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A Study on Relationship Between the Factors Influenced on Inventory Management System in Food Processing Industry

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ABSTRACT
In this research the investigation is made on the identification and analysis of different factors which influenced on the inventory management system in food processing units by focusing on different types of industries and types of food. Analysis results shows that operational efficiency and productivity are strong drivers of technological adoption. Results also highlights the impact of strategy and digital technology on perishable goods food waste reduction management. Analysis of variance reveals that where the partnership industries significantly impact strategic decision making, but it's not significant on the level of technological adoption across different industry types. Compared to Solid and Liquid, the Semi Solid food product processing industries exhibit distinct patterns in adopting technologies and strategies. The findings shows that dynamics between the operational practice and technology integration in food processing industry.
Keywords: Food processing; Inventory Management; Technology adoption; Strategy

1. Introduction

Management of Inventory plays a crucial position in the food processing industry, where the management of perishable goods, seasonal demand, and stringent food safety regulations create unique challenges. Effective management of inventory will ensure the optimization of the stock level and also quality of the raw materials and finished products. [1] [2]. The maintenance of these factors is important for maintaining productivity, and these are also reason for achieving the efficient conversion of inputs into high quality products [3]. The food processing industry is described by complex supply chain, concerning multiple stages from raw material procurement to distribution. Technologies like Blockchain, Artificial Intelligence (AI) and Internet of Things (IoT) are effectively being integrated into inventory management system. From these technologies real time tracking, forecasting enhancement, and making of better decision can be done and it leads to higher productivity.[4] [5].

In the food processing industry, effective inventory management is crucial for enhancing operational efficiency, reducing food waste, and ensuring sustainability. Despite the advancements in technologies such as IoT, AI, and blockchain, many organizations still face challenges in optimizing inventory management practices for perishable goods. Research has shown that while AI and IoT can improve demand forecasting and reduce manual errors (Wamba & Mishra, 2020), there remains a significant gap in understanding how these technologies impact overall efficiency and productivity in managing perishable goods. Moreover, while strategies like VMI and JIT are employed to manage perishable goods, their effectiveness in reducing waste and adapting to demand fluctuations needs further exploration. Digital technologies have demonstrated potential in enhancing sustainability by reducing food waste and operational costs, but the extent of their impact is not fully understood. This research try to address these gaps by examining the advanced inventory management systems impact on operational efficiency, evaluating the effectiveness of strategies for perishable goods, and assessing the impact of digital technologies in reducing the wastage of food and enhancing sustainability.

2 Literature Review

Management of Inventory is one of the important components of operational efficiency in various industries, particularly in food processing industries, where the management of perishable goods is a significant concern. To reduce the risk of overstock and stockout situations, effective inventory management system is very essential it will ensure that right quantity of goods available at right time. Rom the recent studies it's clear that, day by day the technology dependency is increasing to optimize inventory management processes. For example, by using advanced data analytics and AI driven inventory management system focusing accuracy can be improved, thereby waste can be reduced, and productivity can be improved[1]. In food processing industry, inventory management directly impacts shelf life and product quality. A well-managed inventory system will ensure that perishable goods are utilised well within its lifespan, results in minimisation of spoilage and losses. Latest technologies like IoT can be used monitor real time inventory levels and goods conditions by enabling responsive and efficient inventory control [2].

Due complexity of supply chain and goods perishability, food processing industry faces more challenges in inventory management. Seasonal variation in the demand and availability of the raw materials further complicate the inventory management in food processing sector. From the studies it's clear that, the traditional inventory management practices are lacking in addressing these issues lead to negative impact on the productivity[3]. Therefor it's very important to adopt more agile and flexible inventory management system by including JIT and VMI to overcome these challenges. Some of the food processing sectors already implemented and improved the responsive ness to demand changes and reduce the wastage of food products [4]. High level of coordination and trust between supply chain partners requires to adoption of these systems.

The integration of digital technologies in inventory management is changing the food processing industry. Blockchain technology is used to enhance traceability and transparency in food supply chain system, which is very important for food quality and safety management [5]. This technology not only helps in tracking the goods movement and also in verifying the authenticity of products, thereby reducing the risk of fraud. Furthermore, AI and ML can help in identifying trends in inventory usage, enabling more accurate inventory planning [6][5].Literature study shows that the effective relationship between Inventory management and productivity in food processing industry. Case study of an leading food processing company shows that, the implementation of AI driven inventory management system resulted in 15% cost reduction in inventory cost and 20% increase in productivity. [7]. In the same way, another study found that the implementation of IoT based inventory monitoring systems leads to significant reduction in waste, thereby enhancing overall operational efficiency [8]. These case studies highlight the benefits of integrating advanced technologies into inventory management practices. It's also indicates the need for companies to invest in the necessary infrastructure to get the full of these benefits [9]

The main objective of the study is to check, how various factors influences the adoption of technologies and strategies in inventory management. First, the study aims to evaluate the impact of operational efficiency and productivity on advanced technologies adaption and also to examine the role of perishable goods management in shaping strategies. Another key objective is to analyse the impact of digital technologies on food waste management practices within the food processing industry. The study also aims to investigate implementation of technological and strategic adoption across the different industry types like Sole Proprietorships, Partnerships, Limited, and Cooperative societies and also across the various food product types like Solid Food, Liquid Food, and Semi-Solid Food forms, to understand how the nature of the food products and business forms influences best practices.

3. Research design

A structured survey questionnaire will be distributed to stakeholders, including inventory managers, operations personnel, and supply chain managers in food processing industries. The survey is done by using 5 point closed ended Likert scale questions, to capture data on technology adoption, inventory management practices, operational performance, and reductions in food waste. The collected data analyzed statistically using techniques such as correlation and regression analysis to test the relationships between variables. Research includes probability-based sampling method, specifically stratified random sampling, to ensure a representative sample of food processing industries. Data was collected from November 2023 to June 2024, total of 258 food processing industries were surveyed in and around Mysore and Bangalore.

The questionnaire design and data collection process were created in line with the research objectives. Structured questionnaires are carefully designed to capture data, by addressing nine essential factors. The first factor, Adoption of Advanced Technologies, focuses on evaluating the impact of AI driven systems [10], IoT based management[11], and advanced analytics on inventory practices [12]. The second factor, Operational Efficiency, determines how these technologies contribute to reducing the manual errors [13], optimizing the inventory turnover rates[14], and reducing the time required for the inventory audits [15]. Productivity is the third factor, measuring improvements in production schedules [16], increase the rate of order fulfilment [17], and overall increases in productivity of employee [18] resulting from advanced inventory systems. The fourth factor is Effectiveness of Strategies, measures how JIT inventory management reduces excess stock accumulation [19], how VMI helps to maintain optimal stock levels[20], and how advanced prediction techniques minimize waste and enhance efficiency in managing perishable goods[21]. The fifth factor is Challenges in Perishable Goods Management, focused on issues such as managing the shelf life of perishables [22], temperature control[23], and tracking expiry dates[24]. The sixth factor is evaluated the flexibility of inventory systems in responding to demand changes [22], seasonal fluctuations[25], and supply chain disturbances [26]. The seventh factor is Integration of Digital Technologies, explores role of blockchain in supply chain enhancement traceability [27], the contribution of AIML to waste reduction[28], and the overall streamlining of inventory processes[29].Eighth one is The Impact on Food Waste factor, which examines how digital inventory technologies lead to a reduction in food waste [30], less cases of expired products[31], and improved control over inventory [32]. The ninth factor is Efficiency and Sustainability factor, which is included to measure contributions to sustainability goals and environmental friendliness[33][34][35].

4. Results and Discussions

Pilot study

The pilot survey was conducted between six-month duration and initially the Cronbach's Alpha value is 0.890 indicates the questionnaire were reliable and could effectively measure the proposed hypothesis. After six months repeated the survey with same individuals, the value increase to 0.944 dictates that the reliability improved even further, suggesting that there are no potential issues. The high Cronbach's Alpha values both initially and after six months suggest that the tool used for the study is reliable and well suited for ongoing research.

Data Analysis

Graph 1 shows that, In the context of Adoption of Advanced Technologies, both operational efficiency and productivity exhibit strong positive correlations, with Pearson values of 0.579 and 0.542, respectively. The Beta coefficients (0.42 for operational efficiency and 0.355 for productivity) further indicate that the adoption of advanced technologies has a substantial positive impact on improving these metrics. Additionally, the low standard error values (0.05 for operational efficiency and 0.053 for productivity) suggest a high degree of precision in these estimates, making the relationship both statistically significant and practically relevant.

Figure 1. Correlation and regression values at 1% confidence level

Regarding Strategies, the relationship with perishable goods management shows a high Pearson Correlation of 0.558, coupled with a Beta value of 0.466, indicating that effective strategies have a considerable positive influence on managing perishable goods. In contrast, adaptability and flexibility, while still positively associated with strategies, exhibit a lower Pearson correlation of 0.43 and a Beta coefficient of 0.16, suggesting a more moderate but still meaningful impact.In the category of Digital Technologies, the reduction of food waste shows a moderate Pearson correlation (0.507) with a Beta value of 0.461, indicating a strong influence of digital technologies on food waste reduction. This is further supported by a B coefficient of 0.506, implying that the application of digital technologies plays a crucial role in minimizing waste. On the other hand, the impact of digital technologies on efficiency and sustainability is more modest, with a Pearson correlation of 0.333 and a Beta value of 0.085, suggesting that while digital technologies contribute to improvements in these areas, the effect is comparatively weaker.

One-Way ANOVA

Table 1.Analysis of Variance with respect to different types of industries

ANOVA		Sum of Squares	df	Mean Square	F	Sig.
Adoption of Advanced Technologies	Between Groups	2.273	3	0.758	0.288	0.079
	Within Groups	84.103	254	0.331		
	Total	86.376	257			
Strategies	Between Groups	7.540	3	2.513	0.171	<0.001
	Within Groups	103.450	254	0.407		
	Total	110.989	257			
Digital Technologies	Between Groups	3.083	3	1.028	0.158	0.093
	Within Groups	120.930	254	0.476		
	Total	124.012	257			

The table 1 presents the one-way ANOVA test resultswhich is used to determine whether there are statistically significant differences between groups for three variables: Adoption of Advanced Technologies, Strategies, and Digital

Technologies. Each of these variables has been analysed based on the variance between groups (how much the groups differ) and within groups (the individual differences within each group), along with the overall variance. For Advanced Technologies Adoption, the analysis shows a variance of 2.273 between groups and 84.103 within groups, resulting in a total variance of 86.376. The F statistic is 2.288, and the p value is 0.079. Since the p > 0.05, the result indicates that there is no different groups have significantly different levels of adoption of advanced technologies.For Strategies, the variance between groups is 7.540, while the variance within groups is 103.450, with a total variance of 110.989. The F statistic is 6.171, and the p value is < 0.001.

This p value is less than 0.05, which means the result is statistically significant. Therefore, there are meaningful differences between the groups in terms of the strategies they adopt. This suggests that group membership significantly impacts the strategies used. In the case of Digital Technologies, the variance between groups is 3.083, and the variance within groups is 120.930, leading to a total variance of 124.012. The F statistic is 2.15, and the p value is 0.09. Since the p > 0.05, indicates that there is no strong evidence to indicate significant differences between groups in the adoption of digital technologies. Therefore, the ANOVA results show that there are no significant differences between groups for the Adoption of Advanced Technologies and Digital Technologies. However, for Strategies, the differences between the groups are statistically significant, meaning group membership or conditions have a significant influence on the strategies adopted by the organizations.

Table 2.Tukey HSD Multiple Comparisons for types of food industries

Dependent Variable	(I) Type of Industry	(J) Type of Industry	Mean Difference (I-J)	Std. Error	Significance	95% Confidence Interval	
						Lower Bound	Upper Bound
Strategies	Sole Proprietorship	Partnerships	0.38571*	0.09945	0.001	0.1285	0.6429
		Limited	0.27333	0.11054	0.067	-0.0125	0.5592
		Cooperative	0.01754	0.12162	0.999	-0.2970	0.3321
	Partnerships	Sole Proprietorship	-0.38571*	0.09945	0.001	-0.6429	-0.1285
		Limited	-0.11238	0.11817	0.777	-0.4180	0.1932
		Cooperative	-0.36817*	0.12859	0.023	-0.7007	-0.0356
	Limited	Sole Proprietorship	-0.27333	0.11054	0.067	-0.5592	0.0125
		Partnerships	0.11238	0.11817	0.777	-0.1932	0.4180
		Cooperative	-0.25579	0.13734	0.247	-0.6110	0.0994
	Cooperative	Sole Proprietorship	-0.01754	0.12162	0.999	-0.3321	0.2970
		Partnerships	0.36817*	0.12859	0.023	0.0356	0.7007
		Limited	0.25579	0.13734	0.247	-0.0994	0.6110

* The mean difference is significant at the 0.05 level

Table 3.Analysis of Variance with respect to different types of food products

ANOVA		Sum of Squares	df	Mean Square	F	Significance
Adoption of Advanced Technologies	Between Groups	2.047	2	1.024	3.095	0.047
	Within Groups	84.328	255	0.331		
	Total	86.376	257			
Strategies	Between Groups	3.183	2	1.591	3.764	0.024
	Within Groups	107.806	255	0.423		
	Total	110.989	257			
Digital Technologies	Between Groups	4.662	2	2.331	4.981	0.008
	Within Groups	119.350	255	0.468		
	Total	124.012	257			

The Tukey HSD test presented in the table 2, compares the mean differences in strategies among different types of industries: Sole Proprietorships, Partnerships, Limited, and Cooperatives. The results show significant differences in strategic practices between Sole Proprietorships and Partnerships, with a mean difference of 0.38571 (p = 0.001), indicating that Sole Proprietorships employ more distinct strategies than Partnerships. A significant difference is also observed between Partnerships and Cooperatives, with a mean difference of -0.36817 (p = 0.023), where Cooperatives appear to adopt different strategic approaches compared to Partnerships.

However, comparisons between Sole Proprietorships and Limited companies, as well as Limited and Cooperative firms, do not reveal statistically significant differences, suggesting that these industry types may adopt similar strategies.

Table 3 shows that the one way ANOVA results, it reveals significant differences in the adoption of advanced technologies, strategies, and digital technologies among different food product types like Solid Food, Liquid Food, and Semi Solid Food. For advanced technologies, the analysis shows a significant difference with a p value of 0.047, indicating that Semi Solid Food products differ from Liquid Food in their adoption of these technologies. Similarly, the significant p-value of 0.024 for strategies suggests that Semi-Solid Food products adopt distinct strategies compared to both Solid Food and Liquid Food. In terms of digital technologies, the results indicate a significant difference with a p-value of 0.008, where Semi-Solid Food products exhibit different adoption patterns compared to Solid Food.

Table 4.Tukey HSD Multiple Comparisons for types of food products

Dependent Variable	(I) Type of Product	(J) Type of Product	Mean Difference (I-J)	Std. Error	Significance	95% Confidence Interval	
						Lower Bound	Upper Bound
Adoption of Advanced Technologies	Solid food	Liquid food	0.04206	0.08181	0.865	-0.1508	0.2349
		Semi solid food	-0.19691	0.09423	0.094	-0.4191	0.0252
	Liquid food	Solid food	-0.04206	0.08181	0.865	-0.2349	0.1508
		Semi solid food	-0.23898*	0.10030	0.047	-0.4754	-0.0025
	Semi solid food	Solid food	0.19691	0.09423	0.094	-0.0252	0.4191
		Liquid food	0.23898*	0.10030	0.047	0.0025	0.4754
Strategies	Solid food	Liquid food	0.00833	0.09250	0.996	-0.2097	0.2264
		Semi solid food	-0.26944*	0.10655	0.032	-0.5206	-0.0183
	Liquid food	Solid food	-0.00833	0.09250	0.996	-0.2264	0.2097
		Semi solid food	-0.27778*	0.11341	0.040	-0.5451	-0.0104
	Semi solid food	Solid food	0.26944*	0.10655	0.032	0.0183	0.5206
		Liquid food	0.27778*	0.11341	0.040	0.0104	0.5451
Digital Technologies	Solid food	Liquid food	-0.10238	0.09733	0.545	-0.3318	0.1271
		Semi solid food	-0.35370*	0.11211	0.005	-0.6180	-0.0894
	Liquid food	Solid food	0.10238	0.09733	0.545	-0.1271	0.3318
		Semi solid food	-0.25132	0.11933	0.091	-0.5326	0.0300
	Semi solid food	Solid food	0.35370*	0.11211	0.005	0.0894	0.6180
		Liquid food	0.25132	0.11933	0.091	-0.0300	0.5326

*. The mean difference is significant at the 0.05 level.

Table 4 shows that the Tukey HSD test confirms these findings, showing significant differences in adoption rates for Semi-Solid Food compared to the other types in all three areas. These results shows that the nature of the food product significantly influences how companies implement technologies and strategies, with Semi-Solid Food demonstrating more advanced practices compared to Solid and Liquid Foods.

5. Conclusions

The correlation and regression analysis shows that the advanced technologies adaption in inventory management is significantly influenced by improvements in operational efficiency and productivity, with both factors showing strong positive relationships. Effective perishable goods management is a key element of strategic decision making, while food waste management is crucial in the use of digital technologies.

Even though efficiency and sustainability have a weaker influence, the results show that operational efficiency, perishable goods management, and food waste reduction are the strongest predictors for adopting advanced technologies, strategies, and digital solutions.The one way ANOVA analysis results suggest that the type of industry significantly impacts the strategies adopted by businesses, particularly highlighting the best strategic approaches used by Partnerships compared to Sole Proprietorships and Cooperatives. Partnerships seem to develop more unique strategies, potentially driven by their collaborative nature. When adoption of advanced technologies considered, the type of industry does not appear to play a significant role. All industry types whether Sole Proprietorships, Partnerships, Limited, or Cooperatives adopt these technologies at similar levels. The type of food product significantly impacts the adoption of advanced technologies, strategies, and digital technologies. Semi-Solid Food products demonstrate distinct differences compared to Solid Food and Liquid Food in all three areas. Specifically, Semi Solid Food products adopt advanced technologies and digital technologies at different rates and employ distinct strategies compared to Solid Food. These differences show that, the nature of the food product influences technological and strategic approaches, with Semi Solid Food showing more unique patterns. Solid Food and Liquid Food exhibit more similarities in their adoption and strategies, suggesting a less pronounced impact of product type on their technological and strategic practices.

6. Scope for future work

Future research can explore why industry structure is not significantly impact the adoption of advanced technologies and digital solutions, by examining external factors like market pressures as well as regulatory frameworks. Investigating the specific drivers behind Semi Solid Food products unique strategic and technological approaches could provide insights into optimizing strategies for different food types.

***Conflict of interest*:** Authors declare that there is no conflict of interest.

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