

Impact of Menu Engineering on Food Waste Reduction and Restaurant Profitability

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Abstract: Menu engineering is a data-driven restaurant management approach that evaluates menu items according to their popularity, contribution margin, selling price, ingredient cost, and operational requirements. Traditionally, menu engineering has been applied primarily to improve restaurant profitability; however, its potential contribution to food waste reduction has received increasing attention. Food waste is a major operational, economic, and environmental problem in restaurants because excess purchasing, preparation, overproduction, unpopular dishes, large portions, and poor inventory planning increase food costs and reduce profitability.

Recent research indicates that menu design can influence customer food choices and consequently affect the quantity of food wasted. In particular, narrower and more carefully structured menus may reduce unnecessary ordering and food waste while maintaining food intake. A recent experimental study reported that a narrower menu reduced food waste by 57% compared with a broader menu.

Keywords: Menu Engineering, Food Waste, Restaurant Profitability, Menu Design, Contribution Margin, Food Cost, Sustainability.

I. INTRODUCTION

The restaurant industry operates within a highly competitive environment in which profitability depends on effective control of food costs, labour, inventory, purchasing, production, pricing, and customer demand. Among these factors, menu management is particularly important because the menu determines what ingredients are purchased, what products are prepared, how customers make choices, and which dishes contribute to revenue. Menu engineering provides a systematic approach for analysing these relationships by examining menu-item popularity and contribution margin. Traditional menu engineering generally classifies dishes according to their profitability and popularity, allowing managers to identify items that should be promoted, modified, repriced, repositioned, or removed. However, the significance of menu engineering extends beyond financial performance. Restaurant food waste is increasingly recognized as a major sustainability and economic challenge, and systematic reviews show that menu design and specifications are among the managerial variables associated with food waste generation and reduction.

Food waste occurs at several stages of restaurant operations, including purchasing, storage, preparation, cooking, serving, and post-consumption disposal. When restaurants continue offering unpopular dishes, they may need to maintain ingredients that have low turnover, increasing the possibility of spoilage and preparation waste. Similarly, dishes requiring specialized ingredients may create waste when demand is unpredictable. Menu engineering can address these problems by linking sales data with ingredient requirements and contribution margins. Consequently, a restaurant can identify products that generate sales but also consume excessive resources and can redesign the menu to improve both financial and environmental performance.

CONCEPT OF MENU ENGINEERING

Menu engineering is a quantitative approach for evaluating the performance of individual menu items. The traditional framework generally uses two principal dimensions: popularity and contribution margin. Popularity indicates how

frequently an item is ordered, whereas contribution margin represents the amount remaining from the selling price after subtracting relevant variable food costs.

A simplified contribution-margin formula is:

Contribution Margin = Selling Price – Food Cost

Menu items can then be categorized into four broad groups:

Menu Category	Popularity	Contribution Margin	Typical Management Action
Star	High	High	Promote and maintain
Plowhorse	High	Low	Reduce cost or improve price
Puzzle	Low	High	Improve promotion and visibility
Dog	Low	Low	Redesign, replace, or remove

Menu engineering research has traditionally concentrated on profitability, but contemporary approaches increasingly consider operational and sustainability variables. Lai et al. (2020), for example, reviewed menu profitability approaches and highlighted the importance of integrating menu analysis with revenue-management perspectives. More advanced approaches can combine menu engineering with activity-based costing to provide a more realistic assessment of profitability because food costs alone may not capture all traceable operating costs.

RELATIONSHIP BETWEEN MENU ENGINEERING AND FOOD WASTE

The relationship between menu engineering and food waste arises because menu decisions influence purchasing, inventory, preparation, and customer consumption. A menu containing numerous low-demand dishes can require restaurants to purchase a wide variety of ingredients, many of which may not be fully utilized before deterioration. By identifying low-popularity dishes, menu engineering provides an opportunity to remove unnecessary ingredients from the procurement system.

Menu-dependent food choices are also important. Research published in *Resources, Conservation and Recycling* found that participants exposed to a narrower menu ordered less food while maintaining similar food intake, resulting in a reported 57% reduction in food waste. This finding suggests that menu structure itself can influence waste-generating consumer decisions.

Menu engineering can therefore reduce waste through several mechanisms: reducing unnecessary menu variety, improving demand forecasting, aligning menu items with ingredient availability, reducing unpopular dishes, controlling portion sizes, and encouraging the sale of dishes using ingredients with high utilization rates. Recent research involving restaurant chefs similarly indicates that small and agile menus, seasonal ingredients, monitoring dish popularity, repurposing ingredients, and using multiple parts of ingredients can contribute to waste minimization.

MENU ENGINEERING AND RESTAURANT PROFITABILITY

Restaurant profitability depends on the difference between revenue and total operating costs. Menu engineering improves profitability by helping managers understand which menu items generate strong contribution margins and which products consume resources without generating sufficient returns. High-popularity and high-margin items should generally receive greater promotional attention, whereas low-performing items can be modified or removed.

However, profitability should not be evaluated solely on selling price. Ingredient costs, labour requirements, preparation time, energy consumption, storage requirements, wastage, and customer demand can affect the true profitability of an item. Activity-based costing integrated with menu engineering has therefore been proposed as a more comprehensive approach to evaluating menu-item profitability.

Food waste reduction can further increase profitability because wasted ingredients represent costs that generate no revenue. When a restaurant purchases ingredients that are subsequently spoiled, discarded during preparation, overproduced, or left uneaten, the business absorbs the associated purchasing and labour costs. Thus, reducing food waste can improve the effective contribution margin of menu items.

MENU DESIGN AS A FOOD WASTE REDUCTION STRATEGY

Menu design influences both customer selection and kitchen operations. A complex menu with excessive options can increase ingredient diversity and operational complexity. Conversely, a strategically designed menu can concentrate demand on products that use overlapping ingredients, thereby improving ingredient utilization.

For example, restaurants may design several dishes around common vegetables, sauces, grains, proteins, or garnishes. This approach allows ingredients to be utilized across multiple menu items and reduces the probability of leftover inventory. Seasonal menu changes can also align purchasing with ingredient availability and quality. Research with head chefs found that chefs often considered ingredient cost, availability, seasonality, customer demand, and operating costs when designing menus.

An effective menu should therefore consider not only what customers want to purchase but also how efficiently the restaurant can produce each item.

PORTION SIZE AND CONSUMER FOOD WASTE

Portion size is another important connection between menu engineering and food waste. Excessively large portions can increase plate waste when customers are unable or unwilling to consume the entire serving. Menu engineering can identify dishes associated with high levels of plate waste and allow restaurants to modify portion sizes.

Restaurants can introduce multiple portion options, smaller servings, half portions, or flexible add-ons. Such strategies allow customers to select quantities according to appetite while reducing unnecessary food disposal. Menu descriptions can also communicate portion characteristics more clearly, helping customers make more informed choices.

INVENTORY MANAGEMENT AND MENU ENGINEERING

Inventory management is closely connected to menu engineering. When menu-item sales data are analysed regularly, managers can forecast ingredient requirements more accurately. High-volume products require reliable supply, whereas low-volume products may require smaller purchasing quantities.

Food waste literature identifies purchasing, storage, forecasting, menu design, food provisioning, and inventory management as important variables affecting restaurant food waste. Therefore, menu engineering should not be treated as an isolated marketing activity; it should be integrated with procurement and inventory-control systems.

A restaurant can use historical sales data to estimate expected demand and adjust purchasing accordingly. This can reduce over-purchasing and improve stock rotation. Digital point-of-sale systems can further support this process by providing item-level sales information.

SUSTAINABLE MENU ENGINEERING

Sustainable menu engineering expands the traditional profitability model by including environmental and resource-efficiency considerations. A menu item can be financially attractive but environmentally inefficient if it requires large quantities of scarce ingredients, produces considerable waste, or depends on ingredients that have poor utilization rates.

Sustainable menu engineering therefore considers:

- Ingredient cost
- Contribution margin
- Sales popularity
- Ingredient utilization
- Food waste
- Portion size
- Seasonality
- Local availability
- Preparation time
- Energy requirements

- Storage requirements
- Customer acceptance

Recent research indicates that chefs increasingly consider sustainability alongside profitability, particularly through seasonal sourcing, local ingredients, agile menus, and improved utilization of ingredients.

INTEGRATED FRAMEWORK

The relationship between menu engineering, food waste, and profitability can be conceptualized as follows:

Customer Demand → Sales Data → Menu Engineering → Menu Classification → Menu Modification → Purchasing & Production Optimization → Food Waste Reduction → Cost Reduction → Higher Contribution Margin → Improved Restaurant Profitability

This framework demonstrates that menu engineering can operate as an intermediary mechanism connecting customer behaviour with restaurant sustainability and financial performance.

Author/Year	Research Focus	Major Finding	Relevance to Present Review
Dhir et al. (2020)	Food waste in hospitality and food services	Identified multiple managerial, operational, behavioural, and waste-management factors	Establishes menu design as one component of food-waste management
Principato et al. / literature synthesized by Dhir et al. (2020)	Restaurant food-waste practices	Forecasting, purchasing, menu design, and operational practices influence waste	Supports integration of menu engineering with operational planning
Filimonau & De Coteau (2019)	Hospitality food-waste mitigation	Emphasized systematic managerial approaches to waste reduction	Supports strategic waste-management perspective
Malefors et al. / foodservice strategy literature	Foodservice waste interventions	Demonstrates importance of interventions across different waste stages	Supports multi-stage menu and operational management
Strategies review (2021)	Food-waste reduction strategies	Identified 180 strategies across 30 groups; highlighted gaps in evidence	Demonstrates broad intervention opportunities
Menu-dependent food-choice study (2022)	Menu structure and food waste	Narrower menu produced substantially less food waste in experimental conditions	Direct evidence linking menu design and waste
Lai et al. (2020)	Menu profitability management	Compared menu analysis and revenue-management approaches	Supports profitability-oriented menu management
Menu engineering + ABC study	Menu profitability	Activity-based costing can improve assessment of true menu profitability	Supports comprehensive profitability measurement
Jones et al. (2025)	Restaurant menu design and sustainability	Chefs emphasized small agile menus, seasonality and waste reduction	Connects menu design, sustainability and financial considerations
Lee et al. (2026)	Food-waste management and restaurant performance	Menu planning/design forms part of a broader food-waste management capability linked with restaurant performance	Supports integrated sustainability-profitability framework

The broader foodservice literature confirms that food waste is not simply a disposal problem. Systematic research has identified numerous strategies across purchasing, preparation, service, consumer behaviour, and leftover management, although evidence quality varies considerably across interventions.

DISCUSSION

The literature indicates that menu engineering has the potential to contribute simultaneously to economic and environmental objectives. Traditional menu engineering focuses primarily on sales and contribution margin, whereas sustainable menu engineering expands the analysis to include waste generation, ingredient utilization, seasonality, customer behaviour, and operational efficiency.

One important finding is that high sales volume does not necessarily indicate optimal profitability. A popular item with a low contribution margin may generate substantial revenue while providing limited profit. Recent empirical menu-engineering research in a tourism-oriented café found that 41% of analysed items were classified as plowhorses—high in popularity but comparatively low in contribution margin—illustrating the importance of distinguishing sales popularity from profitability.

The relationship between profitability and sustainability can therefore be mutually reinforcing. Reducing unnecessary food purchases lowers food costs; reducing preparation waste lowers labour and ingredient costs; reducing plate waste improves resource efficiency; and removing low-demand dishes can simplify purchasing and inventory management. However, managers should avoid reducing menu variety indiscriminately because customer satisfaction and perceived choice also influence restaurant performance.

Recent research specifically conceptualizes food-waste management as a strategic capability for restaurant performance and identifies menu planning and design alongside procurement/storage, stakeholder engagement, and leftover handling as important dimensions.

Although menu engineering and food-waste management have each received considerable academic attention, relatively fewer studies directly examine their combined effects on restaurant profitability and waste reduction. Existing menu-engineering research frequently focuses on contribution margins and popularity, whereas food-waste studies often focus on behavioural, operational, or environmental interventions. The integration of these perspectives remains an important research opportunity.

Future studies should therefore develop integrated menu-engineering models that simultaneously measure menu popularity, contribution margin, food waste per item, ingredient utilization, preparation cost, plate waste, customer satisfaction, and environmental impact. Longitudinal research involving multiple restaurants would also provide stronger evidence than single-restaurant case studies.

II. CONCLUSION

Menu engineering should no longer be viewed solely as a technique for identifying profitable menu items. The reviewed literature demonstrates that it can also become an important component of restaurant food-waste management. By analysing menu popularity, contribution margin, ingredient requirements, portion sizes, customer preferences, and operational costs, restaurants can identify opportunities to eliminate poorly performing products, redesign dishes, improve ingredient utilization, and align purchasing with actual demand. Evidence that menu structure can substantially influence food waste further strengthens the argument that menu design is an important sustainability intervention.

At the same time, recent research shows that sustainable menu decisions need to remain financially viable because restaurants operate under significant labour, ingredient, and operating-cost pressures. Therefore, the most effective approach is not simply to reduce the number of menu items but to develop a balanced menu portfolio that maximizes customer satisfaction, contribution margin, ingredient utilization, and sustainability. An integrated model combining menu engineering, activity-based costing, demand forecasting, inventory management, and food-waste measurement could provide restaurants with a more comprehensive method for improving profitability while reducing environmental impacts.

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