

UDC 658.512.011.56
AGRIS J10

<https://doi.org/10.33619/2414-2948/131/14>

AUTOMATION OF FOOD AND BEVERAGE PROCESSES USING INTEGRATED SOFTWARE SOLUTIONS

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АВТОМАТИЗАЦИЯ ПРОЦЕССОВ ПРОИЗВОДСТВА ПРОДУКТОВ ПИТАНИЯ И НАПИТКОВ С ИСПОЛЬЗОВАНИЕМ ИНТЕГРИРОВАННЫХ ПРОГРАММНЫХ РЕШЕНИЙ

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Abstract. The rapid digital transformation of the hospitality industry has increased the importance of software-based automation in food and beverage (F&B) operations. Restaurants, cafés, catering companies, hotels, and other food-service businesses increasingly rely on integrated digital systems to manage ordering, inventory, kitchen operations, procurement, workforce scheduling, customer relationships, payments, and managerial analytics. This study examines the role of software solutions in automating F&B processes and evaluates their potential contribution to operational efficiency, cost control, service quality, and data-driven decision-making. The research applies a qualitative analytical approach based on a structured review and synthesis of contemporary studies concerning restaurant technologies, self-service systems, artificial intelligence, digital inventory management, demand forecasting, and service automation. The analysis identifies five major areas of F&B automation: order and payment management, kitchen operations, inventory and procurement, workforce management, and business intelligence. The findings indicate that the greatest value is generated when individual digital applications are integrated into a unified information environment in which operational data are automatically exchanged between point-of-sale systems, kitchen displays, inventory modules, customer interfaces, and analytical platforms. At the same time, technological fragmentation, implementation costs, employee resistance, cybersecurity concerns, data quality, and dependence on reliable digital infrastructure remain significant barriers. The study proposes an integrated model of F&B process automation and argues that software automation should be considered not simply as a mechanism for replacing manual tasks but as an organizational capability supporting scalability, operational transparency, resource optimization, and improved customer experience.

Аннотация. Стремительная цифровая трансформация индустрии гостеприимства повысила важность автоматизации процессов в сфере общественного питания (F&B) на основе программного обеспечения. Рестораны, кафе, кейтеринговые компании, отели и другие предприятия общественного питания все чаще полагаются на интегрированные цифровые системы для управления заказами, запасами, работой кухни, закупками, расписанием работы персонала, взаимоотношениями с клиентами, платежами и управленческой аналитикой. В этом исследовании рассматривается роль программных решений в автоматизации бизнес-процессов и оценивается их потенциальный вклад в повышение операционной эффективности, контроль затрат, качество обслуживания и принятие решений на основе данных. В работе используется качественный аналитический подход, основанный на

структурированном обзоре и обобщении современных исследований, касающихся ресторанных технологий, систем самообслуживания, искусственного интеллекта, цифрового управления запасами, прогнозирования спроса и автоматизации обслуживания. Анализ выявил пять основных областей автоматизации предприятий общественного питания: управление заказами и платежами, кухонные операции, инвентаризация и закупки, управление персоналом и бизнес-аналитика. Полученные результаты свидетельствуют о том, что наибольшая ценность достигается при интеграции отдельных цифровых приложений в единую информационную среду, в которой происходит автоматический обмен оперативными данными между системами торговых точек, кухонными дисплеями, модулями инвентаризации, клиентскими интерфейсами и аналитическими платформами. В то же время технологическая фрагментация, затраты на внедрение, сопротивление сотрудников, проблемы кибербезопасности, качество данных и зависимость от надежной цифровой инфраструктуры остаются существенными препятствиями. В исследовании предлагается интегрированная модель автоматизации бизнес-процессов и утверждается, что внедрение программного обеспечения следует рассматривать не просто как механизм для замены ручных задач, но и как организационную возможность, поддерживающую масштабируемость, прозрачность работы, оптимизацию ресурсов и улучшение качества обслуживания клиентов.

Keywords: F&B automation, food and beverage management, restaurant technology, software solutions, digital transformation, POS systems, inventory management, hospitality technology, artificial intelligence, business process automation.

Ключевые слова: автоматизация общественного питания, управление продуктами питания и напитками, ресторанные технологии, программные решения, цифровая трансформация, POS-системы, управление запасами, гостиничные технологии, искусственный интеллект, автоматизация бизнес-процессов.

Digital transformation has become one of the major forces reshaping contemporary hospitality and food-service businesses. Traditional F&B operations depend on numerous interconnected activities, including customer ordering, menu management, food preparation, stock control, procurement, employee scheduling, payment processing, delivery management, customer communication, and financial reporting. When these activities are performed manually or through disconnected systems, businesses may face duplicated data entry, delayed information exchange, inaccurate inventory records, operational errors, and limited managerial visibility.

Software automation provides an alternative operational model. Instead of treating individual restaurant activities as isolated processes, contemporary information systems can connect front-of-house, back-of-house, administrative, and analytical functions through common digital workflows.

The expansion of self-service technologies illustrates this transformation. Recent restaurant research shows that ordering interfaces, kiosks, tablets, and related technologies are increasingly changing the traditional interaction between employees and customers. Perceived usefulness, ease of use, service speed, system functionality, and interface design are among the factors associated with customer acceptance of, and satisfaction with, restaurant self-service technologies [1–3].

Automation is simultaneously expanding beyond customer-facing operations. Contemporary restaurants increasingly employ software for inventory monitoring, demand forecasting, workforce planning, recipe management, procurement, waste tracking, and managerial analytics. Artificial intelligence further expands these capabilities through predictive models, computer vision, intelligent recommendations, and service robotics [4–6].

Consequently, the issue is no longer whether F&B companies should use digital technologies, but rather how different software applications can be integrated into an efficient operational ecosystem. The purpose of this study is to analyze the major applications of software-based automation in F&B operations and develop an integrated conceptual framework explaining how automation may influence operational performance. The following research questions were formulated:

RQ1: Which F&B processes have the greatest potential for software-based automation?

RQ2: How can integrated software systems improve operational efficiency and managerial decision-making?

RQ3: What organizational and technological barriers may reduce the effectiveness of F&B automation?

RQ4: How can F&B companies move from isolated digital tools toward integrated process automation?

Materials and Methods

The study employed a qualitative analytical research design based on secondary data and structured literature synthesis. This methodological approach was selected because F&B automation represents a multidimensional phenomenon involving information systems, hospitality management, customer service, inventory management, artificial intelligence, and organizational transformation.

The analysis focused on research and applied evidence addressing the following technological categories: point-of-sale (POS) systems, digital and self-service ordering, kitchen display systems, inventory management software, procurement systems, workforce-management applications, customer relationship management (CRM), demand forecasting, artificial intelligence, service robotics, food-waste monitoring, and managerial analytics and business intelligence.

Particular attention was paid to the interaction between technologies rather than to individual applications in isolation.

The analyzed F&B processes were classified into five functional areas: customer and order management, kitchen and production management, inventory and procurement, workforce and administrative management, and analytics and strategic decision-making.

For each functional area, four analytical dimensions were considered: degree of automation, data generated by the process, integration potential, and expected operational outcome.

Table 1

ANALYTICAL FRAMEWORK FOR F&B PROCESS AUTOMATION

<i>Functional area</i>	<i>Typical manual process</i>	<i>Software-based process</i>	<i>Expected outcome</i>
Customer service	Waiter manually records orders	POS, QR ordering, kiosk, mobile ordering	Faster order processing
Kitchen	Printed/handwritten tickets	Kitchen Display System (KDS)	Improved order coordination
Inventory	Manual stock counting	Real-time inventory software	Better stock visibility
Procurement	Manual supplier ordering	Automated purchasing module	More accurate replenishment
Workforce	Manual shift preparation	Scheduling and forecasting software	Improved labor allocation
Customer management	Informal customer records	CRM and loyalty platforms	Personalization and retention
Reporting	Spreadsheet-based reporting	Real-time dashboards	Faster managerial decisions

The study assumes that automation produces maximum operational value when information flows continuously between operational systems.

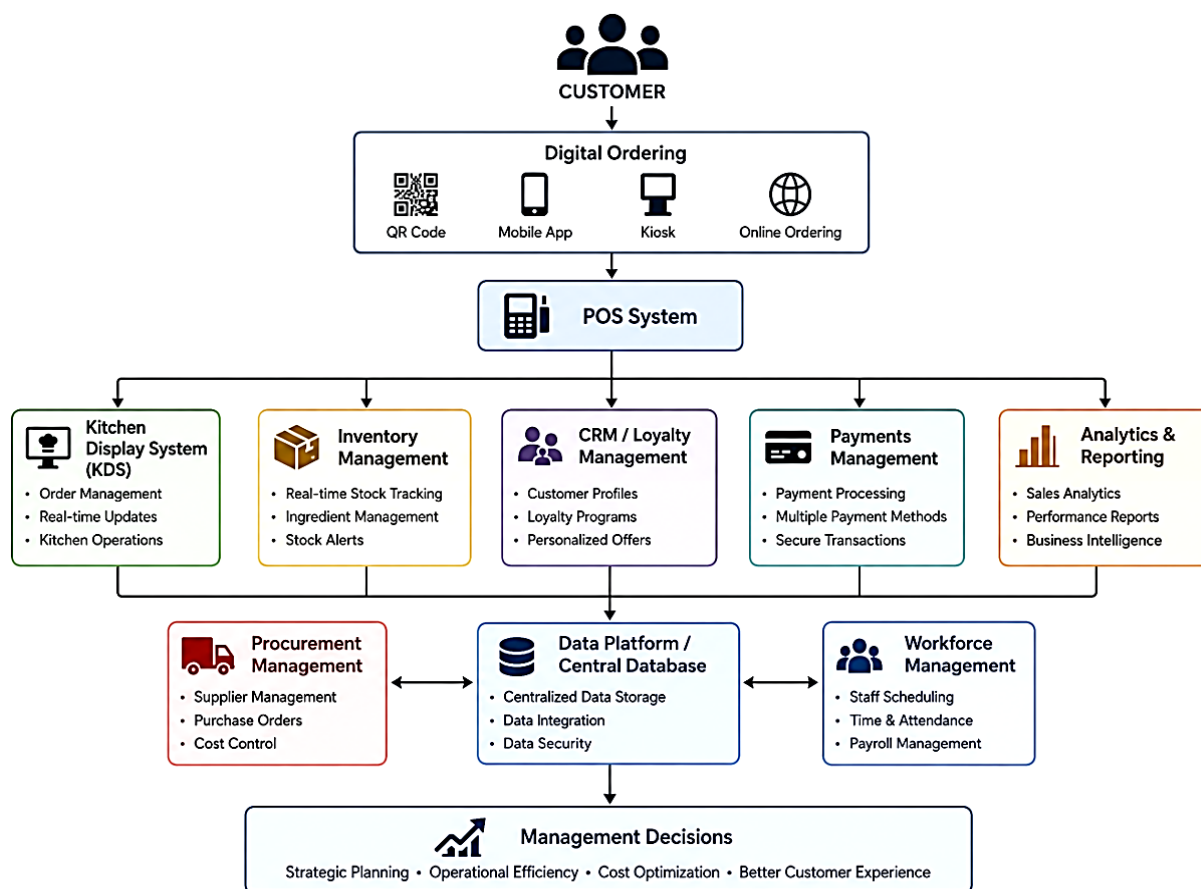


Figure 1. Integrated F&B Automation Architecture

The conceptual architecture demonstrates that the POS system can operate as a central transactional component. A customer order generates data that can simultaneously trigger kitchen production, update sales information, reduce theoretical inventory, update customer profiles, and contribute to managerial analytics.

Results

Ordering is one of the most visible areas of F&B digitalization. Traditional restaurant ordering involves several human-mediated stages: the customer communicates the order to an employee, the employee records it, the information is transferred to the kitchen, and the transaction is later processed for payment. Digital ordering reduces the number of manual information transfers. Contemporary solutions include QR-code menus, mobile applications, self-service kiosks, tabletop ordering devices, online ordering platforms, and integrated POS terminals. Studies of restaurant self-service technologies indicate that customers evaluate such systems according to factors including functionality, design, usefulness, convenience, speed, and ease of use [1–3].

Therefore, automation should not be interpreted simply as replacing employee interaction. The quality of the technological interface becomes part of service quality. The automated process can be represented as follows: the primary advantage is not merely faster ordering. Digital order capture creates structured data that can be reused by other operational systems. The kitchen represents another critical point for software integration. Kitchen Display Systems replace or complement printed tickets and allow incoming orders to be displayed according to preparation station, priority, order type, or

preparation time. A digitally connected kitchen can receive orders directly from the POS or online ordering platform. This reduces unnecessary information transfer and enables management to monitor operational indicators such as preparation time and order completion. Kitchen automation can also provide the technological foundation for more advanced solutions. Research concerning artificial intelligence and service robotics demonstrates the increasing interest in AI-enabled restaurant operations [4].

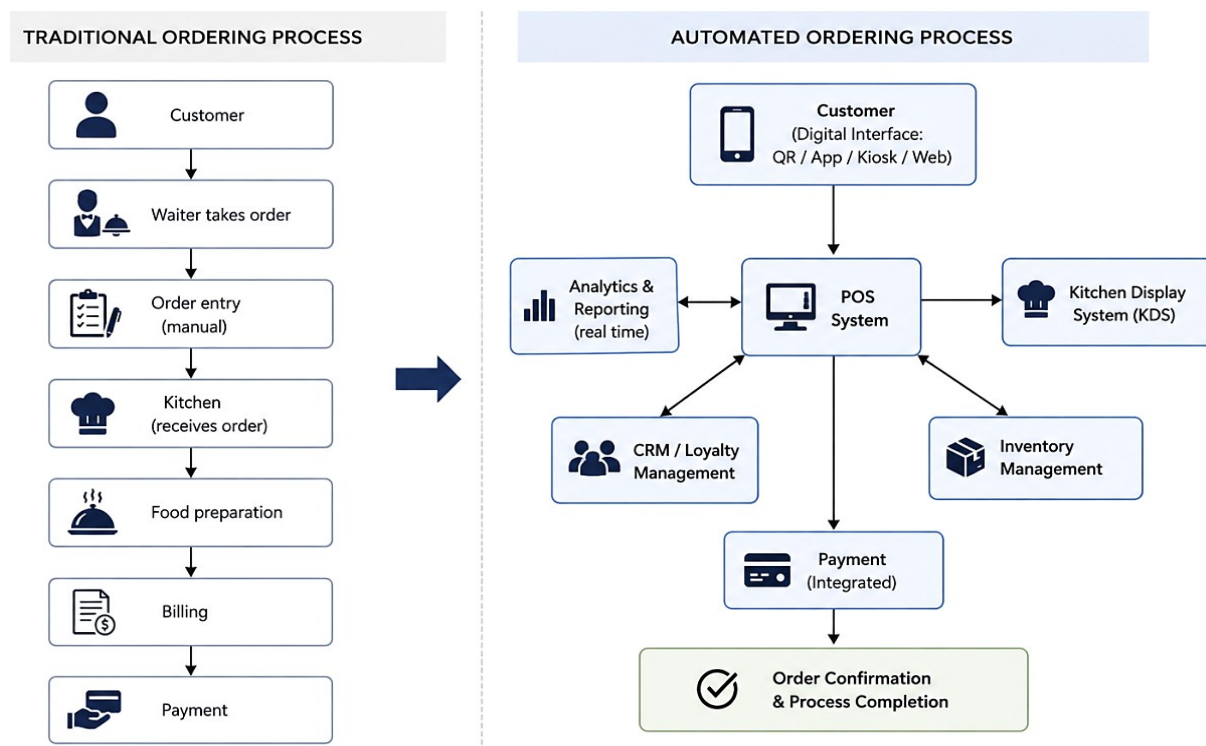


Figure 2. Transformation of the F&B Ordering Process

However, kitchen automation does not necessarily mean replacing chefs or service personnel. In most practical applications, software primarily coordinates information, prioritizes tasks, and eliminates repetitive administrative activities.

Inventory management represents one of the strongest potential applications of F&B software because restaurant inventory is characterized by perishability, fluctuating demand, multiple ingredients, supplier dependence, and limited storage periods. Under a traditional model, employees may periodically count stock and compare physical quantities with sales records. Such an approach provides only a retrospective picture.

An integrated system can create a continuous relationship between sales and theoretical inventory: Sale → Recipe → Ingredient Consumption → Inventory Update → Reorder Decision.

For example, when one menu item is sold, the software may automatically calculate the theoretical consumption of all ingredients associated with its standardized recipe. Evidence from restaurant inventory research indicates that reliance on manual, experience-based inventory practices can contribute to inefficiency, while structured inventory control, forecasting, FIFO procedures, and digital monitoring can improve operational effectiveness and support food-waste reduction [7].

The potential of artificial intelligence is particularly relevant here. Demand forecasting models can process historical orders and other variables to estimate future demand. Recent research applying deep-learning forecasting to online food-delivery supply chains has demonstrated the potential of predictive approaches to improve inventory decisions and reduce supply-chain instability [8].

Table 2

COMPARISON OF MANUAL AND AUTOMATED INVENTORY MANAGEMENT

<i>Criterion</i>	<i>Manual approach</i>	<i>Software-automated approach</i>
Inventory visibility	Periodic	Near real-time
Ingredient consumption	Estimated manually	Calculated from recipes and sales
Reordering	Manager judgment	Threshold/forecast-based
Waste identification	Limited	Digitally recorded and categorized
Cost updates	Manual	Can be linked to purchasing data
Variance detection	Delayed	Continuous or periodic automated comparison
Forecasting	Experience-based	Data-driven

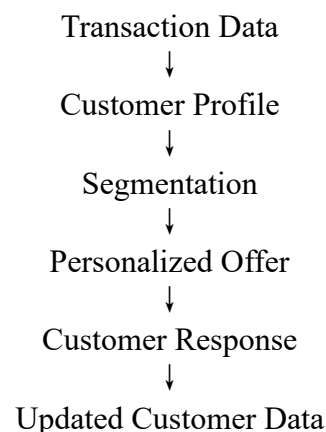
Food waste represents both an economic and sustainability problem in F&B operations. Software automation creates opportunities to move from retrospective waste reporting toward continuous waste monitoring. Possible systems include digital waste logs, ingredient-level variance monitoring, expiry alerts, demand forecasting, computer-vision waste recognition, and automated purchasing recommendations. Recent computer-vision research demonstrates that image-based systems can estimate plate-level food waste, suggesting that automated waste measurement may become increasingly scalable in institutional and commercial food-service environments [5].



Figure 3. Data-Driven Food-Waste Reduction Cycle

An automated waste-management cycle can therefore be represented as follows, where waste information becomes a feedback mechanism rather than merely a record of losses. Labor represents another critical operational resource in restaurants and hospitality establishments. Demand fluctuates based on the hour, weekday, season, weather, events, promotions, and other factors; consequently, static schedules may result in understaffing or excessive labor allocation. Workforce-management software can combine historical sales data with scheduling information and predicted demand.

Automated systems may support shift scheduling, attendance tracking, payroll preparation, labor-cost monitoring, demand-based staffing, employee availability management, and performance reporting. The underlying management logic shifts from "manager experience → schedule" to "historical data + forecast demand + employee availability + labor constraints → optimized schedule." Nevertheless, algorithmic recommendations should support rather than completely replace managerial judgment, as employee skills, customer expectations, local labor requirements, and unexpected events may not be fully represented in historical datasets. Automation also changes how F&B companies interact with customers after a transaction. When POS, ordering, loyalty, and CRM systems are integrated, companies may obtain structured information concerning visit frequency, average transaction value, product preferences, ordering channels, loyalty activity, and promotion responses. Such information enables segmentation and personalized communication. For example:



The important distinction is that automation transforms isolated transactions into longitudinal customer information. However, organizations must ensure compliance with applicable privacy and data-protection requirements and limit customer data collection to legitimate business purposes. The final stage of F&B automation is the transformation of operational data into managerial intelligence. When software platforms remain isolated, managers may receive separate reports from POS, accounting, delivery, inventory, and workforce systems. Integrated business-intelligence tools can consolidate these data streams into dashboards. Potential indicators include: sales by hour, average check, food cost, labor cost, stock variance, menu-item profitability, preparation time, table turnover, waste level, customer retention, and sales-channel performance.

Table 3

EXAMPLES OF KPIS ENABLED BY INTEGRATED F&B AUTOMATION

<i>Area</i>	<i>KPI</i>	<i>Managerial application</i>
Sales	Revenue by hour/day	Demand planning
Menu	Contribution margin	Menu optimization
Inventory	Stock variance	Loss control
Kitchen	Preparation time	Workflow improvement
Labor	Labor cost/sales	Staffing optimization
Customer	Repeat purchase rate	Retention management
Waste	Waste per sales unit	Sustainability/cost control
Procurement	Purchase price variance	Supplier management

This integration shifts managerial decision-making from retrospective reporting to continuous operational control. Based on the analysis, three levels of F&B digital maturity can be distinguished. The distinction is important. A restaurant that uses five independent applications is not necessarily more automated than a restaurant using three deeply integrated applications. The proposed model is presented below.

Table 4

LEVELS OF F&B AUTOMATION MATURITY

Level	Characteristics	Example
Level 1: Digitalization	Individual manual activities become digital	Electronic POS
Level 2: Automation	Software automatically performs predefined tasks	Automatic inventory deduction
Level 3: Integration and Intelligence	Multiple systems exchange data and generate recommendations	POS + inventory + forecasting + procurement + BI

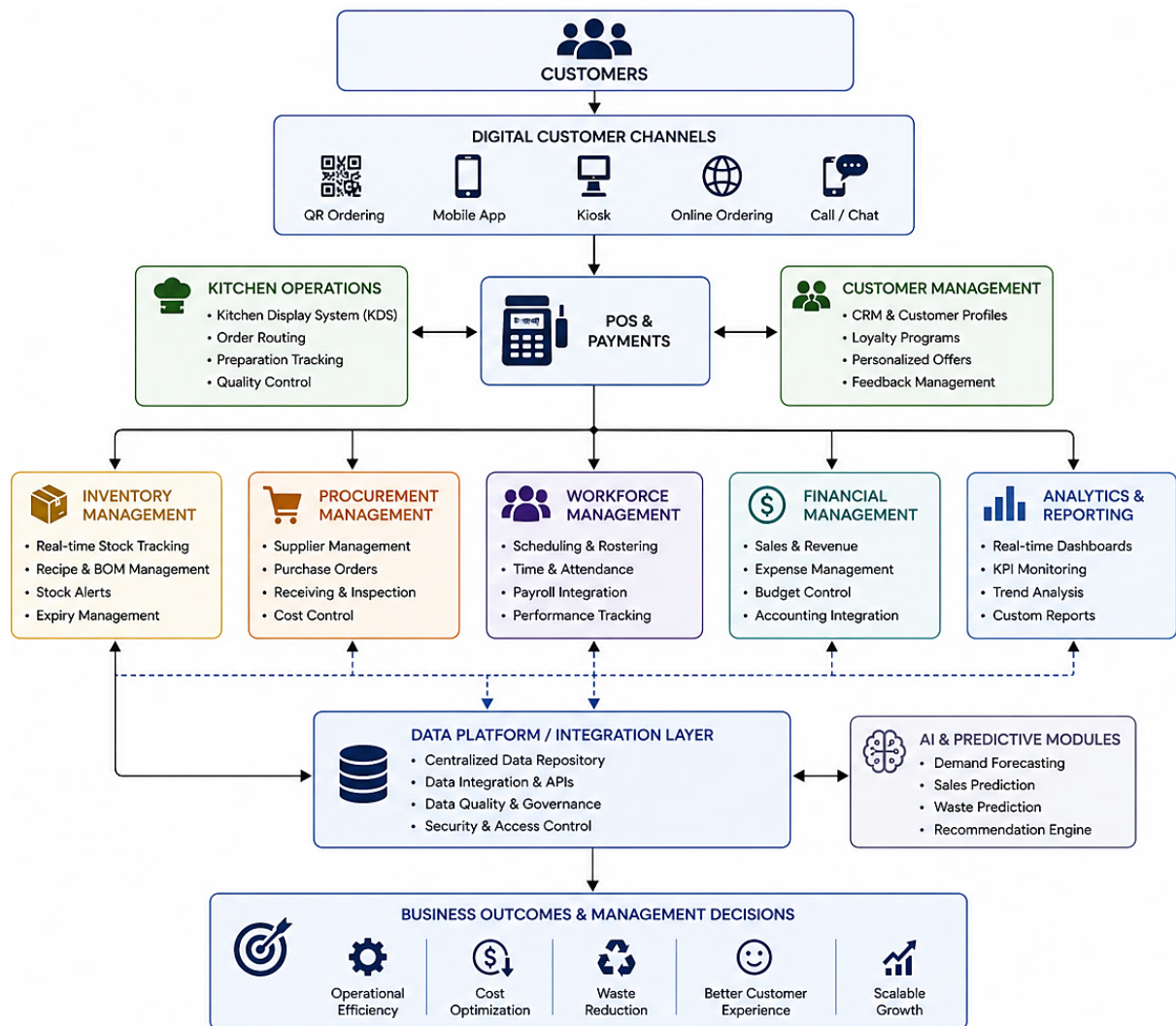


Figure 4. Integrated Model of Software-Based F&B Automation

The findings indicate that software automation can influence F&B performance through several interconnected mechanisms. First, automation reduces repetitive information processing. When an order is digitally captured once and transferred automatically to kitchen, inventory, payment, and analytical systems, the need for repeated manual data entry decreases. Second, automation increases operational visibility. Managers can access current information rather than waiting for end-of-day or end-of-month reports. Third, integrated software makes operational data reusable. A single transaction can contribute simultaneously to revenue reporting, ingredient consumption calculations, customer analytics, demand forecasting, and labor planning. Fourth, automation provides an infrastructure for predictive management. Traditional F&B management is largely reactive: managers

identify shortages, excess labor, waste, or declining demand after they occur. Predictive analytics creates opportunities to anticipate these conditions.

The relationship can be conceptualized as: Digital Data → Integration → Automation → Analytics → Prediction → Decision → Operational Outcome.

Nevertheless, the results also suggest that automation should not be treated as an inherently beneficial technological intervention.

Table 5

BENEFITS AND RISKS OF F&B SOFTWARE AUTOMATION

<i>Potential benefits</i>	<i>Potential risks/barriers</i>
Faster order processing	High implementation costs
Reduced manual data entry	Integration problems
Improved inventory visibility	Poor data quality
Better demand forecasting	Employee resistance
Lower probability of human error	Training requirements
Improved managerial analytics	Cybersecurity risks
Scalable operations	Vendor dependence
Better waste monitoring	System downtime
Personalized service	Privacy concerns

A particularly important problem is technological fragmentation. If POS, inventory, accounting, delivery, and CRM platforms cannot exchange information effectively, employees may still need to export files or manually transfer data between applications. In this situation, digitalization may create additional administrative complexity rather than eliminating it. Therefore, integration capability should be considered one of the primary criteria when selecting F&B software. Another important finding concerns the relationship between automation and human labor. Restaurant automation should not automatically be interpreted as employee replacement. Research on self-service systems demonstrates that customer experience remains influenced by usability and technological reliability [1–3].

Similarly, service-robot research shows that restaurant AI adoption involves complex relationships among technology, service experience, and consumer responses [4].

The most sustainable model is therefore likely to be human-centered automation. Under this model, machines and software handle repetitive tasks, data processing, monitoring, forecasting, and transaction processing, while employees handle hospitality, creativity, problem-solving, empathy, and exception handling, resulting in enhanced F&B service. Automation can consequently redistribute employee time from routine administrative work toward customer-facing and value-creating activities. For restaurant and hospitality managers, the findings suggest that software implementation should follow process priorities rather than technological trends. A recommended implementation sequence is: Stage 1 — Process Mapping: Identify repetitive, error-prone, expensive, or data-intensive processes. Stage 2 — Core Transaction Digitalization: Implement a reliable POS and digital payment environment. Stage 3 — Operational Integration: Connect ordering, kitchen, inventory, and purchasing systems. Stage 4 — Data Consolidation: Create common dashboards and standardized performance indicators. Stage 5 — Predictive Automation: Introduce demand forecasting, automated replenishment, workforce forecasting, and AI-supported recommendations. Stage 6 — Continuous Optimization: Compare actual results with predicted results and modify automation rules. For small and medium-sized F&B companies, gradual implementation may be preferable to attempting full automation simultaneously. The priority should be technologies with measurable operational

outcomes and reliable integration capabilities. The study has several limitations. First, it is based primarily on secondary evidence and conceptual synthesis rather than an experimental implementation in a specific restaurant chain. Second, the F&B sector is heterogeneous: automation requirements differ significantly between quick-service restaurants, fine-dining establishments, cafés, catering businesses, institutional food service, and hotel restaurants. Third, technological performance depends on organizational context. A software solution effective in a large restaurant chain may not generate equivalent benefits for an independent small restaurant. Future research should therefore conduct empirical studies comparing operational indicators before and after automation. Such research could measure order-processing time, labor hours, food cost, inventory variance, waste, customer satisfaction, and profitability.

Conclusion

The study demonstrates that software-based automation is transforming F&B operations from collections of manually coordinated activities into interconnected digital processes. The major areas of transformation include ordering, kitchen operations, inventory, procurement, workforce management, customer relationship management, food-waste monitoring, and business intelligence. The main value of automation does not arise from any single software application. Rather, it emerges from the integration of multiple operational systems into a common data environment. When transaction data move automatically from customer interfaces to POS systems, kitchens, inventory modules, CRM platforms, and analytical tools, restaurants can reduce repetitive administrative work and obtain greater operational transparency. The proposed framework distinguishes between three stages of technological development: digitalization, automation, and integrated intelligence. This distinction is important because the mere adoption of software does not guarantee process automation. Fragmented systems may preserve manual work even within technologically advanced organizations. Artificial intelligence further extends F&B automation by enabling demand forecasting, waste recognition, predictive inventory management, and intelligent decision support. Nevertheless, technology should complement rather than eliminate the human dimension of hospitality. The strategic objective of F&B automation should therefore be to automate repetitive and data-intensive processes while allowing employees to concentrate on customer interaction, creativity, service recovery, and other activities where human capabilities remain particularly valuable. In this context, integrated software solutions should be regarded not only as operational tools but also as strategic infrastructure for scalable, data-driven, and sustainable F&B management.

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Поступила в редакцию
12.08.2026 г.

Принята к публикации
23.08.2026 г.

Ссылка для цитирования:

Dzhangaziev K. Automation of Food and Beverage Processes using Integrated Software Solutions // *Бюллетень науки и практики*. 2026. Т. 12. №10. С. 122-132. <https://doi.org/10.33619/2414-2948/131/14>

Cite as (APA):

Dzhangaziev, K. (2026). Automation of Food and Beverage Processes using Integrated Software Solutions. *Bulletin of Science and Practice*, 12(10), 122-132. <https://doi.org/10.33619/2414-2948/131/14>