related gases, **C**olor changes	e-nose based on semiconductor metal oxide gas sensors, RGB, computer vision
Chemical Composition Analysis, Physicochemical Properties Analysis, Texture Analysis [6]	Unpaid	Protein fat content, Collagen, salt content, pH, Tenderness, Springiness, Gumminess, hardness	Near-Infrared Spectroscopy (NIR)
PCR instruments, DNA extraction, amplification tools [7]	Unpaid	High nutritional value, low fat, high protein, low heavy metals	PCR assay for species-specific identification
Microbial Supplements, Lipidomics and Proteomics, Molecular Biology, Statistical and Computational [8]	Paid	Intramuscular Fat Content, Muscle Fiber Type, Flavor Compounds, Amino Acid Profiles:	Camera
Colorimetric technique [9]	Paid	pH, color freshness, spoilage, color, odour	Colorimetric freshness indicators (CFIs)

Bionic Technology, Spectral Technology, Electromagnetic Characteristic Technology, [10]	Unpaid	Convenience and Speed, Low Cost,	Spectrometers, Electronic Nose (E-nose), Electronic Tongue (E-tongue)
Imaging Technology, Artificial Intelligence (AI) Technology [11]	Paid	Automated Processing, Rapid and Accurate Detection	Sensors, Processors
Consumer and Trained Sensory Panels, Laboratory-Based Methods [12]	Paid	Predefined Sensorial Properties, Threshold Definition	Texture Analyzers, Scoring Instruments for Sensory Panels
Big Data Analytics, Mixed Integer Linear Programming (MILP) Model [13]	Unpaid	Halal Integrity and Cross-Contamination Prevention, Operational Cost Considerations, Shelf Life and Delivery Window	IOT Devices, AI-Based Decision Tools, Cloud Computing Platforms
Wet and Dry Aging Techniques, Calpain and Cathepsin Enzymes, Controlled	Unpaid	Tenderness, Juiciness and Aroma, Chemical Composition Analysis, Enzymatic Activity, Sensory and Texture Indices	Refrigerated Aging Rooms, Physicochemical Testing Equipment

Environment Parameters [14]			
Spectrophotometry or Chromatography (e.g., HPLC or GC), [15]	Paid	Oxidative deterioration, shelf-life	Drying Device, Grinding Device
Colorimetric Freshness Indicators (CFIs) , Natural Polymer Matrix in CFIs, pH-Sensitive Pigments [16]	Unpaid	Real-Time Freshness Feedback, Natural vs. Synthetic Pigments, Color Change Mechanism	Modern Green Extraction Equipment
Computational Analysis Tools [17]	Paid	Color, tenderness, texture, pH levels ,fat content, Biogenic Amine Content, Oxidation protein	Colorimetric Sensor Array (CSA),Back-Propagation Neural Network (BPNN**),** Computational Analysis Tools

3. PROBLEM STATEMENT

The traditional destructive method of assuring the quality of meat items are time consuming, less accessible and need expensive equipment resource (i.e. human, machine etc.) which is very difficult for common consumers to afford, to overcome the above gaps, proposed project will provide an efficient, portable and effective application using deep learning and computer vision techniques for non-destructive meat items for consumers where they can assure the quality of meat items.

4. PROJECT OBJECTIVES

The project objectives are as follow

- An empirical investigation will be conducted to identify the tools, techniques and methodologies used in the study domain.
- A customized dataset will be created from multiple online repositories and real time scenarios.
- An efficient application will be deliver which assure the quality of raw meat items to consumers.
- The proposed application will not only facilitate the consumers but also help the food authorities to measure raw meat quality anywhere anytime.

5. PROJECT SCOPE

It will be a client-server based mobile application. The tentative modules of the proposed solution are

- **Mobile App Manager:** The mobile app manager will serve as an interface for the consumer where they capture the meat item(s) images from the mobile camera. The

acquired images are subsequently stored on the server for further processing. This module will also provide consumers with AR-based report, which will allow them to readily determine the quality of meat items.

- **Image Processing:** The image processing module will analyse visual data captured on the user's mobile device. It will acquire the saved images from the server and then refined those images using computer vision technique. It will then save the finalized images to the server for further processing.
- **Raw Meat Item Type Classification:** This module will extract the saved images and classify the various types of meat items (poultry, livestock and sea food) using deep learning technique. At the end, this module save the classified images into the server.
- **Raw Meat Quality Classification:** This module will classify the quality factors of raw meat items using deep learning technique and after meat quality classification, it will send classified images to the meat quality assurance estimation module to estimate the meat quality level.
- **Raw Meat Quality Assurance Estimation:** Raw Meat Quality Assurance Estimation module will assure the meat quality factors along with their metrics level(s) using AI based technique (i.e. fuzzy logic) and save the results to the server.
- **AR Based Report Generation:** This module will generate a report to the user where he/she can get the quality of meat items in AR based view.

6. METHOD | PROCESS

The proposal project is based on both Qualitative and Quantitative Research techniques. The proposed project is decomposed on following phases: Literature Review, Finalization

of Raw Meat Items, Quality Factors, Metrics and Estimation Level, SDLC, Testing and Validation.

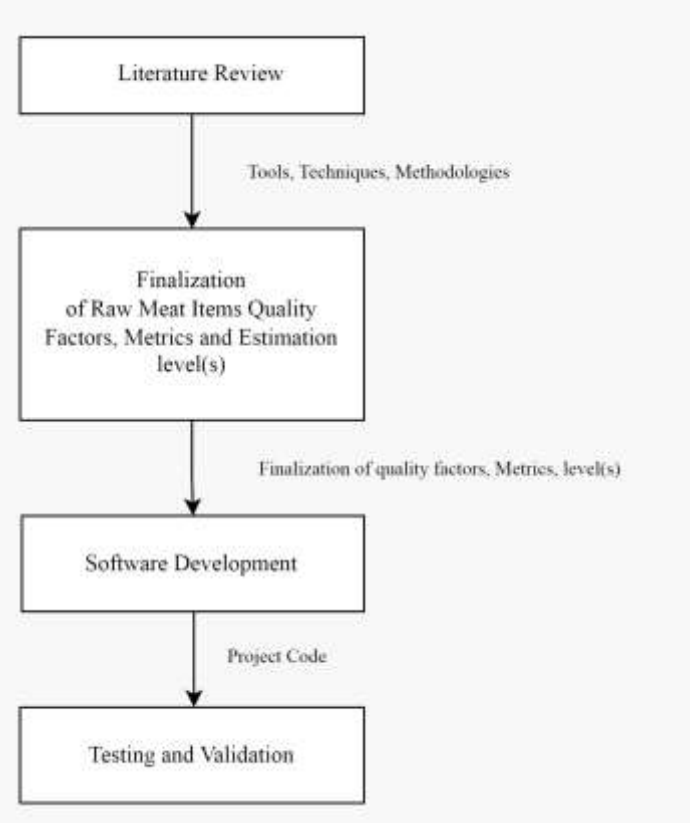

Figure 3: Proposed Project Methodology

In the first phase literature review have been conducted from various online repositories (e.g. IEEE, Science direct, MDPI, ACM, Springer etc.) the review data is further input to the next phase named as Finalization of Raw Meat Items Quality Factors, Metrics and Estimation level. In this phase the raw meat items quality factors, metrics and estimation level will be finalized. The parameters are input to the next phase called SDLC. In this phase the software has been worked on the parameters which are input by the previous phase. The last and final phase for this methodology is Testing and Validation. In this phase the testing of model have been conducted and their respective results have been matched which verify the accuracy of model.

7. PROPOSED SOLUTION

In the proposed project a real time non-destructive AR based mobile application will be created for assuring the quality of raw meat items using computer vision and deep learning techniques.

8. IMPLEMENTATION TECHNOLOGIES

For the successful completion of the project following tentative technologies will be used

- Python
- Android
- Computer vision (CV)
- Augmented Reality (AR)
- Artificial Intelligence (AI)
- SQL server

9. PROJECT PLAN

The proposed project plan and their corresponding deliverables are presented in Table 3.

Table 3: Project plan, its phases and deliverables

Share

TASK	START DATE	END DATE	DURATION (DAYS)	ASSIGNED TO
Project Planning & Research	02/09/2024	11/09/2024	10	Ayesha Munawar, Ghania Shahzad, Raeesa Asif, Shifa Zahra
Discussion with Supervisor	12/09/2024	12/09/2024	1	All Members
Project Planning & Research	13/09/2024	29/09/2024	17	Ayesha Munawar, Ghania Shahzad,

				Raeesa Asif, Shifa Zahra
Discussion with Supervisor	30/09/2024	30/09/2024	1	All Members
Literature Review	01/10/2024	10/10/2024	10	All Members
Proposal Documentation (Abstract, Inroduction, Conclusion)	11/10/2024	16/10/2024	6	Ghania Shahzad
Proposal Documentation (Project Scope, Project plan, Problem Statement)	11/10/2024	16/10/2024	6	Ayesha Munawar
Proposal Documentation (Method, Technologies, Conclusion)	11/10/2024	16/10/2024	6	Shifa Zahra
Proposal Documentation (Objectives, Proposed Solution, References)	11/10/2024	16/10/2024	6	Raeesa Asif
Proposal Submission	17/10/2024	17/10/2024	1	All Members
Presentation Preparation	18/10/2024	26/10/2024	9	Ayesha Munawar, Ghania Shahzad, Raeesa Asif, Shifa Zahra
Requirement Gathering	27/10/2024	3/11/2024	8	Ayesha Munawar
Requirement Gathering	4/11/2024	11/11/2024	8	Ghania Shahzad
Requirement Gathering	12/11/2024	19/11/2024	8	Shifa Zahra
Requirement Gathering	20/11/2024	27/11/2024	8	Raeesa Asif
Discussion with Supervisor	28/11/2024	28/11/2024	1	All Members
Proposal Presentation	29/11/2024	29/11/2024	1	All Members
Proposal Re-submission	30/11/2024	17/12/2024	18	All Members
Technology Stack Selection	18/12/2024	20/12/2024	3	Ayesha Munawar, Ghania Shahzad
UI/UX Design (Prototyping)	21/12/2024	23/12/2024	3	Raeesa Asif
Database Design	24/12/2024	26/12/2024	3	Shifa Zahra
Final Term Exam Break	27/12/2024	07/01/2025	12	All Members

Backend Development Phase 1	08/01/2025	17/01/2025	10	Raeesa Asif, Shifa Zahra
Frontend Development Phase 1	18/01/2025	28/01/2025	10	Ayesha Munawar, Ghania Shahzad
Discussion with Supervisor	29/01/2025	29/01/2025	1	All Members
Backend Development Phase 2	30/01/2025	8/02/2025	10	Shifa Zahra, Raeesa Asif
Frontend Development Phase 2	09/02/2025	18/02/2025	10	Ayesha Munawar, Ghania Shahzad
Integration of Frontend & Backend	19/02/2025	26/02/2025	8	All Members
Discussion with Supervisor	27/02/2025	27/02/2025	1	All Members
Testing & Debugging Phase 1	28/02/2025	08/03/2025	9	Ayesha Munawar, Ghania Shahzad
Testing & Debugging Phase 2	09/03/2025	17/03/2025	09	Shifa Zahra, Raeesa Asif
Discussion with Supervisor	18/03/2025	18/03/2025	1	All Members
User Feedback & Final Improvements	19/03/2025	07/04/2025	20	Al Members
Final Documentation	08/04/2025	15/04/2025	8	Ayesha Munawar, Ghania Shahzad, Shifa Zahra, Raeesa Asif
Discussion with Supervisor	16/04/2025	16/04/2025	1	All Members
Final Presentation Preparation	17/04/2025	22/04/2025	06	All Members

Gantt chart

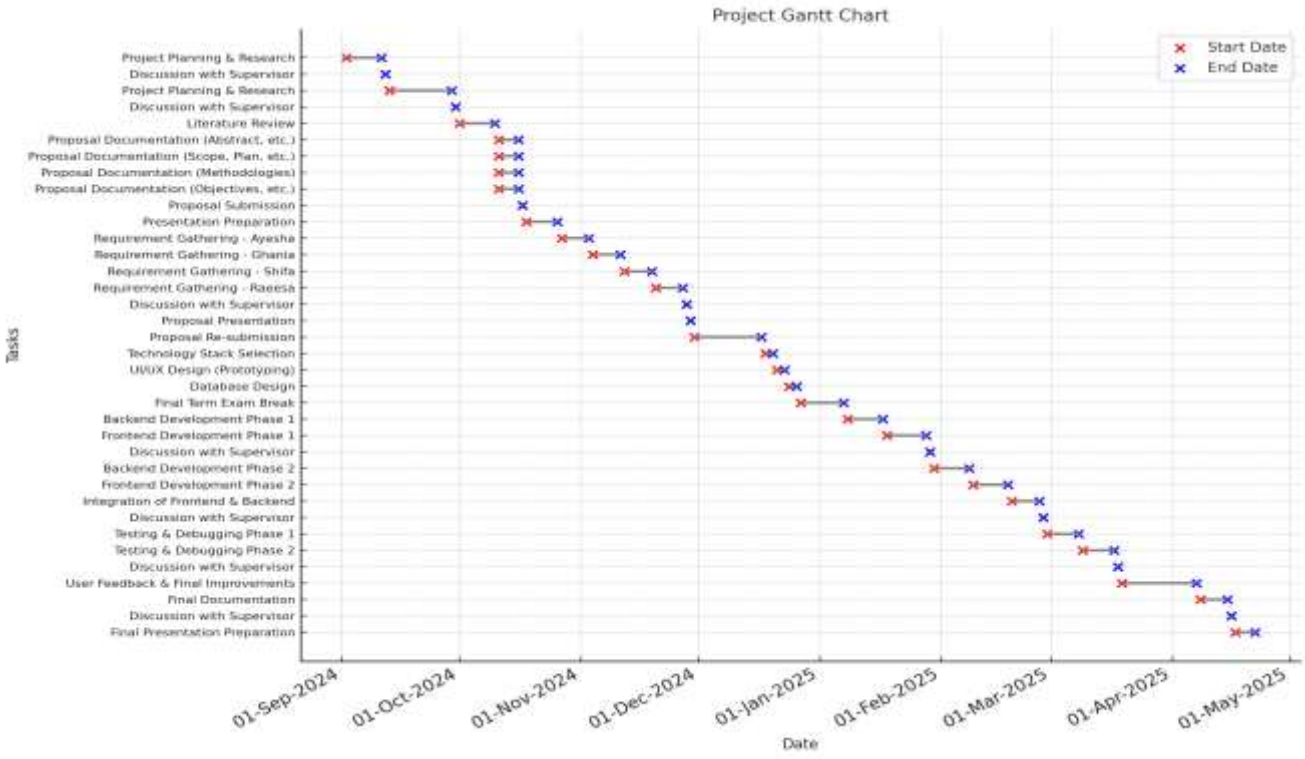

Figure 4: *Gantt chart of Project plan*

10.CONCLUSION

Meat quality is tightly related to human life and it is the most critical aspect for consumers to consider when purchasing such items. In the destructive technique, meat quality was assessed in a laboratory based environment utilizing chemical components, which need high human resources and equipment. Traditionally, non-destructive approaches have been used to estimate the physiological and morphological features of raw meat items which is also time consuming. This real-time application provide a more accurate, efficient, and cost-effective solution compared to traditional methods. It not only enhances quality assurance but also makes the system easily accessible for local vendors, ensuring consumers have access to fresher and high quality meat products.

11. REFERENCES

[1] Xiaohong Wu 1, Non-Destructive Techniques for the Analysis and Evaluation of Meat Quality and Safety, 2022.

[2] Eric Zhou 1, Developing a Prototype Device for Assessing Meat Quality Using Autofluorescence Imaging and Machine Learning Techniques, 2024.

[3] b. Philip Donald C. Sanchez a, Emerging nondestructive techniques for the quality and safety evaluation of pork and beef: Recent advances, challenges, and future perspectives, 2022.

[4] K. J. a, "Hyperspectral imaging–based assessment of fresh meat quality: Progress and applications," *Microchemical Journal,* vol. 197, 2024.

[5] V. Z. a, "Monitoring of meat quality and change-point detection by a sensor array and profiling of bacterial communities," vol. 1320, 2024.

[6] M. Wegner, "Basic chemical composition, physicochemical, and textural characteristics of male and female guinea fowl meat," *Poultry Science,* vol. 103, 2024.

[7] B. M. Adenuga, "Unravelling red deer (Cervus elaphus) meat adulteration in gourmet foods by quantitative real-time PCR," *Food control,* 2025.

[8] S. D. Smet, "Meat products in human nutrition and health – About hazards and risks," *Meat Science,* vol. 218, 2024.

[9] Z. Shao, "Colorimetric freshness indicators in aquatic products based on natural pigments: A review," *Food Bioscience,* 2024.

[10] L. Zhang, "Intelligent detection of quality deterioration and adulteration of fresh meat products in the supply chain: research progress and application," *Foodbioscience,* 2023.

[11] P. Elangovan, "A Novel Approach for Meat Quality Assessment Using an Ensemble of Compact Convolutional Neural Networks," 2024.

[12] B. W. Holman, "The use of conventional laboratory-based methods to predict consumer acceptance of beef and sheep meat: A review," *Meat Science,* 2021.

[13] D. A. Kurniawati, "Toward halal supply chain 4.0: MILP model for halal food distribution," *Procedia Computer Science,* vol. 223, 2024.

[14] V. Bulgaru, "Assessment of Quality Indices and Their Influence on the Texture Profile in the Dry-Aging Process of Beef," 2022.

[15] K. N. Ngongoni, "Keeping quality of raw ground beef patties fortified with polyphenols extracted from Acacia mearnsii bark and leaves," *Meat Science*, vol. 219, 2025.

[16] Z. Shao, "Colorimetric freshness indicators in aquatic products based on natural pigments:," *Food bioscience*, vol. 58, 2024.

[17] J. S. M. Ivana M. Mileusnić, Computer Assisted Rapid Nondestructive Method for Evaluation of, 2022.

[18] J. T. L. b. a, "Augmented reality for food quality assessment: Bridging the physical and digital worlds," *Journal of Food Engineering*, 2024.

[19] P. Elangovan, "A Novel Approach for Meat Quality Assessment Using an Ensemble of Compact Convolutional Neural Networks," 2024.

[20] M. Hou, "Innovations in seafood freshness quality: Non-destructive detection of freshness in Litopenaeus vannamei using the YOLO-shrimp model," 2025.

[21] G. Weng, "Effects of dietary Brevibacillus laterosporus BL1 supplementation on meat quality, antioxidant capacity, and the profiles of muscle amino acids and fatty acids in finishing pigs," 2025.

[22] K. N. Ngongon, "Keeping quality of raw ground beef patties fortified with polyphenols extracted from Acacia mearnsii bark and leaves," 2025.