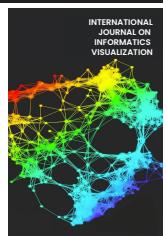




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Addressing Challenges and Enhancing Sustainability in the Food Supply Chain Management for the Malaysian Armed Forces Based on IoT Technologies

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Abstract—The critical nature of the food supply chain issues within the Malaysian Armed Forces (MAF) necessitates careful consideration to establish a well-structured and organized sustainable food supply. The primary source of frustration arises from the contractor's failure to adhere to contractual obligations, resulting in inadequate supplies, delivery delays, and provisions that do not meet the specified requirements. These shortcomings indirectly impede the management process. This paper aims to identify the relationship between delivery handling, quality control, storage condition, food supply chain management, and contract management towards the quality of military fresh rations. It also focuses on improving MAF's food supply chain management, especially the quality of fresh military rations. Moreover, this study also suggests potential solutions to address these issues. The research methodology for this study employs a qualitative approach. The primary data will be gathered via questionnaire surveys and analyzed using SPSS. The survey's outcome shows that implementing IoT technologies is feasible for MAF's food supply chain management. Finally, the study concludes with recommendations for future research, highlighting areas for further investigation.

Keywords—Supply chain management; IoT; military supply chain; military food supply chain.

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I. INTRODUCTION

The volatile and unpredictable environment demands continuous improvement in logistics processes for the military food supply chain. Several phenomena significantly affect the food supply process, including customer orientation, revenue and cost solutions related to quality management systems and food safety, shifts in consumption patterns, increased consumer awareness of health-food relationships, climate change, supply chain consolidation, demand uncertainty, and the emphasis on sustainable food supply [1].

In the context of this study, numerous food supply contracts are in place with the Malaysian Armed Forces. Some contractors have encountered issues such as being unable to supply, late deliveries, and supplies that do not meet contract specifications. The recurring problems encountered in food supplies for the military have had a lingering effect, causing profound disruptions in the procurement and supply

management processes. Despite some attempts at centralization and the influence of overarching authorities, the system remains highly fragmented [2]. Internal auditors have identified several issues, such as untimely delivery of rations, non-compliant ration packaging, inconsistent inspection and testing of non-uniformed ration specifications, supply deviations from specified requirements, provision of non-fresh rations, discrepancies in fish supplies, inadequate quantity control, damage to ration storage equipment, and suboptimal conditions in ration stores [3].

The primary challenge lies in procuring and delivering food that is safe and maintained at an appropriate standard until it is cooked [4]. This challenge is particularly critical for fresh rations or perishable foods [5]. Although food supply chains are well-established and widely practiced, the failure to maintain fresh food supplies has become a significant issue within the armed forces. Furthermore, in a crisis, the significance of logistics efficiency in managing the food supply chain becomes evident. Any disruptions can adversely

affect various aspects, including food quality, freshness, safety, and market access [6]. It is important to efficiently address these challenges to uphold a food supply chain that is both resilient and sustainable. Despite various audit efforts, this problem continues to persist. Given the direct impact of freshness and quality of rations on the well-being of military personnel [7], it is a priority to comprehensively study the causes of this problem, especially in the context of the Food Supply Chain in the Malaysian Armed Forces (MAF), and to address the inherent challenges and future implications of the military food supply chain.

According to the research background and problem described above, this study aims to address several key aspects of the Food Supply Chain Management in the Malaysian Armed Forces (MAF). Firstly, it seeks to identify the relationship between delivery handling, quality control, storage condition, food supply chain management, and contract management towards the quality of military fresh ration. Secondly, the study aims to propose possible solutions in improving the Food Supply Chain Management in MAF, especially the quality of military fresh ration. By examining these various dimensions, the study aims to provide valuable insights and recommendations for enhancing the effectiveness and sustainability of the food supply chain management in MAF.

The findings are profoundly significant. They address critical challenges in the Malaysian Armed Forces' (MAF) food supply chain, directly impacting operational efficiency and soldier well-being. These findings offer practical solutions for quality assurance, cost-effective resource allocation, and fortifying food security, benefiting taxpayers and military personnel. The collaborative approach recommended enhances supply chain practices, aligning with global sustainability goals. Moreover, the research underscores the need for continuous improvement, emphasizing ongoing progress in military food supply chain management to ensure the MAF's readiness and resilience.

II. MATERIALS AND METHOD

A. Food Supply Chain Management

The supply chain concept is described as a collaborative relationship between management, procurement, and efficiency and logistical efficiency along the entire supply chain [8]. Whereas Harland [9] describes supply chain management as managing business activities and internal relationships within an organization, with immediate suppliers, first and second-tier suppliers and customers along the supply chain, and the entire supply chain. These partnerships and relationships enable customer satisfaction [10] because the private sector can offer flexible, efficient, and reliable alternatives to food safety standards, quality assurance, and product differentiation [8]. Compared to other supply chain networks, the food supply chain is quite complex and rife with fraud and adulteration. Customers desire prompt food delivery with the highest safety and quality [11]. Moreover, consumers prefer more affordable, fresher items for perishables, which necessitates fine-tuning supply chain management. However, this complexity is increased if middlemen buy and sell produce [12], [13]. Not excluding the complexity of the military food supply chain, Although the

implementation of military food supply chain management is subject to thorough regulatory and control activities, which make it possible to maintain the appropriate level of quality and safety for food supplied, the reliability of logistical processes related to the flow of goods, information, and financial resources. The complexity of logistical processes implemented in the field of food supply for the military is influenced by certain circumstances because of the needs of recipients (soldiers perform tasks in different conditions), legal norms that determine the requirements for production processes, rules for the collection, transportation, storage, term life and amount of inventory, etc. However, in a situation of dynamic change, the supply chain should be characterized by functions such as the ability to respond quickly and meet rapidly changing demands, flexibility, and the ability to adapt to optimal service cost levels as well as the ability to use resources optimally and use all available information [14]. Based on the facts of the importance of the military food supply chain above, it is important to continue to study how improvements can be made in terms of management and sustainability of the food supply chain to the military.

B. Quality Control of Fresh Ration

Ensuring the safety and quality of fresh food is a critical priority for all stakeholders in the food supply chain. Fresh food is highly sensitive and necessitates meticulous care throughout the supply chain to maintain quality. Poor quality can have severe consequences, including foodborne illnesses and even fatalities. To safeguard the quality of fresh food, it is imperative to implement robust quality control measures. Quality control ensures the food supply's safety, nutritional value, and consumer satisfaction [15]. Extensive research has identified inefficient and inadequate quality control as a major contributor to food loss and waste, resulting in significant losses for suppliers and consumers [16], [17]. Regrettably, without proper quality control, fresh food products may be marketed based solely on their visual appearance, disregarding their quality [18], leading to consumer dissatisfaction, disappointment, and a decline in trust. To mitigate these risks, suppliers must exert strict control over their products to ensure the safety and quality of fresh food. Quality control measures must be implemented comprehensively throughout the entire fresh food supply chain, encompassing preparation, storage, packaging, and delivery [18], [19]. The absence of monitoring and incomplete quality control significantly heightens the likelihood of quality and safety issues, emphasizing suppliers' need to adopt effective quality control measures [20]. In conclusion, quality control is paramount in ensuring the safety and quality of fresh food. Suppliers must diligently apply quality control measures across the entire supply chain to mitigate the risks of quality and safety problems. Given the growing consumer concerns regarding the freshness and quality of fresh food, inadequate quality control can result in substantial losses for suppliers and consumers by implementing stringent quality control measures, suppliers can guarantee the safety, wholesomeness, and consumer satisfaction of fresh food.

C. Delivery Handling of Fresh Ration

The delivery process is a critical aspect of the food supply chain that plays a crucial role in maintaining the quality and

safety of food [21], [22]. However, this process is fraught with various challenges, including unforeseen events that may occur during transportation [23]. These challenges are not unique to suppliers alone, as farmers face similar issues while delivering their produce [24]. Inadequate attention to the delivery process can compromise the quality of fresh, perishable, and fragile food. According to Wu et al. [25], suppliers face three primary challenges during the delivery process: timeliness, elasticity of delivery capability, and cost efficiency. Effective delivery helps prevent losses for both consumers and suppliers. Since fresh food requires a high-cost cold chain to maintain quality, suppliers must invest in appropriate transportation and equipment, such as refrigerators, to ensure fresh food reaches customers in optimal condition [26]. Several researchers have emphasized the need for research in various aspects of the delivery process to ensure fresh food is delivered of the right quality, at the right time, and at a reasonable cost [23]. Albrecht et al. [27] and Chen et al. [21] recommend shortening the delivery period for fresh food to ensure maximum freshness at the point of sale. In conclusion, handling fresh food delivery is a priority concern for suppliers in assuring the quality and safety of fresh food products consumed by consumers. It is necessary to address the challenges associated with the delivery process through adequate investment in equipment and transportation, as well as research to improve the efficiency and effectiveness of the delivery process.

D. Contract Management

Contracts are legally enforceable agreements between two or more parties, and effective management of these agreements is crucial to prevent loss and misuse of public funds. According to Hughes and Murdoch [28], a contract agreement is a document that proves the offer and acceptance between two parties. Kamil et al. [29] define a contract as an exchange of promises between parties that is enforceable in a court of law. Failure to manage contracts effectively can lead to losses for the parties involved, such as payment for services not covered by the initial agreement. Azizi et al. [30] identified five crucial factors contributing to effective contract management: financial support, leadership support, contract compliance, technology support, and contracting officer competency. Muhammad et al. [31] suggest that government agencies and firms should re-evaluate their approach to contract management to improve results through cost-benefit analysis, timely project delivery, and budgetary compliance. They recommend that contract managers and other business operators oversee efficient operations to avoid losses. Poor contract management can result in very poor stakeholder relations, non-performance from service providers, and inadequately handled contracts that have a detrimental influence on service delivery [32]. Christine and Gamariel [33] suggest that effective contract management is required to ensure the performance of procuring and disposing and that improper procurement methods may be the root cause of inadequacies. They recommend using e-procurement by senior management and individual discipline for officials who impede procurement procedures and operations. Military procurement also presents challenges, including control, scrutiny, documentation, and accountability [34]. Proper evaluation of procedures, staffing, and implementation can

lead to remedial innovations that protect rural taxpayers and food producers from loss, damage, and intimidation while protecting soldiers from exploitation and corruption.

E. The Condition of Fresh Ration Storage in Military

In fresh food management, storage is crucial in ensuring freshness, nutrition, and quality. Failure to adhere to proper storage temperatures according to fresh food storage standards can result in fresh food damage and loss of nutrients [35]. The temperature of the storage place also affects the quality of fresh food [36]. Adequate equipment, sufficient space, and conducive storage conditions are required to preserve the quality of fresh food. Different types of fresh food have specific temperature requirements for storage, including poultry, meat, seafood, and vegetables, and inaccurate storage temperatures can lead to foodborne illnesses [37], [38]. Farmers also face challenges related to the lack of refrigerated warehousing for storing their products, which can impact the quality of fresh food throughout the supply chain [24]. To guarantee the quality, safety, freshness, and nutrition of fresh food, emphasis must be placed on proper storage. Therefore, it is necessary to ensure superior warehouses and proper storage for fresh food [39].

F. Conceptual Framework

Drawing from the literature reviewed earlier, this study's conceptual framework has been formulated, as depicted in Figure 1. The independent variables encompass the Food Supply Chain, Quality Control of Fresh Rations, Contract Management, Conditions of Fresh Ration Storage in Military Settings, and Delivery Handling of Fresh Rations. These variables collectively influence the dependent variable, namely, the Quality of Military Fresh Rations.

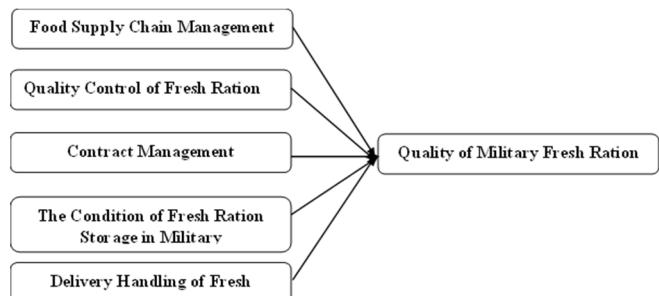


Fig. 1 Conceptual Framework

This study employed a quantitative approach to elucidate the relationships between key factors, namely the Food Supply Chain, Quality Control of Fresh Rations, Contract Management, Conditions of Fresh Ration Storage in Military Settings, and Delivery Handling of Fresh Rations, concerning the overall Quality of Military Fresh Rations. Additionally, the study addressed pertinent issues and challenges within the Military Food Supply Chain Management while proposing potential solutions for enhancement.

The research encompassed data collection through administering questionnaires, utilizing a primary data collection method. 395 respondents contributed to the dataset, comprising personnel from diverse ranks, including other ranks, officers, and civilian employees engaged with the armed forces and possessing a logistics background. The collected data underwent analysis employing the Statistical Package for

the Social Sciences (SPSS). The analytical procedures comprised correlation studies among the variables, followed by regression analysis to delve deeper into relationships.

III. RESULTS AND DISCUSSION

The total data collected is from 395 respondents comprising other ranks, officers, and civilian employees who work with the armed forces and have a background in logistics. The data collected consists of a dependent variable, the mean of the quality of military fresh ration (MEANQMFR), and five independent variables, as shown in Table 1 below. This study aims to find a relationship between these five independent variables and MEANQMFR to identify which factors contribute to the quality of military fresh ration.

TABLE I
VARIABLE NAMES

Variable	Full name
MEANQC	Mean of Quality Control
MEANDH	Mean of Delivery Handling
MEANSC	Mean of Storage Condition
MEANFSCM	Mean of Supply Chain Management
MEANCM	Mean of Contract Management
MEANQMFR	Mean of Quality of Military Fresh Ration

TABLE II
SPSS OUTPUT OF THE CORRELATION STUDY OF THE VARIABLES

	MEANQC	MEANDH	MEANSC	MEANFSCM	MEANCM	MEANQMFR
MEANQC	1					
MEANDH	0.835	1				
MEANSC	0.711	0.814	1			
MEANFSCM	0.789	0.833	0.808	1		
MEANCM	0.696	0.697	0.549	0.745	1	
MEANQMFR	0.653	0.719	0.697	0.792	0.710	1

The examination of Table 2 shows that the independent variables are quite highly correlated with the dependent variable MEANQMFR. With a sample size of $n = 395$, the correlations presented in the table above are statistically significant. The correlation coefficients range from a minimum value of 0.653 to a maximum value of 0.792, as indicated in the last row of the table. These findings suggest that the independent variables considered in this study could be suitable candidates for univariate linear regression analysis.

However, investigating interrelationships among the independent variables reveals a significant level of correlation. Notably, the correlation coefficient between MEANDH and MEANQC is 0.835, while the correlation coefficient between MEANFSCM and MEANDH is 0.833. The weakest correlation is observed between MEANCM and MEANFSCM, with a correlation of 0.549. These relatively high correlation values among the independent variables may raise concerns regarding multicollinearity. In instances where independent variables exhibit substantial correlation, changes in one variable tend to induce corresponding changes in others, leading to significant fluctuations in the model's outcomes. Consequently, when considering a multivariate model, the results could be unstable and susceptible to considerable variation in response to even slight changes in the data or model specification.

TABLE III
SPSS OUTPUT OF THE REGRESSION ANALYSIS WHERE MEANQMFR IS THE DEPENDENT VARIABLE

Independent variable	Constant term	Variable coefficient	Adjusted R ²	t-test of significance	ANOVA test
MEANQC	1.428	0.615	0.425	17.091 (0.000)	292.086 (0.000)
MEANDH	1.404	0.650	0.516	20.529 (0.000)	421.439 (0.000)
MEANSC	1.864	0.549	0.485	16.501 (0.000)	372.068 (0.000)
MEANFSCM	0.913	0.769	0.626	25.706 (0.000)	660.811 (0.000)
MEANCM	1.079	0.695	0.503	20.005 (0.000)	400.214 (0.000)

Consider the simple linear regression model given by the following equation:

$$Y = \beta_0 + \beta_1 X + \epsilon_i \quad (1)$$

where Y is the dependent variable MEANQMFR, β_0 represents the constant term of the line or the vertical axis intercept, β_1 is the variable coefficient, X is the independent variable, and ϵ_i is the error term associated with the model.

Table 3 shows the results of the univariate linear regression analysis with MEANQMFR as the dependent variable, considering five independent variables separately. The constant term represents the value of the dependent variable when all independent variables are equal to zero. The variable coefficients represent the change in the dependent variable for a one-unit change in the corresponding independent variable. The adjusted R-squared value indicates the proportion of variance in the dependent variable explained by the model's independent variables. In this case, the highest adjusted R-squared value is when MEANFSCM is included in the model, indicating that it explains the most variance in MEANQMFR. The t-test of significance tests whether each independent variable is a significant predictor of the dependent variable. In this case, all independent variables have a p-value of 0.000, indicating that they are all statistically significant predictors of MEANQMFR. The ANOVA test determines whether there is a significant relationship between the dependent variable and all independent variables combined. In this case, for all models considered, p-values are 0.000, indicating a statistically significant relationship.

IV. CONCLUSION

The study aimed to identify factors contributing to the quality of military fresh rations by examining their relationship with five independent variables: Quality Control, Delivery Handling, Storage Condition, Food Supply Chain Management, and Contract Management. The analysis revealed significant positive correlations between all five independent variables and the Quality of Military Fresh Ration. Based on previous research, supply Chain Management was highlighted as a critical aspect of quality assurance for military fresh ration. As the food supply chain becomes more complex, partnerships with the private sector enable the industry to meet customer demands effectively and ensure high food safety and quality [11]. Quality control is pivotal in the food supply chain, encompassing the assurance of safety, nutritional integrity, and comprehensive contentment about food items. The deficiency or insufficiency

of quality control measures can precipitate substantial losses for suppliers and consumers, eroding trust in the process. Notably, the implementation of adept quality control practices exhibits a positive correlation with elevated evaluations of the quality of military fresh rations. This observation aligns with prior research by Sterns and Reardon [15] and Buisman et al. [16]. Delivery Handling also showed a positive correlation with the quality of military fresh rations, emphasizing the importance of the delivery process in maintaining food freshness and safety. Proper transportation and equipment, such as refrigerators, are essential to ensure products reach customers in optimal condition and shortening the delivery period can maximize freshness at the point of sale [21], [27]. Effective contract management was crucial for ensuring the quality of fresh military rations. Proper contract management, including the use of e-procurement and disciplinary actions, can safeguard public funds, protect soldiers from exploitation, and maintain the quality of military fresh rations [33]. The study also highlighted the significance of proper storage conditions in preserving freshness, nutrition, and overall food quality. Adhering to appropriate storage temperatures is essential to prevent food damage and nutrient loss [35].

In conclusion, this research underscores the importance of various factors in maintaining the quality of military fresh rations. By understanding and effectively managing quality control, delivery handling, storage conditions, supply chain management, and contract management, it is possible to ensure the highest safety and quality standards in military fresh ration supply. These findings are essential for enhancing food supply practices and can contribute significantly to the well-being and satisfaction of military personnel.

The intricate nature of the food supply chain necessitates strategic collaboration, understanding, and cooperation between the military and suppliers. This collaborative approach enhances efficiency and responsiveness in meeting the demands of military fresh rations. Beyond operational efficiency, it upholds stringent military standards, security protocols, and the premium quality expected of fresh rations.

Quality control is paramount to ensuring the safety and excellence of military fresh rations. Implementing robust quality control measures, in alignment with established food safety procedures such as HACCP and GMP, assures the delivery of high-quality rations to the military. The Malaysian Armed Forces should devise and implement a comprehensive Standard Operating Procedure universally applied within the organization. Equipping military personnel with requisite knowledge and skill through training programs like MS1480 and Food Hygiene and Safety Training is crucial for effective quality control procedures.

Recognizing the positive correlation between delivery handling and the quality of military fresh rations, it becomes imperative to equip all transportation units delivering rations with appropriate storage, cooling facilities, and secure packaging. Maintaining optimal temperatures during transportation and handling is vital to preserving the freshness and integrity of military fresh rations. Additionally, reducing delivery timeframes enhances the overall quality of the rations.

A robust contract management strategy is pivotal. Utilizing e-procurement, enforcing penalties, and imposing disciplinary actions for non-compliance safeguard public funds and military personnel from potential exploitation. Upholding the quality of

military fresh rations through well-structured contractual agreements ensures supplier adherence to established standards, bolstering satisfaction and overall well-being.

Investing in proper storage equipment is crucial for maintaining suitable temperatures for fresh rations. Upgrading outdated storage facilities is imperative to uphold the freshness and safety of military fresh rations. Implementing stringent storage protocols prevents food damage and nutrient deterioration, guaranteeing that military personnel receive rations that cater to their dietary requirements and preferences.

The Internet of Things (IoT) provides alternative solutions to maintaining the rations' freshness. As investment in cloud technology is projected to grow to \$3.7 billion by 2024 in Malaysia, the unifying data intelligence would improve sustainability reporting by enhancing the tracking and tracing of rations. The Prime Minister of Malaysia has announced that the 2024 budget outlines a strategic focus on Artificial Intelligence (AI) and Cyber Security as key drivers for economic growth and digital transformation. These initiatives would have a significant impact on food supply chain industries. The upcoming research journal will discuss the IoT-based food chain management system.

In conclusion, numerous food supply contracts with the Malaysian Armed Forces have faced persistent challenges, including supply failures, late deliveries, and non-compliant provisions. This has led to significant disruptions in procurement and supply management processes. These issues are particularly acute in the procurement and delivery of fresh rations, where the primary concern is ensuring the procurement and delivery of safe food held to appropriate standards until consumption, with heightened importance during crises when efficient logistics management is crucial. Such disruptions can detrimentally impact food quality, freshness, safety, and market accessibility. These ongoing issues underscore the necessity for comprehensive examination and resolution within the Malaysian Armed Forces' Food Supply Chain, given the direct impact of ration quality on military personnel's well-being. In military food supply chain management, it is imperative to recognize the complexity of logistical processes influenced by diverse operational conditions, legal regulations, transportation rules, storage conditions, shelf life, and inventory levels. This highlights the need for effective management and sustainability, especially in dynamic environments. Central to ensuring food safety and freshness are quality control and delivery handling for fresh rations; insufficient quality control can lead to foodborne illnesses and consumer dissatisfaction, while inadequate delivery handling risks compromising perishable items. Additionally, effective contract management is essential to prevent fiscal misuse, and maintaining proper storage conditions is crucial for preserving fresh food quality, nutrition, and safety. Addressing these multifaceted challenges is paramount for enhancing sustainability and resilience within the military food supply chain, ultimately safeguarding the well-being of military personnel and ensuring efficient resource allocation.

Proposed areas for future research include investigating the sustainability and environmental impact of military fresh ration supply chains. This research aims to identify opportunities for enhancing sustainability practices.

Additionally, conducting surveys or focus groups with soldiers could provide valuable insights into their perceptions and satisfaction regarding the quality of fresh rations in the military. Moreover, gathering direct feedback from the end-users would assist in pinpointing specific areas for improvement.

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