ENHANCING QUALITY ASSURANCE SYSTEMS IN FEED AND FLOUR PRODUCTION: A CASE STUDY OF A FEED AND FLOUR MILL IN NIGERIA.

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A PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.Eng) DEGREE.

IN THE DEPARTMENT OF PRODUCTION ENGINEERING,

THE FACULTY OF ENGINEERING,

THE UNIVERSITY OF BENIN.

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MARCH, 2026.

CERTIFICATION

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DEDICATION

This project is dedicated to my family who have had my back right from the first academic step I ever took in my life. Your unwavering support and commitment to my success has been my pillar and comfort especially in hard times. I am eternally grateful for that.

ACKNOWLEDGEMENT

My gratitude goes to God Almighty for His protection, provision and divine guidance throughout my stay in the University of Benin. He alone has brought me this far. I would like to thank my project supervisor, Engr. Prof. R. O. Edokpia, for his expert advice, understanding and unwavering support throughout the duration of my project; his invaluable insights, constructive feedback and encouragement have been instrumental to the success of this project. I would also like to extend my gratitude to the Head of Production Engineering Department, University of Benin, Engr. Prof. P. E. Amiolemhen. My gratitude also goes to my course advisor Engr. R. O. Idada for his guidance and commitment to my success from the beginning of my journey here in this prestigious university. I would also like to acknowledge the lecturers who have taught me all I know both pertaining to academics and how to navigate life in general, Prof. J. A. Akpobi, Dr. Francis, Prof. Raphael, Dr. Ihenyen, Dr. Afoke, Dr. Etuk, Dr. Ashama, Engr. Aigbangbe. Your commitment to my academic excellence is deeply appreciated.

To the family UNIBEN gave me, Ogboh Sochukwu Obinwanne, Osoba Scholastica Oseobulu , Olomukoro Destiny Omorodion, Ovwurhughen Oghenemudiakevwe Anthonio, Omoregie Ernest Osakpolor, Mokolade Melchizedek Amobiojo, thank you for your love and friendship. I’m glad our paths crossed. See you guys at the top.

To myself, I say congratulations. You did it! God did!

ABSTRACT

This project explores the quality assurance (QA) practices in Prime Feed and Flour Mill Limited, aiming to improve product safety, ensure regulatory compliance, and enhance customer satisfaction. With the increasing demand for high-quality food and animal feed, alongside the public health threats posed by contaminated or inferior products, it is crucial to maintain consistent quality throughout production processes. The research investigates the existing QA frameworks utilized by the quality control sector, assesses their conformity with national regulatory standards established by NAFDAC and SON, and identifies prevalent challenges in their implementation. Data was gathered through document analyses from the laboratory results and log book.

The results recognize that various factors affect quality standards, including insufficient staff training, inadequate documentation, limited QA infrastructure, and weak enforcement mechanisms. The study emphasizes key quality indicators such as moisture content, aflatoxin levels, microbial load, and packaging integrity as vital control points.

Recommendations include regular QA training for personnel, strengthening internal audits, improving record-keeping systems, and adopting technology for process monitoring. The study concludes that a more structured and proactive quality assurance system is necessary to meet both regulatory and consumer expectations in the feed and flour production sector in Nigeria.

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ACRONYMS

CL- Control Limit

FAO- Food and Agriculture Organization

FDA- Food and Drug Administration

FSMA- Food Safety Modernization Act

GMP- Good Manufacturing Practices

HACCP- Hazard Analysis and Critical Control points

ISO- International Standards Organization

LCL- Lower Control Limit

NAFDAC- National Food and Drug Administration and Control

NIS- Nigeria Industrial Standards

QA- Quality Assurance

QC- Quality Control

SON- Standard Organization of Nigeria

SOPs- Standard Operating Procedures

SPC-Statistical Process Control

TQM- Total Quality Management

UCL-Upper Control Limit

WHO- World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The feed and flour production sectors are essential elements of the food supply chain, significantly affecting public health, animal productivity, and national food security. Flour is a fundamental food source for millions worldwide, while feed is crucial for livestock and poultry farming, which contributes to the production of meat, eggs, and dairy products. The feed and flour production industry serves as a fundamental component of both human and animal food systems. In numerous developing and developed nations, the demand for high-quality flour and feed is on the rise, driven by factors such as population growth, urbanization, and evolving dietary preferences. As consumption escalates, manufacturers bear an increasing responsibility to guarantee product safety, consistency, and quality throughout every phase of the production process. Despite the surging demand, the feed and flour industries continue to grapple with various quality-related challenges.

Common issues include microbial contamination (for instance, Salmonella in animal feed and flour products), the occurrence of mycotoxins resulting from inadequate grain storage, incorrect mixing ratios, foreign object contamination, and nutrient degradation. These challenges not only compromise the quality of the end product but can also lead to serious health consequences, including foodborne illnesses in both humans and animals, diminished livestock performance, and, in severe cases, mortality. Given their extensive influence, it is of utmost importance to maintain high quality standards in these industries.

However, achieving consistent product quality in feed and flour production presents numerous challenges, including contamination from foreign substances, pathogens or chemical residues, microbial growth due to inadequate storage, incorrect ingredient formulation, variability in product quality, failure to meet local or international food safety regulations, and insufficient traceability systems. Such problems can lead to severe repercussions, including product recalls, diminished consumer confidence, regulatory penalties, and risks to both animal and human health. These problems not only jeopardize the safety and nutritional integrity of the products but can also result in regulatory fines, damage to market reputation, and, in severe cases, public health emergencies. Upholding quality and safety standards in these industries is not only economically vital but also essential for public health. Despite technological advancements in production, numerous feed and flour manufacturing facilities, particularly those that are small to medium-sized, continue to face quality-related challenges. Quality Assurance (QA) systems are established to oversee and regulate production processes to avert such issues. An effective QA system covers all phases of production—from the sourcing of the raw materials to the handling of raw materials, through the various processing procedures and packaging, to final distribution. It entails the establishment of quality benchmarks, the execution of inspection and testing protocols, and the maintenance of comprehensive documentation. Nevertheless, in numerous feed and flour production facilities, particularly within small and medium-sized enterprises, QA practices frequently remain outdated, reactive rather than proactive, and inadequately integrated into everyday operations.

These systems involve a comprehensive array of activities, including the implementation of Standardized Operating Procedures (SOPs), the implementation of Quality Control (QC) tools (Pareto, Fishbone), Continuous Improvement (Kaizen) Approach, Statistical Process Control (SPC), International Standards Organization (ISO) standards, employee training, monitoring and verification processes, thorough documentation, and corrective measures. Effective QA also necessitates compliance with regulatory standards such as HACCP (Hazard Analysis and Critical Control Points), ISO9001, or GMP (Good Manufacturing

Practices). Nevertheless, in numerous regions, especially in developing countries, QA systems are either inadequately implemented or completely absent. Factors such as insufficient infrastructure, a shortage of skilled personnel, lack of investment in quality systems, and weak regulatory enforcement impede advancement. Furthermore, technological deficiencies, including the lack of automated quality monitoring tools, enhance these challenges.

In numerous production environments, quality control measures are often applied solely at the final stage of production, limiting the potential for corrective actions. This reactive strategy has been shown to be insufficient in averting quality failures. Contemporary quality assurance frameworks advocate for a proactive, process-oriented approach, wherein quality is integrated into each phase of the production cycle. This entails preventive controls, ongoing monitoring, risk assessment, and corrective measures informed by real-time data. Global regulatory entities and food safety organizations, such as the Food and Agriculture Organization (FAO), World Health Organization (WHO), and various national agencies, have established rigorous standards to direct quality assurance in the production of feed and flour. Adherence to frameworks like the Hazard Analysis and Critical Control Points (HACCP), Good Manufacturing Practices (GMP), ISO9001 (Food Safety Management), and the Food Safety Modernization Act (FSMA) has become an essential requirement for manufacturers.

A robust Quality Management System provides the mechanism to ensure that all the standard criteria are met and provides a system to constantly monitor laboratory results and identify opportunities for improvement. A Quality Management System provides management, staff and customers with confidence that all technical, administrative and human factors that influence the quality of the results being generated are under continuous supervision with the aim to prevent non conformity and identify opportunities for improvement. This research is driven by the necessity to enhance the quality, safety, and competitiveness of feed and flour products via improved quality assurance systems. Through the analysis of current QA practices in Prime Feed and Flour Mill, Limited, the identification of significant deficiencies, and the investigation of contemporary enhancement strategies—such as employee training, process optimization, and digital integration, this study seeks to provide practical recommendations for production facilities. The ultimate goal is to facilitate superior quality results and ensure adherence to regulatory standards.

1.2 Statement of the Problem

The production of feed and flour plays a vital role in the food and agriculture industries; however, numerous manufacturing facilities encounter substantial challenges related to quality. These challenges encompass issues such as product contamination, variability in output, insufficient traceability, and frequent violations of both local and international food safety regulations and standards. Often, these problems arise from inadequately designed or outdated quality assurance systems. In the absence of effective QA protocols, production processes are susceptible to inefficiencies, health hazards, and damage to reputation. Consequently, it is imperative to evaluate and improve current quality assurance frameworks to guarantee product safety, enhance operational efficiency, and comply with regulatory requirements in the feed and flour production sector.

1.3. Aim and Objectives

1.3.1. Aim of the Study

The aim of this study is to analyze the current quality assurance practices in Prime Feed and Flour Mill Limited, Ewu, compare against the standards (nationally and internationally), identify gaps and recommend improvement strategies to enhance quality assurance systems in this chosen case study.

1.3.2 Objective of the Study

This project will pursue the following objectives:

Examining staff and quality control worker's training on good manufacturing practices, HACCP, and other standard QA practices.

Analyze the role of documentation and traceability in ensuring effective quality management.

1.4. Significance of the Study

For manufacturers, it offers practical insights into improving quality control measures, reducing waste, and avoiding regulatory penalties.

For regulatory bodies, the research provides evidence to support the development or strengthening of food safety policies

For the consumers also stand to benefit from safer, higher-quality products that meet nutritional and safety standards.

The findings can serve as a reference for future academic research and provide a basis for policy formulation and industrial training programs.

1.5. Scope of the Study

This analysis is centered on the assessment and advancement of quality assurance frameworks within the Prime Feed and Flour Mill Limited.

The study will scrutinize specific the companies' production sites, reviewing its current QA practices, identifying issues, and recommending enhancements to improve the overall production.

It will address critical components such as raw material assessment, process supervision, documentation, employee training, and compliance with global standards like HACCP, ISO9001, and GMP and the use of log book for documentation and traceability.

This research will cover a data period of three (3) months of laboratory testing results.

1.6. Limitation of the Study

This research encounters challenges related to obtaining proprietary data or internal quality audit documents from private enterprises.

The company may operate under different internal standards due to its size, or target market, making uniform comparisons difficult.

CHAPTER TWO

LITERATURE REVIEW

2.1. Theoretical Framework

This study is based on essential theories and models that support the advancement of quality assurance systems in production sectors, particularly in feed and flour processing. These frameworks direct the methodical assessment and enhancement of quality processes to guarantee that the end products comply with the necessary safety and quality benchmarks.

2.1.1. Total Quality Management (TQM)

This is a management philosophy that emphasizes continuous improvement, customer satisfaction, and the engagement of all employees in quality-related activities. TQM promotes a company-wide dedication to quality, which is especially significant in the production of feed and flour, where risks associated with contamination and inconsistency can have dire consequences. The adoption of TQM principles encourages the establishment of effective quality policies, comprehensive employee training, process oversight, and routine evaluation of systems to achieve long-term enhancements in product quality.

Implementing TQM can lead to:

i. Improved Quality: Reduce errors, defects, and waste in all production operations, ranging from the quality of the raw materials to manufacturing methods, bagging and packaging operations and to distribution and marketing of the finished products.

ii. Increase Customer Satisfaction: Meet and exceed the customer expectations in terms of product quality and usability.

iii. Enhance Efficiency: Optimize processes and resource utilization.

iv. Promote a Culture of Quality: Make quality a core value and priority for everyone in the organization. This includes the employee quality and technical know-how, raw materials used to make the finished goods, manufacturing processes and everything that affects the product quality.

2.1.2. Hazard Analysis and Critical Control Points (HACCP)

The HACCP system represents a proactive, risk-oriented methodology for ensuring food safety, which systematically identifies, assesses, and mitigates biological, chemical, and physical hazards during the production process. Essentially HACCP helps ensure food is safe from farm to the table by focusing on prevention rather than relying solely on end-product testing. This approach is extensively implemented within the food and feed sectors to avert contamination and guarantee product safety. The significance of HACCP in this research lies in the provision of a systematic framework for pinpointing critical control points, where risks to quality and safety can be effectively managed. The system is based on scientific pr4inciples and is designed to be verifiable and documented.

The seven (7) key principles of HACCP include the following:

i. Conduct a Hazard Analysis: Detect potential risks.

ii. Determine Critical Control Points (CCPs): Identify points where hazards can be controlled effectively.

iii. Establish Critical Limits: Set specific measureable criteria for each CCPs.

iv. Establish Corrective actions: Describe the steps to follow if critical limits are not satisfied.

v. Establish Verification Procedures: Validate the HACCP plan is functioning as intended.

vi. Establish Record-keeping and Documentation Procedures: Maintain detailed records of all HACCP activities.

Implementing HACCP can lead to:

i. Enhanced Food Safety: HACCP helps prevent foodborne illnesses.
ii. Improved Product Quality: By controlling hazards, HACCP can impr4ove overall product quality.
iii. Reduced Waste and Cost: By preventing problems, HACCP can minimize waste and associated costs.
iv. Increased Consumer Confidence: Consumers are more likely to trust products from businesses that use HACCP.
v. Meeting Regulatory Requirements: Many food safety regulations require the implementation of HACCP.

2.1.3. Continuous Improvement (Kaizen) Approach:

The Kaizen methodology focuses on gradual and continuous enhancements in processes, products, and overall workplace efficiency. In the realms of feed and flour production, this philosophy can significantly contribute to the refinement of quality assurance protocols, the enhancement of employee engagement, and the reduction of waste and defects. By implementing strategies for continuous improvement, production facilities can cultivate more robust and flexible quality assurance systems. This method is useful for nurturing a culture of continuous improvement and achieving sustainable positive change within an organization.

The core principles of this approach includes the following:

i. Continuous Improvement: The Kaizen method is not merely a one-time solution; rather, it represents a continuous journey of implementing small, beneficial modifications to processes, products, or services.
ii. Incremental Changes: Rather than pursuing large, disruptive transformations, Kaizen prioritizes the execution of small, manageable modifications that are simpler to implement and maintain.
iii. Employee Involvement: The Kaizen approach promotes the active participation of all employees, irrespective of their roles, in recognizing opportunities for enhancement and proposing solutions.
iv. Teamwork: The Kaizen method emphasizes the importance of collaboration and teamwork in effectively addressing challenges and executing changes.
v. Waste Reduction: The objective of Kaizen is to pinpoint and eradicate waste in all its forms, encompassing time, materials, and resources.
vi. Standardization: Kaizen frequently entails the standardization of processes to guarantee consistency and facilitate the identification of areas needing improvement.

The benefits of this method includes the following:

i. Increased Efficiency: By removing inefficiencies and optimizing workflows, Kaizen can result in notable enhancements in productivity and operational efficiency.
ii. Improved Quality: Ongoing improvement initiatives can yield superior quality in products and services.
iii. Reduced Costs: By minimizing waste and enhancing efficiency, Kaizen can contribute to cost reductions.

iv. Enhanced Employee Morale: Engaging and empowering employees can elevate morale and enhance job satisfaction.
v. Greater Customer Satisfaction: By enhancing quality and efficiency, Kaizen can foster higher levels of customer satisfaction.

2.1.4 Statistical Process Control

Statistical Process Control (SPC) represents a systematic approach that utilizes statistical methods to monitor, manage, and refine processes. The primary goal is to diminish variation in a process, which ensures uniform quality and operational efficiency. SPC depends on the gathering and examination of data to recognize discrepancies from the expected process behavior and to apply corrective actions.

The following should be noted when using SPC:

i. Variation: SPC recognizes that every process exhibits some level of variation. The objective is to comprehend and regulate this variation.
ii. Control Charts: These are graphical representations utilized to observe process data over time and to identify when a process is not within control limits.
iii. Control Limits: These are statistically defined boundaries on a control chart. Data points that fall outside these boundaries indicate a possible issue that requires investigation.
iv. Special Cause Variation: This refers to rare or unexpected variations in a process that demand investigation and correction.
v. Common Cause Variation: This refers to the inherent variation in a process that is perpetually present and cannot be removed.

The principles of SPC include:

i. Data Acquisition: Obtain relevant data from the ongoing process under observation.
ii. Control Chart Construction: Represent the data on a control chart, which consists of a median line and specified control limits.
iii. Evaluation and Interpretation: Scrutinize the data points on the chart to uncover any atypical patterns or points that exceed the control limits.
iv. Corrective Measures: If a concern is recognized, execute necessary actions to resolve the fundamental issue and return the process to a state of control.

The benefits of the Statistical Process Control (SPC) includes:

i. Enhanced Quality: SPC aids in diminishing defects and elevating the overall quality of products or services.
ii. Boosted Efficiency: By pinpointing and addressing process challenges, SPC can foster increased efficiency and productivity.
iii. Cost Reduction: A reduction in defects and waste can yield substantial cost savings.
iv. Improved Process Comprehension: SPC delivers critical insights into the dynamics of processes, enabling enhanced management and control.

2.2. Conceptual Framework

This conceptual review offers precise definitions and elucidations of essential terms, concepts, and processes pertinent to quality assurance in the production of feed and flour. Grasping these concepts is crucial for laying the groundwork of this study and for understanding the elements that lead to effective quality management within the industry.

2.2.1 Quality Assurance (QA)

In the production of feed and flour, quality assurance (QA) encompasses the systematic processes and activities aimed at ensuring that the final products adhere to defined quality standards and fulfill customer expectations. This involves the proactive prevention of defects through the establishment of procedures and continuous monitoring throughout the production cycle, starting from the sourcing of raw materials to the delivery of the finished product. QA includes organized processes and procedures that are implemented to ensure that products consistently meet specified quality standards. In the context of feed and flour production, QA encompasses the entire production cycle—from sourcing raw materials to packaging the final product—ensuring that every stage adheres to safety, regulatory, and customer requirements. The focus of quality assurance is on preventing defects rather than merely detecting them.

2.2.2 Quality Control

Within the context of feed and flour production, quality control includes physical, chemical, and microbiological evaluations of raw materials, in-process products, and finished goods to confirm that they adhere to established specifications. Quality Control is an integral part of quality assurance that emphasizes the testing and inspection of products and processes to identify and amend defects. In contrast to the proactive nature of quality assurance, quality control is characterized by its reactive approach. Quality raw materials is of utmost importance since the quality of the raw materials affect the entire feed and flour production. This is important because the quality of the raw materials can be affected by various factors which include manufacturing process, seasonal conditions, shipping handling etc.

2.2.3 Feed Production

Feed production refers to the manufacturing process of food intended for animals. This process encompasses the sourcing of raw materials like grains, the mixing of nutrients, processing, and packaging. The importance of quality assurance in feed production cannot be overstated, as contaminated or poorly formulated feed can have detrimental effects on animal health and, indirectly, on human health through the food chain. Feed (fodder) produced by manufacturing industries is formulated to meet specific animal nutrition requirements for different species of animals at different life stages.

2.2.4 Flour Production

The process of flour production involves the milling of various grains, including wheat, maize, soybean, into flour that is suitable for human consumption or for further processing. Quality assurance in this domain is vital to confirm that the flour complies with safety, purity, and nutritional benchmarks. Typical quality characteristics of flour consist of fineness, moisture content, the absence of contaminants, and stability on the shelf.

2.3.5. Regulatory Compliance

Regulatory compliance signifies the commitment to follow laws, guidelines, and standards set forth by national and international regulatory entities that govern food and feed safety. In the sectors of feed and flour, compliance is imperative to guarantee that products are safe for consumption and that production methods adhere to both legal and ethical norms. Prominent regulatory organizations include the following:

i. **NAFDAC** (National Agency for Food and Drug Administration and Control

ii. **SON** (Standards Organization of Nigeria)
iii. **ISO** (International Organization for Standardization)
iv. **FDA** (Food and Drug Administration)

2.2.6. Quality Assurance System

A quality assurance system is a systematic arrangement of procedures, standards, and practices aimed at ensuring the quality of products. It typically involves process control, documentation, corrective measures, staff training, and continuous oversight. In the context of feed and flour production, a robust QA system reduces risks, guarantees consistency, and boosts customer satisfaction. By establishing a comprehensive quality assurance system, producers of feed and flour can guarantee the creation of safe, high-quality products that fulfill customer expectations and comply with regulatory standards.

2.3. Review of Existing Quality Assurance Practices in Feed and Flour Production

This section analyzes the contemporary quality assurance methods utilized in the feed and flour industries, concentrating on the processes, standards, and challenges that impact product quality and safety.

2.3.1 Quality Assurance Systems in Feed Production

Feed production is a critical aspect of the agricultural value chain, and it is vital to uphold high-quality standards for animal health, food safety, and public health. The current quality assurance practices in feed production generally consist of the following listed below:

i. Raw Material Inspection: Feed producers typically implement stringent inspections of raw materials, including grains, additives, and supplements. These inspections are essential to prevent contamination from mycotoxins, pesticides, or foreign materials.

ii. Process Control: Feed manufacturing involves processes such as blending, grinding, pelleting, and packaging. Process controls, including temperature monitoring, moisture content regulation, and mixing consistency, are enforced to ensure product uniformity and nutritional balance.

iii. Laboratory Testing: Routine microbiological and chemical testing is conducted to identify potential contaminants such as Salmonella, E. coli, heavy metals, and aflatoxins. Analytical testing ensures that the feed meets nutritional and safety specifications.

iv. Compliance with Standards: Feed producers are required to comply with regulatory standards such as Good Manufacturing Practices (GMP), Hazard Analysis and Critical Control Points (HACCP), and ISO9001 certifications. These frameworks help mitigate safety risks in animal feed.

v. Challenges: Common challenges in feed quality assurance include inconsistent raw material supply, limited laboratory resources, inadequate staff training, and poor regulatory enforcement in some regions.

2.3.2. Quality Assurance Practices in Flour Production

The flour milling industry emphasizes quality and safety due to the extensive consumption of flour-based products. Key quality assurance practices in flour production include the following listed below:

i. Grain Selection and Inspection: The selection of high-quality grains is essential for producing safe and nutritious flour. Flour producers carefully inspect grains for moisture content, pest infestation, and physical defects before processing.

ii. Process Control: Quality assurance systems in flour milling monitor parameters such as milling temperature, flour extraction rate, ash content, and granulation to ensure product consistency and compliance with required standards.

iii. Contamination Prevention: Strict sanitation and hygiene practices are implemented to prevent contamination from pests, foreign objects, or microbial agents. This includes regular cleaning of equipment and storage facilities.

iv. Quality Testing: Flour is routinely tested for physical (particle size, moisture), chemical (protein content, gluten strength), and microbiological (bacterial load) properties to meet quality specifications.

v. Regulatory Compliance: Flour producers are typically required to comply with national and international food safety regulations such as NAFDAC guidelines, SON standards, GMP protocols, and ISO certifications.

vi. Challenges: Challenges in flour quality assurance often include equipment maintenance issues, fluctuating grain quality due to seasonal variations, and the need for continuous staff training on quality control practices.

Both the industries of feed and flour production have instituted quality assurance measures that involve the examination of raw materials, control of processes, laboratory assessments, and compliance with regulations. Nonetheless, inconsistencies persist in the areas of implementation, training, and the adaptation to modern quality management systems, particularly within developing countries.

2.4. Regulatory and industry Standards in Feed and Flour Production

Regulatory and industry standards are pivotal in ensuring the safety, consistency, and superior quality of feed and flour products. Adhering to these standards is fundamental for protecting public health, fostering international trade, and enhancing consumer confidence.

This section provides an overview of the essential regulatory frameworks and industry guidelines that govern quality assurance in the production of feed and flour.

2.4.1 National Regulatory Standards

These are regulatory bodies endowed with the responsibilities of creating standards and maintaining the standards as it concerns fed and flour production. These bodies are recognized nationally(Nigeria) and internationally. They include the following:

i. **National Agency for Food and Drug Administration and Control (NAFDAC):** NAFDAC is responsible for regulating food and feed safety within Nigeria. The agency defines requirements for product registration, labeling, manufacturing practices, and performs periodic inspections to ensure that feed and flour products comply with minimum safety and quality standards.

ii. **Standards Organization of Nigeria (SON):** SON holds the responsibility for the development and enforcement of **Nigerian Industrial Standards (NIS)** across various industries, including the production of feed and flour. SON provides quality specifications for raw materials, processing methods, and final products to ensure uniformity and adherence to standards.

iii. **Food and Drug Administration (FDA):** In countries such as the United States, the FDA establishes strict guidelines for food and feed production, encompassing areas like ingredient safety, labeling, processing environments, and contaminant thresholds. Although this study may emphasize local practices, the FDA serves as a global reference for best practices.

2.4.2. International Quality and Safety Standards

i. ISO9001 Food Safety Management Systems: ISO9001 is an internationally acknowledged standard that combines food safety management principles with the

Hazard Analysis and Critical Control Points (HACCP) framework. It provides a detailed structure for identifying and managing food safety hazards throughout the entire production chain.

ii. Good Manufacturing Practices (GMP): GMP guidelines ensure that products are produced and controlled consistently in line with quality standards. GMP addresses various factors including facility design, equipment maintenance, employee hygiene, process validation, and documentation practices.

iii. Hazard Analysis and Critical Control Points (HACCP): HACCP is a preventive framework that identifies potential biological, chemical, and physical hazards in the production process. It requires continuous oversight of critical control points to ensure that hazards are effectively managed or eliminated.

iv. Codex Alimentarius Standards: The Codex Alimentarius, developed by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), sets forth international food safety standards, guidelines, and codes of practice. These standards are widely embraced to promote fair trade and protect consumer health.

2.4.3. Relevance of Regulatory Compliance

Compliance with both local and international quality standards is crucial for:

i. Guaranteeing product safety and safeguarding consumer interests.

ii. Boosting the competitiveness of domestically produced feed and flour in global markets.

iii. Minimizing the risks associated with contamination and product recalls.

iv. Facilitating regulatory inspections and certifications necessary for market entry.

Regulatory and industry standards constitute the foundation of quality assurance systems in the production of feed and flour. Adhering to these frameworks guarantees that products fulfill legal, safety, and consumer expectations. Nevertheless, challenges related to enforcement, awareness, and infrastructure may obstruct effective implementation, particularly in developing nations i.e. Nigeria.

2.5. Empirical Review of Studies

This section provides an overview of empirical research and studies concerning quality assurance in the production of feed and flour. It emphasizes the approaches taken by previous studies towards quality management, the methodologies utilized, and their significant findings. The objective is to comprehend what has been accomplished in the past, identify existing limitations, and explore how this current study can offer new insights. These empirical studies provide valuable insights into the practical realities of implementing quality assurance systems. They show that while the frameworks exist, the real challenge lies in consistent execution, monitoring, and adaptation to local contexts. The current study seeks to contribute to this area by proposing practical recommendations to enhance QA systems in feed and flour production, especially in resource-constrained environments.

2.5.1 Studies on Quality Assurance in Feed Production

A number of empirical studies have investigated the implementation and effectiveness of quality assurance systems in the animal feed industry.

Oladipo et al (2020) – Assessment of Quality Control Practices in Nigerian Feed Mills: This research investigated the quality control mechanisms implemented in various feed mills throughout Nigeria. The results indicated that although the majority of mills possessed fundamental quality procedures, numerous facilities were deficient in formal documentation, standardized testing methods, and adequately trained staff. The research suggested that enhanced training and stricter regulatory enforcement are necessary to improve adherence to GMP and HACCP standards.

Yeboah & Boateng (2018) – Evaluating the Effectiveness of Feed Safety Standards in Ghana: This study underscored the efficacy of feed safety regulations in enhancing livestock productivity and minimizing contamination occurrences. Nevertheless, it also noted that numerous small-scale producers faced challenges related to the expenses and intricacies of adopting HACCP-based frameworks. The research stressed the necessity for cost-effective, adaptable quality assurance models tailored for smaller manufacturers.

Okonkwo et al (2020) In their research, examined quality control practices in Nigerian feed mills. The findings indicated that while most feed producers had basic quality control procedures in place, many lacked formal documentation and adequate staff training, which obstructed the effective implementation of quality assurance.

Adeyemi and Akinwumi (2018) analyzed the adoption of HACCP principles in livestock feed production in southwestern Nigeria. Their findings revealed a low level of awareness and limited application of HACCP, attributed to financial limitations and insufficient technical expertise.

Zhou et al (2019) evaluated the impact of quality assurance programs on feed safety in China. They concluded that firms with organized QA systems reported fewer contamination incidents and exhibited improved product consistency.

These studies underscore the importance of enhanced training, standardization, and regulatory enforcement to bolster quality assurance in feed manufacturing.

2.5.2. Studies on Quality Assurance in Flour Production

Empirical research into the quality of flour milling has brought to light both achievements and areas of concern.

Okonkwo & Ibrahim (2019) – An Analysis of Quality Management Systems in Nigerian Flour Mills: This empirical research revealed that prominent flour mills in Nigeria have implemented ISO9001 and GMP practices; however, they encountered difficulties including inadequate equipment maintenance, variable quality of raw grains, and deficiencies in employee training. The authors recommended ongoing process audits and enhanced collaborations with regulatory agencies.

Kumar et al. (2021) – Implementation of HACCP in Wheat Flour Mills in India: The analysis focused on the practical application of HACCP protocols in wheat flour mills across India. It found a considerable reduction in microbial contamination and an extension of product shelf life post full HACCP implementation. The research underscored that technical training and the commitment from top management were vital success factors.

Musa and Bello (2021) undertook a study examining the effectiveness of ISO9001 implementation within Nigerian flour mills. Their findings indicated enhancements in product quality and adherence to regulations in facilities that were ISO-certified; however, they also observed that the high costs associated with implementation hindered adoption among smaller mills.

Ezekiel et al (2017) investigated the levels of microbial contamination in flour samples sourced from both open markets and industrial mills. Their results demonstrated a significantly greater level of contamination in samples from the market, highlighting the critical need for standardized quality assurance practices and appropriate packaging.

Kumar and Singh (2020) conducted research in India focusing on customer satisfaction regarding flour quality. Their study found that consumer grievances were frequently associated with variations in texture, moisture levels, and the presence of foreign particles—all of which could be reduced through more rigorous quality control measures.

These investigations emphasized the necessity for standardized quality assurance protocols, ongoing testing, and improvements in infrastructure to bolster flour safety and quality.

2.5.3 General Observations from Literature

Common trends: Most studies agree that quality assurance enhances safety, customer trust, and operational efficiency. The implementation of ISO, GMP, and HACCP standards has had measurable positive impacts on product quality.

2.6. Critical Evaluation of the Literature

This section offers a thorough examination of the literature evaluated in prior sections, pinpointing essential strengths, limitations, and gaps that validate the requirement for the ongoing study.

2.6.1. Strengths in Existing Literature

Availability of Established Frameworks: The literature underscores a variety of internationally recognized quality assurance frameworks, such as HACCP, ISO9001, and GMP, which deliver a methodical approach to ensuring product safety in the production processes of feed and flour.

Evidence-Based Improvements: A multitude of empirical research has shown quantifiable advancements in product safety, consistency, and compliance with regulations after the integration of structured quality assurance systems.

Global and Local Perspectives: The reviewed literature features both international and Nigerian case studies, presenting a well-rounded perspective on the functionality of quality assurance systems across various contexts and regulatory landscapes.

Recognition of Training Needs: Numerous studies have pinpointed staff training as a pivotal component in the success of quality assurance systems, reflecting a common understanding of the human element in the execution of quality assurance.

2.6.2. Limitations in Existing Literature

Limited Emphasis on Developing Nations: While some researches have considered the African context, there is still a significant gap in comprehensive, localized studies regarding the practical difficulties encountered by feed and flour manufacturers in Nigeria and comparable areas.

Excessive Focus on Large-Scale Enterprises: The majority of existing research centers on established, large-scale firms that possess the means to implement global standards, thereby neglecting small and medium-sized enterprises (SMEs) that may face challenges in this regard.

Inadequate Information on Long-Term Effects: Numerous studies highlight short-term gains following implementation but do not assess the long-term viability of quality assurance (QA) systems or their capacity to adapt to changing regulatory frameworks.

Deficiency in Innovation-Centric Research: There is a scarcity of investigation into innovative, cost-efficient, and scalable QA approaches, particularly those that are appropriate for resource-limited environments or rural feed and flour producers.

2.6.3. Contribution of The Current Study

This study contributes to existing literature by analyzing the current quality assurance practices in Prime Feed and Flour Mill Limited, Ewu, compare against the standards (nationally and internationally), identify gaps and recommend improvement strategies to enhance quality assurance systems in this chosen case study.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Description of Feed Production Process

Feed production constitutes a systematic approach that involves the conversion of raw agricultural materials into feed that is nutritionally balanced and suitable for animal consumption. The process begins with the procurement and reception of raw materials such as maize offal, palm kernel cake, soya meal, wheat bran, and rice offal. Upon their arrival at the production facility, these materials are weighed and sampled for quality analysis to assess parameters including moisture content, crude protein, fiber, and other essential nutrients. Only those materials that meet the specified standards are accepted for use, while those that do not conform to the required specifications are discarded to ensure the quality of the final product.

Following acceptance, the raw materials are cleaned and sorted meticulously to remove any foreign substances such as stones, dust, metals, and other impurities. This process is vital for ensuring the quality of the feed and for protecting processing equipment from damage. The cleaned materials are then ground down to smaller particle sizes using machinery such as a hammer mill. This size reduction not only increases the efficiency of mixing but also enhances the digestibility of the feed for animals.

Following the grinding stage, the materials are assessed in specific proportions according to a predetermined feed formulation, a process known as batching. This practice ensures that the final feed contains the correct balance of nutrients necessary for animal growth and productivity. The weighed ingredients are then transferred into a mixing unit, where they are thoroughly blended to achieve a uniform and homogeneous mixture. Proper mixing is crucial to ensure that all nutrients, including vitamins and additives, are evenly distributed throughout the feed.

The mixed feed, commonly referred to as mash, is then conditioned by the addition of steam. Conditioning improves the physical and nutritional quality of the feed by increasing nutrient availability, enhancing pellet formation, and reducing microbial contamination. The conditioned mash is subsequently passed through a pellet mill, where it is compressed into pellets. Pelleting improves feed handling, reduces wastage, and enhances feed intake by animals.

After the pelleting stage, the feed is cooled to decrease its temperature and moisture content. This cooling process is essential for stabilizing the pellets, enhancing their durability, and extending their shelf life. In some cases, particularly for young animals, the pellets may be further processed through crumbling to create smaller, more manageable particle sizes. Additionally, the feed may be screened to remove fines and ensure uniformity in size and quality.

Finally, the finished feed is packaged into bags, properly labeled, and stored in a dry and well-ventilated environment to prevent spoilage and maintain quality. Throughout the entire production process, quality control measures are implemented at various stages to ensure that the feed meets the required nutritional and safety standards. Statistical Process Control tools can also be applied to monitor consistency and detect variations, thereby enhancing overall process efficiency and product quality.

3.2. Research Design

This study employed a quantitative research framework, utilizing Statistical Process Control (SPC) techniques to assess the consistency of quality in selected feed raw materials used in the production of feed mills. SPC tools were used to monitor the stability of processes and to identify variations in quality parameters over time.

3.3. Materials Used

The raw material used for the purpose of this study include:

i. Groundnut Cake (GNC)
ii. Wheat Bran

iii. Rice Offal
iv. Soya Meal
v. Palm Kernel Cake (PKC)
vi. Maize Offal

These materials were selected due to their common use in feed formulation and significant importance in determining the quality of feed produced.

3.4. Data Collection Procedure

Data were obtained over a duration of 30 days in the month of November, 2025, from routine laboratory evaluations at Prime Feed and Flour Mill Limited. For every raw material, five samples (S1–S5) were collected each day to ensure both representation and accuracy.

Each sample was subjected to analysis for relevant quality parameters, which were determined based on the type of material.

3.5. Quality Parameters Measured

The following parameters were analyzed based on the type of raw material:

i. Crude Protein: This measures the total protein content in a material. It's estimated from nitrogen content (because proteins contain nitrogen). Important for growth, repair and production.
ii. Crude Fat: This measures the total fat/oil content in the material. This provides high energy, helps in absorption of fat-soluble vitamins, and also improve palatability.
iii. Crude Fibre: This represent the indigestible portion of plant materials. Helps with digestion, and gut health. High concentration of fibre can lead to reduced nutrient absorption and a low concentration of fibre can lead to digestive issues.

iv. Moisture: This is the concentration of water present in the material. High concentration can lead to mold growth, spoilage, and reduced shelf life. A low concentration improves storage stability.

v. Ash: This represents the total mineral content remaining after burning the material. It includes minerals like calcium, phosphorous, and potassium. High concentration of ash may indicate good mineral content or contamination like sand or dirt

vi. Starch: This is a major carbohydrate source and provides energy. It is easily digestible, essential for weight gain and energy supply. A high concentration of starch can lead to metabolic issues.

3.6. Statistical Tools for analysis

The study utilized two main SPC tools:

3.6.1 $\bar{X}$ (Mean) Chart

The $\bar{X}$ chart was used to monitor the average values of the quality parameters over time and determine whether the process mean remained stable.

3.6.2 R (Range) Chart

The R chart was used to assess process variability, showing the consistency of the measurements within each sample set.

3.7 Determination of Control Limits

Control limits for the SPC charts were calculated using standard formulas:

For $\bar{X}$ Chart:

i. $UCL = \bar{X} + A_2\bar{R}$

ii. $CL = \bar{\bar{X}}$

iii. $LCL = \bar{\bar{X}} - A_2\bar{R}$

For R Chart:

i. $UCL = D_4\bar{R}$

ii. $CL = \bar{R}$

iii. $LCL = D_3\bar{R}$

Where:

i. $\bar{\bar{X}} = \frac{\sum \bar{X}}{n}$ Grand mean of sample means

ii. $\bar{R} = \frac{\sum R}{n}$ Average of sample ranges

3.8. Data Analysis Technique

The computed control limits were used to construct $\bar{X}$ and R charts for each parameter. The process was considered:

i. In control → if all points fall within control limits with no abnormal patterns

ii. Out of control → if points fall outside limits or show non-random trends

The results were then interpreted to evaluate process stability and identify sources of variation.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSION OF RESULTS

4.1 Data Presentation

This includes the tables of values that were obtained by the sampling method for a period of 30 days. The raw materials sampled includes rice offal, wheat bran, groundnut cake (GNC), soya meal, palm kernel cake (PKC), and maize offal.

4.1.1. Rice Offal

This contains the sampling data of rice offal highlighting crude fibre and ash content as the essential parameters.

Table 4.1 shows the crude fibre values for rice offal below

Table 4.1: Crude Fibre Values for Rice Offal

Rice Offal - Crude Fibre (Max: 5.0)							
Day	**S1**	**S2**	**S3**	**S4**	**S5**	**$\bar{x}$ (Mean)**	**R (Range)**
1	4.3574	4.0086	2.4982	3.9176	4.4048	3.8373	1.9066
2	3.7669	3.8179	4.6765	2.1301	2.3173	3.3417	2.5464
3	4.4981	2.9568	3.7461	3.0874	3.0403	3.4657	1.5413
4	4.1864	2.8199	3.5418	4.4133	4.9445	3.9812	2.1246
5	2.1309	3.3884	3.6928	2.5606	3.8036	3.1153	1.6727
6	4.0218	4.6002	4.6590	4.3097	3.2793	4.1740	1.3797
7	3.8826	3.6745	2.1063	2.3267	4.6223	3.3225	2.5160
8	3.1938	3.3289	3.6746	2.7102	4.0656	3.3946	1.3554
9	3.6878	2.1508	4.1697	3.6339	3.6002	3.4485	2.0189
10	4.9803	2.6187	2.9687	4.0403	2.7855	3.4787	2.3616
11	4.8948	4.4512	2.8878	4.8706	4.0673	4.2343	2.0070
12	3.2037	4.8889	2.7944	4.2921	3.8970	3.8152	2.0945
13	4.3316	3.4124	3.5544	2.0419	4.3019	3.5284	2.2897
14	2.2292	3.1153	3.0941	4.7470	2.5977	3.1567	2.5178
15	4.7561	2.3419	4.2433	2.4379	4.6173	3.6793	2.4142
16	4.0523	4.8759	2.1908	2.7462	3.6268	3.4984	2.6851
17	2.6491	2.4750	4.5395	4.0996	2.8198	3.3166	2.0645
18	3.1656	4.3398	3.7813	3.2891	4.3747	3.7901	1.2091
19	2.2056	3.0982	3.3779	4.5017	3.5694	3.3506	2.2961
20	4.8217	2.2314	4.9980	4.9693	4.4266	4.2894	2.7666
21	4.6261	4.5977	2.4534	4.7877	4.0269	4.0984	2.3343
22	3.7913	4.9666	2.7626	4.9790	4.9879	4.2975	2.2253
23	4.7558	2.7447	2.0264	3.2790	4.7421	3.5096	2.7294
24	4.3716	2.7091	3.0626	3.5005	3.1841	3.3656	1.6625
25	4.7545	3.2709	2.8349	3.3860	3.8228	3.6138	1.9196

26	3.5918	4.5846	2.9300	4.9058	4.3032	4.0631	1.9758
27	2.9247	4.0901	4.9926	4.7975	4.0414	4.1693	2.0679
28	2.5271	2.7761	3.1371	3.9063	3.5510	3.1795	1.3792
29	3.1793	2.9279	2.4489	4.2383	2.7862	3.1161	1.7894
30	2.3032	2.7569	2.3171	4.3998	2.7572	2.9068	2.0966

Table 4.2 shows the ash content values for rice offal below

Table 4.2: Ash Content Values for Rice Offal

Rice Offal - Ash (Max: 7.5)							
Day	**S1**	**S2**	**S3**	**S4**	**S5**	**$\bar{x}$ (Mean)**	**R (Range)**
1	3.6484	4.2487	7.1709	5.7561	6.6871	5.5022	3.5225
2	7.1062	6.9737	6.4000	4.7987	5.5216	6.1600	2.3075
3	4.5042	4.3084	5.3586	3.7823	6.8652	4.9637	3.0829
4	5.2909	7.0311	3.5064	3.7235	5.0268	4.9157	3.5247
5	5.8225	5.9341	7.0818	6.7110	6.1575	6.3414	1.2593
6	5.3938	5.2036	5.4896	6.6549	4.3076	5.4099	2.3473
7	6.9778	4.6829	4.3443	6.7678	6.0781	5.7702	2.6335
8	6.3438	6.7710	4.9435	5.2901	5.4031	5.7503	1.8275
9	5.0013	3.8687	3.5958	4.3405	7.4575	4.8528	3.8617
10	3.2838	5.9750	5.4796	3.5538	5.7154	4.8015	2.6912
11	3.9230	5.8991	6.3365	7.2284	5.7423	5.8259	3.3054
12	6.9626	3.6603	6.8990	3.7265	4.2308	5.0958	3.3023
13	6.6359	5.7724	5.4263	6.6149	4.2279	5.7355	2.4080
14	7.1703	4.2287	4.0791	4.6983	6.3521	5.3057	3.0912
15	4.8557	6.3077	6.9982	7.4743	6.8781	6.5028	2.6186
16	6.8403	4.8977	4.2505	6.9125	7.4149	6.0632	3.1644
17	4.2656	7.1898	5.8664	5.4001	5.1803	5.5804	2.9242
18	7.4458	4.3889	3.3443	5.7217	5.9142	5.3630	4.1015
19	5.4187	6.3500	3.2059	7.2013	5.5102	5.5372	3.9954
20	3.2209	7.4682	3.1452	6.5550	5.0458	5.0870	4.3230
21	4.4852	5.5697	4.8939	3.7099	4.9065	4.7130	1.8598
22	6.1402	7.2123	6.0986	6.6768	6.5036	6.5263	1.1137
23	3.0206	7.3962	6.6809	4.4481	6.6076	5.6307	4.3756
24	4.3242	3.6084	3.9779	3.3571	5.0983	4.0732	1.7412
25	5.9810	5.4042	5.3557	4.6168	5.3438	5.3403	1.3642
26	4.7177	5.0432	4.6165	7.2771	6.7770	5.6863	2.6606
27	3.8537	5.4219	7.2339	5.6307	4.1799	5.2640	3.3802
28	5.8880	4.2266	6.7407	6.6419	5.9176	5.8830	2.5141
29	6.5204	3.7297	4.0599	4.4801	3.4305	4.4441	3.0899
30	6.6828	5.7970	3.0060	4.4923	5.8865	5.1729	3.6768

4.1.2. Wheat Bran

This contains the sampling data of wheat bran highlighting crude fibre and moisture content as the essential parameters.

Table 4.3 shows the crude fibre values for wheat bran below

Table 4.3: Crude Fibre Values for Wheat Bran

Wheat Bran - Crude Fibre (Max: 8.0)							
Day	**S1**	**S2**	**S3**	**S4**	**S5**	**$\bar{x}$ (Mean)**	**R (Range)**
1	4.7406	7.8867	4.6341	7.3463	5.2631	5.9742	3.2526
2	4.3757	7.7978	5.0800	6.6550	3.9966	5.5810	3.8012
3	7.8281	3.8655	7.4020	3.2708	4.7210	5.4175	4.5573
4	5.4848	6.6401	6.5499	4.5299	3.5592	5.3528	3.0809
5	3.6664	3.2001	6.8697	3.8512	7.1098	4.9394	3.9097
6	4.5295	4.0428	5.4267	6.7415	7.2648	5.6011	3.2220
7	5.7014	4.5918	5.2363	7.7834	7.0473	6.0720	3.1916
8	5.0350	6.5410	5.2430	6.9399	4.5713	5.6660	2.3686
9	5.1917	6.1745	3.9406	6.6995	6.3993	5.6811	2.7589
10	7.9342	6.6658	6.1951	6.0200	6.3262	6.6283	1.9142
11	7.8007	3.7280	7.4626	4.7448	3.2219	5.3916	4.5788
12	4.3272	5.7230	5.8571	5.8270	6.0351	5.5539	1.7079
13	3.3544	7.9963	5.2466	3.9658	4.2700	4.9666	4.6419
14	6.6640	4.7996	5.9012	7.7741	5.4336	6.1145	2.9745
15	5.8896	4.6892	6.6948	6.6592	5.0898	5.8045	2.0056
16	5.0096	6.4393	6.4381	7.2684	7.8550	6.6021	2.8454
17	4.6264	4.8332	4.9398	5.9543	4.5813	4.9870	1.3730
18	6.0585	5.7505	4.1278	6.9285	6.8795	5.9490	2.8007
19	3.6442	6.0328	6.2618	3.6809	4.2481	4.7736	2.6176
20	6.7087	4.3069	4.1165	3.6765	5.7327	4.9083	3.0322
21	7.9710	5.5140	7.0163	7.1892	5.6852	6.6751	2.4570
22	3.9774	3.9031	6.7149	6.9639	5.2208	5.3560	3.0608
23	5.8082	5.4115	5.2162	7.1682	5.1033	5.7415	2.0649
24	6.4461	3.4812	3.7977	4.3076	6.0945	4.8254	2.9649
25	5.1678	6.6790	4.3398	7.8521	6.0814	6.0240	3.5123
26	7.4981	3.8105	4.3818	5.4938	6.0109	5.4390	3.6876
27	6.3836	3.2745	7.1529	6.8180	7.9179	6.3094	4.6434
28	4.4275	6.4633	6.4966	5.6146	3.8141	5.3632	2.6825
29	4.4470	7.9916	7.7430	6.7861	6.4881	6.6912	3.5446

30	7.4717	4.4693	3.9002	3.8406	5.5439	5.0451	3.6311

Table 4.4 shows the moisture content values for wheat bran below

Table 4.4: Moisture Values for Wheat Bran

Wheat Bran - Moisture (Max: 10.0)							
Day	**S1**	**S2**	**S3**	**S4**	**S5**	**$\bar{x}$ (Mean)**	**R (Range)**
1	9.7328	6.9185	8.7709	8.8824	5.8675	8.0344	3.8653
2	6.3861	4.7132	8.1669	9.8699	5.7523	6.9777	5.1567
3	8.4789	7.3762	4.9130	9.0634	5.3321	7.0327	4.1504
4	5.7016	6.6015	7.2130	9.0519	6.6940	7.0524	3.3503
5	6.8651	4.6760	9.4636	5.8715	6.5218	6.6796	4.7876
6	8.6203	5.8609	5.2286	7.3054	7.3026	6.8636	3.3917
7	4.6436	9.1873	4.5314	9.5954	9.6597	7.5235	5.1283
8	9.4816	9.1412	8.4787	8.7898	5.9032	8.3589	3.5784
9	4.6256	6.3050	4.8066	8.8771	4.2885	5.7806	4.5886
10	9.9845	6.6465	9.9426	8.0022	9.7154	8.8582	3.3380
11	7.4002	7.9994	9.3191	5.5834	4.9728	7.0550	4.3463
12	9.5888	6.9926	4.2404	5.7153	5.7387	6.4552	5.3484
13	4.7524	9.6582	5.1892	7.1914	4.3094	6.2201	5.3488
14	8.0293	9.6264	7.1895	7.8439	9.0591	8.3496	2.4369
15	8.3390	5.1977	4.2369	9.8749	7.3633	7.0024	5.6380
16	8.6625	6.5350	6.3003	5.1120	9.1361	7.1492	4.0241
17	8.9757	4.6350	6.8436	7.7469	9.5370	7.5476	4.9020
18	5.9617	7.2066	6.4441	5.2319	6.6880	6.3065	1.9747
19	4.3961	9.2976	8.9269	6.3211	6.5503	7.0984	4.9015
20	7.0471	8.7157	9.9162	4.9914	9.2523	7.9845	4.9248
21	5.4339	9.2994	5.0546	7.3265	8.2869	7.0803	4.2448
22	8.3053	7.2832	9.9708	7.8114	8.8795	8.4500	2.6876
23	5.3322	4.5939	8.1719	7.3013	5.1537	6.1106	3.5780
24	5.0081	9.5963	4.1701	6.1853	4.0408	5.8001	5.5555
25	5.7136	9.0020	5.6139	5.7825	6.2579	6.4740	3.3881
26	8.2727	5.3109	6.7429	4.1696	6.4726	6.1937	4.1031
27	4.3526	5.9434	4.6079	9.8444	4.0906	5.7678	5.7538
28	7.6214	4.4722	6.2611	8.7547	5.6194	6.5458	4.2825
29	9.0826	6.7831	4.8801	5.4077	6.7034	6.5714	4.2025
30	9.2298	4.8114	5.1727	7.0745	8.8347	7.0246	4.4184

4.1.3. Groundnut Cake (GNC)

This contains the sampling data of groundnut cake highlighting crude protein and crude fat content as the essential parameters.

Table 4.5 shows the crude protein values for groundnut cake below

Table 4.5: Crude Protein Values for Groundnut Cake

Groundnut Cake (GNC) - Crude Protein (Min: 45.0)							
Day	**S1**	**S2**	**S3**	**S4**	**S5**	**x̄ (Mean)**	**R (Range)**
1	51.0505	49.3927	52.4295	45.2830	52.2724	50.0856	7.1465
2	50.0906	47.6786	45.4203	53.9156	45.0614	48.4333	8.8542
3	51.9281	51.7209	48.3970	49.4473	53.3605	50.9708	4.9635
4	48.5591	53.7656	49.7197	45.8425	52.3198	50.0413	7.9231
5	46.9052	49.9891	47.6304	52.3453	52.4524	49.8645	5.5472
6	46.9942	50.8035	45.8566	48.7050	45.8718	47.6462	4.9469
7	46.2961	46.9098	49.2899	45.6985	47.1154	47.0619	3.5914
8	45.0590	53.0878	49.9701	46.5079	53.3599	49.5969	8.3009
9	49.8788	45.3758	49.7239	50.7613	52.2059	49.5891	6.8301
10	52.5143	47.2737	53.7145	49.1961	47.3768	50.0151	6.4408
11	49.9444	48.3960	46.8336	53.2392	53.4526	50.3732	6.6190
12	52.5374	48.8951	51.4450	52.6621	45.7114	50.2502	6.9507
13	48.6896	50.7741	53.7881	51.3476	50.7296	51.0658	5.0985
14	46.8485	47.6376	46.4401	47.7354	51.4666	48.0256	5.0265
15	53.6218	45.1420	47.8134	45.4402	52.8729	48.9781	8.4798
16	51.2438	52.4390	53.2651	46.3781	49.2303	50.5113	6.8870
17	49.9164	49.6463	51.4838	52.4027	47.1174	50.1133	5.2853
18	45.9499	50.5249	47.1929	52.4425	49.1898	49.0600	6.4926
19	51.2193	48.1932	45.9312	47.6899	46.4689	47.9005	5.2881
20	47.0954	49.8998	48.1942	51.7018	50.8334	49.5449	4.6064
21	51.9303	52.1130	49.7393	47.3066	53.9583	51.0095	6.6517
22	45.9596	48.7345	46.3916	49.5637	52.2619	48.5823	6.3023
23	49.2729	48.9073	47.9853	45.6907	51.5180	48.6748	5.8273
24	51.7622	50.5354	53.1196	46.1982	46.8059	49.6843	6.9214
25	52.6341	50.9501	49.6479	51.9532	51.9878	51.4346	2.9862
26	49.9938	51.2058	47.2422	51.3303	48.5951	49.6734	4.0881
27	50.5612	50.4071	50.4967	51.3278	45.6920	49.6970	5.6358
28	46.9067	47.6861	53.6946	50.9185	46.5667	49.1545	7.1279
29	51.1358	52.5696	53.1005	46.8717	53.5280	51.4411	6.6563
30	47.0859	46.3840	50.6769	45.3291	52.1630	48.3278	6.8339

Table 4.6 shows the crude fat values for groundnut cake below

Table 4.6: Crude Fat Values for Groundnut Cake

Groundnut Cake (GNC) - Crude Fat (Min: 7.3)							
Day	**S1**	**S2**	**S3**	**S4**	**S5**	**$\bar{x}$ (Mean)**	**R (Range)**
1	7.6127	7.4894	9.0936	9.4096	8.9666	8.5144	1.9202
2	9.0946	9.3518	8.2063	7.9984	8.8489	8.7000	1.3534
3	8.6750	8.8002	8.8618	8.8659	7.7862	8.5978	1.0797
4	7.4822	8.3959	9.3588	8.9085	7.6602	8.3611	1.8766
5	7.4456	8.5769	8.5774	8.7769	7.8307	8.2415	1.3313
6	8.2836	8.8309	7.6473	7.7102	8.2610	8.1466	1.1836
7	7.8486	9.3137	7.7159	8.1754	9.0903	8.4288	1.5978
8	7.3841	8.7632	7.3308	9.3327	7.5501	8.0722	2.0019
9	7.6326	8.6329	9.1555	8.2557	8.3192	8.3992	1.5229
10	9.1315	8.4161	8.3089	7.9431	8.0937	8.3787	1.1884
11	8.0181	8.5458	9.0125	8.8811	8.7862	8.6487	0.9944
12	9.3335	9.1990	9.3253	7.3921	8.1625	8.6825	1.9414
13	8.5778	8.3115	8.7878	9.4624	7.6363	8.5552	1.8261
14	8.0297	9.3873	8.2348	8.2134	9.2080	8.6146	1.3576
15	7.3914	7.5617	7.5775	9.4670	7.4958	7.8987	2.0756
16	8.1814	9.2516	8.1415	7.3521	8.2185	8.2290	1.8995
17	7.4835	8.5944	8.3241	8.0805	9.1598	8.3285	1.6763
18	9.2937	8.3848	8.2801	9.3093	9.2239	8.8984	1.0292
19	9.1542	8.7114	8.4647	9.4131	7.9400	8.7367	1.4731
20	7.9703	7.5221	8.1831	8.4353	7.5276	7.9277	0.9132
21	8.0326	8.2251	9.4667	9.4398	7.5533	8.5435	1.9134
22	8.2015	9.0206	8.6452	8.8450	9.1787	8.7782	0.9772
23	8.0799	8.8337	8.7010	7.4440	8.7558	8.3629	1.3897
24	7.4117	7.8031	7.5416	7.8076	9.3822	7.9892	1.9705
25	9.1849	7.9413	9.3881	7.5657	7.6954	8.3551	1.8224
26	8.2956	7.4199	8.1999	8.5481	9.0053	8.2938	1.5854
27	8.9753	9.4886	8.4585	9.1213	8.8839	8.9855	1.0301
28	8.9837	7.9424	8.5402	9.0702	8.4940	8.6061	1.1278
29	9.1726	8.4039	7.8515	7.5442	7.8644	8.1673	1.6284
30	8.6535	8.3083	8.9218	8.1254	8.9871	8.5992	0.8617

4.1.4. Soya Meal

This contains the sampling data of soya meal highlighting crude protein and moisture content as the essential parameters.

Table 4.7 shows the crude protein values for soya meal

Table 4.7: Crude Protein Values for Soya Meal

Soya Meal - Crude Protein (Min: 45.0)							
Day	**S1**	**S2**	**S3**	**S4**	**S5**	**$\bar{x}$ (Mean)**	**R (Range)**
1	51.1255	51.3870	53.2681	46.0797	48.4477	50.0616	7.1884
2	46.8404	52.4450	45.3399	46.5359	49.3758	48.1074	7.1051
3	45.3593	49.5243	53.8729	53.3450	46.7163	49.7636	8.5136
4	48.8996	48.7751	46.3062	52.7779	51.1821	49.5882	6.4717
5	53.4782	52.3382	49.1882	47.8150	49.6920	50.5023	5.6632
6	51.0163	48.4693	47.4104	52.9590	50.5708	50.0852	5.5486
7	50.6357	50.2234	52.7308	51.3121	50.0570	50.9918	2.6738
8	49.9667	53.9207	49.2363	49.8206	51.4152	50.8719	4.6844
9	53.9852	49.9203	51.7263	46.5797	52.6610	50.9745	7.4055
10	48.3215	50.9339	49.1737	51.6999	45.5773	49.1413	6.1226
11	46.9105	50.0613	52.0674	51.0032	49.4458	49.8976	5.1569
12	48.7161	46.3250	52.5925	46.0897	53.4976	49.4442	7.4079
13	47.8058	52.9158	49.6206	45.0276	50.6194	49.1978	7.8882
14	45.0392	46.8121	51.3175	45.0002	52.8411	48.2020	7.8409
15	46.9484	51.5615	48.2480	52.9649	49.8528	49.9151	6.0165
16	47.6172	52.8320	47.8584	46.1932	52.7482	49.4498	6.6388
17	52.1515	51.0379	52.3105	51.1126	53.0939	51.9413	2.0560
18	46.2191	51.3351	51.2200	51.1297	47.1304	49.4069	5.1160
19	49.0425	51.1855	51.4936	50.2732	46.4610	49.6912	5.0326
20	53.8577	47.2706	52.1141	52.1995	49.1609	50.9206	6.5871
21	51.7128	47.4324	51.0158	52.2275	50.8821	50.6541	4.7951
22	53.1289	46.7833	53.5312	51.3336	53.3801	51.6314	6.7479
23	46.8698	49.8032	45.5434	47.0082	53.1888	48.4827	7.6454
24	50.1577	45.2118	49.2219	47.0536	50.6897	48.4669	5.4779
25	49.6198	48.1549	47.3739	48.3192	46.7227	48.0381	2.8971
26	46.1983	49.9112	52.6445	46.1988	45.2462	48.0398	7.3983
27	51.7892	51.7197	52.7972	51.9772	45.2300	50.7027	7.5672
28	47.1637	47.2915	45.8070	52.2253	52.8328	49.0641	7.0258
29	49.5422	49.7887	46.8683	47.9773	50.6310	48.9615	3.7627
30	48.3795	51.5709	47.2590	47.2739	51.7997	49.2566	4.5407

Table 4.8 shows the moisture values for soya meal below

Table 4.8: Moisture Values for Soya Meal

Soya Meal - Moisture (Max: 10.0)							
Day	**S1**	**S2**	**S3**	**S4**	**S5**	**$\bar{x}$ (Mean)**	**R (Range)**

1	8.6446	4.1911	9.0376	7.8751	7.3998	7.4296	4.8465
2	5.8593	4.5201	4.2505	6.8210	9.0425	6.0987	4.7920
3	5.2524	4.9936	6.8405	6.5028	9.1958	6.5570	4.2022
4	4.4359	5.2503	7.5585	5.5114	9.8530	6.5218	5.4171
5	9.4170	6.8384	9.3869	6.5384	6.4567	7.7275	2.9603
6	5.0195	6.2089	8.2797	4.0478	9.1553	6.5422	5.1075
7	7.0859	6.9972	7.5736	9.6159	6.4951	7.5535	3.1208
8	5.4660	5.0871	6.3453	8.1644	4.8988	5.9923	3.2656
9	7.7648	4.6558	6.3900	6.2530	7.6207	6.5369	3.1090
10	8.1085	8.8318	8.6785	9.2327	6.1640	8.2031	3.0687
11	8.7065	5.5371	8.8586	5.4417	8.7477	7.4583	3.4169
12	9.0633	4.7748	4.7282	6.3972	5.8059	6.1539	4.3351
13	9.5757	9.7733	6.4624	9.2489	9.0294	8.8179	3.3109
14	9.7576	4.4539	5.6993	7.4045	9.2438	7.3118	5.3037
15	4.6298	5.8606	4.3202	5.8651	7.3299	5.6011	3.0097
16	9.2929	6.9064	6.9950	9.7821	6.0394	7.8032	3.7427
17	7.9035	5.9566	5.5377	5.9570	5.7636	6.2237	2.3658
18	5.4820	4.5020	5.7393	4.3039	6.1969	5.2448	1.8930
19	6.2440	6.8100	9.1977	8.8105	5.9499	7.4024	3.2478
20	8.2574	7.2856	9.6696	9.9660	9.5062	8.9370	2.6804
21	4.2803	9.4319	7.9046	8.4088	7.3099	7.4671	5.1516
22	8.9881	9.7129	7.1343	4.1487	4.2286	6.8425	5.5642
23	7.0145	8.8778	8.3974	4.7942	4.8911	6.7950	4.0836
24	7.6052	4.7650	4.3194	6.1143	4.9184	5.5445	3.2858
25	9.1085	5.2811	5.0610	8.3911	5.8035	6.7290	4.0475
26	6.0176	7.3105	4.5674	7.6165	9.5055	7.0035	4.9381
27	4.9803	9.6678	5.1100	7.4636	7.8571	7.0158	4.6875
28	9.2899	6.2779	9.8377	7.0898	9.9125	8.4816	3.6346
29	8.9664	6.7688	8.1299	4.4367	8.3859	7.3375	4.5297
30	4.9980	8.6457	4.8078	4.5373	7.3246	6.0627	4.1084

4.1.5. Palm Kernel Cake (PKC)

This contains the sampling data of Palm kernel cake highlighting crude fibre and crude protein content as the essential parameters.

Table 4.9 shows the crude fibre values for Palm kernel cake below

Table 4.9: Crude Fibre Values for Palm Kernel Cake

Palm Kernel Cake (PKC) - Crude Fibre (Max: 18.0)							
Day	**S1**	**S2**	**S3**	**S4**	**S5**	**$\bar{x}$ (Mean)**	**R (Range)**
1	12.3949	13.7152	16.0113	15.6091	13.4706	14.2402	3.6164
2	9.0683	9.1705	10.1425	12.7756	12.5781	10.7470	3.7073
3	9.0746	15.3665	17.0921	12.4232	13.5957	13.5104	8.0175
4	15.7817	16.2997	9.7144	10.0859	10.4447	12.4653	6.5853
5	11.4305	14.4356	14.3973	12.9004	10.9459	12.8219	3.4897
6	13.4704	9.9801	14.5880	15.5050	10.3217	12.7730	5.5249
7	16.9603	17.2940	17.4598	15.4568	10.1496	15.4641	7.3102
8	7.3955	8.3806	16.4262	8.1263	17.6280	11.5913	10.2325
9	14.5918	14.9461	12.9348	13.1851	12.8621	13.7040	2.0840
10	17.1162	7.4857	17.5467	16.1648	8.0601	13.2747	10.0610
11	13.9159	13.0894	11.2613	17.4241	11.9787	13.5339	6.1628
12	8.8185	14.1616	14.2135	8.5106	7.4394	10.6287	6.7741
13	10.3070	15.7980	17.4331	16.4053	8.9358	13.7758	8.4973
14	15.7677	13.4490	10.0839	17.4077	8.9690	13.1355	8.4387
15	12.3071	10.1997	10.0027	16.9581	16.5120	13.1959	6.9554
16	13.1568	8.8231	10.4391	8.0390	15.9384	11.2793	7.8994
17	8.2249	17.2502	12.0557	13.6449	8.0110	11.8373	9.2392
18	16.6076	12.0782	12.8915	11.5712	16.1073	13.8512	5.0364
19	15.9783	17.6510	8.1976	14.8328	13.4745	14.0268	9.4534
20	7.8306	8.5581	13.9991	14.5742	17.1297	12.4183	9.2991
21	10.4399	14.9794	14.3748	10.6159	13.4884	12.7797	4.5395
22	11.3716	9.7423	16.8952	17.7446	15.1516	14.1811	8.0023
23	16.0076	14.1075	16.1258	13.2460	8.0261	13.5026	8.0997
24	15.9646	14.6753	15.1936	10.9551	11.4176	13.6412	5.0095
25	11.8833	11.3325	14.8143	14.4285	17.5620	14.0041	6.2295
26	10.8393	12.8562	9.5991	17.4040	15.5849	13.2567	7.8049
27	12.6623	8.2978	8.0081	8.2346	9.9892	9.4384	4.6542
28	13.6743	16.2659	12.8691	9.2222	11.6930	12.7449	7.0437
29	15.1101	15.8806	8.8400	10.6922	14.0187	12.9083	7.0406
30	12.6476	8.7746	9.8367	8.0786	15.1862	10.9047	7.1076

Table 4.10 shows the crude protein values for Palm kernel cake below

Table 4.10: Crude Protein Values for Palm Kernel Cake

Palm Kernel Cake (PKC) - Crude Protein (Min: 14.7)

Day	S1	S2	S3	S4	S5	$\bar{x}$ (Mean)	R (Range)
1	15.5044	16.3896	16.4152	17.1370	16.3521	16.3597	1.6326
2	16.8675	15.0727	16.8867	16.5043	15.1201	16.0903	1.8140
3	17.2566	14.7585	14.7863	16.0291	15.3858	15.6433	2.4981
4	16.5600	15.4521	15.2464	17.3998	17.1704	16.3657	2.1534
5	15.7517	15.4462	16.1720	15.4371	14.8429	15.5300	1.3291
6	16.8919	16.2708	16.7492	14.8250	14.8131	15.9100	2.0788
7	14.7488	16.0674	16.1619	17.2130	15.3209	15.9024	2.4642
8	16.9804	17.5169	14.8687	16.1752	16.6017	16.4286	2.6482
9	16.7805	15.5502	14.8526	16.9162	16.6622	16.1523	2.0636
10	16.8881	15.3613	15.5947	15.1976	16.2493	15.8582	1.6905
11	14.9132	16.6589	15.3141	17.5756	15.5824	16.0088	2.6624
12	17.0604	14.7123	17.5151	14.8390	17.3243	16.2902	2.8028
13	16.0564	17.0622	17.4306	16.9323	16.1289	16.7221	1.3742
14	16.0241	17.1913	17.5628	16.3162	14.9730	16.4135	2.5898
15	16.7025	15.9849	15.0328	17.3143	15.6869	16.1443	2.2815
16	16.6599	15.0264	17.5203	16.8933	15.3841	16.2968	2.4939
17	16.2722	16.0001	16.5746	17.6338	17.3990	16.7759	1.6337
18	15.9883	16.9168	16.7408	17.1107	15.4497	16.4413	1.6610
19	15.2121	16.6751	15.9099	16.2337	14.8154	15.7692	1.8597
20	14.7315	14.7273	17.3388	16.2271	16.5748	15.9199	2.6115
21	16.8044	17.4118	16.6731	16.3816	16.7785	16.8099	1.0302
22	16.6907	16.6209	16.1049	15.1124	16.9119	16.2882	1.7995
23	15.8051	16.1379	16.8469	16.7328	16.3850	16.3815	1.0418
24	15.9132	17.4089	16.3670	16.8697	17.2482	16.7614	1.4957
25	15.3683	16.2371	16.9611	15.8935	17.5850	16.4090	2.2167
26	16.7791	16.3680	15.6298	15.5619	16.6119	16.1901	1.2172
27	16.5355	16.7123	14.7600	15.4829	17.4013	16.1784	2.6413
28	17.3981	16.5110	16.8291	14.9786	16.8865	16.5207	2.4195
29	16.3286	16.5363	16.7012	17.2395	15.2418	16.4095	1.9977
30	15.6975	15.9423	15.6147	17.3939	17.4123	16.4121	1.7976

4.1.6. Maize Offal

This contains the sampling data of maize offal highlighting crude fibre and starch content as the essential parameters.

Table 4.11 shows the crude fibre values for maize offal below

Table 4.11: Crude Fibre Values for Maize Offal

Maize Offal - Crude Fibre (Max: 4.9)							
Day	**S1**	**S2**	**S3**	**S4**	**S5**	**$\bar{x}$ (Mean)**	**R (Range)**
1	4.6062	3.5235	2.3679	2.5300	3.9388	3.3933	2.2383
2	2.6192	2.4700	3.7519	4.7704	3.7432	3.4709	2.3004
3	1.9986	3.6893	3.9475	2.3000	4.1337	3.2138	2.1351
4	2.4882	4.5118	4.8819	2.0709	3.4723	3.4850	2.8110
5	3.4433	3.4145	2.4367	3.1786	4.7464	3.4439	2.3097
6	4.5192	2.8181	2.5704	4.8998	3.5182	3.6651	2.3294
7	4.4316	3.9168	4.6241	3.4471	3.6328	4.0105	1.1770
8	4.5724	2.3208	2.7792	4.3081	2.3637	3.2688	2.2516
9	3.9280	3.7593	4.7813	2.8037	4.3027	3.9150	1.9776
10	4.6817	3.5055	2.7334	4.2357	2.7156	3.5744	1.9661
11	4.0493	2.8026	3.9175	2.0406	3.2779	3.2176	2.0087
12	3.5132	3.3658	4.2468	2.9402	2.2106	3.2553	2.0362
13	2.0627	4.4871	4.8256	3.1081	3.6036	3.6174	2.7629
14	4.6741	2.1697	3.0771	2.9088	4.4443	3.4548	2.5044
15	2.8177	2.1819	3.5879	3.2882	2.8666	2.9485	1.4060
16	2.1040	2.8822	2.3455	2.5806	3.5606	2.6946	1.4566
17	2.4074	2.9368	4.0210	3.8657	2.4839	3.1430	1.6136
18	4.4634	3.7821	3.3837	2.0430	3.9526	3.5250	2.4204
19	3.9347	3.9163	3.4262	2.1204	2.5856	3.1966	1.8143
20	3.4066	4.0873	3.5105	3.1082	4.6843	3.7594	1.5761
21	3.8980	3.6522	3.4012	2.1631	3.2676	3.2764	1.7349
22	2.9447	3.9184	3.9674	3.7884	3.8365	3.6911	1.0227
23	2.9401	4.3327	3.5674	2.8047	4.1213	3.5532	1.5280
24	3.3549	3.4960	2.9286	2.1349	3.0272	2.9883	1.3611
25	3.8518	2.8354	3.1374	2.0842	4.7217	3.3261	2.6375
26	2.2501	2.3694	2.1952	4.5821	2.4720	2.7738	2.3869
27	3.5557	3.1837	4.1997	4.8764	4.6822	4.0995	1.6927
28	4.0334	3.5928	2.1147	3.8874	3.3918	3.4040	1.9187
29	4.6349	2.3896	2.2590	4.6549	3.7090	3.5295	2.3959
30	3.7540	3.1697	1.9867	2.9463	2.1392	2.7992	1.7673

Table 4.12 shows the starch values for maize offal below

Table 4.12: Starch Values for Maize Offal

Maize Offal - Starch (Max: 43.0)

Day	S1	S2	S3	S4	S5	$\bar{x}$ (Mean)	R (Range)
1	24.1808	40.1120	37.1358	29.9914	22.0681	30.6976	18.0439
2	24.1541	31.4945	26.7406	32.7040	32.7593	29.5705	8.6052
3	19.3440	34.6991	29.6928	35.0815	21.2992	28.0233	15.7375
4	31.4483	17.2031	37.7527	31.8346	18.7922	27.4062	20.5496
5	25.0081	27.7229	25.8627	24.5440	42.2409	29.0757	17.6969
6	24.2657	41.1808	30.5992	21.7881	19.6584	27.4984	21.5224
7	41.2237	33.9693	18.3303	24.6356	23.6153	28.3548	22.8934
8	40.4123	37.4047	17.7398	17.3011	23.6346	27.2985	23.1112
9	36.8961	20.3430	18.5922	29.7189	33.9501	27.9001	18.3039
10	31.6223	19.3205	22.4872	35.2652	21.3276	26.0046	15.9447
11	18.8448	29.3772	34.3524	25.1900	23.9405	26.3410	15.5076
12	30.3973	29.8086	30.8547	21.0252	31.9936	28.8159	10.9684
13	36.7977	17.4625	34.7155	40.4749	41.2268	34.1355	23.7643
14	27.2287	36.9534	40.8104	25.4295	42.5877	34.6019	17.1582
15	40.9816	23.3781	31.7335	30.4394	22.3340	29.7733	18.6476
16	42.3911	18.5462	22.5853	41.9409	17.8779	28.6683	24.5132
17	21.4680	39.4975	42.0386	24.6830	17.7071	29.0788	24.3315
18	18.5596	33.7476	36.2764	32.6017	42.5640	32.7499	24.0044
19	22.9945	39.4255	25.5302	20.4403	22.5018	26.1785	18.9852
20	25.3206	21.4145	33.6074	24.8837	22.4216	25.5296	12.1929
21	30.4102	35.4967	27.9938	20.3260	33.7343	29.5922	15.1707
22	19.2180	30.7472	18.6790	33.7429	32.0990	26.8972	15.0639
23	37.1543	18.9144	36.8873	30.9060	32.3478	31.2420	18.2399
24	25.9490	37.4045	21.9192	23.8786	36.7669	29.1836	15.4853
25	27.6390	41.6220	28.9893	25.3705	25.3915	29.8025	16.2515
26	28.0634	22.3266	21.1861	38.9615	25.6375	27.2350	17.7754
27	28.6264	39.2202	35.3000	41.0874	30.2087	34.8885	12.4610
28	37.1098	17.5027	29.9017	25.5971	35.0174	29.0257	19.6071
29	22.4853	25.0586	32.9751	32.0839	22.6363	27.0478	10.4898
30	38.4919	40.8510	17.8881	22.5152	33.0336	30.5560	22.9629

4.2 Analysis of Data

The findings derived from the data presentation made use of Statistical Process Control tools on chosen feed raw materials. The examination emphasizes assessing process stability and variability through the use of $\bar{X}$ and R charts.

4.2.1 Statistical Process Control Tools

To calculate the grand mean ($\bar{\bar{X}}$): $\frac{\sum \bar{X}}{n}$

This becomes the CL for the X chart

To calculate the grand range ($\bar{R}$): $\frac{\sum R}{n}$

This becomes the CL for the R chart

SPC constants:

Since sample size (n) = 5:

i. $A_2 = 0.58$

ii. $D_3 = 0$

iii. $D_4 = 2.11$

To calculate the control limits:

i. For the $\bar{X}$ chart (Mean chart)

Upper Control Limit (UCL_x): $UCL = \bar{X} + A_2\bar{R}$

Lower Control Limit (LCL_x): $LCL = \bar{X} - A_2\bar{R}$

ii. For the R chart (Range chart)

Upper Control Limit(UCL_R): $= D_4\bar{R}$

Lower Control Limit (LCL_R): $= D_3\bar{R}$

4.3. Statistical Process Control Analysis of Raw Materials

This section presents the analysis of the various raw materials using the Statistical Process Control tools.

4.3.1 Rice Offal Analysis

This section entails the analysis of rice offal crude fibre and ash using Statistical Process Control tools. Below is the table of values presenting the data taken over a period of 30 days.

4.3.1.1. Crude Fibre

i. $\bar{X}$ Chart Control Limits

The mean is calculated as $\bar{X} = \frac{\sum 108.5382}{30}$

$\bar{X} = 3.62$

$UCL = \bar{X} + A_2\bar{R}$

$= 3.62 + (0.58 \times 2.06)$

$UCL = 4.81$

$LCL = \bar{X} - A_2\bar{R}$

$= 3.62 - (0.58 \times 2.06)$

$LCL = 2.43$

ii. R Chart Control Limit

The range is calculated as $\bar{R} = \frac{61.9478}{30}$

$\bar{R} = 2.06$

UCL = $D_4\bar{R}$

$= 2.11 \times 2.06 = 4.35$

LCL = $D_3\bar{R} = 0$

4.3.1.2 Ash

i. $\bar{X}$ Chart Control Limits

The mean is calculated as $\bar{X} = \frac{162.2280}{30}$

$\bar{X} = 5.55$

UCL = $\bar{X} + A_2\bar{R}$

$= 5.55 + (0.58 \times 2.87)$

UCL = 7.21

LCL = $\bar{X} - A_2\bar{R}$

$= 5.55 - (0.58 \times 2.87)$

LCL = 3.89

ii. R Chart Control Limit

The range is calculated as $\bar{R} = \frac{85.0731}{30}$

$\bar{R} = 2.87$

$UCL = D_4\bar{R} = 2.11 \times 2.87 = 6.06$

$LCL = D_3\bar{R} = 0$

4.3.2 Wheat Bran Analysis

This section entails the analysis of wheat bran crude fibre and moisture using Statistical Process Control tools. Below is the table of values presenting the data taken over a period of 30 days.

4.3.2.1 Crude Fibre

i. $\bar{X}$ Chart Control Limits

The mean is calculated as $\bar{X} = \frac{168.4334}{30}$

$\bar{X} = 5.61$

$UCL = \bar{X} + A_2\bar{R}$

$= 5.61 + (0.58 \times 2.94)$

$UCL = 7.32$

$LCL = \bar{X} - A_2\bar{R} = 5.61 - (0.58 \times 2.94)$

$LCL = 3.9$

$= 7.26 + (0.58 \times 4.22)$

$UCL = 9.71$

$LCL = \bar{X} - A_2\bar{R} = 7.26 - (0.58 \times 4.22)$

$LCL = 4.81$

ii. R Chart Control Limits

The range is calculated as $\bar{R} = \frac{90.8277}{30}$

$\bar{R} = 2.94$

$UCL = D_4\bar{R} = 2.11 \times 2.94 = 6.2$

$LCL = D_3\bar{R} = 0$

4.3.2.2. Moisture.

i. $\bar{X}$ Chart Control Limits

The mean is calculated as $\bar{X} = \frac{209.7623}{30}$

$\bar{X} = 7.26$

$UCL = \bar{X} + A_2\bar{R}$

$= 7.26 + (0.58 \times 4.22)$

$UCL = 9.71$

$LCL = \bar{X} - A_2\bar{R}$

$= 7.26 - (0.58 \times 4.22)$

$LCL = 4.81$

ii. R Chart Control Limits

The range is calculated as $\bar{R} = \frac{126.9851}{30}$

$\bar{R} = 4.22$

UCL = $D_4\bar{R}$

= 2.11 × 4.22

UCL = 8.9

LCL = $D_3\bar{R} = 0$

4.3.3 Groundnut Cake (GNC) Analysis

This section entails the analysis of Groundnut cake crude protein and crude fat using Statistical Process Control (SPC) tools. Below is the table of values presenting the data taken over a period of 30 days.

4.3.3.1. Crude Protein

i. $\bar{X}$ Chart Control Limits

The mean is calculated as $\bar{X} = \frac{1490.8226}{30}$

$\bar{X} = 49.87$

UCL = $\bar{X} + A_2\bar{R}$

= 49.87 + (0.58 × 6.37)

UCL = 53.56

LCL = $\bar{X} - A_2\bar{R}$

= 49.87 − (0.58 × 6.37)

LCL = 46.18

ii. R Chart Control Limits

The range is calculated as $\bar{R} = \frac{187.3401}{30}$

$\bar{R} = 6.37$

UCL = $D_4\bar{R}$

= 2.11 × 6.37

UCL = 13.44

LCL = $D_3\bar{R} = 0$

4.3.3.2. Crude Fat

i. $\bar{X}$ Chart Control Limits

The mean is calculated as $\bar{X} = \frac{253.0267}{30}$

$\bar{X} = 8.41$

UCL = $\bar{X} + A_2\bar{R}$

= 8.41 + (0.58 × 1.49)

UCL = 9.27

LCL = $\bar{X} - A_2\bar{R}$

= 8.41 − (0.58 × 1.49)

LCL = 7.5

ii. R Chart Control Limits

The range is calculated as $\bar{R} = \frac{41.4531}{30}$

$\bar{R} = 1.49$

$UCL = D_4\bar{R}$

$= 2.11 \times 1.49$

$UCL = 3.14$

$LCL = D_3\bar{R} = 0$

4.3.4 Soya Meal Analysis

This section entails the analysis of soya meal crude protein and moisture using Statistical Process Control (SPC) tools. Below is the table of values presenting the data taken over a period of 30 days.

4.3.4.1 Crude Protein

i. $\bar{X}$ Chart Control Limits

The mean is calculated as $\bar{X} = \frac{41.4531}{30}$

$\bar{X} = 49.7$

$UCL = \bar{X} + A_2\bar{R}$

$= 49.7 + (0.58 \times 5.96)$

$UCL = 53.15$

$LCL = \bar{X} - A_2\bar{R}$

$= 49.87 - (0.58 \times 5.96)$

$LCL = 46.2$

ii. R Chart Control Limits

The range is calculated as $\bar{R} =$

$\bar{R} = 5.96$

UCL = $D_4\bar{R}$

$= 2.11 \times 5.96$

UCL = 12.57

LCL = $D_3\bar{R} = 0$

4.3.4.2 Moisture

i. $\bar{X}$ Chart Control Limits

The mean is calculated as $\bar{X} = \frac{205.3014}{30}$

$\bar{X} = 7.02$

UCL = $\bar{X} + A_2\bar{R}$

$= 7.02 + (0.58 \times 3.82)$

UCL = 9.23

LCL = $\bar{X} - A_2\bar{R}$

$= 7.02 - (0.58 \times 3.82)$

LCL = 4.80

ii. R Chart Control Limits

The range is calculated as $R = \frac{116.0136}{30}$

$\bar{R} = 3.82$

UCL = $D_4\bar{R}$

= 2.11 × 3.82

UCL = 8.06

LCL = $D_3\bar{R} = 0$

4.3.5. Palm Kernel Cake (PKC) Analysis

This section entails the analysis of palm kernel cake crude fibre and crude protein using Statistical Process Control (SPC) tools. Below is the table of values presenting the data taken over a period of 30 days.

4.3.5.1. Crude Fibre

i. $\bar{X}$ Chart Control Limits

The mean is calculated as $\bar{X} = \frac{386.4010}{30}$

$\bar{X} = 12.89$

UCL = $\bar{X} + A_2\bar{R}$

=12.89 + (0.58 × 6.89)

UCL = 16.89

LCL = $\bar{X} - A_2\bar{R}$

= 12.89 − (0.58 × 6.89)

LCL = 8.89

ii. R Chart Control Limits

The range is calculated as R = $\frac{207.0131}{30}$

$\bar{R}$ = 6.89

UCL = $D_4\bar{R}$

= 2.11 × 6.89

UCL = 14.54

LCL = $D_3\bar{R}$ = 0

4.3.5.2. Crude Protein

i. $\bar{X}$ Chart Control Limits

The mean is calculated as $\bar{X} = \frac{478.3449}{30}$

$\bar{X}$=16.26

UCL = $\bar{X} + A_2\bar{R}$

=16.26 + (0.58 × 2.01)

UCL = 17.43

LCL = $\bar{X} - A_2\bar{R}$

= 16.26− (0.58 ×2.01)

LCL = 15.09

LCL = $D_3\bar{R}$ = 0

ii. R Chart Control Limits

The range is calculated as R = $\frac{56.7429}{30}$

$\bar{R} = 2.01$

UCL = $D_4\bar{R}$

= 2.11 × 2.01

UCL = 4.24

LCL = $D_3\bar{R} = 0$

4.3.6. Maize Offal Analysis

This section entails the analysis of Maize offal crude fibre and starch using Statistical Process Control (SPC) tools. Below is the table of values presenting the data taken over a period of 30 days.

4.3.6.1. Crude Fibre

i. Data Presentation

Table 4.11 presents the crude fibre values for maize offal

ii. $\bar{X}$ Chart Control Limits

The mean is calculated as $\bar{X} = \frac{104.1748}{30}$

$\bar{X} = 3.41$

UCL = $\bar{X} + A_2\bar{R}$

=3.41 + (0.58 × 1.98)

UCL = 4.56

LCL = $\bar{X} - A_2\bar{R}$

= 3.41− (0.58 ×1.98)

LCL = 2.26

LCL = $D_3\bar{R}$ = 0

iii. R Chart Control Limits

The range is calculated as R = $\frac{57.5321}{30}$

$\bar{R}$ = 1.98

UCL = $D_4\bar{R}$

= 2.11 × 1.89

UCL = 3.98

LCL = $D_3\bar{R}$ = 0

4.3.6.2. Starch

i. $\bar{X}$ Chart Control Limits

The mean is calculated as $\bar{X} = \frac{876.3783}{30}$

$\bar{X}$ =29.11

UCL = $\bar{X} + A_2\bar{R}$

=29.11 + (0.58 × 18.08)

UCL = 39.59

$LCL = \bar{X} - A_2\bar{R}$

$= 29.11 - (0.58 \times 18.08)$

$LCL = 18.62$

$LCL = D_3\bar{R} = 0$

ii. R Chart Control Limits

The range is calculated as $R = \frac{525.4655}{30}$

$\bar{R} = 18.08$

$UCL = D_4\bar{R}$

$= 2.11 \times 18.08$

$UCL = 38.15$

$LCL = D_3\bar{R} = 0$

4.4. Interpretation of Results

4.4.1 Rice Offal

For the crude fibre content, the $\bar{X}$ chart shows that all observed values fall within the upper and lower control limits, indicating that the process mean is stable. The R chart also indicates that variability is within acceptable limits. The process is statistically in control, with consistent fibre content over time.

For the ash content, all data points lie within the control limits, although there are slight fluctuations across some days. The process is in control, but minor variations suggest slight inconsistency in mineral composition, possibly due to differences in raw material sourcing.

Figure 4.1 Shows mean chart of crude fibre content for rice offal below

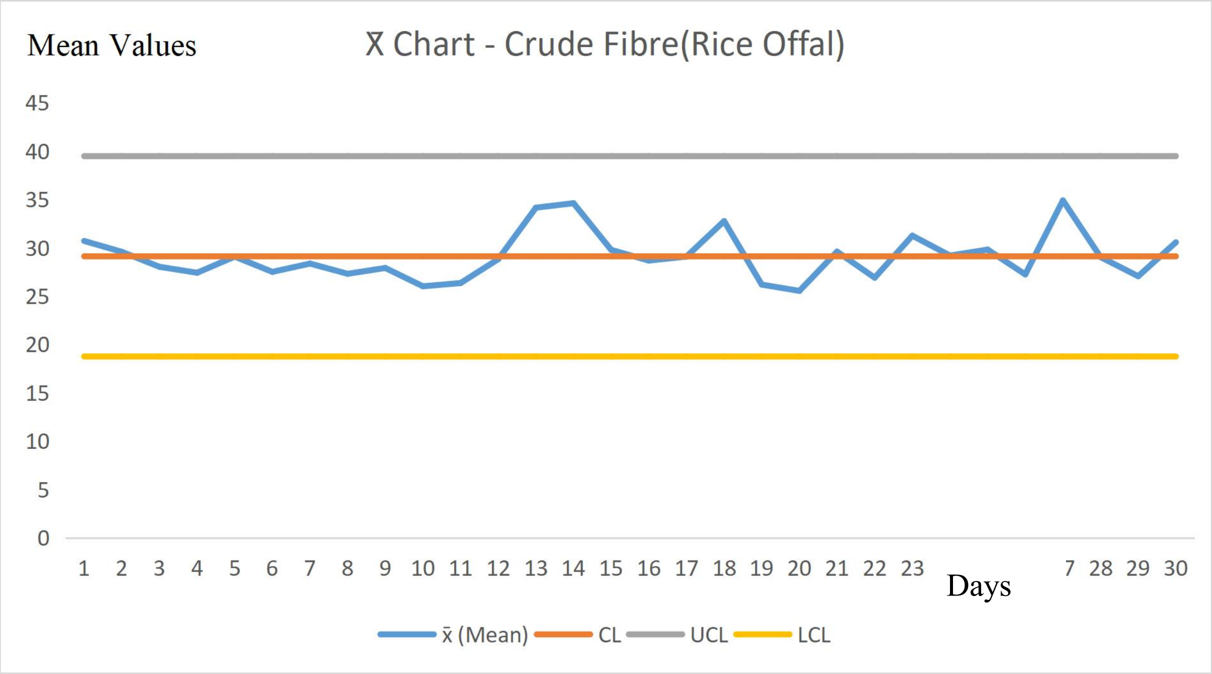

Figure 4.1 X̄ Chart - Crude Fibre(Rice Offal)

Figure 4.2 Shows range chart of crude fibre content for rice offal below

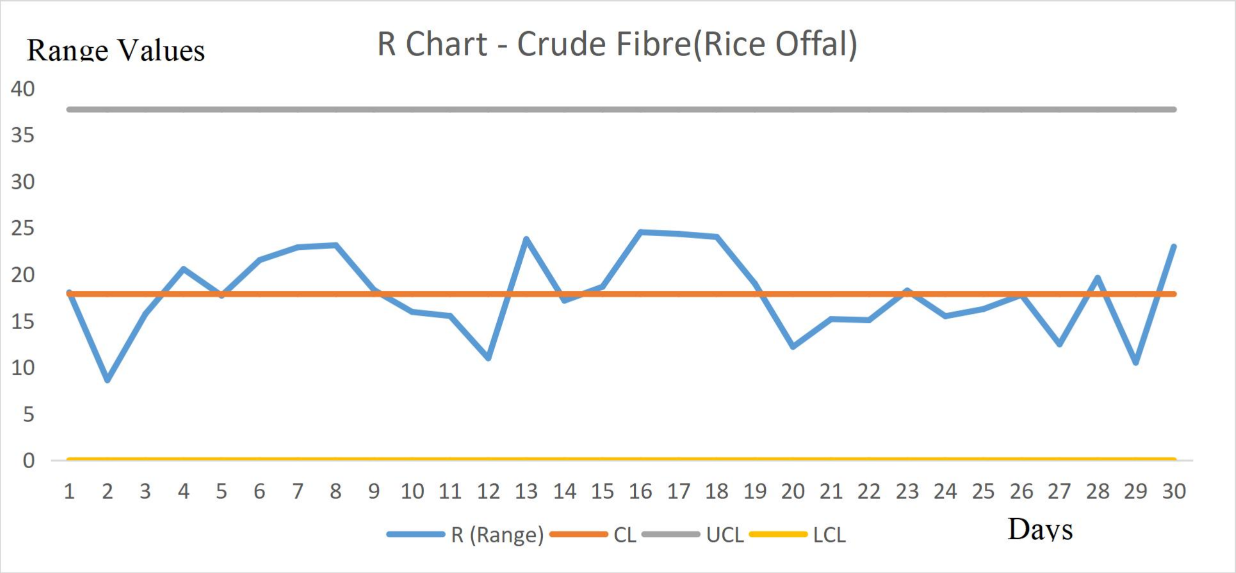

Figure 4.2 R Chart - Crude Fibre(Rice Offal

Figure 4.3 Shows the mean chart of ash content of rice offal below

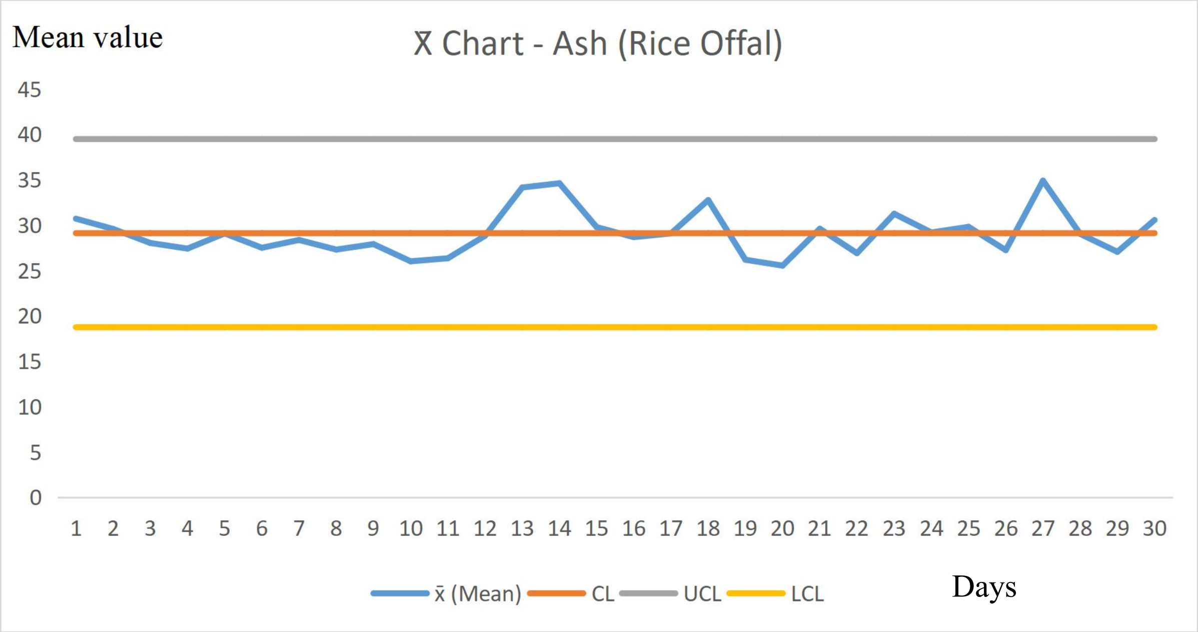

Figure 4.3 X̄ Chart - Ash (Rice Offal)

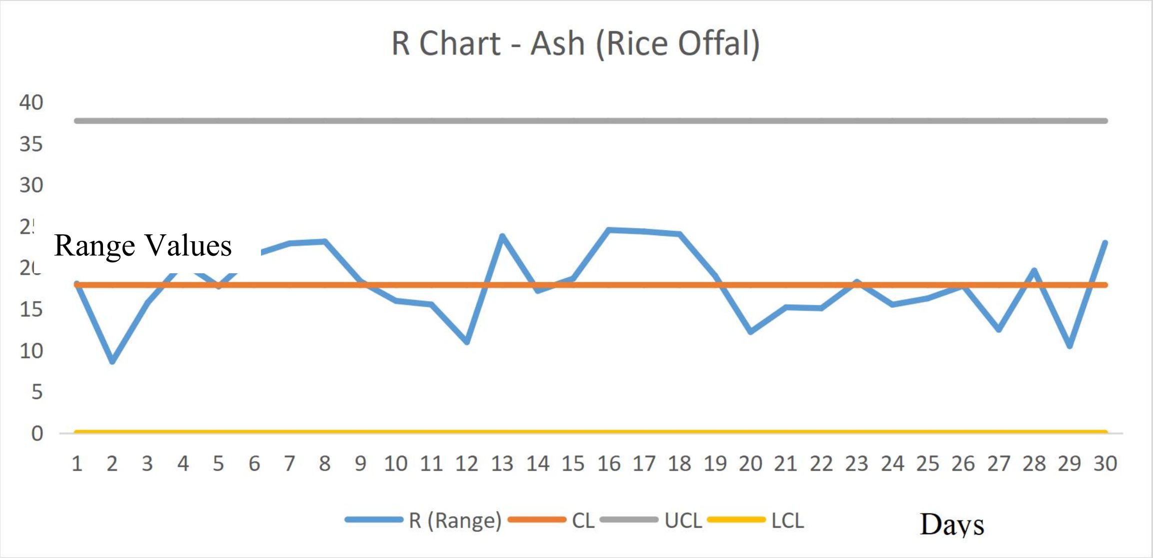

Figure 4.4 R Chart - Ash Rice Offal

4.4.2. Wheat Bran

For the crude fiber content, the control charts indicate that all points fall within the control limits, with no unusual patterns. The process is stable and consistent, indicating good control over fibre content.

For the moisture content, although all values fall within control limits, noticeable fluctuations are observed, with some points approaching the upper control limit. The process is statistically in control but shows signs of instability. Moisture variation may be influenced by environmental factors such as storage conditions or drying efficiency.

Figure 4.5 Shows the mean chart of crude fibre content wheat bran below

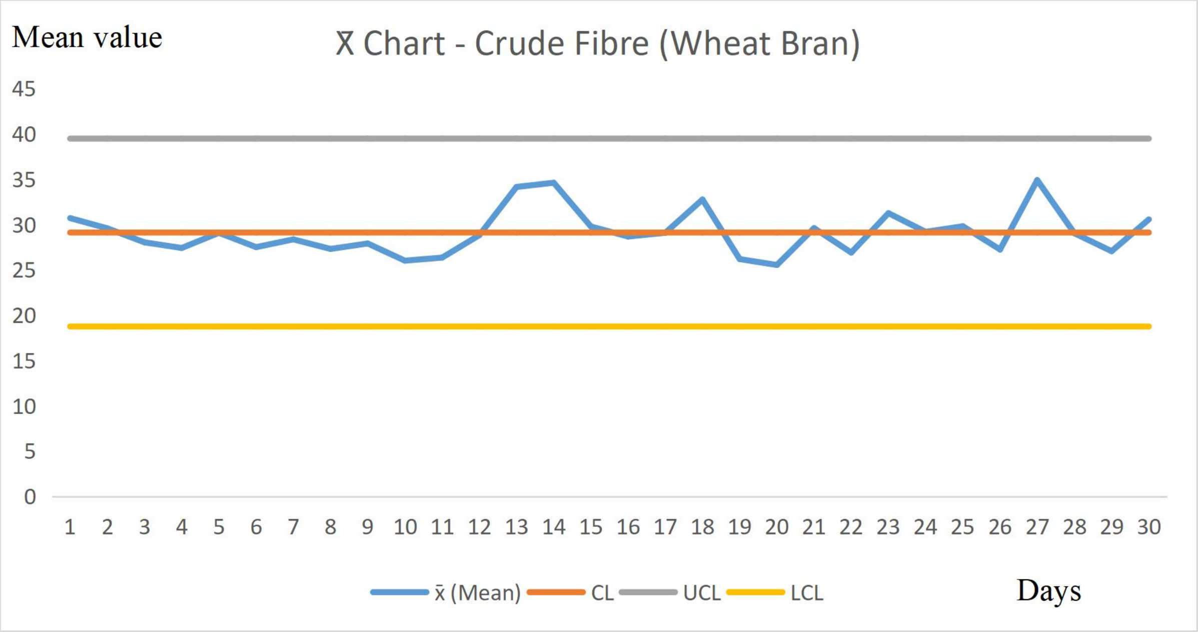

Figure 4.5 X̄ Chart Of Crude Fibre Wheat Bran

Figure 4.6 Shows the range chart of crude fibre content wheat bran below

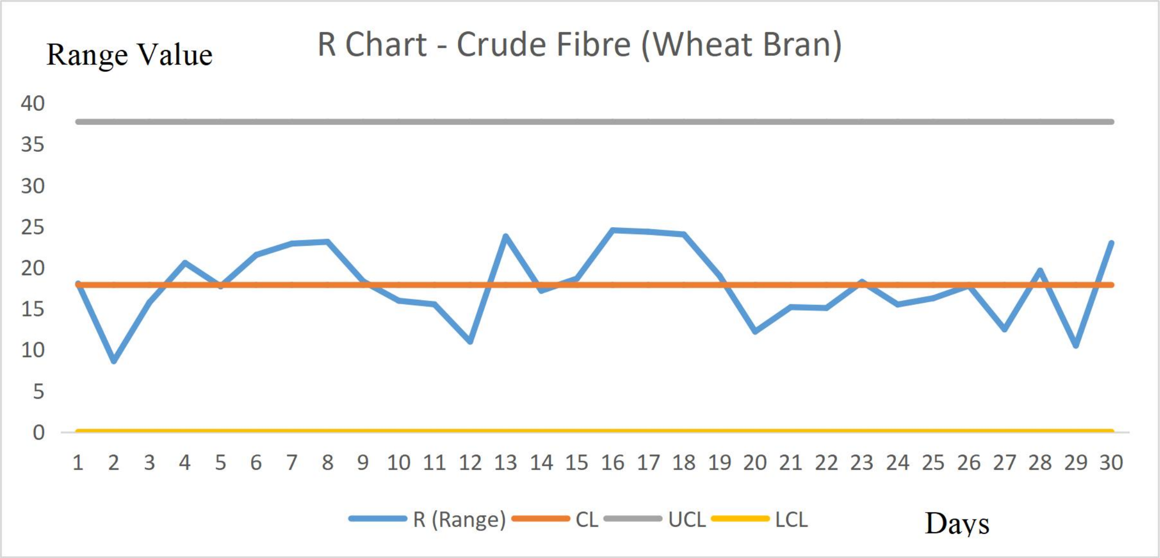

Figure 4.6 R Chart Of Crude Fibre Wheat Bran

Figure 4.7 Shows the mean chart of moisture content wheat bran below

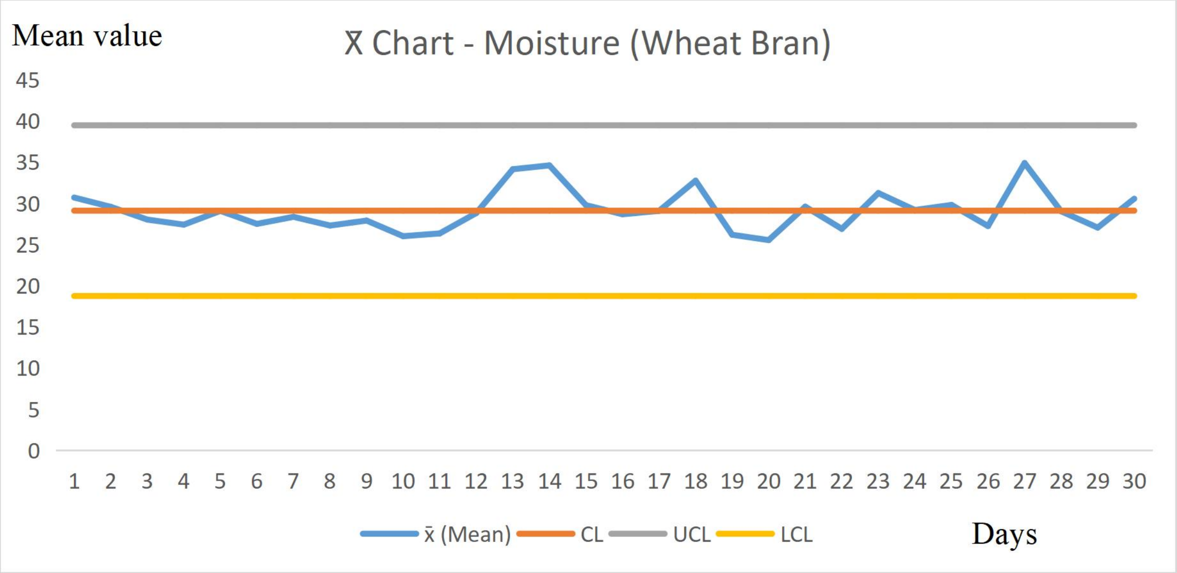

Figure 4.7 X̄ Chart – Moisture Content Wheat Bran

Figure 4.8 Shows the range chart of moisture content wheat bran below

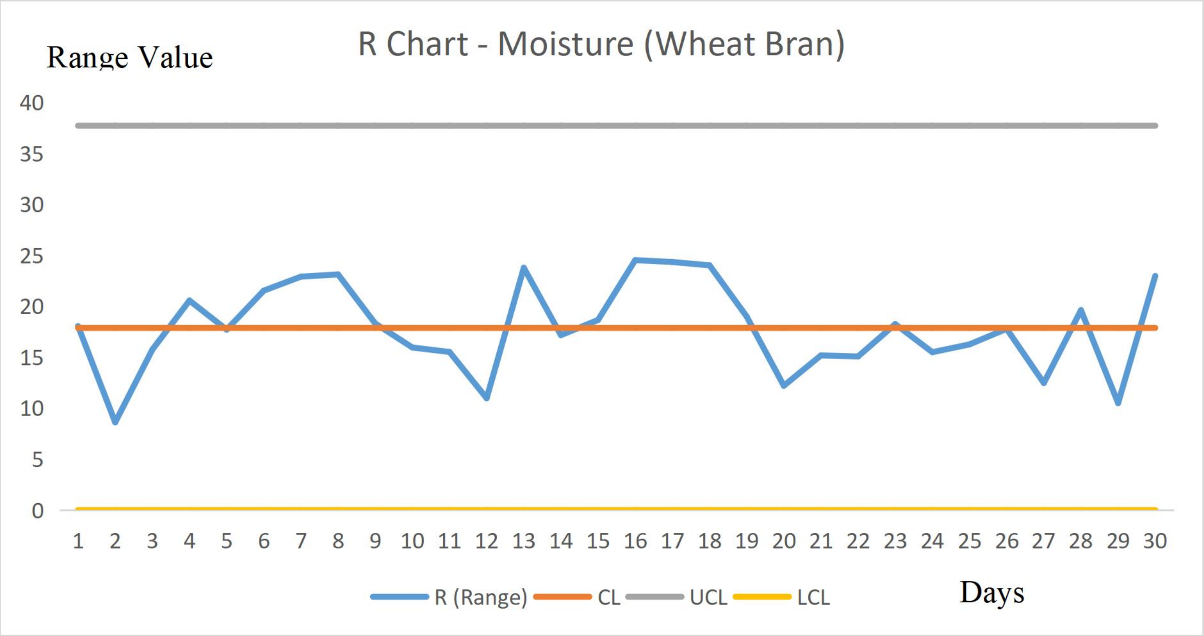

Figure 4.8 R Chart – Moisture Content Wheat Bran

4.4.3. Groundnut Cake (GNC)

For the crude protein, the $\bar{X}$ chart shows that the process mean remains within control limits, but the R chart indicates relatively high variability. The process is in control but highly variable, suggesting inconsistency in protein content, possibly due to variations in oil extraction efficiency or raw material quality.

For the fat content, both the $\bar{X}$ and R charts show that values are well within control limits with minimal fluctuation. The process is stable and consistent, indicating effective control of fat content during processing.

Figure 4.9 Shows the mean chart of crude protein content groundnut cake below

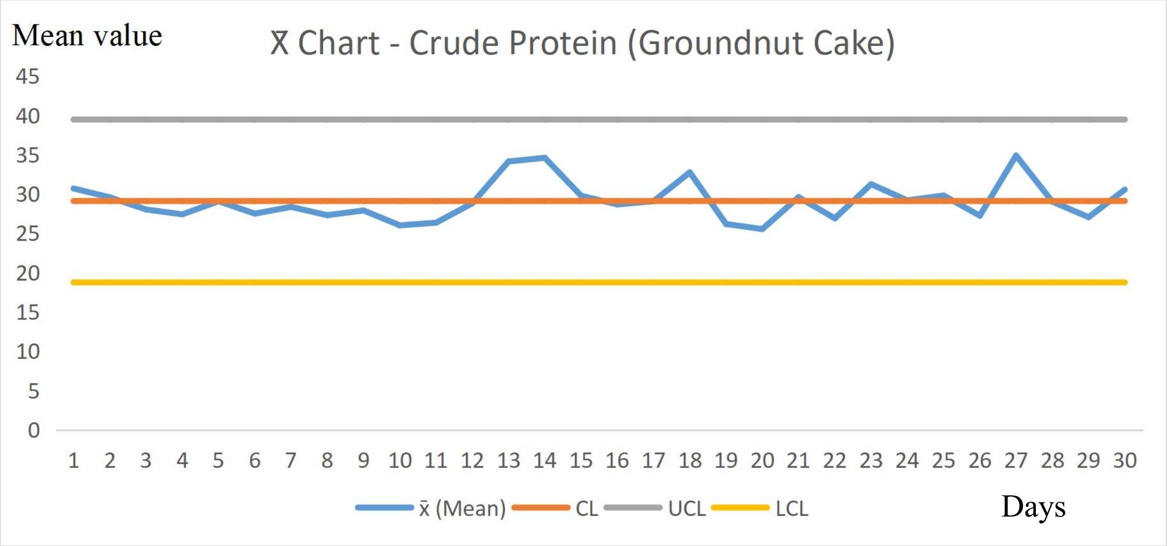

Figure 4.9 X̄ Chart Of Crude Protein Groundnut Cake

Figure 4.10 Shows the range chart of crude protein content groundnut cake below

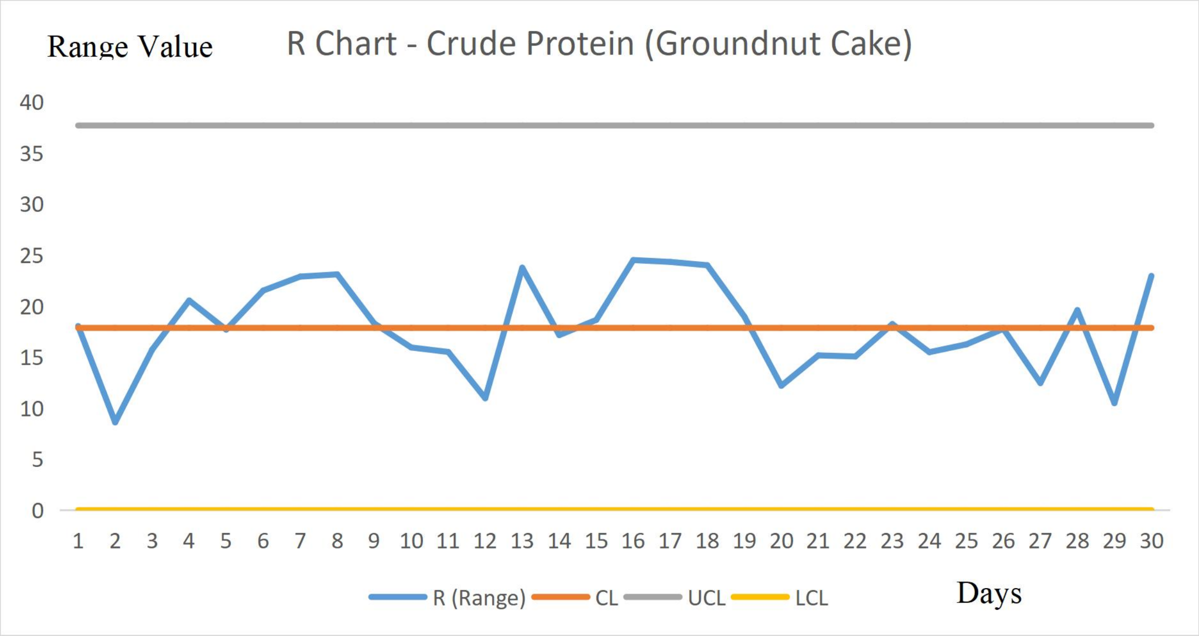

Figure 4.10 R Chart Of Crude Protein Below

Figure 4.11 Shows the mean chart of crude fat content groundnut cake below

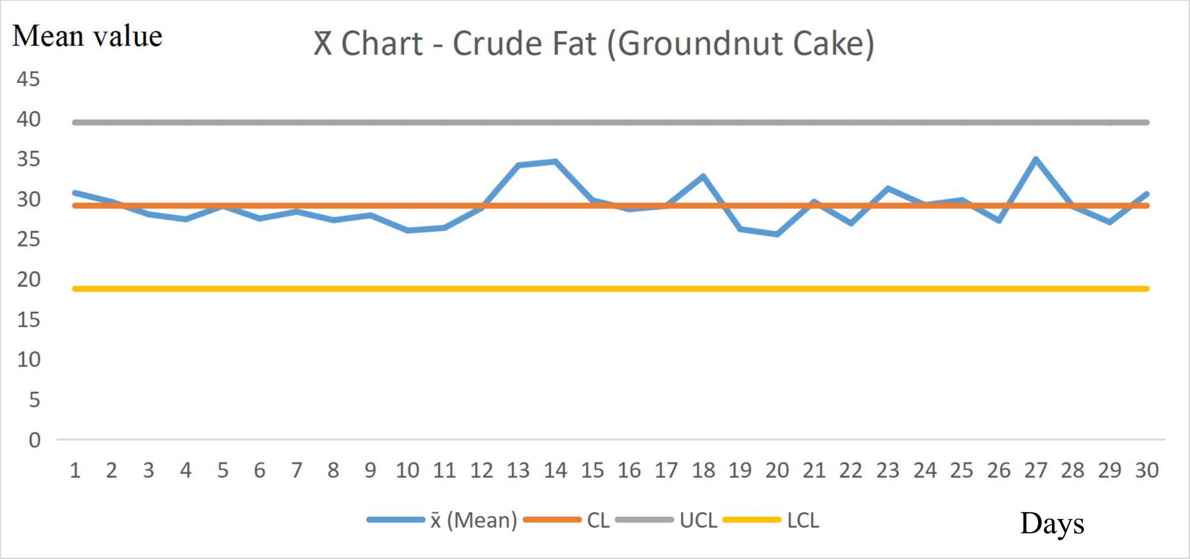

Figure 4.11 X̄ Chart Of Crude Fat Groundnut Cake

Figure 4.12 Shows the range chart of crude fat content groundnut cake below

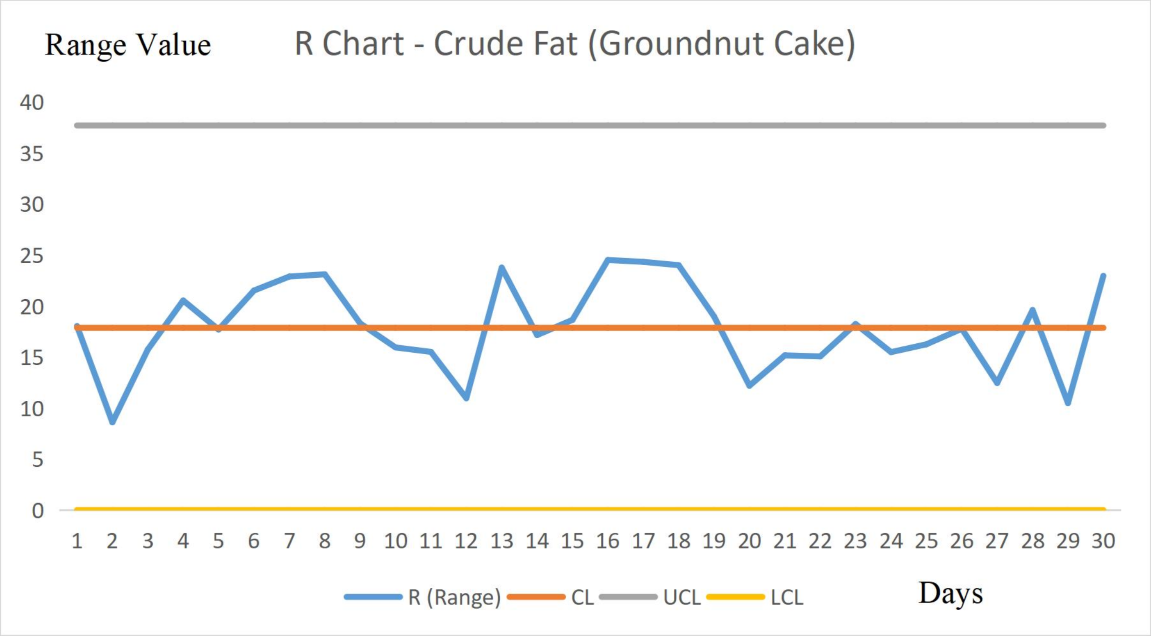

Figure 4.12 R Chart Of Crude Fat Groundnut Cake

4.4.4. Soya Meal

For the crude protein, the control charts indicate stable mean values with relatively low variability. The process is highly stable and consistent**,** reflecting good processing control and uniform raw material quality.

For the moisture content, it is within the acceptable limit and the process is under control with no significant variation that could affect the nutritional value.

Figure 4.13 Shows the mean chart of crude protein content soya meal below

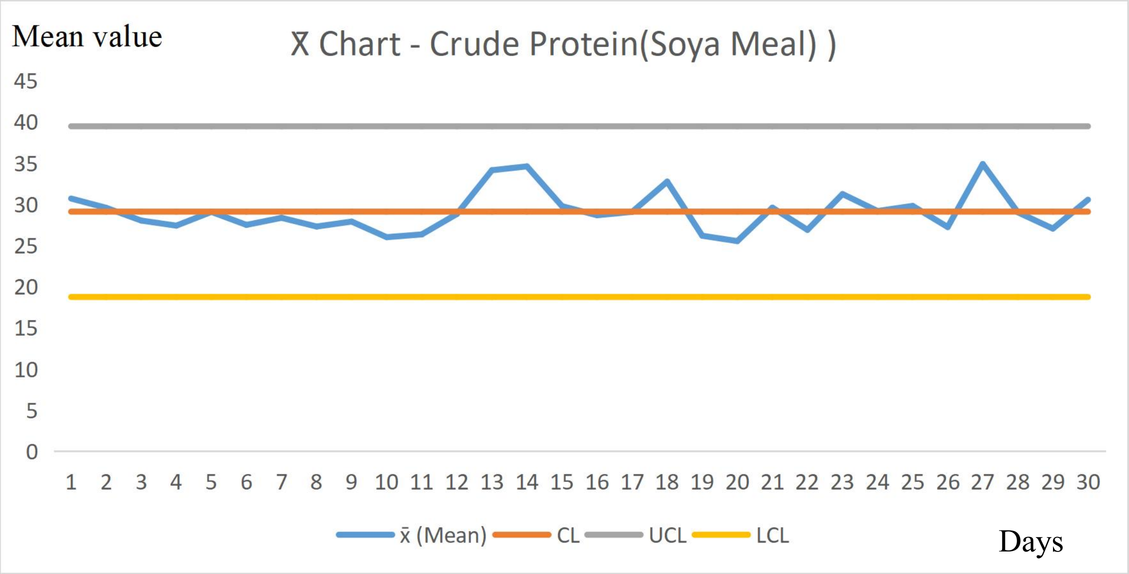

Figure 4.13 X̄ Chart Of Crude Protein Soya Meal

Figure 4.14 Shows the range chart of crude protein content soya meal below

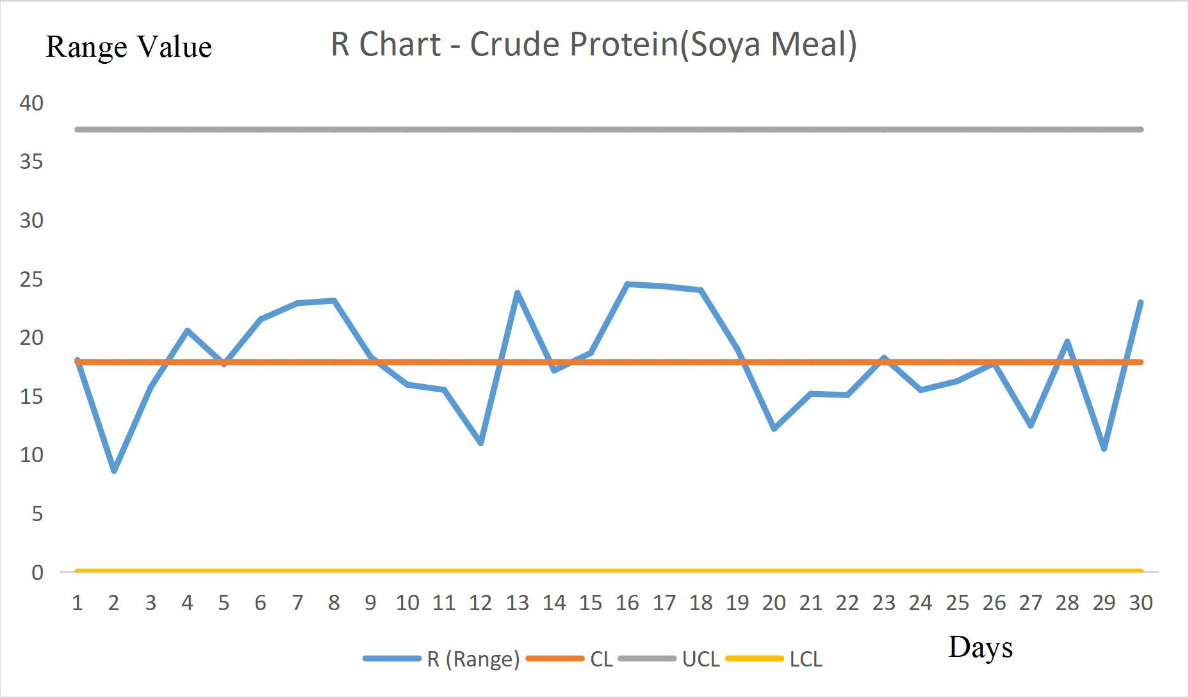

Figure 4.14 X̄ Chart Of Crude Protein Soya Meal

Figure 4.15 Shows the mean chart of moisture content soya meal below

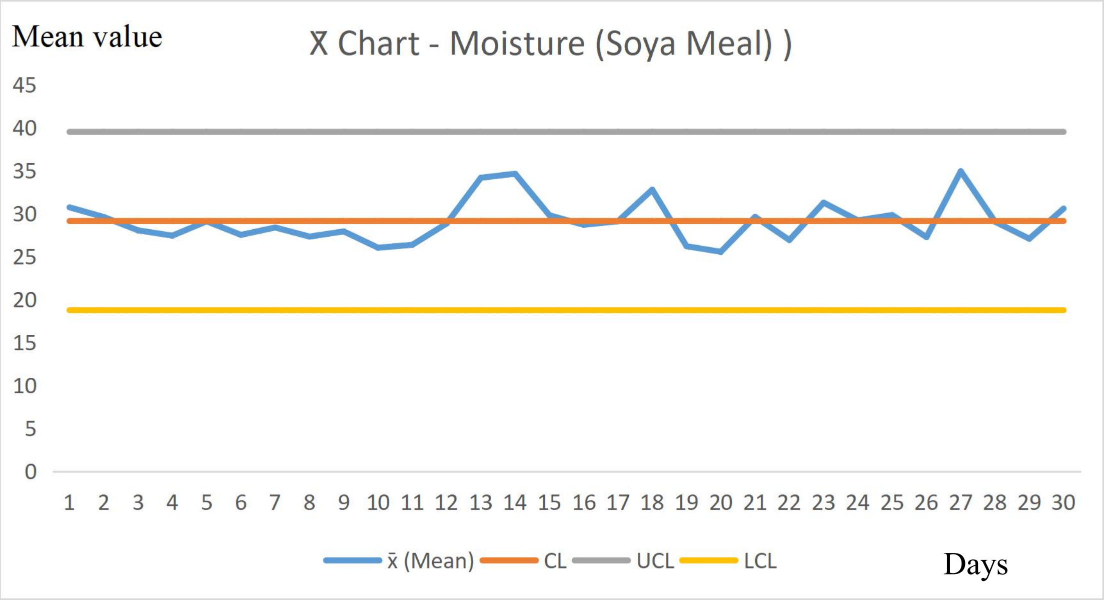

Figure 4.15 X̄ Chart of Moisture Content Soya Meal

Figure 4.16 Shows the rangechart of moisture content soya meal below

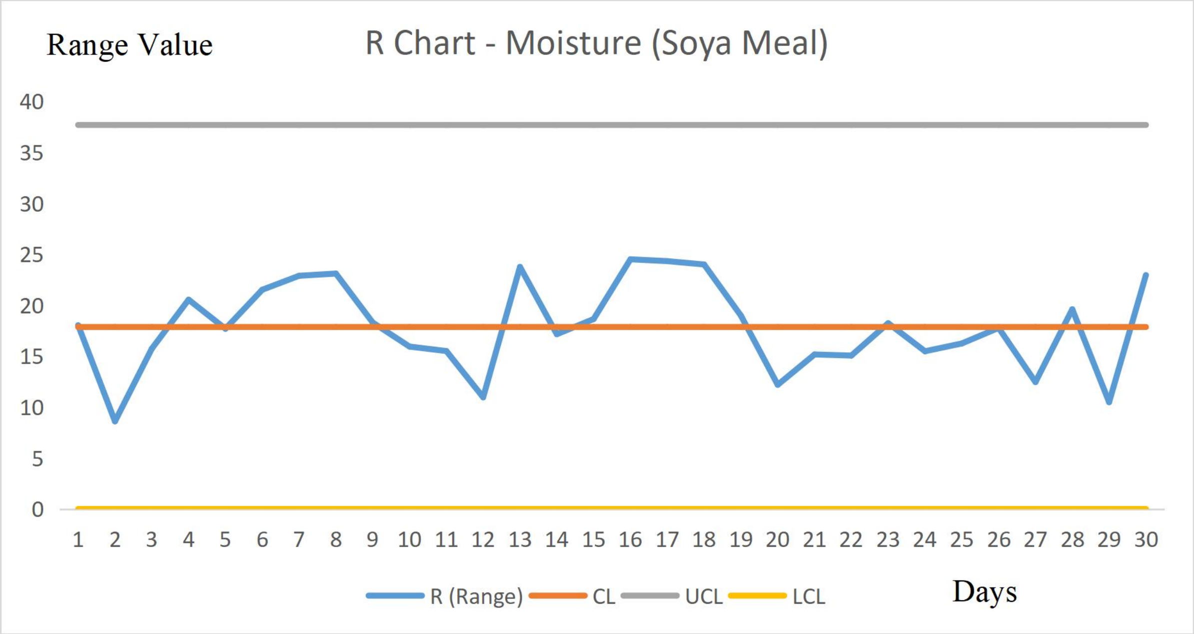

Figure 4.16 R range of Moisture Content Soya Meal

4.4.5. Palm Kernel Cake (PKC)

For the crude fibre content, the control charts show wider spread in data points compared to other materials, though still within control limits. The process is in control but moderately variable**,** indicating inconsistency in fibre composition, likely due to raw material differences.

For the crude protein content, the values remain within control limits with less fluctuation compared to fibre. The process is stable, indicating better control over protein content than fibre.

Figure 4.17 Shows the mean chart of crude fibire content palm kernel cake below

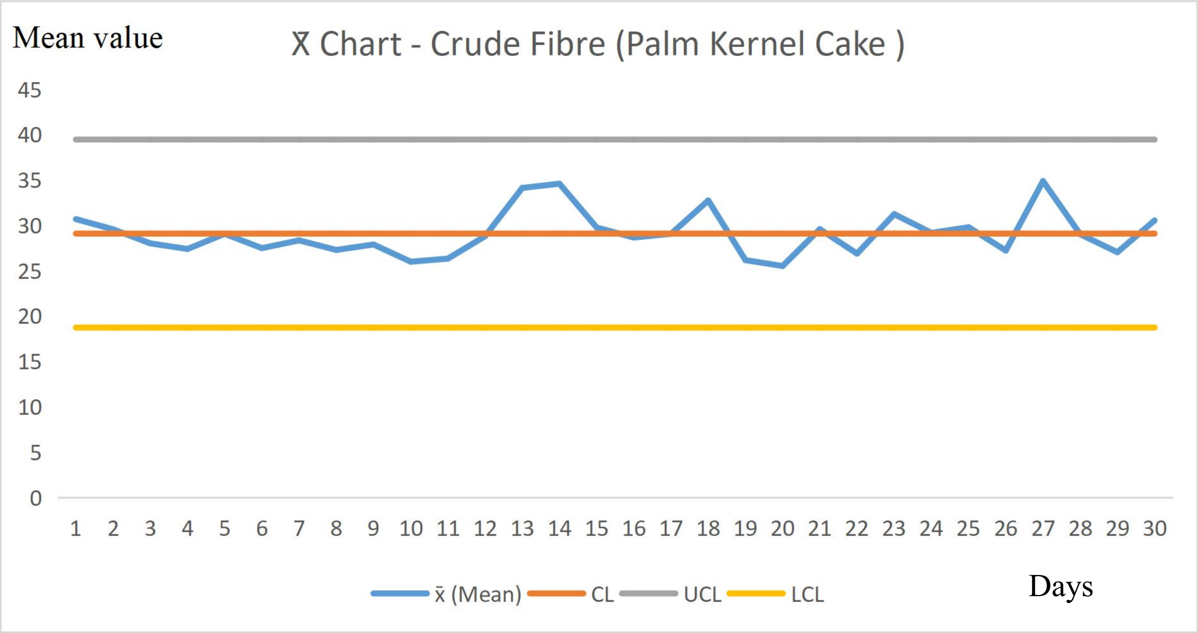

Figure 4.17 X̄ mean Chart of Crude Fibire Palm Kernel Cake

Figure 4.18 Shows the range chart of crude fibire content palm kernel cake below

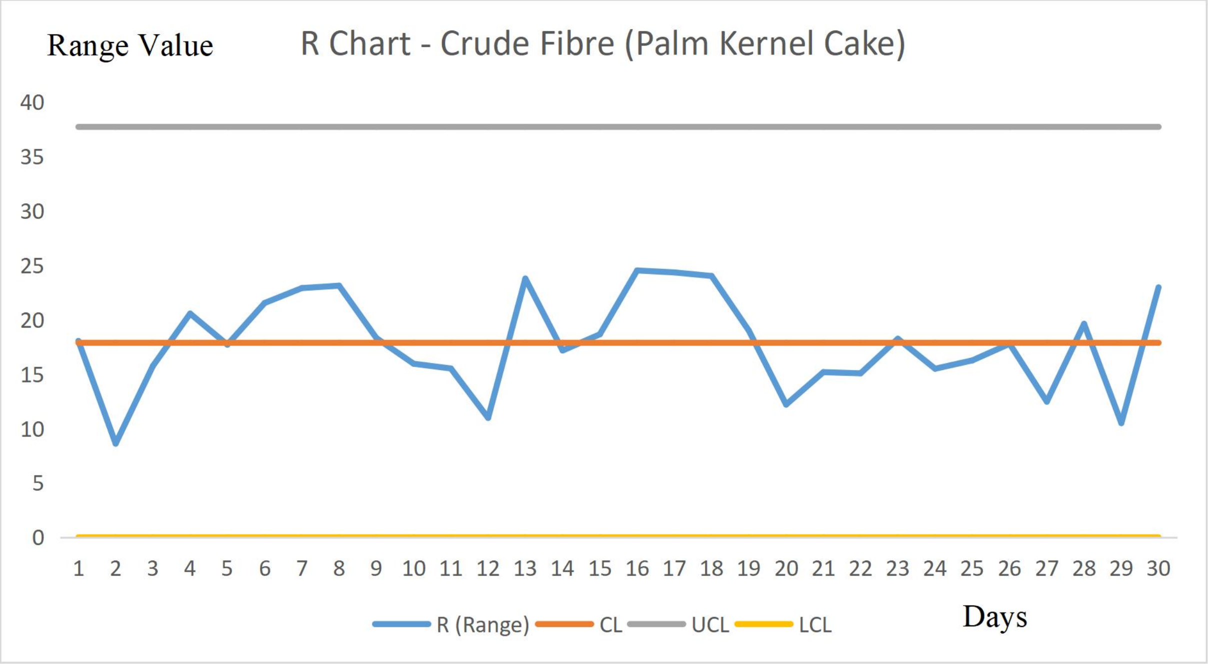

Figure 4.18 R range Chart of Crude Fibire Palm Kernel Cake

Figure 4.19 Shows the mean chart of crude fibire content palm kernel cake below

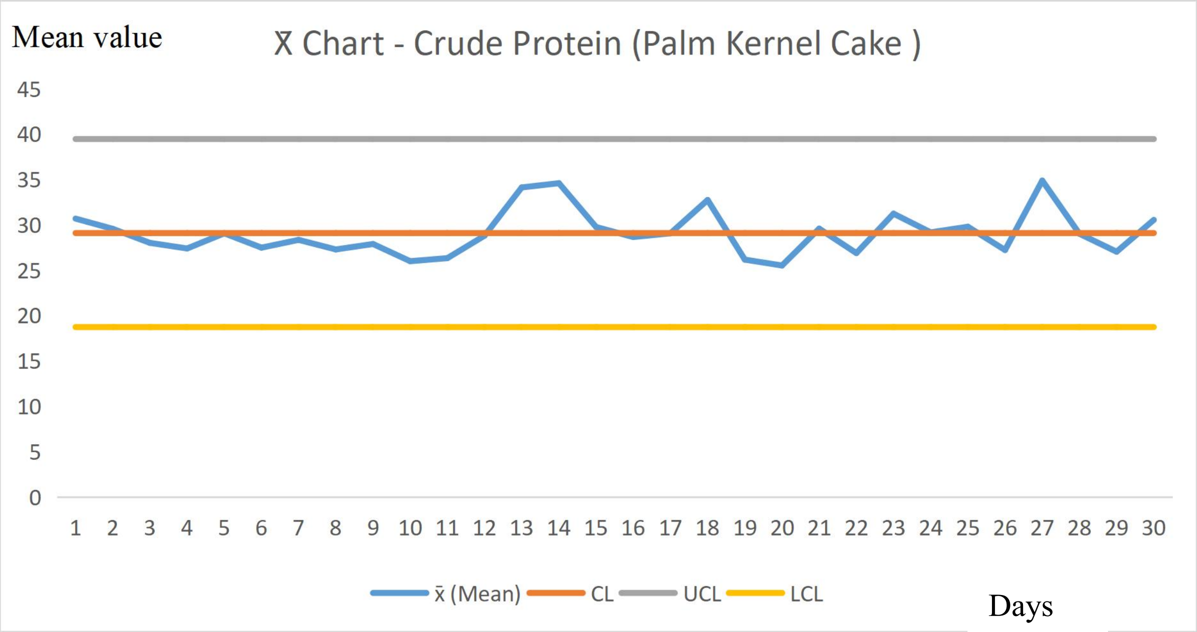

Figure 4.19 X̄ mean Chart of Crude Fibire Palm Kernel Cake

Figure 4.20 Shows the range chart of crude fibire content palm kernel cake below

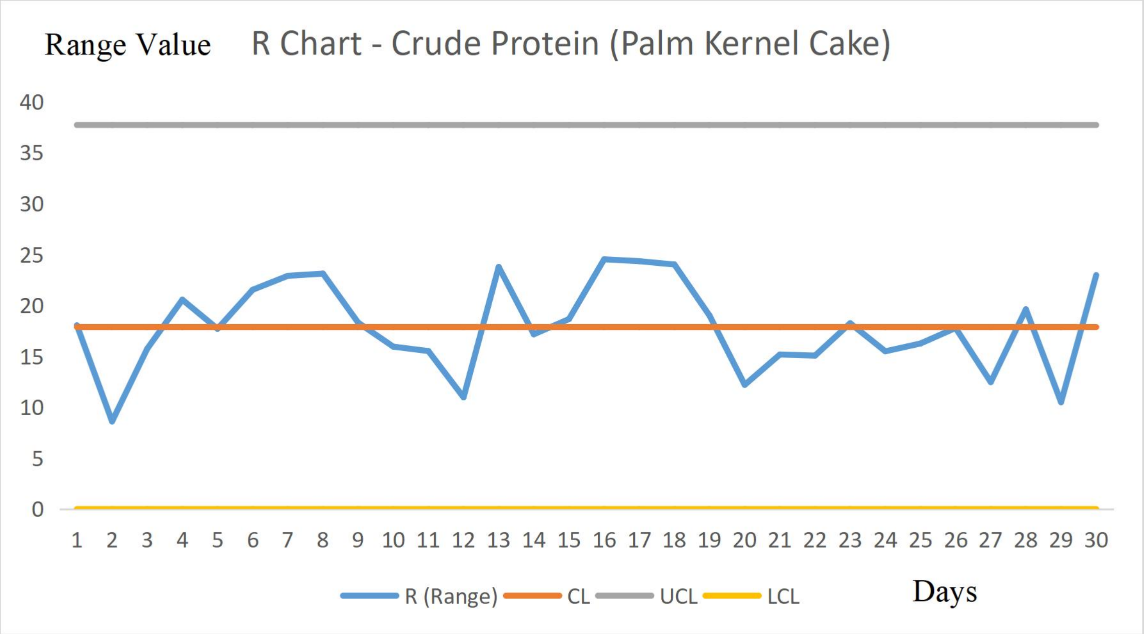

Figure 4.20 R Range Chart of Crude Fibire Palm Kernel Cake

4.4.6. Maize Offal

For the crude fibre content, the stability of the process suggests that the fibre content is well controlled and does not fluctuate significantly across the samples. The process is statistically in control though slight variations may exist due to differences in processing or raw material blending.

For the starch content, the data indicates that the values are relatively consistent across samples suggesting that the energy contribution of the maize offal remains stable.

Figure 4.21 Shows the mean chart of crude fibire content maize offal below

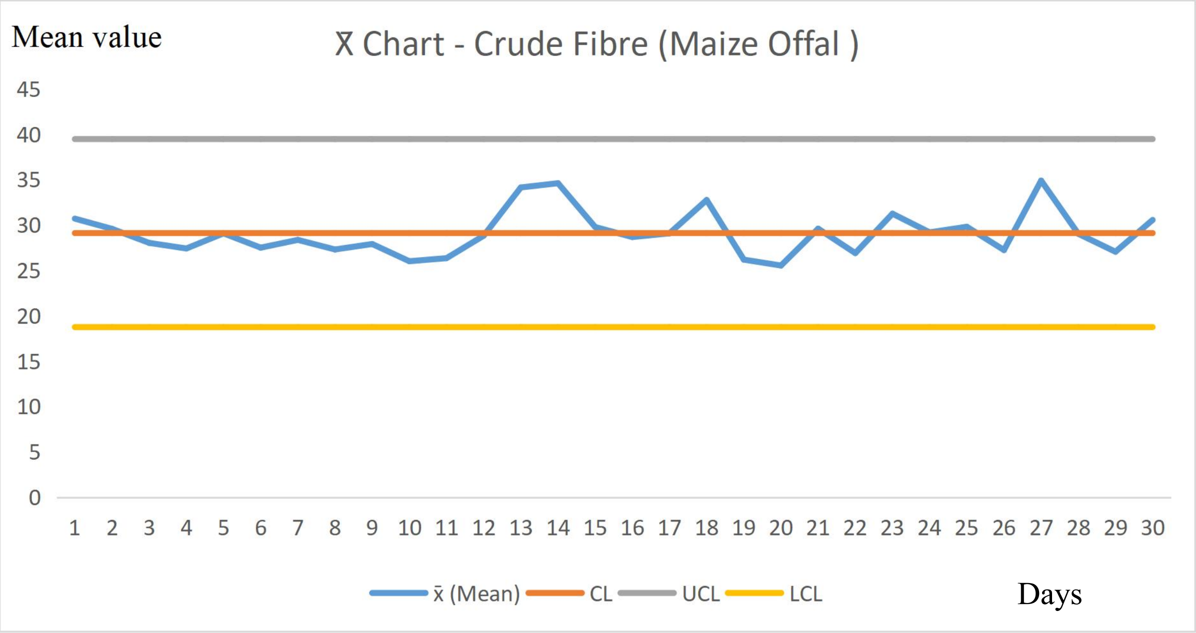

Figure 4.21 X̄ mean Chart of Crude Fibire Maize Offal

Figure 4.22 Shows the range chart of crude fibire content maize offal below

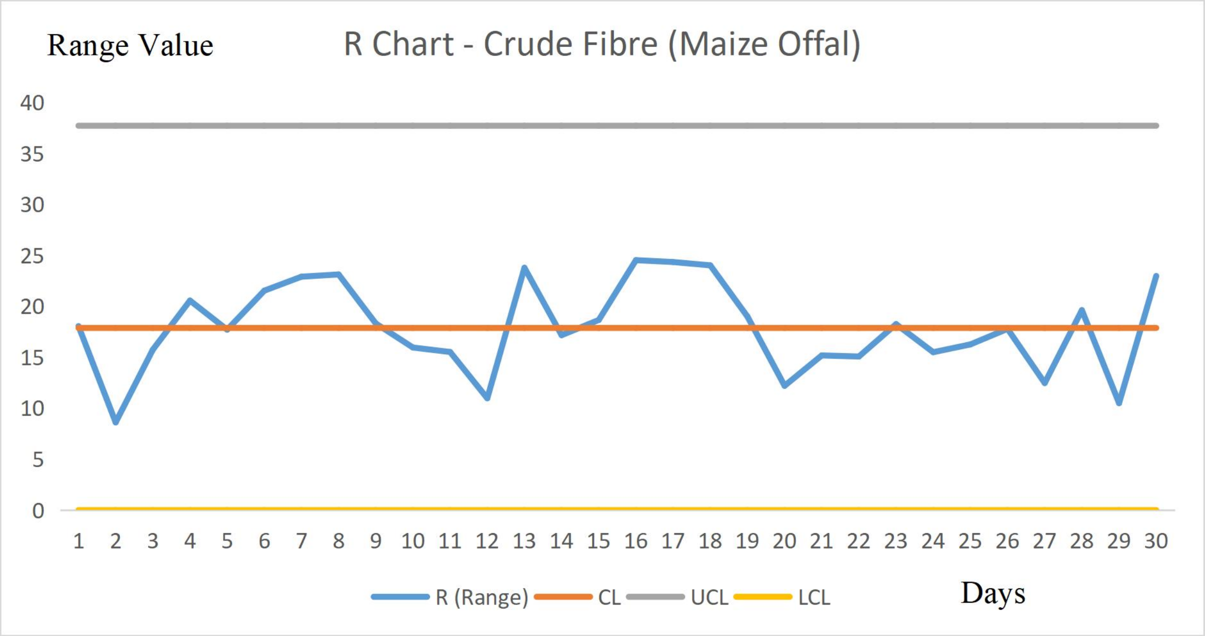

Figure 4.22 R range Chart of Crude Fibire Maize Offal

Figure 4.23 Shows the mean chart of starch content maize offal below

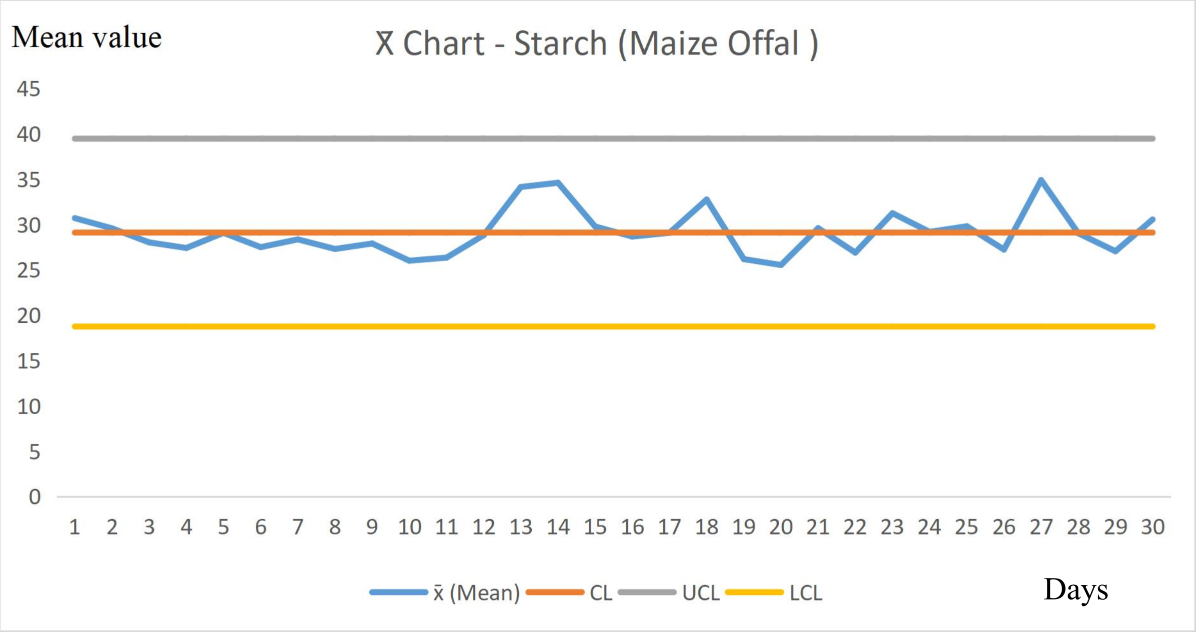

Figure 4.23 X̄ mean Chart of Starch Maize Offal

Figure 4.24 Shows the range chart of starch content maize offal below

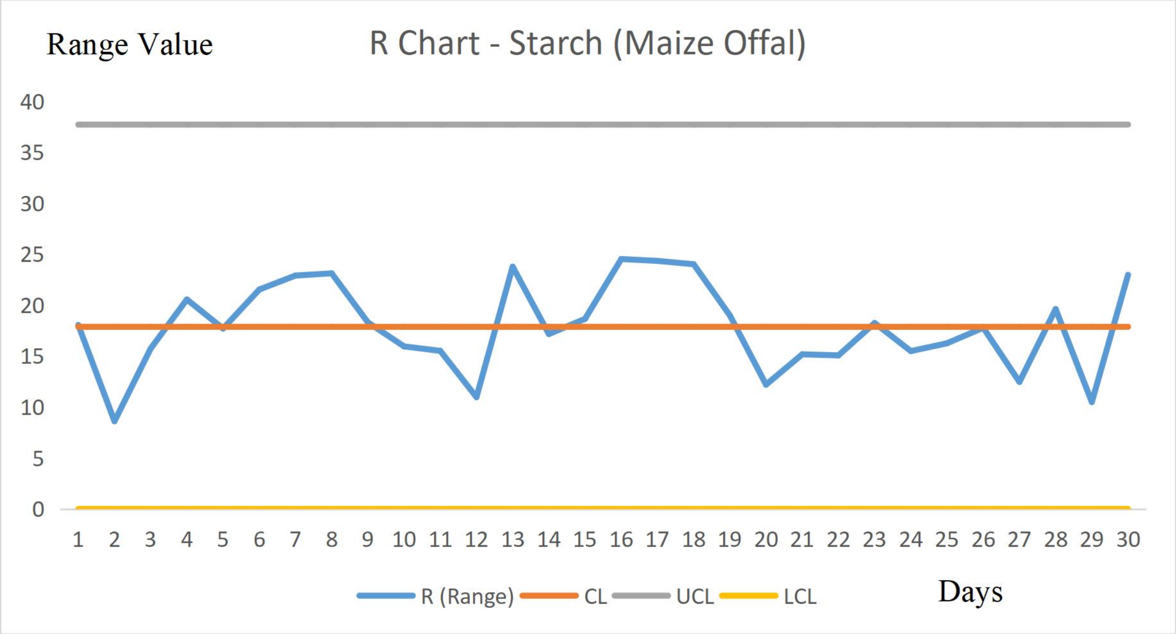

Figure 4.24 R range Chart of Starch Maize Offal

CHAPTER FIVE

CONCLUSION

5.1 Summary of the Study

This study focused on the application of Statistical Process Control (SPC) techniques in evaluating the quality of selected raw materials used in feed production, namely rice bran, groundnut cake (GNC), wheat bran, maize offal, palm kernel cake (PKC), and soya meal.

From the analysis carried out using $\bar{X}$ (mean) and R (range) control charts, it was observed that maize offal and soya meal exhibited stable process behavior, with all sample points falling within the established control limits. This indicates that the variations present in these materials are due to common causes, which are inherent in the process and do not require immediate corrective action. Additionally, both materials consistently met their respective quality specifications, confirming that their production processes are reliable and capable.

On the other hand, palm kernel cake (PKC) showed a relatively high level of variability, as evidenced by the wide range values and fluctuations observed across samples. Although most data points remained within control limits, the degree of variation suggests the presence of assignable (special) causes, which may arise from inconsistencies in raw material sourcing, processing conditions, or handling practices. This indicates that the PKC production process is less stable and requires improvement to ensure consistent quality.

Overall, the application of SPC tools proved effective in identifying process behavior, monitoring quality consistency, and highlighting areas that require improvement. The study demonstrates that SPC is a valuable tool for enhancing quality assurance systems in feed and flour mill production.

5.2. Recommendation

Based on the findings of this study, the following recommendations are proposed:

i. Implement Routine SPC Monitoring: Prime Feed and Flour Mill should adopt SPC as a continuous quality monitoring tool by regularly plotting control charts, tracking process performance over time, detecting deviations early before defects occur.

ii. Staff training and awareness: Personnel involved in production and quality control should be trained on the use of SPC tools, the interpretation of control charts, and the importance of maintaining process consistency.

iii. Equipment Maintenance and Calibration: Regular maintenance and calibration of processing equipment should be ensured to minimize process variation, improve measurement accuracy, maintain consistent output quality.

iv. Raw Material Quality Assurance: Strict quality checks should be enforced at the point of raw material intake to ensure compliance with specifications, and reduce variability

v. Continuous Improvement Strategy: The organization should adopt a culture of continuous improvement by investigating causes of variation, implementing corrective and preventive actions, and periodically reviewing process performance.

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