Understanding Food Selection Behavior Using HCI-Driven Smart Menu Interfaces

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Declaration

It is hereby declared that

1. The thesis submitted is my/our own original work while completing degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. We have acknowledged all main sources of help.

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Abstract

Food waste in University cafeterias has been a persistent sustainability challenge which is usually fuelled by the imbalance between the food choice customer expectation and consumption. The current interventions are mostly oriented at the post-consumption monitoring, which does not emphasize the most important moment of food selection. The method adopted in this research is that of Human-Computer Interaction (HCI) with the view to understand how smart menu system can be used to intervene at the point of decision to reduce food wastage. Following the previous prototype studies, this phase of the research uses qualitative and prototype-based assesment using surveys with 50 respondents and semi-structured interviews with 20 stakeholders, including students, faculty members, cafeteria staff, and management. The subjects were manipulated using a set of 3 menu paradigms, a conventional listing-based menu with a relatively simple set of nutritional information, information-lite menu with a simple nutritional information, and information-rich smart menu with visual previews, sustainability related cues and waste related information. Thematic analysis of the interviews shows that food waste is often caused as a result of expectation-reality discrepancies, time-stressed decisions, social factors, and no control over the amount of portion. Participants constantly emphasised the need of clarity in visuals and belief in quality of food and plainness of design in facilitating improved decisions. Altogether, the results demonstrate the potential of smart menus that are HCI-based, low cost and behaviorally informed, to be able to impact the food preferences prior to eating, and still fitting in with the current cafeteria operations. The research contributes qualitative knowledge to the domain of sustainable interaction design and identifies the directions of practical implementation and testing in the future.

Keywords: Food waste reduction, Smart menu systems, Human–Computer Interaction (HCI), Menu design, Digital nudging, Sustainable consumption, University cafeterias, Behavioral intervention

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Chapter 1

Introduction

1.1 Background

One of the largest sustainability challenges of the institutional setting is food waste, and university cafeterias are not an exception [18]. Conventional approaches to waste reduction have focused on the post consumer intervention such as waste audits and creation of awareness. Such intervention however does not necessarily engage with the user at the crucial stage of decision making in selecting food. Disagreements rising from the amount of portions, customer preferences and instant feedback mechanism will result in massive levels of plate wastage with both financial and environmental consequences.

Digital interfaces present new prospects to address this challenge considering the environment of food services. Literature has recently mentioned the possibilities of consumer behavior influences with the help of information systems [20], and it was revealed that real-time feedback can play an important role in influencing the consumption pattern [10]. A very important touchpoint that is not maximally utilized to provide behavior change interventions lies on the menu that acts as a bridge or the main interface between food service and consumers. Despite the lack of consideration of the significance of menu design as a behavioral intervention, in the past its role in the environment of food waste reduction was disregarded particularly in a developing environment like Bangladesh.

This thesis discusses the way HCI driven smart menu interfaces will be used to reduce food waste in university cafeterias both in design and effectiveness. We establish and experiment with different menu paradigms using the idea of Human-Computer Interaction (HCI) and behavioral economics, which incorporate different types of information and nudges. This study provides a generalized summary of the effect that interface design may exert on food selection practices and waste minimization in institutional food settings by a methodology consisting of qualitative knowledge.

1.2 Motivation

The issue of food waste in university cafeterias is still not eliminated and the new innovative methods need to be investigated in order to achieve the best solutions as old approaches did not succeed in establishing the positive outcomes. The current strategies tend to employ passive awareness campaigns that fail to involve the user into the decision making process which is significant. The similarities in the morphology of successful and unsuccessful interventions in terms of prevention of Food waste may indicate the need to implement context-specific, real-time interventions that can be tailored to the behavioral and preference nature of a specific user.

The new trends in HCI and behavioral science offer some good opportunities in resolving such problems. The digital nudging research has demonstrated that a carefully designed interface may influence user behavior in a profound manner and not restrict them in the choice [28]. Studies on eco-feedback systems have established that consumption behavior can be made visible and this may lead to more sustainable behavioral practices [21]. However, these concepts have not been used in menu design in cafeteria settings where there are limited resources.

The expansion of the number of digital displays and touchscreen interfaces in institutions is an opportunity to increase smart menu systems. Through this kind of technological advances, and with implementation of expertise in different fields, the specified study should be able to offer a practical, evidence-based solution that will assist not only in the reduction of food waste but will also be capable of ensuring that the user remains free and satisfied.

1.3 Problem Statement

The current policies of food waste management in university cafeterias have several weaknesses that dampen their success rate. Past techniques such as informational posters and waste audits are inactive and post-factual where they lack interventions at the point of decision making. Monitoring systems that are labor intensive can hardly be scaled in large dining places.

The digital solutions have just been focused at the back-end operations such as inventory management, yet consumer behavior is a very important part of the waste cycle. The existing menu interfaces currently show minimal information besides the names and prices of the items and do not present much help in regards to making sustainable choices. The reason is that the lack of real-time and personal feedback does not correlate the actions of a user and the result of these actions, and people cannot demonstrate and modify the wasting habits in an easy way.

These restrictions suggest that it is important to develop an integrated, user-oriented solution that would make use of digital interfaces to issue a nudge at an important stage in the process of selecting food. The smart menu system can be considered as the solution to this gap, as it will reveal the implications of the options and will bring them to the forefront of attention and, thus, will be able to make better and more sustainable decisions.

1.4 Research Objectives

The research aimed at establishing and assessing interventions based on smart menu design to reduce food waste in university cafeterias by applying three primary objectives:

1. **Design and Compare Multiple Menu Paradigms:** With the help of three menu interfaces (Traditional, Basic-Info, Info-Rich), the difference in effectiveness between the interfaces will be compared in the sphere of user behavior and the minimization of waste intentions.

2. **Test the Behavioral Impact and Perception:** This includes comparing the decision making process by alternating key indicators such as waste scales, sustainability indications, nutritional information and seeing the effect it brings on both waste reduction and customer satisfaction.

3. **Establish Implementation Framing:** Implementation of the model on a resource constrained environment and reviewing the challenges and successes.

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1.5 Methodology in Brief

The research used a combination of quantitative and qualitative research methods. Firstly, we used 3 menu prototypes through surveys with an aim of having at least 100 respondents. But due to the disinterest of the respondents to participate in the survey, we decided to go for 50 survey respondents and 20 semi-structured interviews. Both the survey and the semi-structured interviews had key stakeholders like students, faculty and cafeteria staff in the experimental stage. Data analysis was a product of both qualitative and quantitative approach in the presentation of data in the statistical form as well as thematic approach providing a clear illustration of the effectiveness of the smart menu interventions and its practical meaning respectively.

1.6 Scopes and Challenges

This research gives some positive prospects on both the research and implementation. This has been successful in information-intensive interfaces, which is the opening of its application in other food service settings besides university cafeterias. The proposed framework is modular in nature, which means that the framework can be adapted to other cultural and institutional contexts. The directions of the future can be personalized prescribing, application of mobile applications, and sustainability of behavior changes. It also has several challenges which it needs to meet in order to be successfully implemented. Resource constrained environments could make a hindrance in technical infrastructure requirements. It must consider cultural acceptance and resistiveness to change among the consumers and service providers. When it comes to the implementation of dynamic information like waste, it should be ensured that the measurement systems are proper to ensure the accuracy of the data.

Chapter 2

Literature Review

2.1 Preliminaries

Food waste in university cafeterias represents both an environmental concern and a design challenge. World-wide, it is estimated that one-third of total food production that is designed to serve humans for consumption will be squandered, and this will be a source of environmental degradation and economic growth loss. Dining in the university setting is an appropriate intervention environment to their naturalistic masses, predictive consumption, and regulated food service operations. The available studies have discussed the food waste in institutional dining in several ways and viewpoints, such as measurement of wastes, technological methods of food disposal monitoring and behavioral interventions to affect food choice.
The literature review is based on the previous research related to the generation of food waste in university cafeterias, technological solutions to monitor this waste and the behavioral strategies connected with the menu design and information presentation. In addition, methodological techniques that are typically applied to Human-Computer Interaction (HCI) studies, especially qualitative research (semi-structured interviews, etc.) are analysed. The chapter ends up stating gaps in the available literature that inspires the current research.

2.1.1 Theoretical Framework

In this study, three primary theories will be utilized to explore how consumers interact with electronic menus in a high-traffic fast food setting. The first theory is the Technology Acceptance Model (TAM) [6], which looks at how students and cafeteria employees perceive the interfaces of electronic menus based on their ease of use and usefulness, and how that affects whether they choose to use an electronic menu. The second theory is Nudge Theory [13], which focuses on the architecture of the electronic menu and how visual cues (e.g., percentage of food waste, icons for sustainably produced food) encourage sustainable eating choices without intervening with anyone's freedom to choose. The last theory used in this study is Dual Process Theory [19]. In a cafeteria, there are two modes that students will use while deciding what to order: fast and intuitive (System 1) decisions versus slower and more thought-out (System 2) decisions. Because most food purchases are made during peak hours (high volume), the expectation is that cafeteria subjects will be in an intuitive (System 1) state of mind, which makes it unlikely that

they will engage with a menu display that has too much information. Therefore, this research will contribute to the understanding of how well-designed electronic menus can positively influence a consumer's decision through outstanding, low-effort ways. Together, these three theoretical frameworks serve as the foundation for this research.

2.2 The Food Waste in University Cafeterias: Scale and Composition

Knowledge of food waste size and structure is necessary in designing effective interventions. The past studies have consistently documented the amount of food waste in college cafeterias to be large and with recurrent patterns in various institutional settings.

2.2.1 Quantifying the Problem

Several studies have documented significant levels of food waste generated in university dining facilities. Hughes, Zhai, and Hallstrom reported that students at Florida Atlantic University generated approximately 0.4 kg of food waste per person during lunch, amounting to an estimated 6.7 kg per student over a sixteen-week academic semester [24]. Comparable findings have been observed in international contexts. Kamaruddin, Jantira, and Alrozi found the rate of food waste production to be between 0.04 and 0.119 kg/capita divided across two campus cafeterias at Universiti Sains Malaysia where the weekly wastes average 22.14 kg at only two consumption points [26].

In addition to the number of waste, there are also severe effects of waste on the environment. Food waste placed in the landfill decomposes without aerobes, generating methane, a greenhouse gas that has a significantly higher global warming capability than carbon dioxide [26]. In the US, the annual wastage of cultivated food is close to 40 percent, and it leads to estimated economic losses totaling at 165 billion and were a significant contributor to landfill accumulation [25]. Similar difficulties have been pointed to in more general food service settings. A study by Johnston, Reardon, and Garrison on the practices of food waste reduction in restaurant training settings revealed that operational factors like time pressure, staff turnover and limited resources are obstacles to a successful reduction of food waste strategy [29]. Their results give an emphasis on tensions between the perceived portion value and actual consumption, which is a difficulty that most closely resembles food selection behavior evident in university cafeteria backgrounds. Likewise, Blum pointed out that it is necessary to deal with food waste through systematic operation plans instead of using consumer-facing interventions only [25].

2.2.2 Composition of Cafeteria Food Waste

Food waste compositional analysis gives information on the food types that are most commonly disposed. Kamaruddin, Jantira and Alrozi carried out an elaborate compositional analyses of 13 food waste samples collected throughout half a year at a college dining hall [26]. The composition of the product is (19.7), protein

(18.7), ash (4.8), fiber (3.4), starch (27.1), soluble sugars (20.9), and the average moisture has been 34.7. Notably, rice and noodles was the highest percentage of food discarded at 52.50 and 55.52 respectively in two study cafeterias, indicating that staple foods that contain carbohydrates were served in standardized amounts that have a disproportional contribution to total waste.
Knowing that the composition of waste is relevant in designing the intervention. Hughes, Zhai, and Hallstrom made a differentiation between pre-consumer food waste (food discarded prior to being consumed by consumers, e.g. spoiled ingredients or preparation waste) and push consumption (food on the plate of customers that is not consumed) [24]. The current studies are dedicated to the topic of post-consumer waste in particular, since this type of waste is directly dependent on the selection of food and menu interface design. Preconsumer waste needs other solutions concerning the inventory management and kitchen operations.
Portion size is a factor that has been credited to food waste. Hughes, Zhai, and Hallstrom had observed that American portions may be up to 700% in size larger than USDA recommendations and FDA recommendations 263 percent larger [24]. Whereas portion size research has conventionally aimed at health and obesity outcomes, over-sized portions are also causes of wastefulness as people choose a lot of food than they are able to eat. This conclusion indicates that intervention to address preliminary food choice and not only post-selection practices can be especially effective.

2.3 Technological Approaches to Food Waste Monitoring

The conventional ways of measuring food waste in the cafeteria involves collecting it manually and which is labor intensive and intermittent. More systematic methods have been implemented in a number of universities but most of them still use manual approaches and short audits.

2.3.1 Manual Auditing Approaches

Numerous colleges carry out food waste audits on a periodical basis with manual approaches. Hughes, Zhai, and Hallstrom examined practices in a number of institutions and found that there were major limitations [24]. An example is UC-Davis which carried out quarterly waste audits throughout lunch time on a three day basis in a row with each quarter, asking students to participate. They categorized the waste into being edible and inedible. Although this approach has made an indicator reduction of 30 percent in food waste (3.6 oz to 1.6 oz per guest) in 2012–2015, audits showed only snapshots and could not offer continuous feedback. Georgia Institute of Technology used the LeanPath tracking system that demanded the manual weighing and classification of every discarded item in the kitchen by the kitchen staff item. This made the staff more aware however this came at a great cost.

2.3.2 Automated Sensor-Based Monitoring

In an attempt to overcome drawbacks of the manual approaches, Hughes, Zhai, and Hallstrom came up with a computerized program named WASTE REDUCE (Waste Auditing Sensor Technology in order to Improve the Minimization of Edible Wastages in University Cafeterias Dining places) and to monitor food waste in real-time [24]. Managed scales were used in the system installed on garbage collection bins, load cells and communication devices. Weight data is transmitted in real-time to a central server by modules. This approach controlled constant measurement without inducing behavioral changes.

Various technical issues were addressed in the system. The balances had to be accurate enough to measure small quantities of waste in the process of working with common volumes of trash receptacles. They had to be durable so as to resist abuse and exposure to fluids due to garbage. The garbage bags would retain their energy efficiency to operate continually over a long period. Hughes, Zhai and Hallstrom obtained an average power consumption of 12mA and this means that each of the balances can last almost one month on a 6000mAh battery [24]. The scales were good at weighing heavier items but they had higher values when dealing with heavier items and percentage errors with lighter objects (maximum error of 21 percent on a 0.284 lb object, which is compared to less than 1% for a 3.2 lb object). But this weakness was not so important in waste accumulated continually.

Monitoring was automated which supported real-time feedback displays. Unlike manual audits that generated reports days or weeks afterwards, the WASTE REDUCE system updated the visual images every minute, indicating that the students had immediate results of their collective food choices [24]. This present moment is of much significance to behavioral change, as the students could observe waste accumulating throughout meal periods and potentially adjust their selections accordingly.

2.3.3 Limitations of Current Monitoring Technologies

Automated monitoring systems are still comparatively simple, in spite of the technological changes. The WASTE REDUCE system was implemented in only two cafeterias (one at the university dining halls and one at the grade schools cafeterias) in the course of its assessment [24]. The wider implementation has a number of impediments. Initial IT is a technical skill that costs money in hardware infrastructure. The system only captures the waste deposited in instrumented receptacles; whereas waste disposed in other places is undetermined. Although the technology is able to measure total waste production, it gives little information concerning which type of food items are squandered or why students take specific decisions.

This is a weakness especially in the current study. Knowing whether waste increased or decreased indicates whether the intervention was successful or not. Understanding the methodological decision-making processes behind food selection are different, involving choice architecture studies and qualitative research on user experiences.

2.4 Behavioral Interventions: Choice Architecture and Menu Design

According to the idea of food selection as a decision process, the presentation of food implies that it is a process of choice. Options, the presented information, and the physical or virtual space in which decisions that are made are all capable of shaping decisions that are taken. This view has inspired a growing body of research on the topic of choice architecture—environment design where individuals take decisions.

2.4.1 Nudging and Visual Feedback Mechanisms

The WASTE REDUCE system was not only built in with a monitoring option but also as ambient displays that are used to affect behavior by providing visual feedback. Three display designs were experimented on by Hughes, Zhai, and Hallstrom each with the application of principles. Within the framework of the success provided by Heath and Heath in their book (SUCCESS) (simplicity, unexpectedness, concreteness, credibility, emotions, stories) [24], Display 1 showed a beach image that turned into a beach with more and more trash bag images exposing the trash as it built up, reflecting simplicity and concreteness. Display 2 represented the amounts of waste as slices of pizza, putting wasted food into context as something to consume to trigger emotional appeal. Display 3 provided a day-to-day account of four characters whose experiences were made better or improved according to whether waste was more than or equal to weekly averages, anthropomorphizing the problem by story-telling.
These displays had both more or less effective results. Display 1 obtained statistically significant decreases in the sales of meat-based meals (19.9 percentage point decline, $p<0.05$) when implemented in two weeks [24]. Display 3 also showed great influence ($p=0.0427$). Display 2 however was not significant in comparison to the baseline; customers actually wasted a little more during that week. Theorizing that pizza is a good food among college students, Hughes, Zhai and Hallstrom theorized that by increasing the visualization on the screen could have been associated with something pleasant as opposed to the case of the trash bags, which clearly indicated a bad omen [24].
Such results emphasize a significant rule that is to not present information in a similar way even though they may have the same underlying data. Emotional resonance and cognitive framing have a great impact on the behavioral consequences. This implies that several presentation formats need to be tested to determine which ones are effective to change the behavior within a certain population and environment.

2.4.2 Availability and the "Mere Exposure" Effect

In addition to display, the availability is another powerful principle of choice architecture which changes the relative share of options presented. Pachey, Bateman, Cook, and Jebb have carried out three studies analyzing the effect of raising the percentage content of meat-free meals on meal choice [31]. In one of their natural experiments they conducted in Oxford University, they altered a cafeteria menu that was used in serving one meat-free meal item and two meat meals in a day, to two meat-free meals and one meat meal in a day. This translates to a reduction in the

sale of meat meal down to 19.9 percentage points ($p<0.001$). However, a time-series, time-lapse analysis of the same study showed that the effect persisted at the end of twelve weeks of study with no evidence of habituation and compensatory behavior. The students made no more purchases of meat based sandwiches and cold items to compensate for the beef meat lowered in the hot menu [31]. It is important to note that total cafeteria sales were increased during the intervention period (by 544 meals per week) and this shows that the students did not avoid the cafeteria due to the reduced meat items. This is significant because the operators of cafeterias are normally anxious that this will have a negative impact on business by offering smaller portions of the most hot food.

Pechey, Bateman, Cook and Jebb discovered similar findings replicated in other situations [31]. Increased menu of meat-free foods in the cafeterias of the worksites led to increased sales of meat-free meals but with smaller effects and high implementation variation across sites. In a UK-based experiment in which 2,205 UK adults were subject to meat-free selections set to 25% of a menu, the reduction in meat-free selections (OR 0.35) was found, but an increase in meat-free selections (OR 2.43) was found when the meat-free selections were set to 75% of a menu. It is noteworthy that there were no findings to suggest that these effects were dependent on gender, socioeconomic status, and the normal amount of meat intake among participants, that the availability interventions could be intensive, and there was no need to increase health disparities.

Such findings of availability are consistent with the principles of behavioral science with regards to the concept of default effects and ease of cognition. When the healthier or more sustainable choices have become more easily accessible, they are simpler to observe and choose and less thinking is required. Micro-environmental interventions, as observed by Pechey, Bateman, Cook, and Jebb, might work more subconsciously as opposed to consciously, hence they could be fairer, even in terms of their effects, since they do not rely on nutritional information or health literacy [31].

2.4.3 The Role of Menu Information and Transparency

Although the availability determines the number of options available, the presentation of information on the available options is important. The layout of the menu, description of the items, the visual aspect, and the clarity of the nutritional value or impact on the environment can all be reasonable factors that affect the choice. Nevertheless, none of the studies reviewed initially tested the effect that various approaches of presenting the same menu items have on waste outcomes. Hughes, Zhai, and Hallstrom showed waste feedback following food selection and consumption [24], and Pechey, Bateman, Cook, and Jebb controlled the description and visualisation of items on the menu at option point [31], but neither manipulated the description and visualisation of menu items themselves.

This is a major missing point in the literature. Research questions are not addressed: Do foods on display decrease over-ordering? Would the difference in waste minimization selections demonstrated by the use of an icon or badge alter the decision? Would the difference in waste minimization selections demonstrated by the use of an icon or badge alter the decision?

The study of smart menus has already started to answer the related questions in

terms of healthier food promotion. The overall conclusion is that the inclusion of visual or informational association with menus can rearrange preferences to highlight choices. Nevertheless, there is not much understanding on the extent of effects and ideal design characteristics especially on the particular outcome of decreasing food waste as opposed to enhancing health.

2.5 Methodology Underlying Qualitative Research in HCI

The qualitative research methods that are involved in understanding behavioral and experiential factors involved in food waste interventions are rigorous. The current research will utilize semi-structured interviews and thematic analysis to examine the student choice of food, which will require a foundation in the well-established practices in qualitative research in the field of HCI. This section presents methodological literature of thematic analysis, qualitative studies in HCI, and new considerations with regard to AI-assisted analysis.

2.5.1 Thematic Analysis in HCI Research

Thematic analysis is also one of the most popular qualitative techniques introduced in studies in HCI. Nevertheless, its use has not necessarily been rigorously methodological. Bowman, Debray, Kalidindi, and co-authors carried out an extensive scoping review of the literature on HCI in healthcare using published papers in CHI conferences within the past ten years (2012–2021) and analyzed 78 papers presenting 100 thematic analyses [32]. They concluded that thematic analysis, despite its rapidly acquired adoption, left a lot of researchers behind quality practices that were promoted by the methodological innovators like Braun and Clarke [11]. There were many problems regarding thematic analysis as a unitary, atheoretical approach; thematic analysis just emerging out of data instead of being constructed by researchers; and the problem of inadequate specification of the form of thematic analysis used. The direct connection of these methodological issues in qualitative research on food waste is the use of qualitative methods. According to Bowman, Debray, Kalidindi, and others, it was discovered that researchers often inadequately reported their analytical processes and rarely acknowledged their own positionality—how their assumptions and experiences might shape interpretation [32]. In the case of research that would require interviews with students, faculty, and cafeteria employees regarding food choice, the explicit definition of the method of analysis is required. Researchers need to explain what they are doing: inductive analysis (creating themes out of what participants say) or deductive analysis (finding patterns based on theories), whether they are analyzing the semantic content (what the participants actually say) or latent meanings (assumptions without explicit statements). The latter are not just technicalities; they are the basis of what can be said based on the results. They have been used appropriately in qualitative research settings where Clarke, Braun and Hayfield have discussed extensively on how thematic analysis can be used in qualitative research [11]. In the case of cafeteria research, when such themes such as expectation/reality mismatch or social and operational friction are found, the researcher is making interpretive decisions on the basis of patterns he or she observes

in the narrations of many participants. There may be various themes constructed by different researchers based on the same transcripts of same interviews, which emphasize the significance of transparency in the analysis process.
A longer literature on thematic analysis as a qualitative research approach highlights that it is flexible but should not be applied in a superficial way. The ease of access to the method may result in its use by researchers without having to confront the epistemological commitments involved in using different variants. To analyze the reasons students waste food or the way they react to various menu designs, the researchers should be aware that the analysis is an active interpretation that necessarily relies on theoretical knowledge about HCI, behavioral science and sustainability.

2.5.2 Diversity of Qualitative Methods in HCI

Although the current research uses thematic analysis to analyse the interview data, the larger picture of qualitative methods of HCI gives them a context of the methodological decision. Researchers in HCI adopt a wide range of qualitative methodologies, based on the question of study, and recent studies have indicated that qualitative HCI research is necessary to explore not only what is done by users but also why and what it means to the users.
Lazar, Feng and Hochheiser give in-depth advice on the variety of qualitative methods that can be applied in HCI research including ethnographic studies, contextual inquiry, and other types of research based on interviews [22]. They focus on the matching of research questions with the methods. To investigate food selection behavior and waste patterns in cafeterias, where semi-structured interviews are suitable as they will offer an opportunity to investigate personal experience and perceptions and will concur with the whole group of participants.
Other scholars have championed a phenomenological approach to HCI which focuses on lived experience. This school of thought maintains that HCI has been inclined at times and is too much of a focus on usability and efficiency metrics to the detriment of comprehension of the different, subtle experiences of technology. In the case of food waste research, this can be related to the current study method of investigating not just whether students select less food with different menu formats, but what that experience feels like for them—whether they feel empowered by having waste information, overwhelmed, or indifferent.

2.5.3 Challenges in Qualitative HCI Research

Recent studies have pointed out significant issues in qualitative HCI research that actually influence the way in which the studies should be carried out and presented. One of the issues is related to reproducibility and inter-researcher reliability. Research into the ability of various researchers to come to varying conclusions based on the same data of HCI has cast doubt on the practices of the field. Wilson, Wagenaar, and others discovered that the conclusions drawn by applying analytical methods, theoretical models, and theoretical lenses are highly influenced by them despite dealing with the same datasets [30].
In the case of food waste intervention research, this brings a pragmatic question: if two research teams interviewed the same participants with similar questions on menu preferences and food waste behaviors, would they uncover the same themes

and draw similar conclusions? This does not mean that the qualitative research is arbitrary, but it reinforced the significance of openness regarding the methodological options and position of the researcher. Qualitative HCI research has been under a growing demand in the research community to be made more explicit regarding the processes. Researchers are supposed to record not only their findings, but the way they were able to find it, how they coded it, how they made their decision, rules, interpretative ambiguities, and the resolution of disagreements within members of the teams. In the case of the current study, it implies providing a clear description on how the research team translated interview transcripts into initial codes and subsequent themes, as well as how the inter-rater consistency was achieved, and which theoretical commitments were used to conduct the analysis.

2.5.4 AI-Assisted Qualitative Analysis

One of the new fields that can be applied to the current qualitative studies is the utilization of AI tools to aid analysis. Yan, Kaur, Kumar, and Chilton conducted a user study that interviewed ten qualitative researchers about their experiences with ChatGPT in their thematic analysis [34]. They discovered that AI may prove useful in the early stages of data exploration, the creation of various coding viewpoints, and a quantitative overview of trends. However, participants also noted that they still had concerns about reliability, knowledge of the situation, and the probability of the application of AI being considered a methodological aspect.

In the case of food waste research, where the interview data on the cafeteria experiences were used, these findings imply an appropriate approach. AI tools might assist with initial familiarization with large volumes of interview text or suggest coding possibilities that researchers had not considered. However, human researchers must retain interpretive authority, as AI cannot fully understand the social context of why a student feels embarrassed about wasting food or how cafeteria staff experience time pressure during peak hours.

Earlier work by Marathe and Toyama on semi-automated coding emphasized that researchers desired assistance in extending coding to new data after developing a codebook, not replacing foundational interpretive work [23]. Their system using natural language processing achieved reliability comparable to human coders, but researchers emphasized maintaining agency and transparency. Recently, Rietz and Maedche discovered that AI coding recommendations positively affected quality and not speed, which makes researchers more premeditated and reveal inconsistencies [33].

In the case of cafeteria research, this literature implies that, in the event that the human interpretation is used, the computational assistance should even serve to complement it, not to substitute it. It is the aim to achieve stringent, credible results on food selection behaviour, rather than accelerated analysis.

2.5.5 Practical Considerations for Interview-Based Research

In addition to the methodological analysis frameworks, literature in HCI offers feasible advice on how to carry out effective interviews. Studies of UX techniques have pointed out that the design of the interview should be sufficiently structured to cover

the main topics, and should be flexible to permit the discovery of unanticipated results [17].
In the case of food waste behavior, this entails possessing a clear interview guide which will address the issues related to food selection processes, experiences with the existing cafeteria menus, and responses to design options, without being restrictive of participants bringing in unexpected concerns. The semi-structure used in the current research is consistent with the best practices of exploratory research wherein the main objective is to develop an understanding of the phenomena based on the perspective of the participants.
Research in UX of conversational application offers some useful information on how individuals characterize their experiences with digital interfaces. Participants find it difficult to describe the processes of decision making that seem automatic or habitual. In the case of menu design study, this implies that interview methods will be required to induce participants to contemplate their choices that they might not be aware of such as requesting them to take a stroll through their recent visits to the cafeteria or to respond to certain menu mock-ups so that the items they are not consciously aware of in their choices could be brought into the surface.

2.6 Implementation Challenges and Organizational Context

When research findings are translated into practice, the challenges that are constantly witnessed indicate whether interventions will be successful or fail to work in actual organizational environments. This section is a literature review of implementation barriers associated with menu design interventions in cafeterias.

2.6.1 Tool Adoption in Organizational Contexts

Studies by Kang and Rzeszotarski on issues and opportunities related to the use of tools in industrial UX research partnerships offer information about the barriers to implementation [27]. Their analysis revealed that adoption of research tools that have proven to have a distinct value in controlled circumstances is extremely dependent on the real organizational situation on factors such as workflow integration, perceived ease of use, and alignment with existing practices.
This directly impacts the smart menu system in cafeterias. Technology can be effective in laboratory testing, unless it is incorporated properly. In case the vendors feel that it is complicating matters without apparent personal gain, they will decline to implement it. In case it is confusing or slow to students, they will not use it. To succeed, it is important to design not only to perfection but also of the realities of functionality of operational cafeterias.
Kang and Rzeszotarski determined a number of factors which predicted successful tool adoption: limited impact on existing workflows, value propositions that are apparent to all stakeholders, and sufficient training and support in the implementation [27]. These factors are especially important in the context of cafeterias that have scarce resources and high staff turnover. A smart menu system should be simple enough to be used by a new employee with minimum training and yet powerful enough to overcome the peak-hour load and useful to be considered by the

management worth its maintenance.

2.6.2 Scalability and Resource Constraints

The results of online experiment that was conducted by Pechey, Bateman, Cook and Jebb indicated noticeable effects of menu change, but the implementation in the worksite cafeteria indicated less robust and inconsistent results in part due to a discretion exercised by the chefs in preparing which menu items to actually prepare on a particular day [31]. This gap in implementation denotes that in spite of a well-planned intervention, the plan is not effective due to its unrealistic application in practice.

Hughes, Zhai and Hallstrom identified that the WASTE REDUCE sensor system had to be robust enough so that the cafeteria employees do not have to alter their behavior in order to make the technology work autonomously [24]. The same applies to menu interventions: only when the chefs are willing to prepare what they are supposed to, the supply chains are reliable when delivering the ingredients, and the digital infrastructure is not disrupted due to high traffic.

In contexts that are resource-constrained like university cafeteria in developing settings, the realities of operations are especially acute. Small-scale proofs-of-concept do not necessarily scale smoothly. An intervention of menus in a cafeteria with 200 students might not be as effective as in one with 2,000 students. Technical solutions that work with a good internet connection will not work when the connection is not reliable.

2.6.3 Population and Cultural Considerations

The consistency of interventions is still a significant issue when applied to various populations. Hughes, Zhai and Hallstrom admitted that their population of Florida Atlantic University was probably better educated and environmentally aware than the average, and so they might have been more susceptible to waste reduction messages [24]. A direct test of the responsiveness of Pechey, Bateman, Cook and Jebb did not show any demographic difference in response to availability differences, however their work site study involved manufacturing workers who had a much higher baseline meat intake than college samples [31].

This casts serious questions in such contexts as Bangladesh. Will menu design interventions effective in Western university cafeterias function similarly in different cultural contexts? Are there cultural factors around food, waste, and technology use that might make certain approaches more or less effective? Do social norms around food selection and waste differ in ways affecting how students respond to waste or sustainability information? UX research literature, particularly work on cross-cultural design and localization, emphasizes that interventions require adaptation to local contexts rather than direct transplantation. What constitutes persuasive framing, which visual design conventions communicate clearly, and what kinds of social proof resonate can all vary across cultural contexts.

2.7 Research Gap and Positioning

The reviewed literature demonstrates that both technological monitoring and behavioral interventions show promise for reducing university food waste. However, several gaps limit the ability to design optimally effective, scalable interventions applicable across diverse contexts.

Gap 1: Lack of Systematic Testing of Menu Presentation Formats. While Pechey, Bateman, Cook, and Jebb tested availability (which items are offered) [31] and Hughes, Zhai, and Hallstrom tested display formats for waste feedback [24], no studies have systematically examined how the menu itself—the interface through which students make selections—is visually and informationally designed. Questions remain unaddressed: Do images of meals affect selections compared to text-only descriptions? Do waste percentages displayed at selection time influence choices? Does showing sustainability icons change behavior? These micro-design decisions collectively shape the choice environment but remain under-researched.

Gap 2: Limited Integration of Real-Time Feedback with Point-of-Selection. Hughes, Zhai, and Hallstrom displayed cumulative waste information on monitors after students had selected and consumed meals [24]. While this created social awareness, it did not provide decision support at the moment of menu selection. An intervention combining smart menu design with real-time waste data (displaying each item's historical waste percentage at selection time) could theoretically be more effective but has not been tested.

Gap 3: Insufficient Understanding of Preference versus Portion Mismatch. Kamaruddin, Jantira, and Alrozi found that rice and noodles dominated waste [26], and Hughes, Zhai, and Hallstrom identified oversized portions as a driver [24]. However, it remains unclear whether students waste these items because they do not like them (preference issue) or because portions are too large (portion issue). In case the parts are troublesome, enabling customization or giving advice at the selection point may come in handy, although qualitative research is necessary to know what is actually happening.

Gap 4: The Absence of Qualitative Determination of Decision-Making. The majority of food waste research studies follow the quantitative approach: measuring weights and counting selections, monitoring time-related waste. Although this shows the effectiveness of interventions, it does not offer the reasons. What do students consider when they are choosing food? What role does the menu play in their decision process? What expectations lead to waste? Qualitative research using interviews and thematic analysis can surface these insights but has been rarely applied to cafeteria food waste.

Gap 5: Limited Research in Resource-Constrained and Developing Contexts. Most food waste intervention research has been conducted in well-resourced Western universities. Hughes, Zhai, and Hallstrom's sophisticated sensor systems, while innovative, require technical infrastructure and maintenance that may not be feasible in all contexts [24]. Evidence about what interventions work in contexts with limited budgets, less technical support, and different cultural norms around food and waste is sparse. Research in developing contexts such as Bangladesh is particularly limited.

Gap 6: Insufficient Attention to Implementation and Adoption. Literature on food waste interventions often focuses on whether something works in research

studies but gives less attention to how it would actually be implemented and adopted in practice. As tool adoption literature demonstrates, interventions successful in controlled trials can fail in real organizations if they do not fit workflows, do not provide value to all stakeholders, or require excessive ongoing effort [27].

2.8 Positioning the Present Research

The current study focuses on some of the established research gaps via the methodological approach and the context of the research.

Gap 1 and 2: This research addresses the gaps used in the previous research, unlike the earlier studies that were not done in a systematic manner, this study has a contrast to three formats of menu presentations: the traditional list, the info-lite with bare nutrition facts, and the info-rich with waste data and sustainability indicators. The research in question, in particular, tries to establish whether the availability of waste information at the point of selection (not post-consumption) affects the decisions of the students. The research separates the effect of interface design by keeping food items the same, but changing only their presentation.

Gap 4: Most importantly, the current research utilizes the qualitative methodology—semi-structured interview and thematic analysis to learn why students choose to eat certain foods, their experiences in cafeteria menus and how they react to the information through various ways of presentation. This method not only uses the measuring ability of a given intervention to work, but focuses on the mechanisms behind it. Thematic analysis is used in accordance with the best practices of qualitative literature of HCI and analytical practices and researcher positionality are addressed clearly as suggested by Bowman, Debray, Kalidindi, and others [32] and Braun and Clarke [11].

Gap 5: This study will be carried out within a developing setting (Bangladesh) in which past studies on food waste interventions are scarce. The results will provide evidence on what works in resource limited university environments, which is important in terms of scalability and wider applicability. The research specifically takes care of practical limitations of technology, manpower, and financial resources that might be dissimilar to the West.

Gap 3 and 6: The interview methodology will enable the discovery of the following issues: portion size expectations, mismatches in preferences, and barriers to implementation by talking to students, faculty, and cafeteria staff directly. Instead of drawing a conclusion as to the cause of waste based on the quantitative patterns, the study directly questions individuals on the subject. Staffing and management views of the cafeteria.

Methodological Contribution: This work is a contribution to the literature of HCI on qualitative research technique, not just in the food waste field. It shows that thematic analysis can be introduced in a rigorous manner to learn about how users with digital interfaces (menus) behave in real-life scenarios. The focus on methodological transparency and multiple stakeholder views is a best practice of the recent HCI methodological literature.

The current study contrasts with the one by Hughes, Zhai, and Hallstrom [24] in that it analyzes the menu interface as the outcome of the problem and uses qualitative techniques to comprehend the reason behind decision-making instead of solely quantifying the results. In contrast to the manipulation of availability

by Pechey, Bateman, Cook, and Jebb [31], this paper holds options constant and manipulates presentation, isolating the effects of interface design. In contrast to the last two studies, the current study is done in a developing environment and focuses on qualitative interviews to comprehend the mechanisms and the difficulties of implementation.

2.9 Summary

There are a number of significant patterns presented in the literature. Universities produce large amounts of food waste with carbohydrate rich staples making huge proportions of garbage food. Systems like WASTE REDUCE have shown that it is possible to have technological monitoring systems, which are automated to track, but it has barriers to adoption like cost, expertise, and integration. Choice architecture behavioral interventions have potential—manipulations of the availability and visual feedback can significantly decrease waste-related behavior, although the effect depends on circumstances.

Theoretically, the discipline is grappling with what should be done to engage in rigorous qualitative research, but thematic analysis has become the leading approach, yet the questions of quality, transparency, and reproducibility remain. The introduction of AI tools promise efficiency but must be carefully considered so as not to harm human interpretive power. The literature of qualitative HCI focuses on clear description of the analytical procedure and recognition of the researcher positionality.

The implementation is also a heavy burden. Interventions that succeed in controlled trials are prone to challenges in practice because of operationalization, workflow, and absence of stakeholder buy-in. There is inconclusive evidence that cultural and population differences will be a problem in practice. There are few studies that last longer, and the questions concerning the sustainability of effects remain open.

The current study relies on these platforms and fills existing gaps especially in terms of systematic testing menu presentation formats, combination of qualitative approaches to comprehend the mechanism, and consideration on how they can be applied in resource constrained developing environments. To ensure that the results of the research are theoretical and practically applicable to university cafeterias, the current research will utilize a combination of knowledge related to food waste and related studies, choice architecture, qualitative HCI methodology, and implementation science.

Chapter 3

Research Methodology

3.1 Workflow

This study begins with the knowledge of the most important factor that leads to food waste. The point is that people are not involved into the process of decision making. Due to this, food waste occurs. The critical aspect is that individuals should be more engaged in decision making process in order to minimize food waste. Food waste is an issue and it has resulted because of lack of user involvement, in the decision making process. From that, different versions of the menu were designed using surveys to test the behavioral and perceptual impacts to develop a scalable implementation framework. Surveys called in 3 different paradigms to compare the menus and get the best one. Data was collected from about 50 participants that included students, staff and faculty members where they were exposed to the three different surveys using google forms. Qualitative data was taken in the form of interviews which had 20 participants. This provided a more detailed overview on the state of consumer choices and behavioral metrics. Both quantitative and qualitative data collected where waste was the core focus. Analysis of the data statistically using pie charts and bar charts.

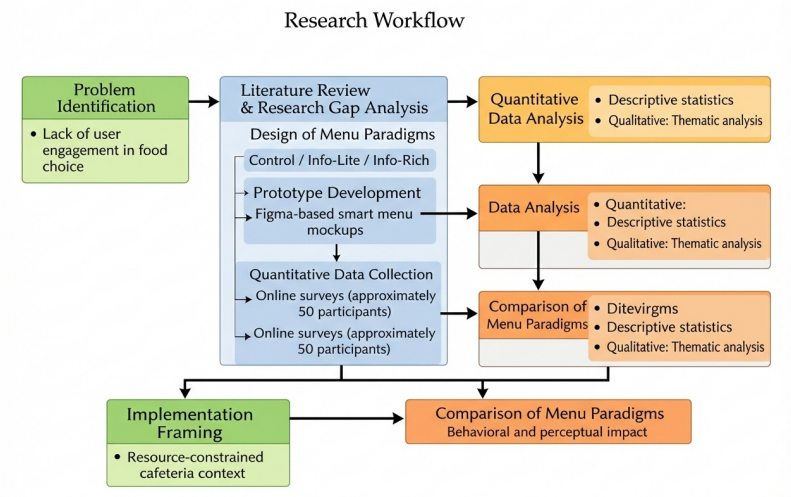

Figure 3.1: Work Flow

3.2 Research Design and Menu Paradigms

The quantitative survey analysis was used as an HCI based method to answer the research questions. We constructed 3 different menu paradigms to test:

1. **Control Menu (Traditional List):** This is a food item digital menu where the names and prices of food items appear in a simple list. This is the typical interface that exists in most cafeterias.

2. **Basic Smart (Info-Lite Menu):** Upgraded interface which includes basic nutritional data (calories, macronutrients) and allergen icons to the standard list. This challenges the impact of simple health and safety information on decision making.

3. **Info-Rich Menu (Advanced Smart):** A high-level interface that features many behavioral nudges. Key features included:

    - Waste Metrics:A visual object (e.g. a bar graph or a traffic light icon) that displays the percentage of that dish that consumers wasted on the prior day in comparison to the entire portion of the dish.
    - Sustainability Cues: Plant-based or locally sourced.
    - Popularity Indicator: Use social proof by displaying a badge that has a title such as a Chef Recommendation or the most popular.
    - Everything the Info-Lite menu had about the food.

These prototypes have been created as interactive and high quality mockups in Figma to replicate a real world digital ordering kiosk

3.3 Qualitative Interview Method

Participants

The qualitative part of the study includes conducting semi-structured interviews with various stakeholders involved in the cafeteria of the university. Various categories of participants in this study include undergraduates, postgraduates, academia, and cafeteria management/staff. The range of participants in inclusion in this quantitative study was aimed at obtaining various views on selecting foods and on wasting foods in the cafeteria setting in an organization/education setup. The purposive method of sampling was aimed at inclusion of more relevant participants in respect of data collection setting.

Procedure

Factors like participants' experiences, views, and practices regarding selecting food and wasting food were collected during interviews. Semi-structured interviews were used to test participants' experiences with selecting food for meals. An interview guide was used to provide consistency to interviews but demonstrated flexibility to allow for participants to elaborate on matters they felt were pertinent to the interview. We wanted to know more about selecting food for meals, expectations around meals at the cafeteria, reasons for wasting food, information effects, and

information system use. The interview was for around 15 to 25 minutes. The interview was conducted in a quiet area to ensure participant comfort.

Ethical Considerations

Ethical approval was gained ahead of time. Permission to conduct the interview had been sought from every participant after having informed them of the purpose, explaining that it was on a voluntary basis, and assuring them of no repercussions should they decide to withdraw from the process at any time. Informed consent was obtained from each participant before the interviews were conducted. The anonymity of the participants was maintained by the use of participant identifiers (P01-P20). The complete consent form is attached in Appendix A.

3.4 Data Analysis Approach

Thematic analysis of the data obtained during interviews was carried out in an inductive and data-oriented manner. The audio recordings were transcribed word for word. Transcripts were read and reread to get acquainted with data. Initial codes were created using meaningful patterns and recurring ideas from participants' responses, which were then grouped into broader themes on common experiences and perceptions relating to a food selection and waste behavior, iteratively. It was theme driven analysis and not a predetermined theoretical coding in order to allow insights to emerge naturally of the data without compromising rigor. Final themes were refined by comparison across groups of participants to ensure that they were consistent and resonant.

Chapter 4

Findings and Analysis

4.1 Overview of Data Sources

This chapter presents findings from both quantitative and qualitative data that were collected in the study. Quantitative data was gathered in the form of a structured survey of about 50 people. Qualitative data were collected using semi-structured interviews with 20 participants including students, faculty members and cafeteria staff and management. The combination of these two data sources allows for the in-depth study of food selection behaviour and food waste in the university cafeteria setting.

4.2 Quantitative Findings

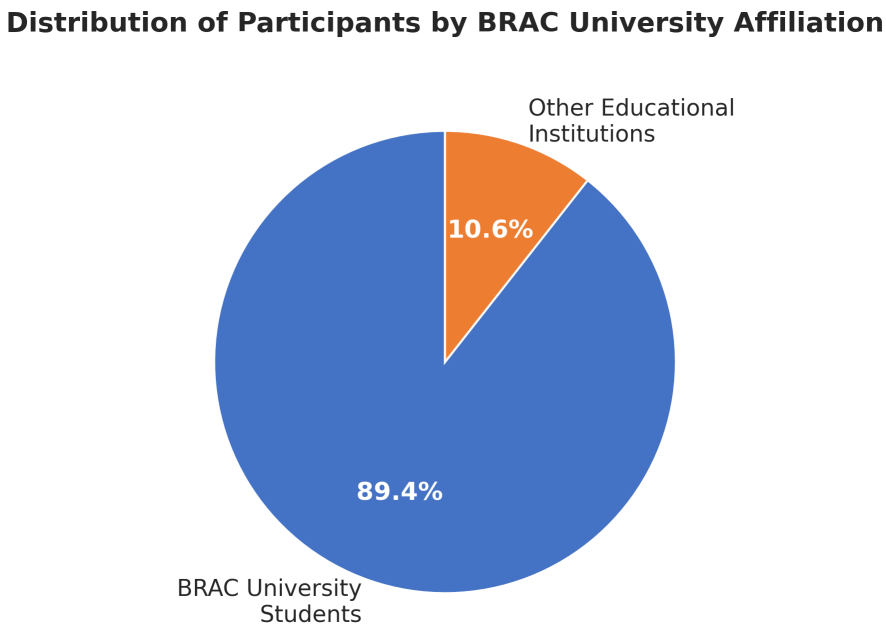

Figure 4.1: Distribution of participants by BRAC University affiliation

In figure 4.1, we checked the university affiliation of students where 89.4% of the respondents were Brac University students whereas 10.6% of them were from other

education institutions.

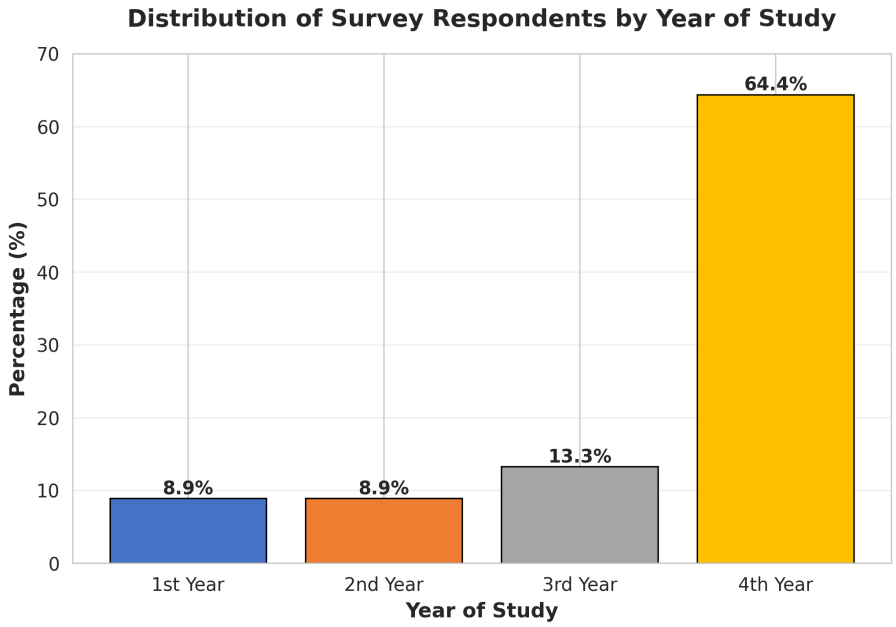

Figure 4.2: Distribution of survey respondents by their year of study

In figure 4.2, we surveyed the distribution of respondents by their year of study and here, almost 64.4% of the respondents are 4th year students. 13.3% are 3rd year and 8.9% are from both 1st and 2nd year.

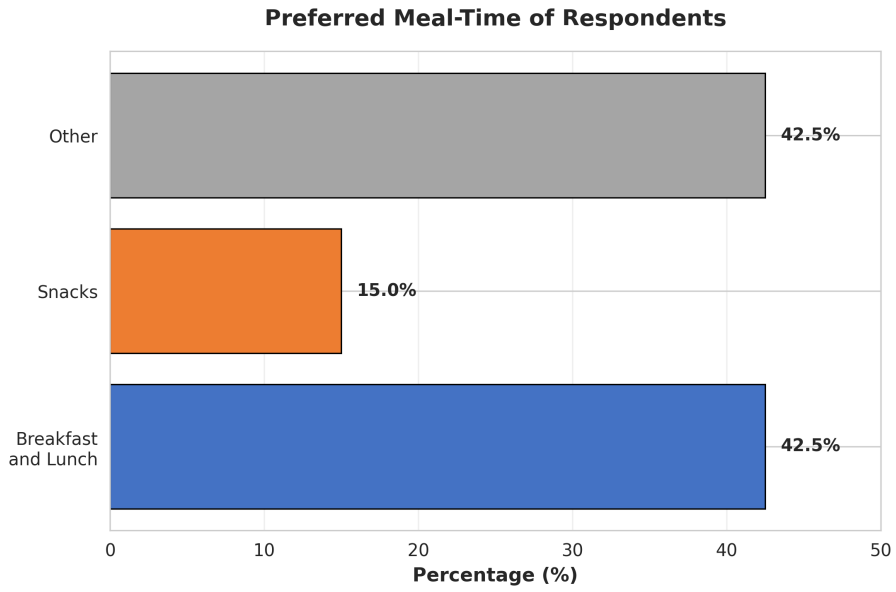

Figure 4.3: Preferred Meal-Time of Respondents

In figure 4.3, almost 42.5% eat breakfast and lunch and 15% eat snacks.

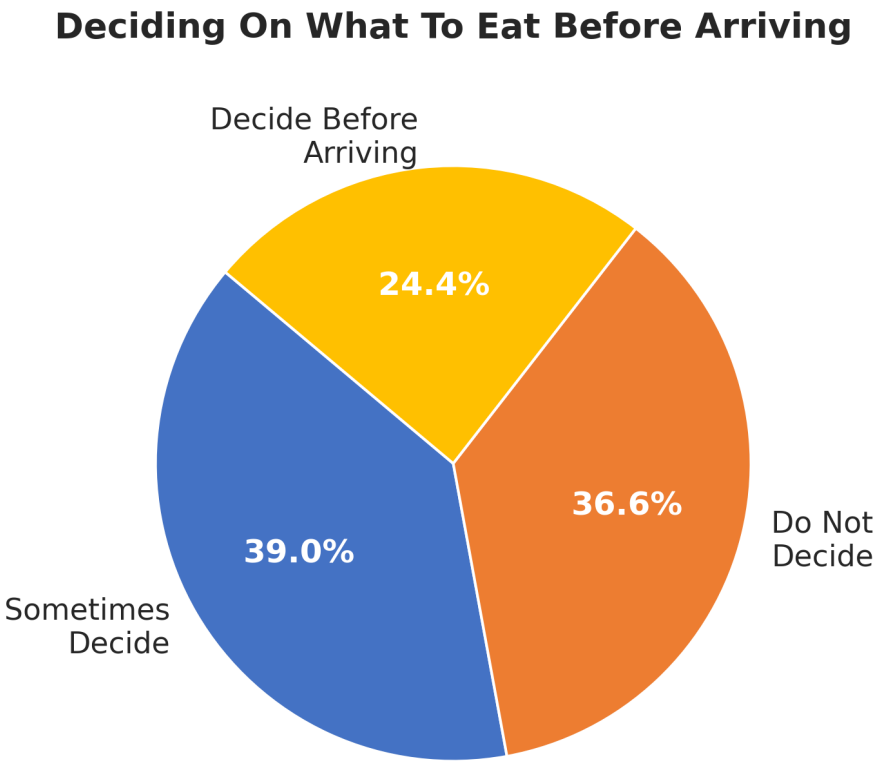

Figure 4.4: Deciding On What To Eat Before Arriving

In figure 4.4, when asked whether the respondents decide what to eat before arriving, 39% say they sometimes decide, 36.6% do not decide and 24.4% decide what to eat before arriving.

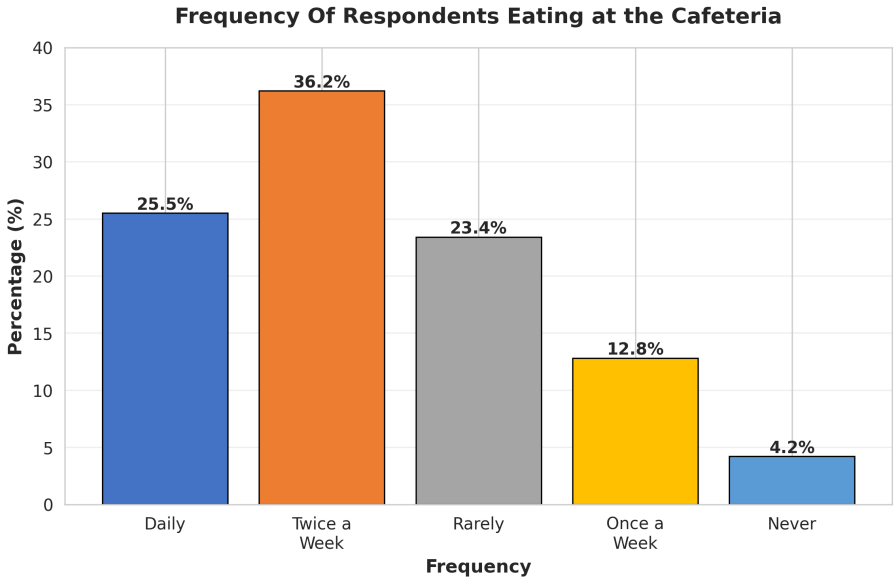

Figure 4.5: Frequency Of Respondents Eating at the Cafeteria

In figure 4.5, when asked about how often they eat at the cafeteria, almost 12.8%

ate once a week, 25.5% ate daily. 36.2% ate twice a week, 23.4% ate rarely and 4.2% of the respondents never ate at the cafeteria.

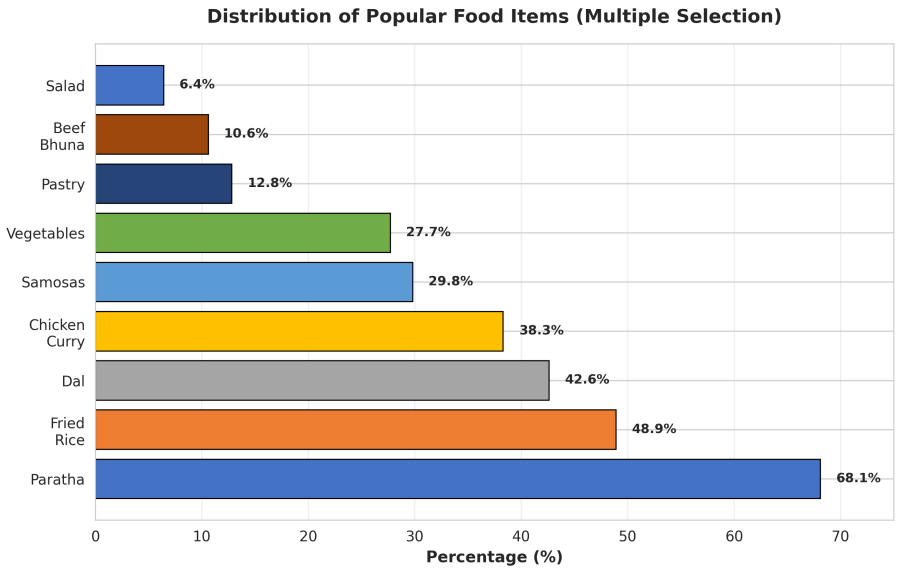

Figure 4.6: Distribution of Popular Food Items

In figure 4.6, when asked about what food item they would choose, 38.3% chose chicken curry, 48.9% chose fried rice, 27.7% chose vegetables, 68.1% chose paratha, 10.6% chose beef bhuna, 6.4% chose salad, 42.6% chose dal, 12.8% chose pastry and 29.8% chose samosas.

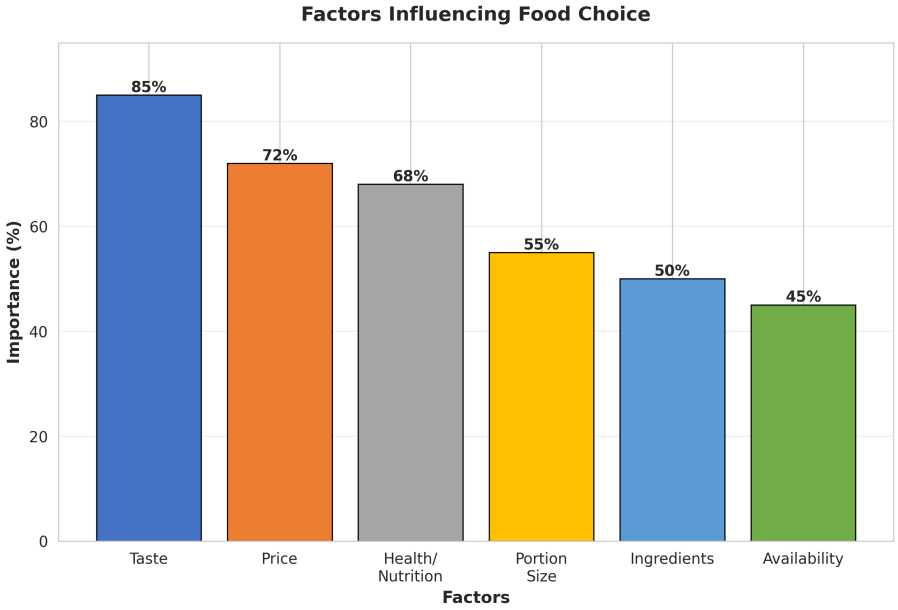

Figure 4.7: Factors Influencing Food Choice

In figure 4.7 taste, price, health/nutrition, portion size, ingredients, availability are the main influencing factors of food choices

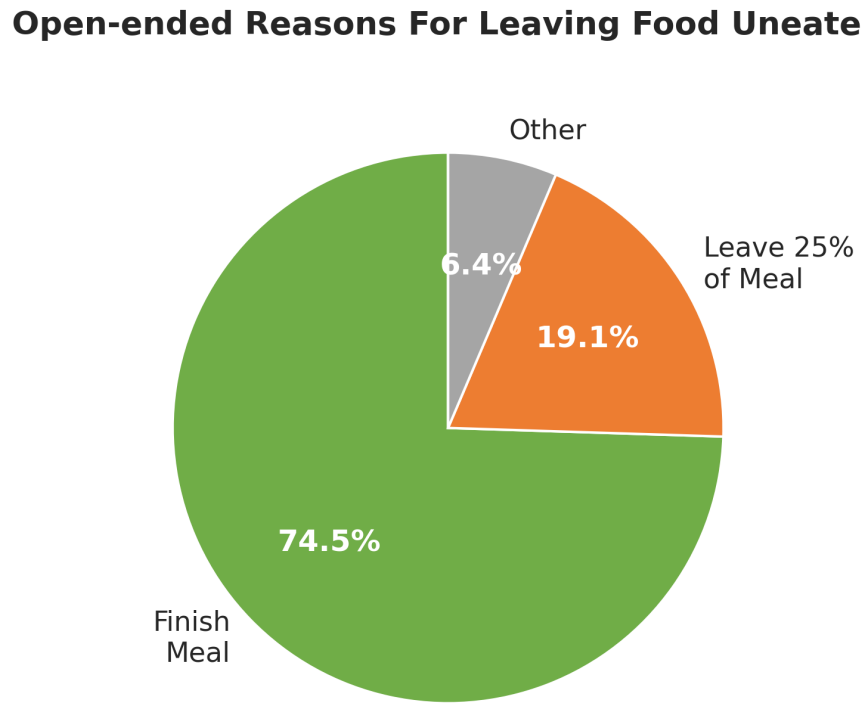

Figure 4.8: Open-ended Reasons For Leaving Food Uneaten

In figure 4.8 which is the waste estimation part of the survey, 74.5% of the respondents said that they would finish their meal and 19.1% said that they would leave 25% of their meal.

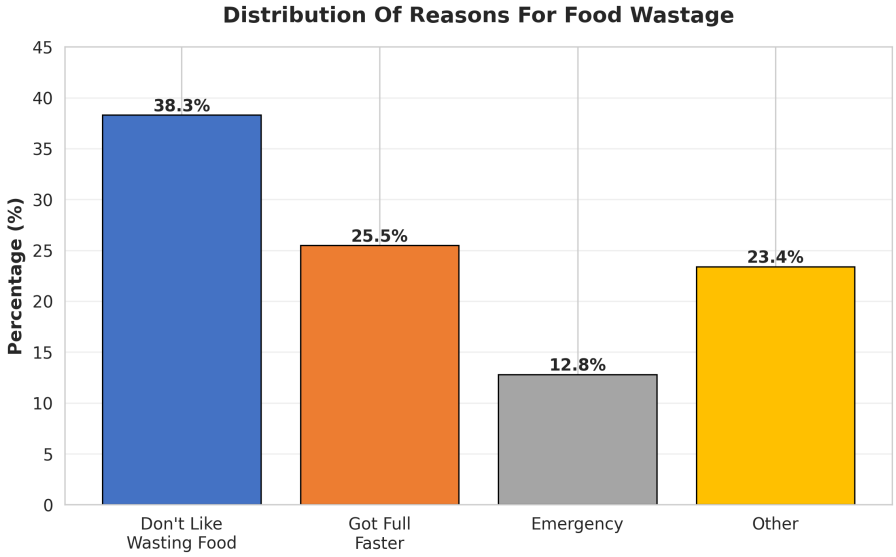

Figure 4.9: Distribution Of Reasons For Food Wastage

In figure 4.9, we asked the participants why they think that people would leave their food and here, 38.3% said that they would not like wasting their food. 25.5% said that they got full faster than expected. 12.8% said that they probably had an emergency. This indicates that most of them would not like to leave their food.

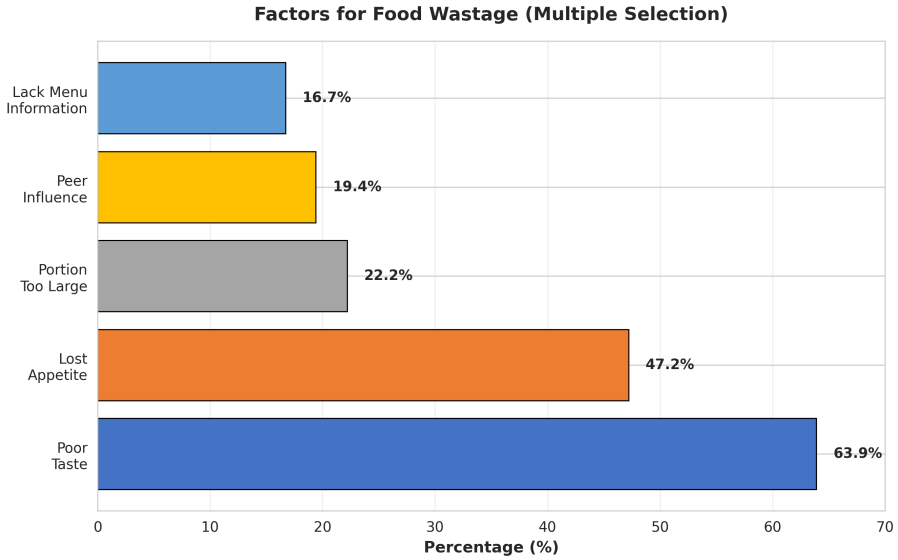

Figure 4.10: Factors for Food Wastage

Whereas in figure 4.10, almost 63.9% indicated poor taste, 47.2% lost appetite, 22.2% said that the portion was too large, 19.4% indicated peer influence and 16.7% indicated a lack of menu information.

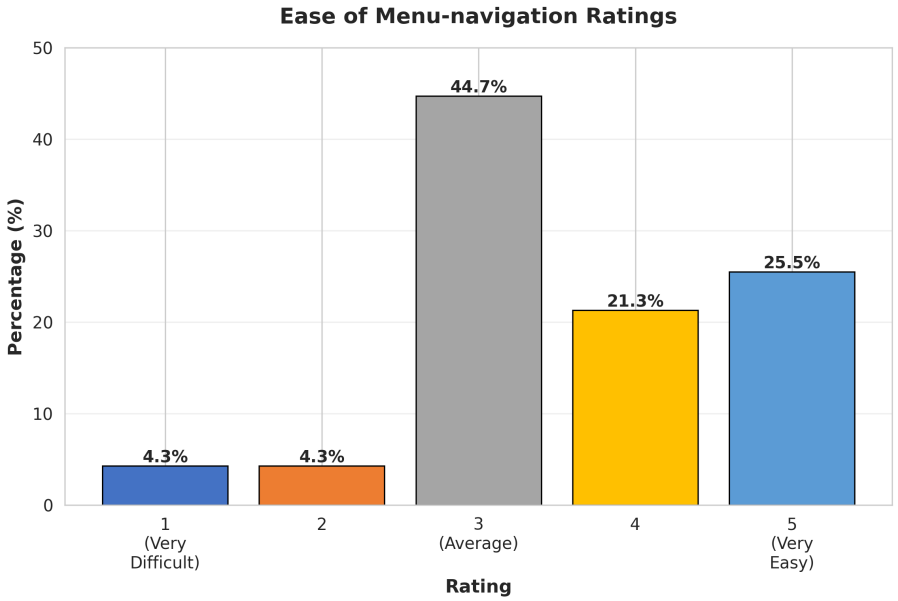

Figure 4.11: Ease of Menu-navigation Ratings

In figure 4.11 which is the feedback part of our menu, we began by asking how easy it was to navigate this menu. This was a likert scale ranging from 1(very difficult) to 5 (very easy). Here, 44.7% gave an average 3 as an answer, 21.3% gave 4, 25.5% gave a 5 and 4.3% gave both 1 and 2. This indicates that the menu was easy to navigate.

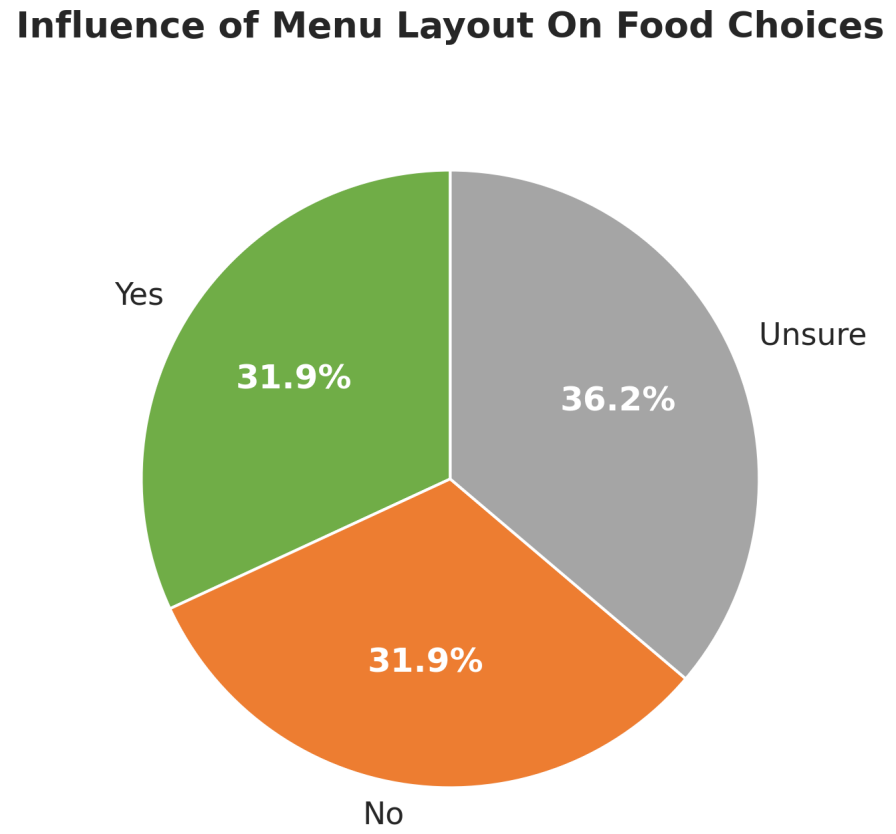

Figure 4.12: Influence of Menu Layout On Food Choices

In figure 4.12, 36.2% of the respondents were unsure and 31.9% of the respondents had both yes and no answers indicating mixed responses

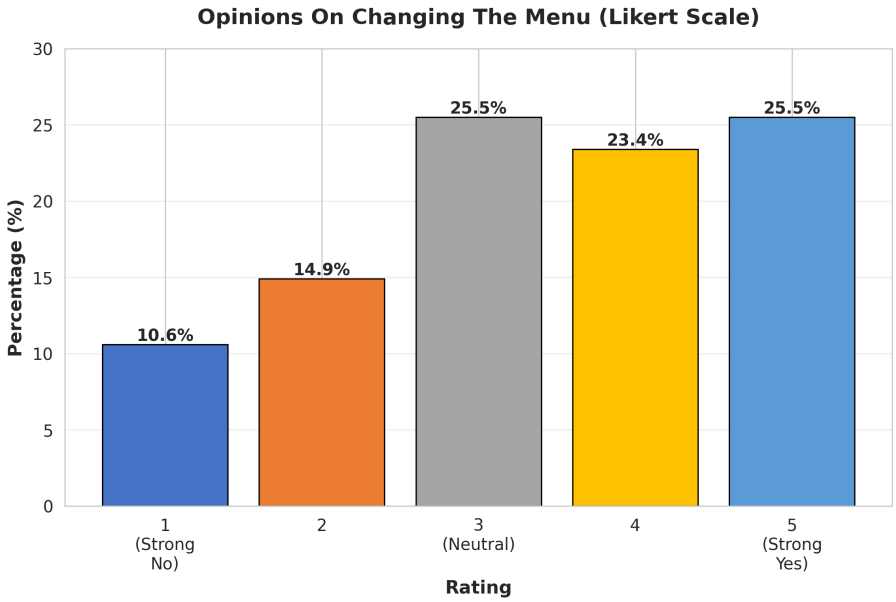

Figure 4.13: Opinions On Changing The Menu (Likert Scale)

In figure 4.13, when asked on whether we should change the menu, 25.5% gave both

3 and 5 on a likert scale with 5 being strong yes and 1 being strong no. 23.4% gave a 4, 14.9% gave a 2 and 10.6% gave a 1 indicating that the majority wants us to change our menu A.

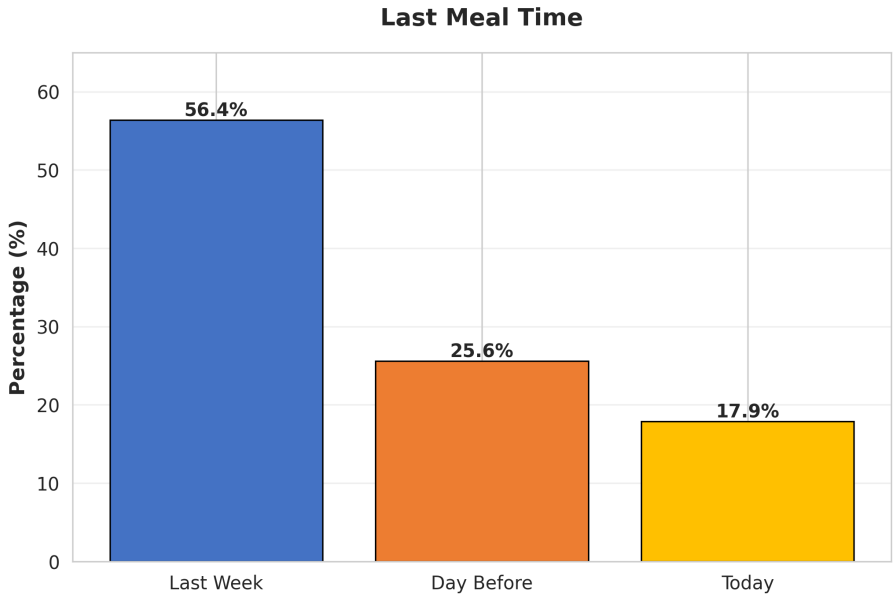

Figure 4.14: Last Meal Time

In figure 4.14, 56.4% had their last meal in our cafeteria in the last week. 25.6% had their last meal on the day before and 17.9% had their last meal on the day the survey was being conducted.

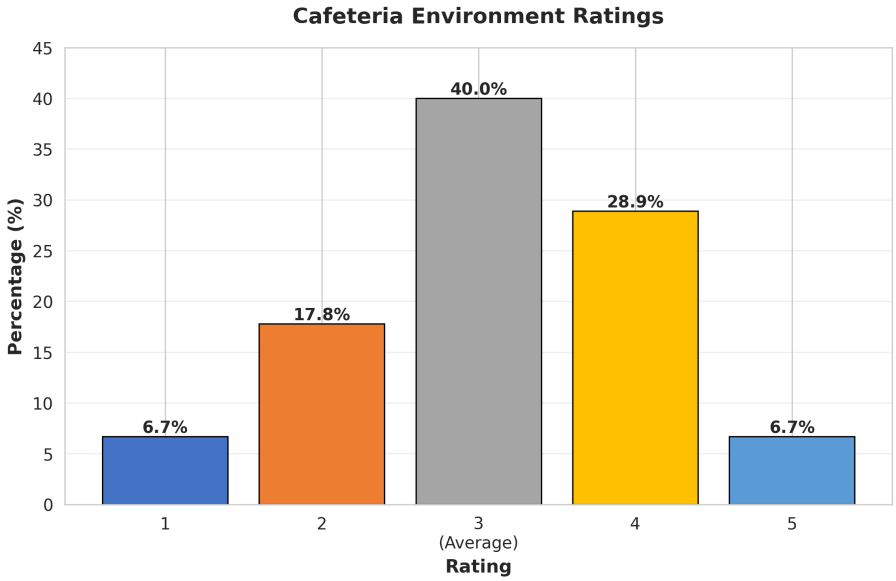

Figure 4.15: Cafeteria Environment Ratings

In figure 4.15, when asked about the cafeteria environment 40% gave an average rating of 3, 6.7% gave a rating of 5 and 2. 28.9% gave a 4, 17.8% gave a 2. This indicates that the average respondents have an average rating of 3.00.

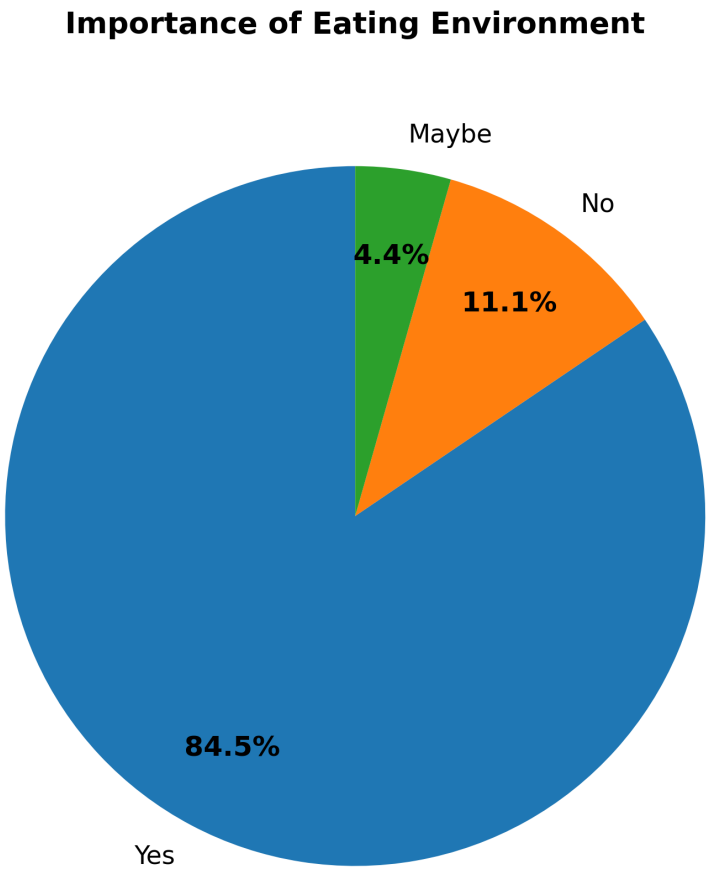

Figure 4.16: Importance of Eating Environment

In figure 4.16, when asked on whether the environment matters to them while eating, a whopping 84.4% said that yes and 11.1% said no indicating that environment is a big factor.

Using the survey analysis of the cafeteria, it is clear that although there exists a faithful group of regulars who prefer the main meals such as paratha and chicken curry, there are major problems with the flavor of the food and a rigid menu, which motivates a quarter-half of the people to leave uneaten food basically because they do not like the flavor or are compelled to order something. Moreover, the cafeteria atmosphere is a significant issue that has the least average level of satisfaction but at the same time, it is extremely essential to the vast majority of students, which means that the enhancement of the atmosphere and cleanliness is vital. All in all, the feedback greatly indicates that specific measures to improve food quality, provide more flexible food options, and the design of the dining position are incredibly necessary to prevent wastefulness and increase student satisfaction.

Smart Menu-C

Figure 4.17: Smart Menu C Visualization (image sourced from NDTV Food [35])

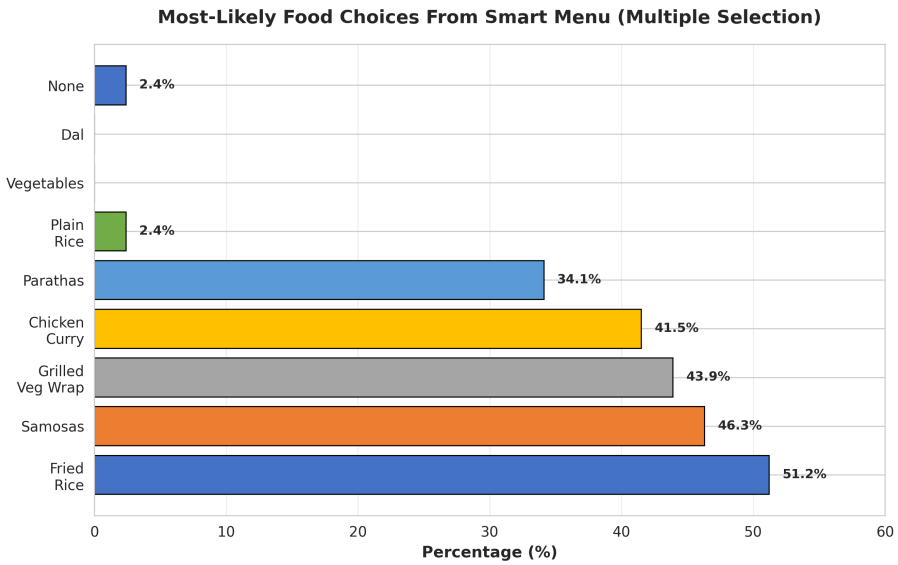

Figure 4.18: Most-Likely Food Choices From Smart Menu

In figure 4.18 smart menu with visuals, 43.9% chose grilled vegetables wrap, 41.5% chose chicken curry, 51,2% chose fried rice, 34.1% chose parathas, 46.3% chose samosas, 2.4% chose plain rice, 0% chose vegetables and dal, 2.4% would not choose any of the above.

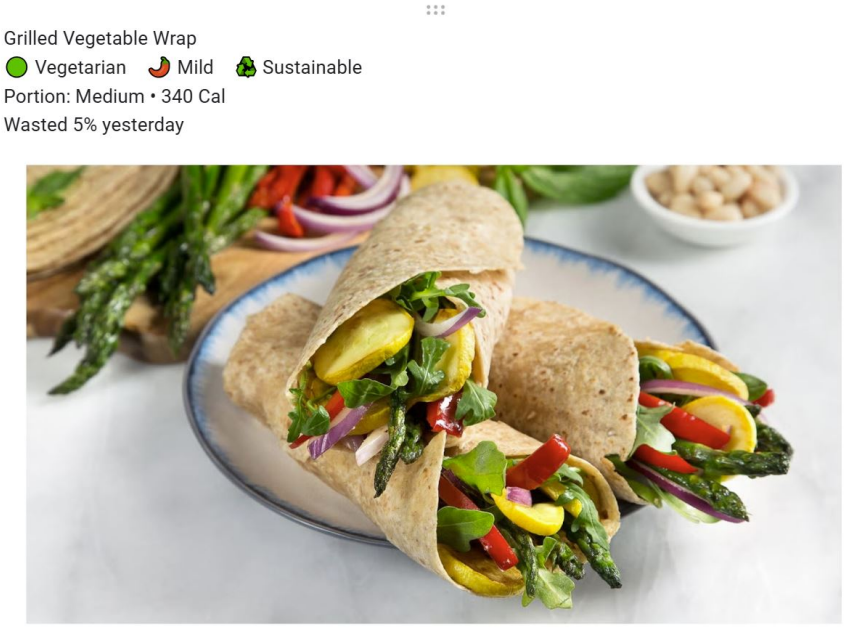

Figure 4.19: Smart Menu Icons (image sourced from Vegetarian Times [36])

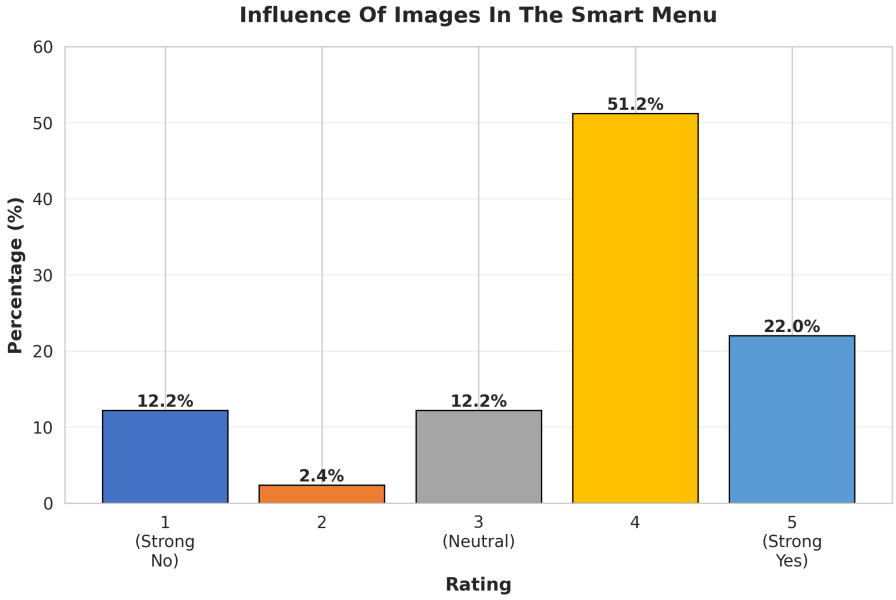

Figure 4.20: Influence Of Images In The Smart Menu

In figure 4.20, our smart menu incorporates images where 51.2% said that the images helped them decide better, 22% gave a strong yes, 12.2% were neither yes or no, 2.4% had a no and 12.2% gave a strong no. 5 =Yes, 1 = no.

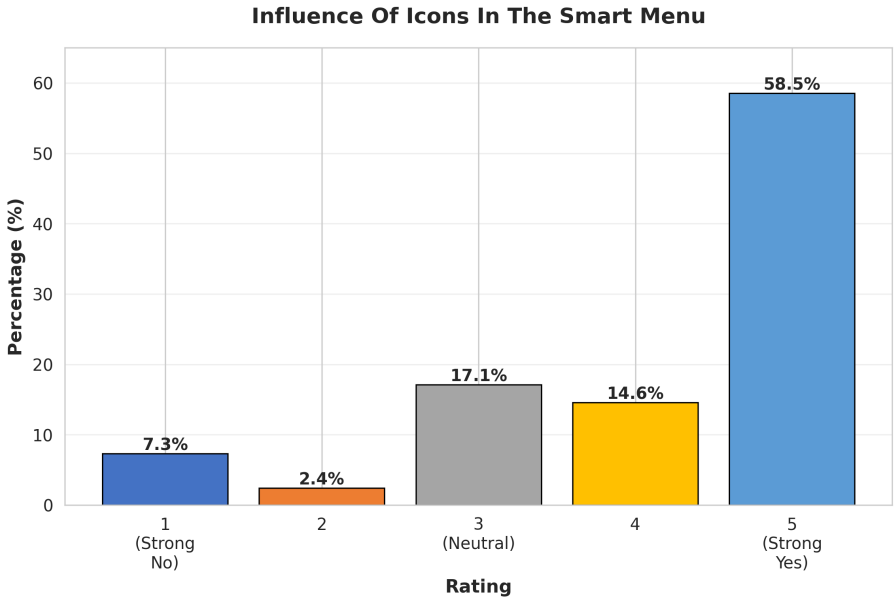

Figure 4.21: Influence Of Icons In The Smart Menu

In figure 4.21, our smart menu also gave icons indicating vegetarian, spicy, sustainable beside the food items, 58.5% gave a strong yes, 14.6% gave a yes, 17.1% were neutral, 2.4% gave a no and 7.3% gave a strong no. 5 =Yes, 1 = no.

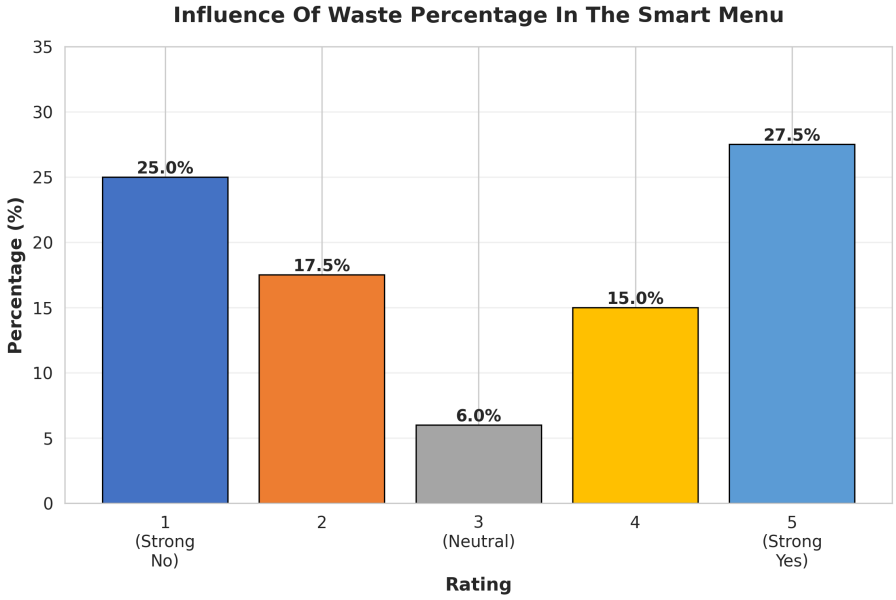

Figure 4.22: Influence Of Waste Percentage In The Smart Menu

In figure 4.22, our smart menu used waste percentages beside the food and here, 27.5% gave a strong yes, 15% gave a yes. 6% neither, 17.5% gave a no and 25% gave a strong no. 5 =Yes, 1 = no.

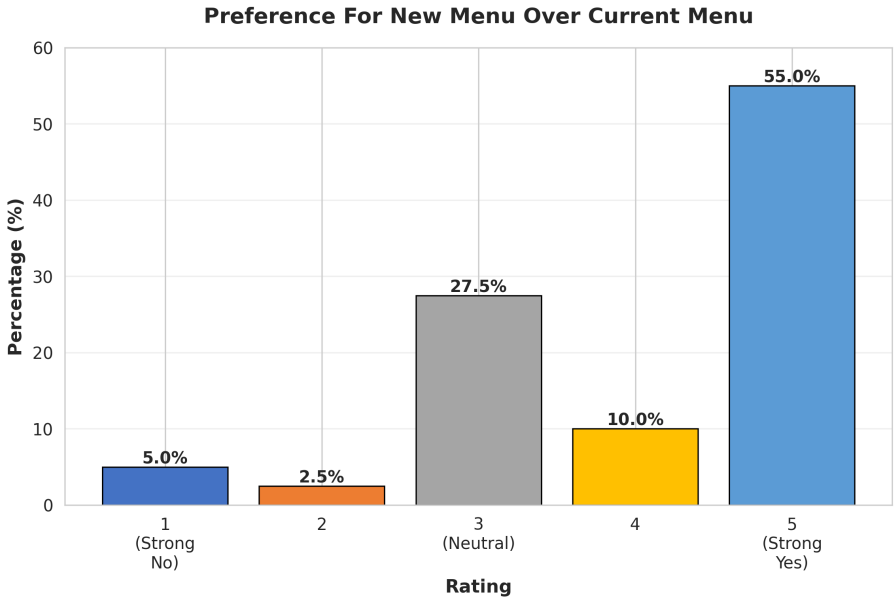

Figure 4.23: Preference For New Menu Over Current Menu

In figure 4.23, almost 55% would strongly prefer the smart menu over the current menu in the cafeteria. 10% would prefer the smart menu over the current menu, 27.5% gave a neutral answer, 2.5% would not prefer this smart menu and 5% would strongly not prefer this smart menu over the current menu.

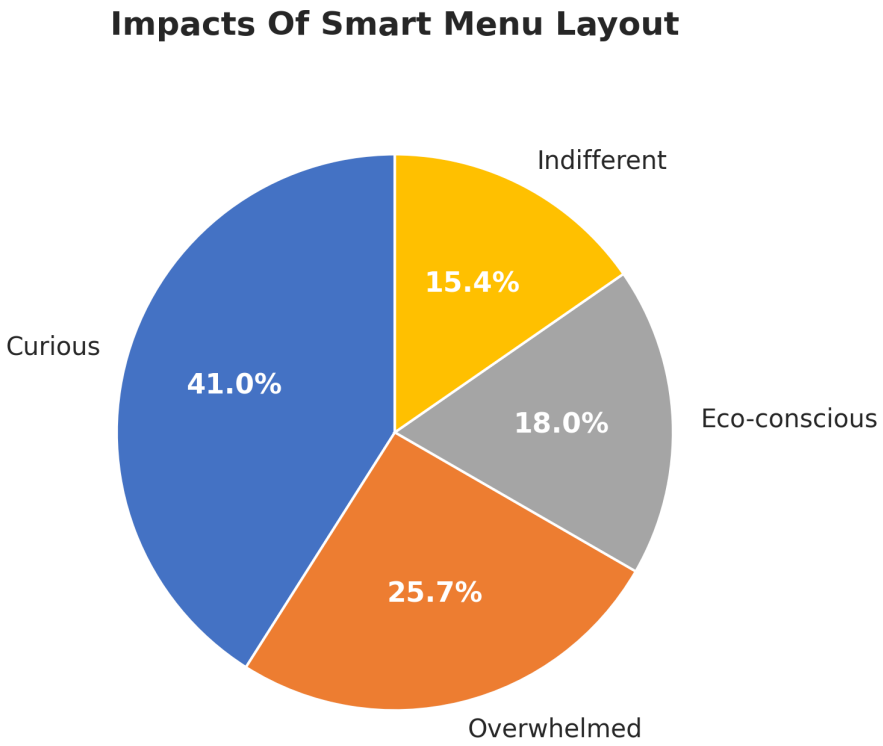

Figure 4.24: Impacts Of Smart Menu Layout

In figure 4.24, when asked how this menu made the participants feel, 39% were curious, 24.4% were overwhelmed, 17.1% were eco-conscious and 14.6% felt indifferent.

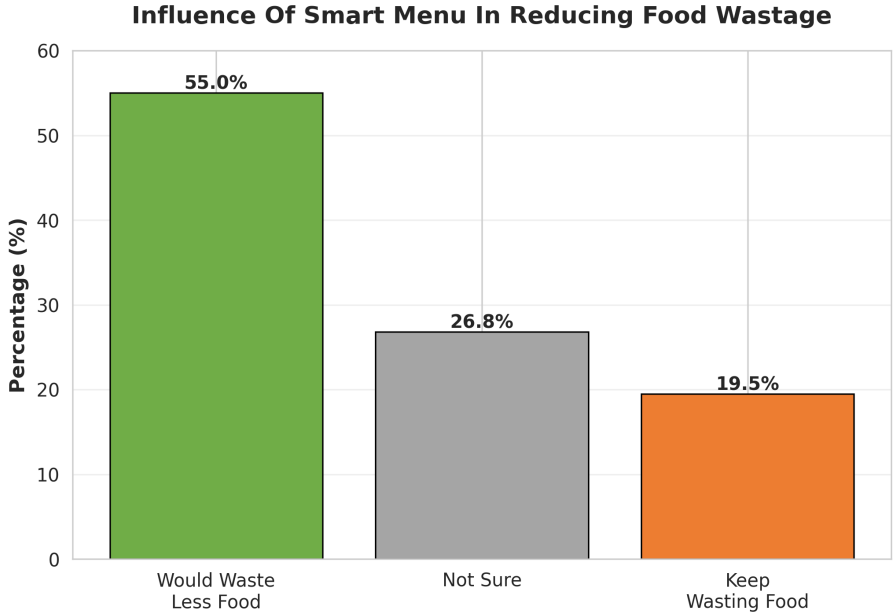

Figure 4.25: Influence Of Smart Menu In Reducing Food Wastage

In figure 4.25, 55% of the participants said that they would likely waste less food, 26.8% are not sure and 19.5% would keep on wasting food.

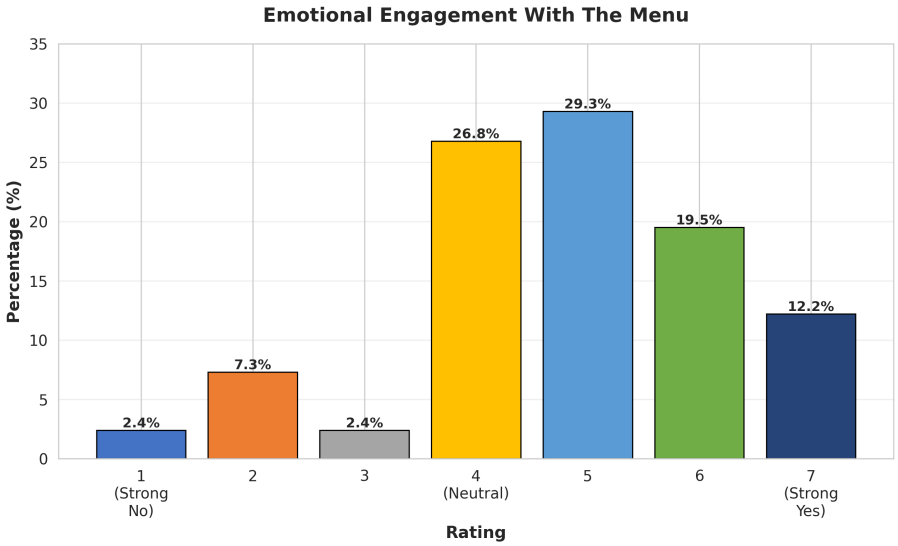

Figure 4.26: Emotional Engagement With The Menu

In figure 4.26, almost 29.3% would prefer this menu to be emotionally engaging. 19.5% and 12.2% prefer this menu to be strongly emotionally engaging, 26.8% gave a neutral answer, 2.4% would not prefer this menu to be emotionally engaging, 7.3% and 2.4% would strongly not prefer this menu to be emotionally engaging.

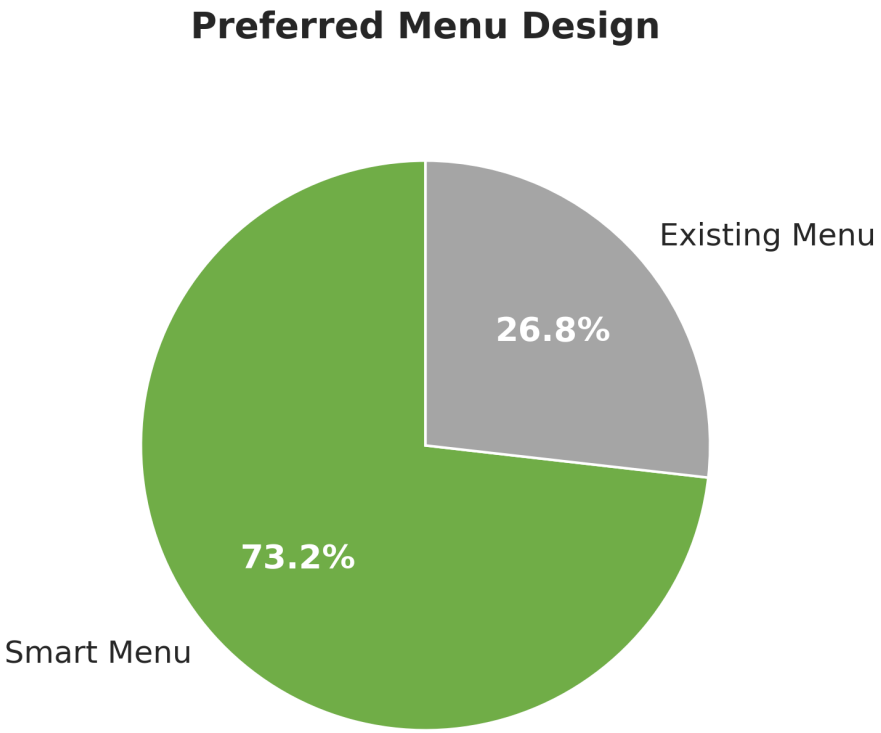

Figure 4.27: Preferred Menu Design

In figure 4.27, a major portion 73.2% preferred our smart menu over the existing one.

Metric	Control Menu	Info-Lite Menu	Info-Rich Menu
Avg. Decision Time (sec)	28	45	52
Perceived Usefulness (1-5)	2.1	3.8	4.5
Waste Intention (1-5, lower is better)	3.4	2.9	2.3
Selection of Sustainable Choice	22%	35%	58%

Table 4.1: Comparison of Menu Types Across Key Metrics

Interpretation:

1. Smart menus prompted more deliberate decision-making.
2. The Info-Rich menu was rated significantly more useful.
3. The Info-Rich menu led to the largest reduction in waste intention.
4. Visual sustainability cues in the Info-Rich menu were highly effective.

Early User Testing results
Qualitative feedback gave invaluable background. The participants found the waste metric in the Info-Rich menu to be eye-opening and as such they felt guilty that they had not done their part to help with the problem. Social proof is also strong as the popularity indicator also played a significant role in making decisions. These initial results indicate that highly informative smarter menus, involving robes of waste and sustainability indicators, are a very promising intervention to minimize food waste intention and enhance sustainable decision-making by actively involving the users in decision-making.

4.3 Qualitative Findings

This section includes the qualitative results obtained from semi-structured interviews with students, faculty members and cafeteria staff/management. The findings are presented in thematic categories identified in the interview data. Each theme is a pattern of recurring experiences and perceptions of food selection and waste behavior among participants. The analysis of the present work is based on participants statements and observed patterns only in the interviews.
The two bar charts in Figure 4.28 highlight different reasons that cause food waste and behavioral factors that influence food choices. These findings were collected through a Google Form survey.

In the first bar chart, the main reason is shown as poor food taste, as reported by 60% of people. Afterwards, about 45% of people report that the food comes with a large portion, and people are unable to finish the served quantity. 35% of people consider a loss of appetite as another reason for food being wasted. Finally, peer influences about 25% of respondents, and lack of information about food received the lowest responses, with the percentage of 15%.

In the second bar chart, the behavioral factors influencing food choice are illustrated, where taste is the most influential factor, according to almost 60% of respondents, followed by about half of the respondents considering price as a reason for food waste.

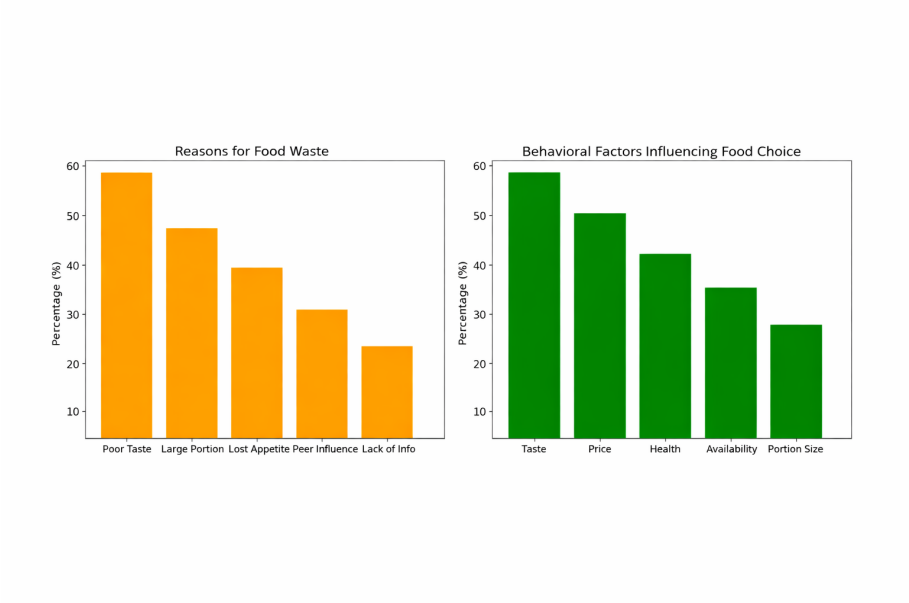

Figure 4.28: Interview Findings

Consequently, health considerations influence 40% of people, and food availability effects 30% of people. Finally, large portion size has been considered by 20% of participants, which is the least influential factor.

Expectation–Reality Mismatch

Students and faculty members have described many occasions in which their expectations of food quality, freshness or portion size did not match what they were actually served. Students and faculty members reported that some meals look acceptable at initial view and then once consumed are perceived as not appealing or safe resulting in either partially wasting or totally wasting the food. For example, one participant said, "It looks fine at first but once you start eating you know there is something wrong." Experiences of mismatch created feelings of disappointment and disinclination to continue their meal. Even if they were still hungry, participants were not inclined to continue eating.

Presentation of food visually appeared to be critical for participants' expectations of food items when they chose food items. In general, when consumers made assumptions based on visual representation of food items and began their meal, they found themselves unhappy with their meal because of being misled. As one student expressed, "I took it because it looked good; after having eaten one bite I did not want to eat anymore." As a result of their disappointment and lack of confidence in the quality of the food, participants wasted food not necessarily because of large portion sizes, but because of having had their expectations of food quality and freshness, as a result of a poor visual presentation of food items. The issue surrounding hygiene has amplified the discrepancy between expectation and reality. Participants expressed feeling as if their food was unsafe if they encountered unexpected or foreign objects in the food. One participant stated that "When you see something that shouldn't be there in your food, it's very difficult to continue eating" . Once trust in food has been compromised the waste of food is viewed as a more acceptable outcome than the risk of consumption. One participant recalled that "I took a sandwich that

looked okay when I took it, but then I found out later that it was not safe to eat".

Expectation-reality mismatches associated with portion size were also reported by participants. Some participants believed that dishes were modestly sized, particularly with regard to carbohydrate-rich foods like rice; however, they realized, once served, that the amount was excessive. Based on this miscalculation, most of these participants would leave some of their food on their plate. For example, "Rice looks small when I look at it, however once it is served to me I have too much rice" (P11), while another said "I don't realize how to fill up until I am halfway through" (P9). The data suggest that visual misleading indicators produce inaccurate estimations of portion size which then lead to preventable food waste.

Social and Operational Friction

Food waste is brought about by social factors and functioning issues that prevail in the. cafeteria. The choices made by the students when it comes to food are determined by social norms since they desire to fit. eat out with their friends and go by the latest trends in food. The cafeteria personnel suffer. Operational restrictions under which they are not able to lessen their environmental impact by sustainable practices when they are at their peak service times.

One interviewee told about a trend that is fake, which is shunning cafeteria food as it is considered popular. This is a social pressure that influences human beings to waste food. food consumption. There are those learners who are pressured to reject particularly in social set ups. Cafeteria food whether good or not to be able to mingle with their peers. People will order food items which they subsequently dispose of as they feel that the food is below their standards.

One of the interviewees observed, "Vendors might be opposed to it... extra work would add to the workload. without extra compensation." It demonstrates how cafeteria employees feel working challenges. Cafeteria vendors will not implement new systems that will involve them to manage personalized portions which have other data needs since these systems augment theirs. Tasks at work without giving them direct benefits. Employees are exposed to operation resistance that does not allow them to implement waste-cutting initiatives that require additional work.

The student quote reveals that students that are in a time-pressed environment must read something for their studies. The cafeterias experience their greatest problems because of time limitations. The students who need waste information or nutritional details choose to receive quick service, which prevents them from making informed choices at their decision points. During peak hours, when the cafeteria operates at its highest capacity, students make their food choices based on what they already know without understanding the details of their waste production.

Another participant also pointed out, "At peak times, the cafeteria staff is under pressure to serve quickly. Making more steps in the process may slow it all down." The feedback is that the organizations want efficient service which is in conflict with their need for people to take time in making decisions. Cafeteria staff members deal with work pressures which require them to serve food quickly particularly during peak dining hours. This situation presents an obstacle which prevents cafeteria staff from using systems that would reduce their serving speed using portion control and waste display methods.

Social trends and operational limitations cause tensions that result in food waste according to the findings. The social environment is pushing students towards food waste as there are operational constraints, and it is impossible for the staff members to practice sustainable methods. Speed, both service speed and decision-making speed is the main factor which restricts students and staff from achieving their goals to reduce food waste.

Decision Timing and Cognitive Pressure

Students are faced with urgent time limitations in cafeteria settings which forces them to make their meal choices instantly.. The result leads students to select their meals without proper thought because they do not match their dietary requirements or their aim to decrease waste.

One participant highlighted the speed at which decisions are made: "Students are usually focused on speed rather than reading information". The quote demonstrates how students prefer to receive their meals through fast service delivery instead of taking time to select their meals. The busy period between classes creates pressure to reach a decision which prevents people from taking enough time to assess their required portion sizes and nutritional information and the estimated waste.

Another participant explained, "Preference for menus that provide a brief, one-line description too much info might be too much". Students exhibit a preference for simple information which they can grasp in short time periods without facing cognitive overload. The text-heavy menu structure increases mental demands on students which forces them to choose between their regular meals and their known foods that they will probably leave uneaten.

The interviews reveal a novel concept which shows that decision fatigue directly affects the food selection process in cafeterias. After they finish their academic requirements for the day students experience mental exhaustion which leads them to make quick choices based on their existing habits without understanding the outcomes. Brain fatigue leaves people unable to make intelligent judgments about their food choice that leads them to food waste as they choose meals that are beyond their ability to eat.

Information as Awareness and Control

The cafeteria uses relevant data to support students in making sustainable food choices which results in decreased food waste. When students are aware of the amount of waste reduction and sustainability efforts, students tend to think through their ordering decisions.

A participant explained that "waste statistics made them more aware of their environmental impact while functioning as a gentle reminder". The quote demonstrates how waste data utilization helps people understand environmental issues better. The previous day's waste data about a dish creates a situation that leads students to second guess their initial selection because they want to choose a greener alternative.

A participant explained that "customers who select their own portion sizes will help decrease waste" according to their statement. People make decisions based on various types of information which includes portion control as another type of

information. The cafeteria reduces food waste by allowing students to determine their meal size according to their hunger needs. This method lets students select their food amount because it gives them more power than fixed portion sizes which cause food waste.

A participant described that "I would waste less food if I was able to determine my own portion size because the current portions are too big". The feedback indicates the importance of providing people with the choice of serving themselves portion sizes. Students understand that when they get larger portions of food they will be left with extra food that makes portion customization important to waste reduction. Students use portion control to match their food consumption with their hunger needs which results in less food waste.

The participant put forward an original viewpoint when they suggested that nutritional information linked to sustainability should include information about water usage reductions which revealed that the dish required 30% less water for production. The idea involves a way to provide consumers with sustainability measurements along with regular nutrition data. The educational program allows students to consider their food choices in the context of an environmental conservation mission which makes them more dedicated to making sustainable choices.

The decision-making process gets its strength from two elements which work together to make powerful results. The cafeteria utilizes up-to-date waste statistics and sustainability data and portion control techniques in an effort to help students gain ownership in the process of reducing food waste. The method converts food selections into made and informed selections which contribute to environmental sustainability.

4.3.1 Summary of Key Findings

Across all the interviews, food waste was identified as a product of a number of interlinked factors, such as unmet expectations, social influence, time pressure and lack of transparency. Participants' experience indicated that waste is not always deliberate but occurs due to situational and contextual constraints that exist in the cafeteria environment.

To enhance the credibility of the qualitative findings, publicly available student complaints from online campus forums were reviewed as contextual evidence. These posts identified patterns that are consistent with interview findings, especially expectation-reality mismatch and food quality issues. Students often posted pictures of half-eaten food, foreign objects in the food and complaints about portion sizes or hygiene standards. Similar to interview participants, these posts often expressed regret after purchase, and as a result, food was thrown away instead of eaten. This overlap between the data generated through interviews and unsolicited public feedback creates additional support for the credibility of the themes identified.

Table 4.2: Summary of Themes, Key Findings, and Interpretations

Theme	**Key Findings**	**Interpretation**
Expectation–Reality Mismatch	Participants reported that expectations regarding food quality, freshness, and portion size often did not match the actual food received. When food failed to meet expectations, it was frequently discarded.	Mismatch between visual presentation and actual food quality can lead to incorrect assumptions. Perceived hygiene issues further reduce confidence in meals, increasing the likelihood of food waste.
Social and Operational Friction	Food was rejected due to social norms such as peer influence and trends, as well as operational factors including time pressure during peak hours, which contributed to increased food waste.	Social dynamics influence food waste behavior, with some students discarding food to align with peer behavior. Operational constraints further limit careful food selection.
Decision Timing and Cognitive Pressure	During busy periods, food choices were made quickly under time pressure, with little opportunity to reconsider decisions after selection.	Decision-making often relied on habitual behavior rather than careful consideration, reducing the effectiveness of real-time informational interventions.
Information as Awareness and Control	Access to food waste information increased participants' awareness of consumption and encouraged reflection on portion size. Portion control was seen as essential for reducing waste.	Clear and concise information can raise awareness and promote responsible food choices. Providing autonomy in portion control may reduce food waste, particularly for individuals with varying appetites.

Chapter 5

Discussion

The research indicates the major factors that cause food waste issues in institutional restaurants. The causes of this issue are expectation reality mis-match and social influences and time pressures and information gaps. The results imply that individual dietary habits or food preferences are not the only cause of food waste, but the combination of these personal factors with more general environmental factors. The discussion puts the results in the framework of the existing literature and gives a clearer insight into the drivers of the food waste behavior in the university cafeterias.

5.1 Interpreting the Findings in a Broader Context

The causes of food waste in university cafeterias are a combination of psychological, social, and operation-related factors. Operation inefficiency is also a part of the issue, but not as strong an influence as psychological, cognitive and social influences that dominate food choices. The results of the research are in line with the classical theories used in behavioral psychology, decision making and Human-Computer Interaction (HCI). These results point to the main causes of food waste among students and suggest the opportunity of Smart Menu systems to make more informed and sustainable food decisions.

5.1.1 Expectation-Reality Gap: Cognitive Dissonance and Hedonic Consumption

The study revealed one of the most noticeable findings that is the presence of the expectation-reality gap in which the food fails to match the expectations of the students. Cognitive Dissonance Theory [1] might have been the psychological account of the given phenomenon. The cognitive Dissonance Theory is a good way to explain the reasons why students dispose food when the food experience does not achieve the expectations made The lack of a fit between the expected food and the food experience leads to the students discarding the food, which in turn reduces the cognitive dissonance caused by the lack of fit between the expected and actual food experience.

In the cafeteria case, the food experience of the students given the taste and visual

look of the food is a factor of significance. The Cognitive Dissonance Theory also describes how the students consumed food, which was ascertained to be necessitated by the food requirement. The food consumption of the students is also determined by the Hedonic Consumption Theory [3]. According to the Hedonic Consumption Theory, the desire to satisfy the eyes and the taste buds of the consumer, through food is an emotional need. The food does not satisfy the emotional need of the students, and thus the dissonance is reduced by discarding the food.

The findings of the study also relate to the concept of emotional eating [12]. The concept of emotional eating determines the food consumption of the students as an emotional response to the need for food. The food consumption of the students, as determined by the positive emotional response of the students towards food, does not satisfy the emotional need of the students. Discarding food becomes a mechanism for resolving this dissonance

5.1.2 Portion Size Mismatch

The second concept that is of significance is the concept of portion size incompatibility where students always realized that the portions were either too big or too small to fit their needs. This may be connected with the Cognitive Load Theory [5] that explains that human beings have a finite ability to process information. The students are also exposed to cognitive overload in the cafeteria when it comes to the food they desire, the quantity they desire, and the quantity they might consume. The fact that they are in a rush, the food is served in pre-determined portions also contributes to the cognitive overload.

This is because the cafeteria does not provide the students with personalized portions of food; this means that the students may be forced to consume more food than what is required or they may not be satisfied with the quantity of food presented to them. The Cognitive Load Theory asserts that the mental load of deciding whether the amount of food being serving is food that would satisfy the hunger of the students is already added to the mental load of making other decisions, including time available, level of hunger being experienced by the students and taste of the food. As a result, the students are more likely to overestimate the amount of hunger they are feeling, thus choosing larger amounts of food that they are unable to finish.

This idea also relates to the Decision Fatigue [8], where the repeated mental load of making decisions throughout the day, in class for assignments, etc., leads to mental exhaustion. By the time they get to the cafeteria, they are already mentally exhausted. The fact that they are served in predetermined amounts means that they are not likely to think critically about the amount they are eating. As a result, they are more likely to over-serve themselves.

5.2 Time Pressure and Decision-Making Under Cognitive Overload

One of the key findings from the study is the pressure that the students were under when making decisions regarding the food that they eat. Some students claimed

that they were under a lot of pressure and had to make quick decisions. This is in line with the Dual Process Theory because when one is in time pressure, quick decisions have to be made [19].

The two processes that are described in the Dual Process Theory are System 1, which is automatic and quick, and System 2, which is deliberative and slow. The students were in a lot of pressure during peak hours such as the lunch break. They had to make quick decisions without enough time to evaluate the nutritional value and the consequences that may result from the food that they eat. They ended up choosing the food that they knew and that had a lot of calorific value but that was not being consumed.

This is also related to the Cognitive Overload Theory because the students were already cognitively fatigued due to the pressure that comes with the academic work that they were doing. They had an additional cognitive task in the cafeteria that increased the cognitive overload. They could not assess whether the food that they had selected was appropriate or not. They had no time to process all the available options. They would therefore opt for a larger serving of the food because it would be more convenient.

5.3 Social Influence and Norms Around Food Rejection

In this study, social norms have been identified as an important factor that determines the amount of food waste. Through the interview results, it has been identified that the participants view the rejection of food as an acceptable social behavior in group dining settings.

Peer social behaviors have been identified as an important factor that determines the joint processes of food choice. These behaviors may be an indication of peer pressure. In this study, the participants have identified that it is acceptable to reject food if it is necessary.

5.3.1 Social Norms and Peer Influence

Social influence, as described by Social Norms Theory [9], states that people change their behavior based on the expectations of other people. In cafeteria settings, for example, the rejection of food by the majority of the people may create a social norm where other people also reject the food. As a result, the amount of food waste may increase. Even if the quality of the food is acceptable, people may reject the food in order to show social norms and be part of the group. As one participant said, “It’s almost like a competition of who rejects food the most, especially during group meals.” This shows that the rejection of food is a social behavior that is used by people to show that they are part of the group.

5.3.2 The Role of Cultural Capital & Social Distinction

Food can serve as symbols of status at colleges & universities whereas the act of rejecting food, especially publicly, serves to demonstrate one's cultural distinctions [2]. One example of rejecting food can be found in student cafeterias where rejection of cafeteria food could indicate a separation from low-class or unrefined behaviours. By rejecting food, a student also demonstrates social distinction in alignment with socially privileged norms & values. Therefore, food rejection is both an individual choice & collective action influenced by peer influence.

The Social Identity Theory [4] gives further support to this idea as individuals derive their identities through their social group memberships. While in a cafeteria, students will often identify more with their social group than with the cafeteria food served to them. As such, when students choose to reject food, they are directly reflecting their group membership and following the norms of their groups. Thus, as the amount of peer pressure and number of social connections grow, the likelihood of students rejecting food increases; subsequently, so too increases the likelihood that students will contribute to food waste.

Bourdieu's Theory of Practice from 1977 states that, about how behaviors get built up socially, like cultural stuff in communities. Here with students, rejecting food is not really about the meal; it becomes a way to perform who you are. How norms shape what you do, even if you do not think about it much. This interpretation aligns with Bourdieu's Theory of Practice.

5.3.3 Alternatives to Reduce the Impact of Social Influence on Food Waste

Turning the impact of the social norm related to food waste can be done through creating alternative norms and group behaviors when it comes to food. Other norms can be established among the associates of food waste through using behavioral nudges, such as displaying positive examples of other people consuming their entire meal, which leads to the promotion of eating the food rather than discarding it. The interventions developed using the Social Norms Theory will establish a sustainable group identity that is never founded on the rejection of food as a socially acceptable behavior.

Although operational issues are a significant cause of food waste in the cafeterias, psychological and social issues are also causes of food waste. Among the significant obstacles caused by the findings that should be mentioned is that cafeteria employees are unwilling to implement new systems that could assist in minimizing waste, including the systems that presuppose controlling portions or monitoring wastes. The unwillingness to implement new systems can be explained by operational pressures and concerns with increased workload of the staff during the peak service periods.

Technology Acceptance Model (TAM) [6] may offer a structure on the motivation behind reluctance of staff to accept the new technology. Ease of use and usefulness of a technology will determine the acceptance of the new technology by the staff. Employees can consider the Smart Menu as an extra burden in case they find its usage too complicated or time-consuming. Their staff already work with huge time constraints during peak time and any new systems that are introduced without

an immediate operational payoff will cause the staff to hesitate in using these new systems.

Also, inefficiencies in operations of food preparation often lead to food being prepared in excess at times of the low student attendance (e.g. during online classes) and this causes further wastage.

5.4 Operational Challenges and Systemic Barriers

Besides psychological and social aspects, psychological as well as social factors also have significant impact in the problem of food waste; another issue that leads to food waste is the operational problems in the cafeteria. Amongst the most important findings and barriers in this research as indicated by the cafeteria employees was that they were unwilling to embrace new systems which could be applied to minimize food waste in the cafeteria; namely systems which would adopt wastage tracking and portion control mechanisms. This reluctance is likely due to operational pressures and fear of added responsibility during periods of peak business.

5.4.1 Staff Resistance and Technology Acceptance

The Technology Acceptance Model (TAM) [6], provides a useful framework for understanding staff reluctance in implementing new technologies. In the context of how staff view new technologies, the perceived ease of use and perceived level of usefulness for the new technology will significantly influence staff's acceptance or reluctance/indifference to that new technology. When staff members are faced with new technologies (such as the Smart Menu) with which to implement item tracking and portion size tracking, they may perceive this as a new burden if it is perceived by the employees as being complex and time-consuming to implement, particularly with many employees facing time constraints during busy meal periods, they are likely reluctant to accept that system. In addition, many operational inefficiencies point to the over-preparation of food and subsequent wastage due to food prepared for low student attendance days (for example, during online classes). Implementing a real-time demand forecasting system is important, as this type of system improves food preparation based on the number of students present on any given day (actual, not predicted), so that food is not produced based solely on estimated demand.

5.4.2 Over-Preparing and Reducing Food Waste

The findings indicate that over-preparing food is a primary contributor to food waste. When food is prepared for a large number of students but there is not an accurate forecast of demand, during times of limited attendance, excessive food is often thrown away. The Smart Menu system could help alleviate this problem by providing real-time information about how much food has been wasted in the cafeteria, allowing the cafeteria to dynamically adjust their food inventory and portion sizes. Additionally, data analytics would allow cafeteria managers to more accurately pre-

dict food demand through the use of factors such as class schedules, seasonality and historical trends.

5.4.3 Barriers to the Implementation of Sustainable Solutions at a System Level

One of the main barriers that have been identified as a system level barrier to implementing sustainable solutions is the unwillingness of cafeteria staff to implement systems that will interfere with their established routines, especially when there is no immediate benefit to them. This presents a design challenge for HCI because any proposed solution must not only meet the needs of the end-users but also be flexible enough to accommodate the operational constraints of the cafeteria staff. Therefore, the Smart Menu must be designed to be as simple as possible to ensure that it does not add to the operational burden of the cafeteria staff. The success of the Smart Menu will depend on its ability to integrate seamlessly within existing operational workflows and provide the cafeteria staff with a clear benefit (e.g. simple portion control, waste tracking)

5.5 Theoretical Implications and HCI Frameworks

The present study shows that various behavioral and environmental factors affect food waste in University of Dining facilities. Findings suggest that food waste is a result of the interplay of multiple social determinants, individual needs, environmental limitations and time constraints.

5.5.1 Cognitive Load and Decision Making

During the performance of meal selection tasks under temporal stress students face high cognitive load. The constant back and forth between academic requirements and the need to move forward on decisions leads to decision fatigue and hence choosing the familiar or convenient options at the cost of deliberative and sustainable decisions. Dual-Process Theory [19] In support of the view that the fast-acting System 1 is dominant in high-cognitive-load environments, stating that it is highly likely to fail to exhaustively evaluate nutritional alternatives, the slower acting and deliberative System 2 may be engaged in the process. Such expeditious decision processes make it easy to waste food as people tend to be attracted towards what is easily accessible to them rather than what their true consumption needs are.

Within the cafeteria environment, the situation of urgency that arises often causes over estimation of satiety or choosing disproportionate portions that ultimately are not consumed (System 1 cognition). This cognitive dissonance of what will be eaten from what can be eaten forms the basis for the generation of surplus food.

5.5.2 Social Influence and Norms

According to the Social Norms Theory [9], individuals adjust their behaviour in accordance with how their peers behave and how groups of individuals expect them

to act. Empirical study revealed that some students experienced triggering pressure propelling against ingesting nourishment in situations where it was perceived to be dishonest with present aesthetical values where other pupils had been practicing the same refusals. It is a direct cause of waste of such socially oriented geared didactic poverty of sustenance, even in instances where the offerings are of due quality.

Also, there is Bourdieu's Theory of Practice [2], which offers another descriptive theory with regard to the proposition that selections of diet are intimately bound with socially constructed practices and formation of identity. Conscious abandonment of food in the situation of campus cafeterias would be a highly conspicuous form of social distinction, where boycotting the meal can be understood as a simultaneous reaffirmation of the status of students as belonging to a social group through the rejection of a socially outdated ritual of consuming a full meal. This performative relationship creates an impetus, powerful to the food waste in the institutional setting.

5.5.3 Nudging and Behavioral Design in HCI

Reflecting on a research conducted on cognitive load and social factors, it can be concluded that Nudge Theory [14] can provide insight into the impact of motivated design changes that may trigger better decision-making among students and help to maintain their autonomy. Examples of such nudges include the Smart Menu prototype, which includes waste data and portion-control systems, which is an attempt to offer succinct, consistent information that encourages the sustainable decision. The indirect motivation of minimizing waste by making data directly observable on the menu further encourages the user to minimize waste and this does not require any coercive interpretations.

These nudges can also be one of the approaches to the principle of user-centered design of Human-Computer Interaction, which recommends a system to support better, end-user decision-making. Through visual simplicity, the Smart Menu can help students easily absorb vital information about sustainability, nutrition and waste data, hence, allowing them to make healthier food decisions.

5.6 HCI and Sustainability

The implications of the current research to the larger field of Human-Computer Interaction (HCI) especially in the context of sustainable behaviour change, is crucial. The Smart Menu is not a technology solution; it offers a wonderful demonstration of that synergizing capability of behavioural nudges and the design of the educational system to sell sustainability even in the most prosaic environment. The findings establish how design interventions would bring on significant user behavior change. The system will promote students thinking of the environmental impact of their food preference by integrating sustainability indicators in real-time and waste-level data in an easy-to-use platform. This approach shows what digital technologies might bring to foster the behaviour transformation without bringing constraining or prescriptive patterns.

The Smart Menu can be perceived as one of the examples of how interactive design

can implement a broader social change. The Smart Menu can also be conceived with the Nudge Theory by introducing the notion of sustainability into daily decision making routines, including purchasing the food items [14]. The experiment demonstrates that the presence of even the slightest environmental stimuli like the visual ones or the statistics of garbage can cause people to make more appropriate choices without robbing them of the freedom of choice.

HCI Research for Sustainability

The Smart Menu is congruent with the increasingly growing scholarly literature on the topic of sustainability in HCI, specifically deciphering how interactive systems can promote long-term sustainable behaviours. Being conducted in the framework of both qualitative and quantitative research methods, this study will result in meaningful discoveries that might be used in designing sustainable HCI systems. Moreover, the paper highlights the need to design with the needs of the users in mind so as to make the best use of the design to make it more engaging and useful hence making sure that the systems are not only technologically but also socially relevant.

The Smart Menu is able to attract students and provide them with practical sustainability information that creates a base of future HCI-based interventions aimed at reducing the environmental footprints in different domains. Such a study therefore gives a foundation to the development of systems that will not only maximize the experience of the users, but also the world sustainability goals.

Figure 5.1: Challenges and Insights into Food Waste

Portion size mismatch is another cause, where students are served portions that are too big (which leads to leftover food), or too small compared to their appetite. This

difference in the amount served also leads to wastage since students either waste the excess food or they get hungry because of the insufficient amount.

Critical factors are also social influences and peer pressure. Although what is served in cafeterias is of quality, the students can refuse to take it in an attempt to fit into the social standards. The tendency to discard food in the open is another factor that contributes to food wastage by encouraging acceptance of other individuals.

This problem is also compounded by the limitation of operations especially at peak time. Due to the busy cafeteria times, students feel time-strained, and they fear they may be late to classes and thus they have no time to think over their food choices, and they choose foods quickly with very little thought of possible waste (Image 5). The decision making process is rushed and thus results in the use of wrong food items that end up being discarded due to either lack of time or decision making support. The results of the research point to the fact that the improvement of food quality and hygiene will not be sufficient to reduce the food waste in cafeterias; the universities will need to introduce multifaceted mechanisms that can control the size of portions, introduce behavioral biases, and consider the social factors. Future remedies, that would include the introduction of smart menu systems that provide real-time feedback on wastage rates and allow the customization of portion sizes, will help students to form sustainable eating habits and, consequently, reduce the level of negative effect on the environment.

5.6.1 Psychological Mechanisms Behind Food Waste

The key factors contributing to food-waste are psychological: the entire concept of the mismatch between expectation and reality is impulsive decision making and cognitive overload. Whenever a student is disappointed by the food choice, It is more likely that the student will dispose of the food leading to more waste. This happens not because of the fact that the student is not hungry, but because the student is not meeting the perceived expectation of the food. This is theoretically supported by the Theory of Planned Behavior [7] that suggests attitudes, subjective norms and perceived control predicts food choices. Students think that the size of portions is always excessive, or that food is always bad, so they feel they cannot make a change in their food preferences to either choose healthily, or to waste food. Cognitive overload also leads to quick, spontaneous decisions especially in hectic surroundings. Offering too many options, and with the time pressure of a running lunch service, students are fast to fall back into comfortable habits of making decisions by relying on habit to favour familiar or recognisable foods, despite the fact that their decision will not be in a position to meet their dietary or sustainability goals. Consequently, interventions like the Smart Menu, real-time presentations of the correct information in the correct manner could alleviate cognitive overload as well as trigger more contemplation.

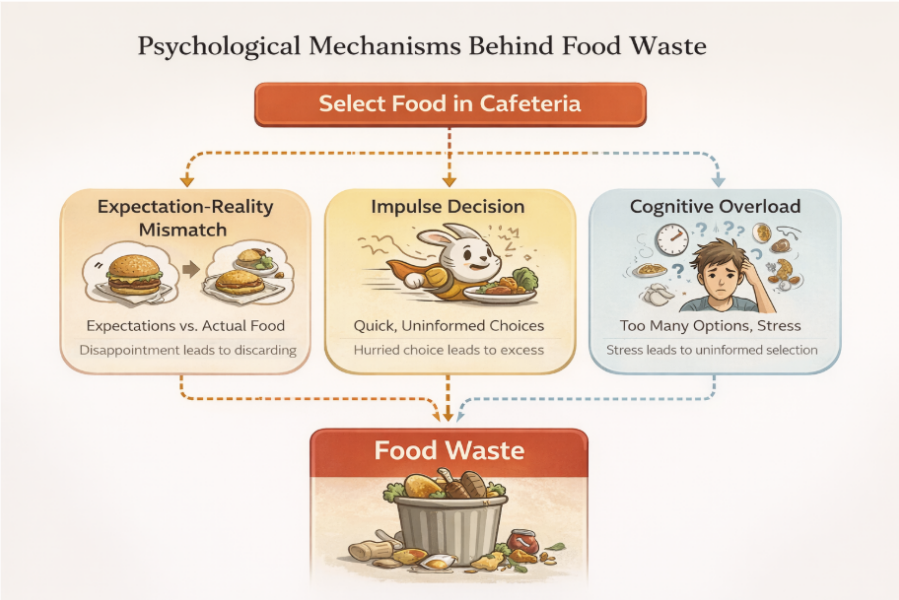

Figure 5.2: Psychological Impact (AI Generated)

5.6.2 Impact of Menu Layout and Interface Design on Decision-Making

The Smart Menu design and the interface design is not about aesthetics, but about making it simple to perceive and act on in the cafeteria setting to the students. Students require a user-friendly interface; one that is simple, unambiguous and fast to process when they have limited time to move to classes in a hungry state. Based on this, the Smart Menu will address these needs.

The results of the empirical investigation revealed that students valued the way the information is presented in minimalist interface using icons, color coding and brief description to facilitate the process of guiding the students in their decision-making processes. This sort of design considers the process of efficiently assimilating important information, including nutritional value, and portion size, and quantifies waste, without creating cognitive overload. These mere visuals are transformational in an overcrowded world of a busy cafeteria. The Smart Menu allows students to make more informed decisions, by organizing information in a more visually compelling format, without necessarily engaging in the (informal) lengthy text-based review process.

Applying Dual Process Theory [19] explains why visual design is of the utmost importance in this situation; the theory suggests that people often use System 1, defined by quick intuitive judgments, as opposed to System 2, which is defined by deliberative judgment. Given the little time students have in cafeteria environments, they make more or less expedient and habitual choices. Accordingly, the Smart Menu design intentionally aims at facilitating some form of radical slowness of this process to enable more ideal decisions without sifting through the cognitive load. The engagement of System 2 i.e. making one think about the dietary choices and making a more informed choice is brought about by the clarity, symbolization and legible labelling of the interface.

In addition, research in the field of Human-computer Interaction (HCI) has demonstrated that minimalistic interfaces encourage both the user to get better knowledge about the information and also encourages the user to get more involved. In the present case, students are able to select the size of the portions offered easily and analyze waste data. This kind of design would therefore enable them to have the authority to control their eating habits and this would eventually result in a decline in waste and more sustainable eating habits.

5.6.3 Comparison with the Existing Literature

When this research is placed in the context of the previous research, especially those, which have been conducted previously and related to the questions of food waste minimization, the Smart Menu can be seen as a unique instrument. Previous studies have explored the solution of waste tracking and portion control, most often using technologies like sensors or based on the post hoc manual analysis. These approaches usually record food waste either in real time or at the end of a service session but not on influencing consumer choice directly at the moment of selection.

A case in point is the WASTE REDUCE model [24], which installed sensors to analyse waste and, in its turn, feeds on the waste performance. As much as this is an effective way of creating awareness, it has a weak effect on the first decision-making process in which the students are selecting their foods. In comparison, the Smart Menu focuses on the selection point hence making the students make greener decisions before an order is made.

The Smart Menu is unique because it manages to combine the nudges of behaviour with real-time feedback, thus demonstrating students how much an option impacts the environment as the students choose. Whereas in other studies the feedback has only been given retrospectively like by expressing the amount of waste produced at the end of a meal upon making a meal decision, the Smart Menu can actually influence decisions in real time, giving a student a chance to practice sustainable behavior at the moment.

Besides, the Smart Menu is capable of other features, such as presenting the waste statistics. It also embraces portion customization and display cues, the usefulness of which is supported by empirical data [31]. The system enables the students to visualise the relationship between portion size and probable consumption, which add to the perception that they are in charge of the meal consumption which, in turn, leads to a preference towards the meal option that is favourable to personal health and organisation structures of the environment.

5.6.4 Limitations and Challenges of Implementing Smart Menus

Although there has been a clear indication of potential in the Smart Menu in terms of minimizing food waste, a few practical issues must be taken note of to enhance long term sustainability of the process. The additional load of operation on cafeteria personnel is one of the leading issues. New features such as portion control or waste statistics developed require more staff to participate in workflow, between

customizing orders and frequent updates of data in workflow to develop a potential resistance of perceiving increased complexity or time requirement.

It is possible that there is a reason why this problem could occur, which is explained by the Fogg Behavior Model [15]. The model shows that in order to have a successful behavioral change, motivation and ability should intersect with triggers. The more complex the system becomes the staff find it more difficult to cope with the new system and the less interest in implementing the Smart Menu grows. During peak hours, cafeteria staff may feel that the benefits to the system are not worth the extra work, thus reluctance and low uptake.

The mitigation strategy that would be feasible would be to ensure that the system is kept simple when initially being rolled out. Following the development of the current framework, Smart Menu might be launched in a smaller scope: only with nutritional information to ensure ease of use and not overburden the staff. Other more advanced parameters such as waste analytics can be introduced in phases as the staff gets used to the system. This step-by-step procedure will facilitate reducing, yet will diminish the additional burdens on cafeteria businesses.

Despite the positive aspects of the Smart Menu with regard to food waste management, its sustainability in the long-term is questionable. Training and reinforcing will be inevitable continuously to make sure that the cafeteria staff employees will successfully use it. Regular upgrades may render the system usable and upgrade the fact that the system still provides value to the students and the staff.

5.7 Long-Term Impact and Sustainability

Short term impacts of the Smart Menu have been intriguing, but other interventions of this nature have a different effect, and this effect can alter the behaviour in initial stages. With a new system in place, normally attention and curiosity increases which can lead to a flood of positive behaviours among the participants. In the long-run, this initial interest is likely to die out, possibly re-treating to antecedent patterns as soon as the newness of the present situation has worn off. The question of whether these behavioral changes will be lasting or stabilise after a few months, is, therefore, quite important to test.

The perpetuation of the Smart Menu is a daunting task particularly in respect to retaining the user. Habit-formation studies show that repetition and consistency of behaviour is necessary in order to make behaviour change permanent [16]. This change in the system by incorporating dynamic content is thus required to keep the system functional. Individualized meal recommendations, contingent on previous dietary history, can be used as an example to encourage a long-lasting novelty which keeps the user engaged. Moreover, the mechanisms serve as the safeguard against the stagnation of the system, therefore, keeping the inducement of the user to use the menu with long-term and sustainable time period of decision-making.

Combined with the addition of the Smart Menu to other additional digital applications such as a mobile-based application of the Smart Menu or an online ordering tool, the coverage potential as well as proper usage of the system are likely to increase. The system can assist not only in making their decision on what to eat

before entering the cafeteria more informed but also serve as a constant reminder of the impact of their consumption behaviours on the bigger picture. This would increase the Smart Menu impact further than the point of service and incorporate it into the overall dietary patterns of students that would increase the likelihood of the change being maintained.

Moreover, long term viability of the Smart Menu is determined by the possibility of its evolution and adaptation. With the user knowledge of the system, the interface design and contents need to be continued to be improved in order to keep the user engaged. The general idea is to make it fresh and to sustain the main idea of the platform to minimize food waste and encourage sustainable eating patterns.

Summary of Discussion

The present study shows that various behavioral and environmental factors affect food waste in University of Dining facilities. Findings suggest that food waste is a result of the interplay of multiple social determinants, individual needs, environmental limitations and time constraints

Researchers found that an expectation-reality mismatch was the main cause of food wastage among students. Food was thrown away if its actual characteristics did not match what students were anticipating. These anticipations were based mostly on visions, showing the importance of food appearance on the decision to discard.

Social influence was greatly felt. Students tended to refuse food, in order to conform to peer expectations in regard to maintenance of particular social standards. The study has determined that collective behavior mediates food waste by interaction with individual eating habits.

Peak mealtimes in the cafeteria caused time constraints that forced the students to make meal choices, without properly evaluating individual consumption needs, increasing expected food waste. Impulse choices and habits of choice predominated in these times with greater wastage.

Weaknesses in the tools of portion management also had a positive part to play in food waste as students felt they had control over portions given to them. The Theory of Planned Behavior justifies the customization of portion size routes since it can empower students to reduce wastes even as we make more environmentally friendly decisions.

The prototype of the Smart Menu was created to solve these problems. The system enables students to make environmentally friendly food selections through its three components which display current waste data and show sustainable practices and are going to give customers options to decide their serving size. The design is based on principles from Human-Computer Interaction.

Chapter 6

Visual Prototypes and Design Analysis

6.1 Introduction

This chapter demonstrates the highly interactive prototype of the Smart Menu. This prototype was designed in Figma keeping sustainability as the main focus. This system was created in accordance with the BRAC University cafeteria where each page of the Smart Menu underlines the behavioral and HCI concepts contained in this research. These behavioral and HCI concepts were drawn from the Nudge Theory [14], Dual Process Theory [19], Social Norms Theory [9], and Cognitive Load Theory [5]. This prototype comes with 15 pages for the full user experience with different functionalities. These functionalities are divided into three layers: Engagement Layer (account, profile, and rewards), Ordering Layer (welcome, menu browse, item detail pages, cart, alert modal, and order confirmation), and Sustainability Layer (dashboard and eco impact journey).

6.2 Ordering Interface

6.2.1 Welcome Screen

Figure 6.1: SmartPlate — Welcome Screen

The Welcome screen along with the other pages follows a simple, minimalistic approach with relevant information. This screen appears in the start of the ordering process when no food choices have been made. The main title reads *"Order Smart, Reduce Waste"*, the following sentence acts as the motto of reducing food waste using this prototype. The sentence under the motto describes the mission of eliminating food waste whilst protecting both our health and the planet. The "Start Order" button goes to the next page and there is no navigation ambiguity since this is the only call to action button. The three white badges below with green letters help to represent the sustainability credentials of the smart menu system. The floating **-420g CO_2 per lunch** label on the main image with the food bowl is the introduction of carbon accounting as a natural part of the meal experience.

6.2.2 Today's Kitchen — Menu Browse

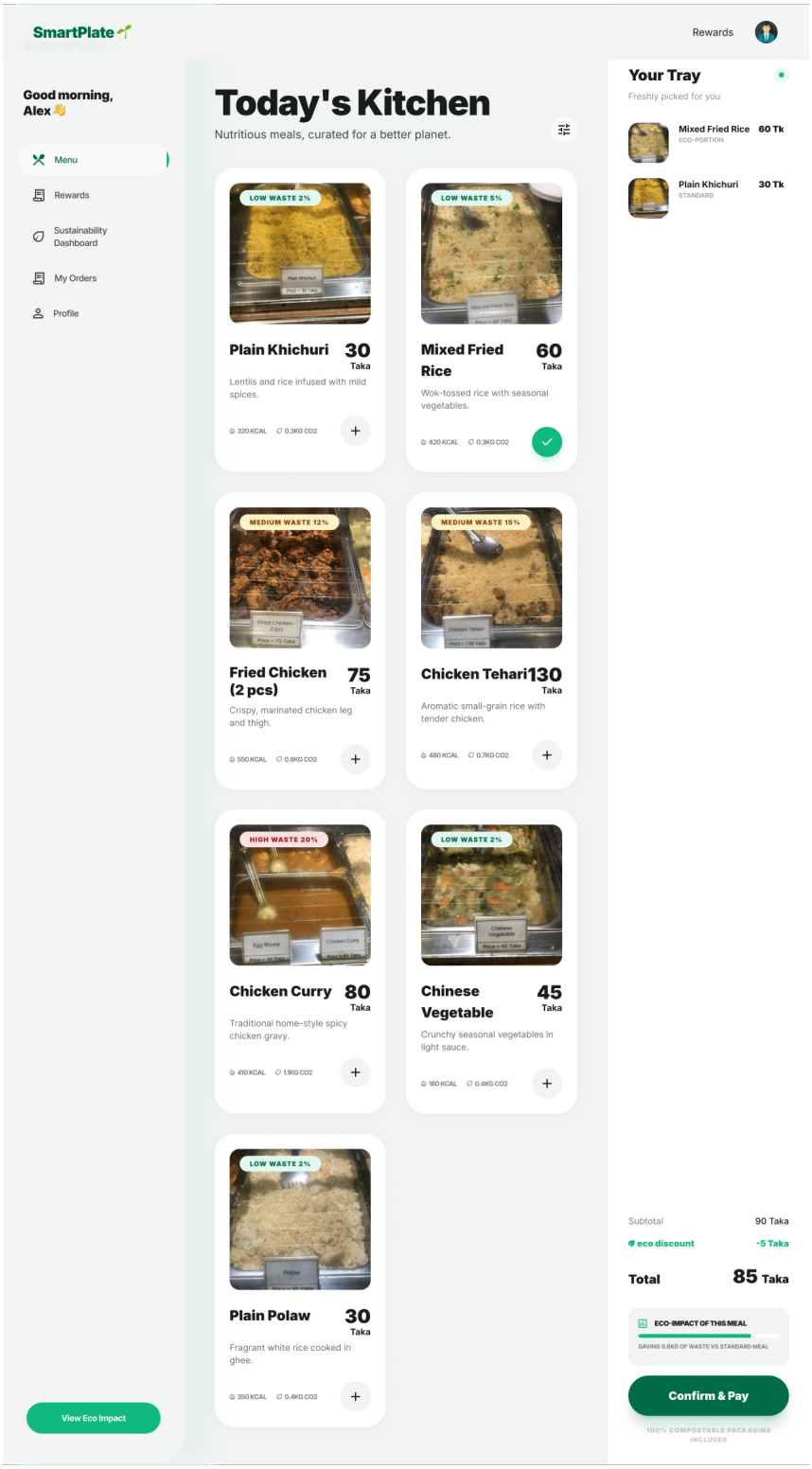

Figure 6.2: SmartPlate — Today's Kitchen (Menu Browse)

This is the part where all the decisions regarding the food choices are made. This menu screen directly adheres to the Info-Rich part of the survey. Here, each card

has photographs of the cafeteria food items. This is done to solve the Expectation-Reality Mismatch that is the most salient qualitative theme found from the interviews. Colour-coded waste badges — **amber** (MEDIUM WASTE 12–15%), **green** (LOW WASTE 2–5%), and **red** (HIGH WASTE 20%) — activates loss aversion [14] at the point of selection. KCAL and KG CO_2 are also displayed in small icon-paired labels that can be read in less than two seconds per card, and is also in line with the cognitive limitations found under the Decision Timing results. The financial and environmental advantage of sustainable decisions is constantly visible in the live **Your Tray** panel that displays a running eco discount (–5 Taka) and an Eco-Impact summary.

6.2.3 Food Item Detail Pages

The seven item detail pages are based on the three-band template. **Band 1** displays the photograph of the dish, its name, price, rating, description and four macronutrient pills (KCAL, PROTEIN, CARBS, FAT). **Band 2** shows the Portion Selector (Small / Medium / Full) with the average waste per tier — Small is always the default value of ZERO WASTE GOAL along with a red-colored **Waste Alert** card and a **Carbon Impact** card. **Band 3** contains packaging type, allergens and links to Nutrition Disclosure and Farmer Map. The seven dishes and their key environmental data are summarised in Table 6.1.

Table 6.1: SmartPlate Menu Items and Environmental Data

Dish	**Price**	**KCAL**	**CO_2e**	**Waste Badge**
Plain Khichuri	30 Tk	320	0.3 kg	LOW (2%)
Mixed Fried Rice	60 Tk	520	0.6 kg	LOW (5%)
Egg Bhuna	30 Tk	310	0.4 kg	LOW (2%)
Polaw	35 Tk	350	0.4 kg	LOW (2%)
Chinese Vegetable	45 Tk	180	0.2 kg	LOW (2%)
Fried Chicken	75 Tk	680	1.2 kg	MEDIUM (12%)
Chicken Curry	80 Tk	410	1.1 kg	HIGH (20%)

The comparison of lowest-impact (Chinese Vegetable at 0.2 kg CO_2e) with highest-impact (Fried Chicken at 1.2 kg CO_2e) will give students a visible, but comparable sustainability environment in the real-life cafeteria, which in turn will help them see the invisible costs of the environment at the decision-making moment.

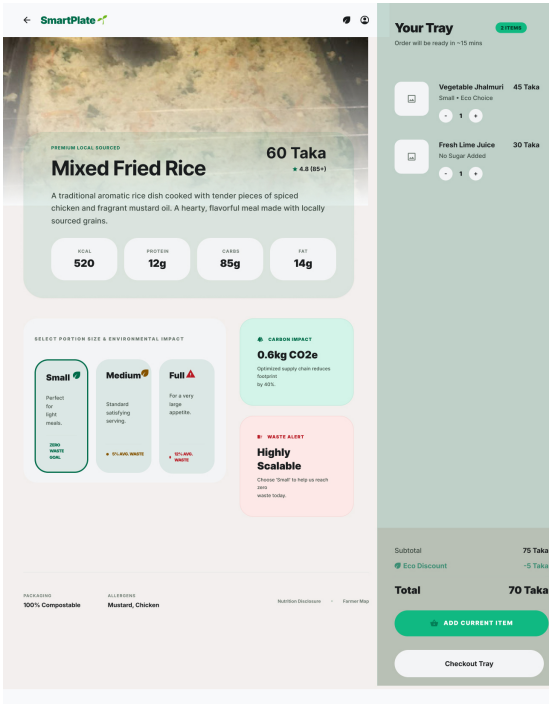

Figure 6.3: SmartPlate — Item Detail: Mixed Fried Rice (representative example)

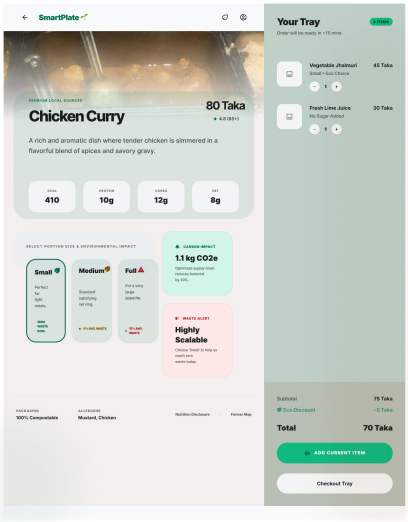

Figure 6.4: SmartPlate — Item Detail: Chicken Curry (highest waste item)

One of the most common dishes ordered in the survey (51.2% like rate) is Mixed Fried Rice which has an average carbon footprint of 0.6 kg CO_2e and a LOW WASTE badge, which makes it a simple environmentally-friendly option. On the contrary, Chicken Curry is the most wasteful product on the menu with 20% historical waste and 1.1 kg CO_2e which elicits the largest Waste Alert card in the system, this was a calculated choice since it was also the most favored dish on the survey at 38.3%.

6.2.4 Sustainability Alert Modal

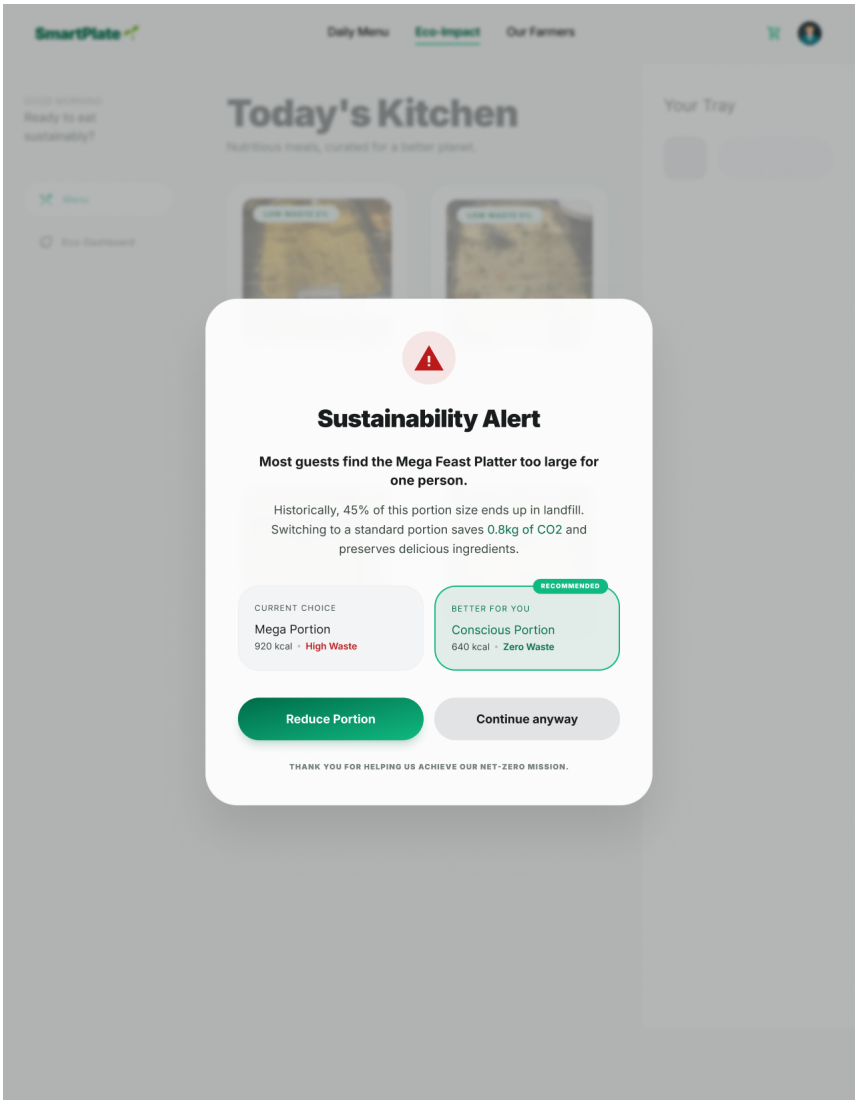

Figure 6.5: SmartPlate — Sustainability Alert Modal

The alert modal will automatically be triggered once a student chooses a high-waste portion and will superimpose the screen to disrupt the automatic System 1 decision-making process and encourage the use of the deliberative System 2 [19]. It integrates three elements of persuasion: a **social proof statement** ("Most guests find the Mega Feast Platter too big to eat on your own"), a **quantified effect** ("45% of this portion goes to landfill; switching saves 0.8 kg CO_2"), and a **side-by-side comparison** of a Mega Portion (920 kcal, High Waste) and a Conscious Portion (640 kcal, Zero Waste). The "Reduce Portion" button acts as the primary component of the whole intervention since this alerts the student and subconsciously influences the student to reduce portion sizes. The "Continue anyway" button continues with the current portion and does not have any impact on the decision-making process. This puts libertarian paternalism [14] into effect: the environment of choice is conducive to the sustainable result, yet not enforced.

6.2.5 Order Confirmation and Pickup Token

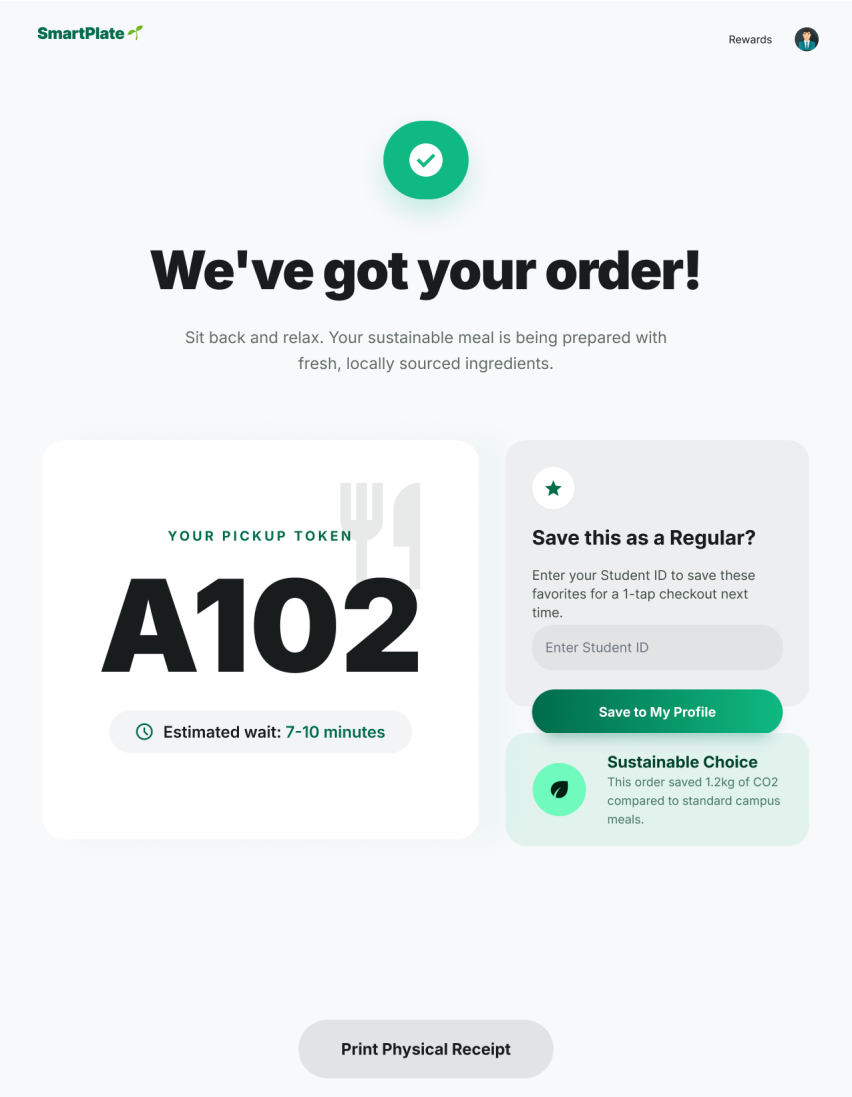

Figure 6.6: SmartPlate — Order Confirmation and Pickup Token

In the confirmation screen, the order confirmation is shown to the students. For instance, the **Pickup Token (A102)** and **Estimated Wait: 7–10 minutes** addresses time anxiety which will lead to more planned decision taking as opposed to making rushed decisions that was proved to lead to more food waste. The **"Save this as a Regular?"** panel requires the students to register their Student ID so that they can reserve their orders. This will lead them to order beforehand and in-turn, they can be billed quickly via one-tap function. This will save time and reduce food waste especially during the rush hours. The **Sustainable Choice** card provides favorable feedback: "This order will save 1.2 kg of CO_2 than the usual campus meals." These statements will subconsciously enable a student to choose items that will emit less CO_2e.

6.3 Sustainability Layer

6.3.1 Sustainability Dashboard

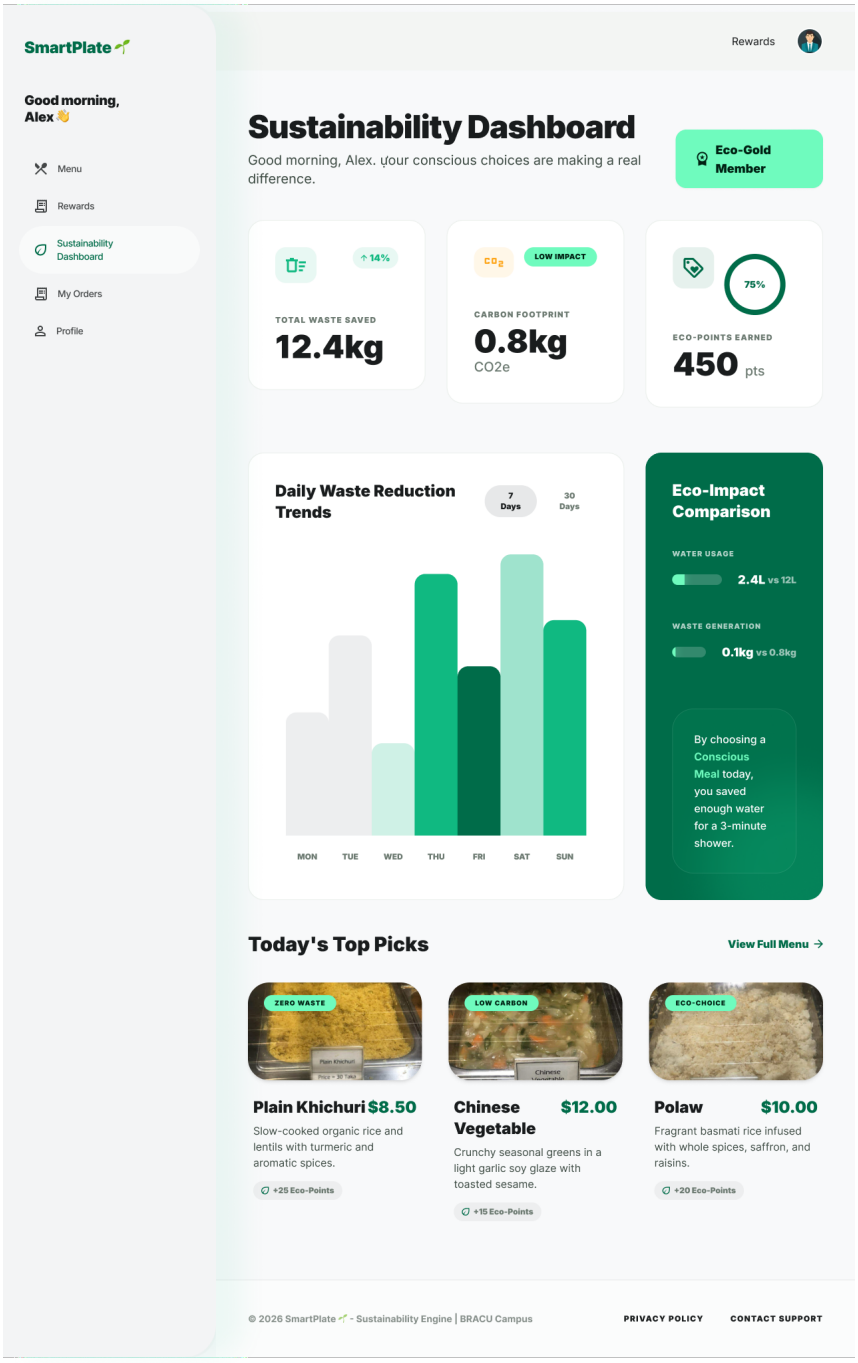

Figure 6.7: SmartPlate — Sustainability Dashboard

The three cards on the top end corner of the page shows the KPIs of carbon footprint, total waste saved and eco-points earned. For instance, each card shows the **Carbon Footprint (0.8 kg CO_2e, LOW IMPACT)**, **Total Waste Saved (12.4 kg)**, and **Eco-Points (450 pts)**. A Daily Waste Reduction Trends chart shows the trends of waste reducing over in both 7-day and 30-day perspectives. This can enable the

students to look at changes in behavior as time goes by seeing the progress [16]. The Today's Top Picks section presents three green choices (Plain Khichuri — ZERO WASTE, Chinese Vegetable — LOW CARBON, Polaw — ECO-CHOICE) and it connects the dashboard to the process of ordering.

6.3.2 Eco Impact Journey

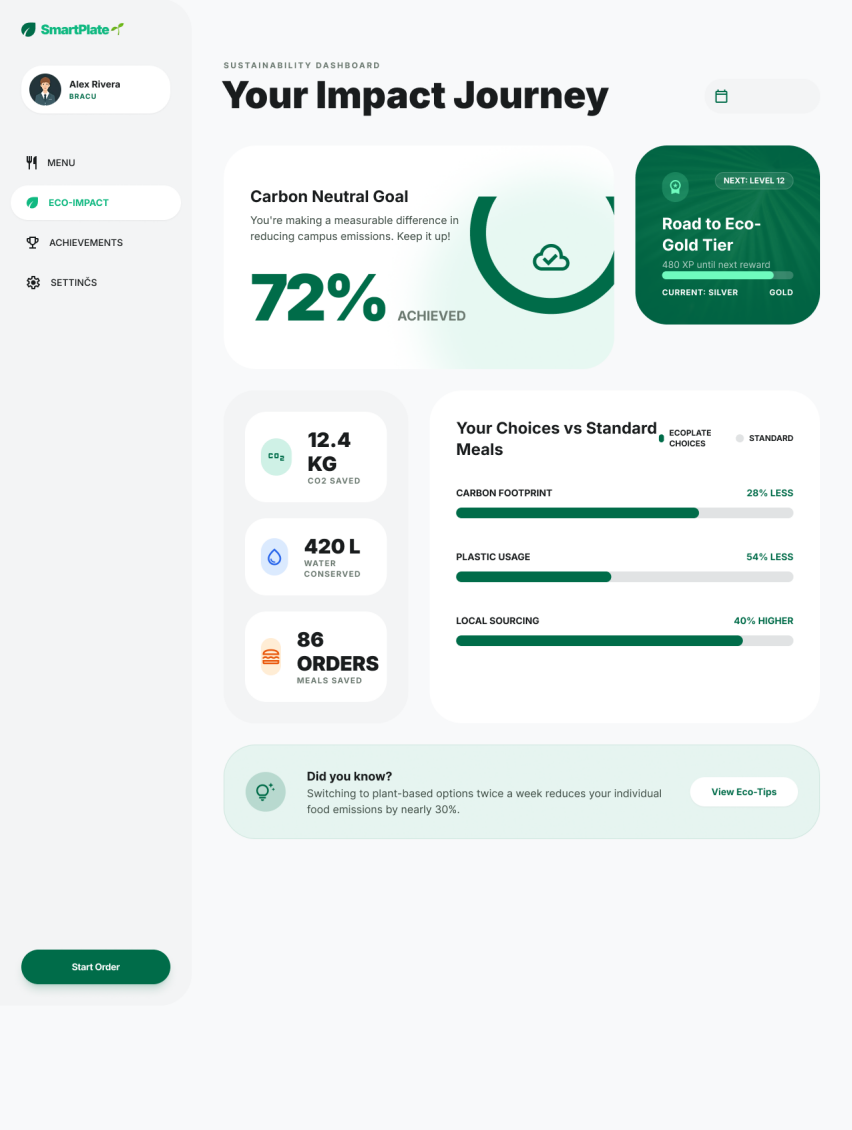

Figure 6.8: SmartPlate — Eco Impact Journey

The Eco Impact Journey screen plays a key role in future proofing the system. It displays a **Your Choices vs Standard Meals** comparison card with three features. For instance, it shows (28% less carbon footprint, 54% less plastic, and 40% higher local sourcing). A **Carbon Neutral Goal** card which is the primary card shows (72% carbon neutral goal achieved, 12.4 kg CO_2 saved, 420 L water conserved, 86 meals saved). This comparative framing activates social comparison [9], positioning the student's behavior favorably against a peer baseline and reinforcing a conscious consumer identity.

6.4 Engagement Layer

6.4.1 Rewards and Points

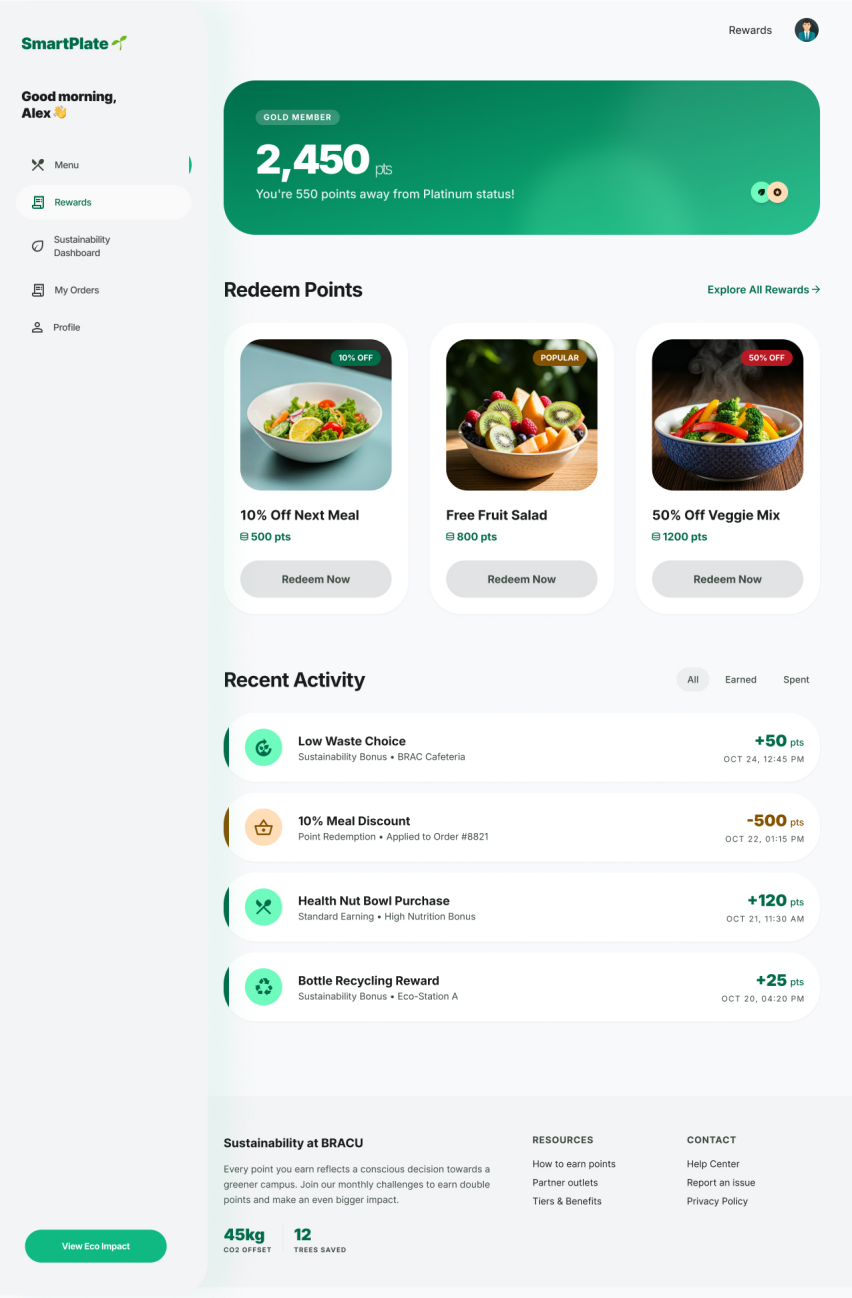

Figure 6.9: SmartPlate — Rewards and Points

The Rewards screen gamifies sustainable ordering behaviour. Here, students are tiered according to the points they received. For instance, a student with (**2,450 pts**) is tiered as a (**GOLD MEMBER**). This status is shown on a green banner with a message: "You are 550 points away from Platinum status!" Reaching a certain threshold can lead to monetary benefits. For example reaching a minimal target with amount to getting three redeemable rewards (10% Off Next Meal at

500 pts, Free Fruit Salad at 800 pts, 50% Off Veggie Mix at 1200 pts) present. The Recent Activity log also comprises time-stamped feedback regarding individual responses coupled with point earning (e.g., "Low Waste Choice +50 pts", "Bottle Recycling Reward +25 pts") making the user feel that even minor personal behaviors can have a significant cumulative effect.

6.4.2 Student Account and Profile

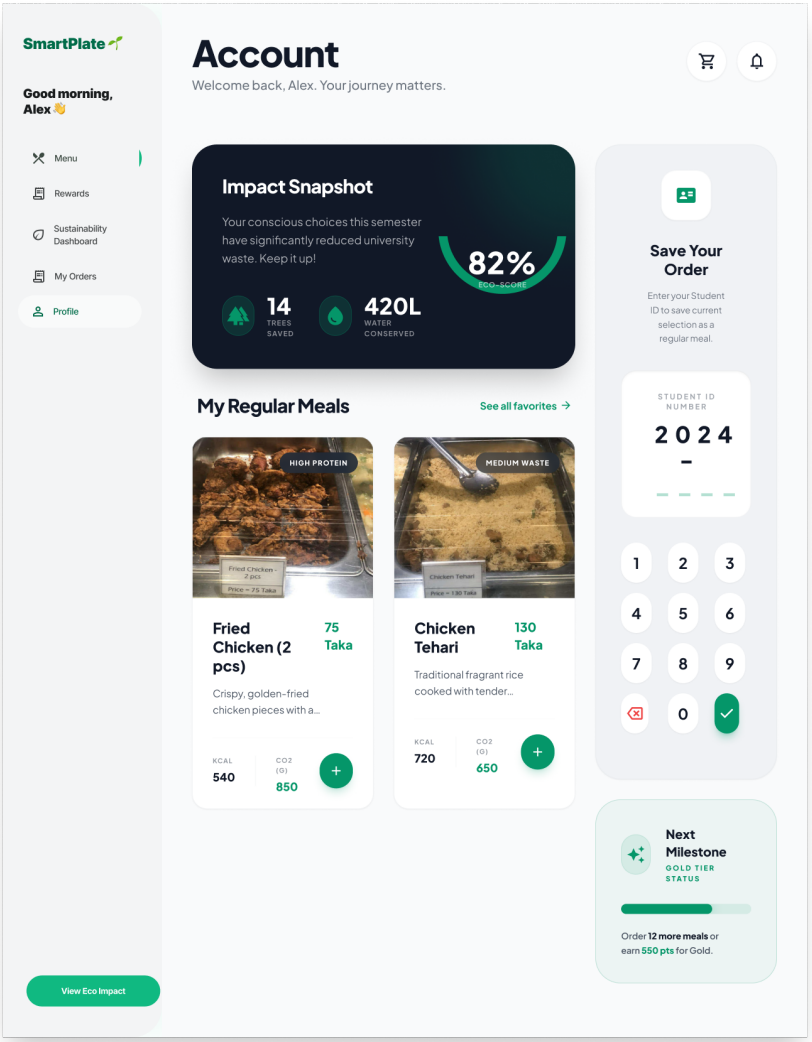

Figure 6.10: SmartPlate — Student Account and Profile

The **Impact Snapshot** card covered with a black ambient interface shows that there is an **82% Eco-Score**, 14 Trees Saved and 420 L Water Conserved. This helps to transform food choices into ecologically-linked emotional food choices [4]. Most ordered meals with their waste badge appear in the **My Regular Meals** section regarding the sustainability of the choices made by regulars. The **Save Your Order** keypad allows registering regular meals by the Student ID, in a manner that supports the idea of green behavior by employing the power of inertia. The **Next Milestone** tracker ("Order 12 more meals or earn 550 pts towards Gold") offers a certain proximal goal, which prompts the goal-gradient motivation.

6.5 Summary of Prototype Design Principles

The prototype of the SmartPlate indicates that the behavioral model created within the framework of this thesis can be put directly into practice into a computer system. One or more evidence-based design mechanisms are embedded in each screen, but arranged in such a way that the information about sustainability can be found. The student free choice is not constrained by the following interfaces where each intervention maintains autonomy and shapes the decision environment to the benefit of low-waste solutions, and all this is consistent with the libertarian paternalism principle [14] that underpins ethical nudge design.

Table 6.2: Mapping of SmartPlate Prototype Screens to HCI and Behavioural Design Principles

Screen	**Key Design Feature**	**Underlying Principle**
Welcome Screen	Sustainability priming; hedonic food image; CO_2 label	Pre-decisional nudge; Hedonic Consumption Theory
Menu Browse	Real dish photos; colour-coded waste badges; CO_2 per dish	Expectation-Reality alignment; loss-framed nudge; Cognitive Load Theory
Item Detail Pages ($\times$7)	Portion selector with waste averages; Carbon Impact and Waste Alert cards; Small pre-selected	Dual Process Theory; choice architecture; Nudge Theory
Sustainability Alert Modal	Social proof; quantified CO_2 impact; side-by-side comparison; dual CTA	Social Norms Theory; choice architecture; Dual Process Theory
Order Confirmation	Pickup token; wait time; Save as Regular; CO_2 saved summary	Anxiety reduction; habit formation; positive reinforcement
Sustainability Dashboard	KPI cards; trend chart; eco top picks	Longitudinal feedback; habit formation; identity reinforcement
Eco Impact Journey	Carbon goal %; comparative impact bars; ecological metrics	Social comparison; concrete impact framing
Rewards and Points	Tier progression; redeemable discounts; activity log	Gamification; Social Norms Theory; goal-gradient motivation
Student Account	Eco-Score; ecological equivalents; regular meals; milestone tracker	Social Identity Theory; inertia nudge; goal-gradient motivation

Chapter 7

Conclusion And Future Work

7.1 Conclusion

Food waste in university cafeterias poses a complex challenge in sustainability metrics globally and this phenomenon is a result of human behaviour and their decision-making process. The primary goal of this research was set to examine whether Human-Computer Interaction (HCI) driven smart menu interfaces could reduce food waste by positively influencing a consumer's food-selection behaviour while ordering food in the cafeteria. This research emphasized interventions at the ordering phase of the process whereas in the previous ones, awareness campaigns and post-consumption tracking was the primary focus.

This research explored this change in consumer behaviour by altering the design and then evaluating three different menu types– Traditional, Info-Lite, and Info-Rich Smart Menus. In these different menus, certain metrics such as having a visual appeal, waste percentage metrics with signs and waste information was used to check how these factors affect the behavioral nudges of users' choices and waste-related intentions. This comprehensive approach used and combined both quantitative data taken from surveys and qualitative insights taken from semi-structured interviews to understand the motivation behind the consumers choices and trends that followed from the data taken.

From the finding, it was observed that there is a mismatch between the expectations vs the reality. Factors such as time pressure between class breaks, portion expectations, lack of trust in food quality and fear of food poisoning from bad food smell are the primary drivers of food waste in university cafeterias. Participants reported a strong preference for the Info-rich menu where the visual cues, waste metrics had a strong positive influence on their perception and decision making. These metrics helped them to get an adequate amount of food in accordance with their time gaps between classes, get better portion sizes and evaluate the food quality according to the pictures and data given in the menu. They also stated that a simple and minimal version of the menu was visually appealing whereas having too much information and waste metrics swayed them away from this design.

This study concludes that menu designs not only act as mere information displays of food items but also as a tool for shaping consumer preference and enacting sustainable consumption practices.

7.2 Future Work

In future iterations of SmartPlate, we plan to incorporate the following sustainability upgrades into our product:

- Implement sensors in the kitchen that can accurately track food waste instead of using estimated values.
- Upgrade the Eco Dashboard by incorporating accurate calculations of CO_2 and water footprints using information on locally sourced ingredients in Bangladesh.
- Make the Carbon Neutral Goal dynamic depending on individual monthly consumption habits.
- Generate impact reports each month displaying the amount of CO_2 emissions, water usage, and food waste reduced visually with graphs and tables.
- Provide supply chain traceability by directly sourcing from local farmers.
- Track other metrics such as plastic usage and energy savings through compostable packaging.

Such upgrades would significantly improve the product's ability to accurately track and inspire its users' impacts on the environment.

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Appendix A

Research Consent Form

Informed Consent Form – Study on Food Waste and Smart Menu Systems at BRAC University

About the Study
You are invited to participate in a research study conducted under the Department of Computer Science and Engineering, BRAC University. The purpose of this study is to explore food waste patterns, behavioral factors influencing meal choices, and perceptions of a smart cafeteria menu system that aims to reduce food waste and promote more informed food selection within BRAC University cafeterias.

Ethical Approval
This research has been reviewed and approved by the Institutional Review Board (IRB) of BRAC University.

Voluntary Participation
Participation is completely voluntary. You may skip any question or withdraw at any time without penalty.

Confidentiality
All responses will remain confidential and will only be used for academic research. No identifying information will appear in any publication.

Estimated Time
The interview will take approximately 15–20 minutes.

Research Contact
Md. Sabbir Ahmed, Lecturer, Department of Computer Science and Engineering, BRAC University
Email: sabbir.ahmed@bracu.ac.bd
For any ethical concerns, you may contact irb@bracu.ac.bd.

* Indicates required question

Full Name *

Your answer

Age *
Your answer

Occupation *
Your answer

Consent to Participate *
- ○ I agree
- ○ I do not agree

Audio Recording Permission *
- ○ Yes
- ○ No

Digital Signature (Type Your Full Name as Consent) *
Your answer

Online Consent Form: Click here

Appendix B

Interview Materials

B.1 Interview Questions

B.1.1 Section 1: Basic Information (Demographics)

1. What is your age?
2. What is your gender?
3. What is your occupation or role in relation to the cafeteria? (e.g., student, cafeteria staff, vendor, cleaner, or administrator)
4. How often are you involved with or visit the cafeteria? (e.g., daily, several times a week, occasionally)

B.1.2 Section 2: Awareness and Current Experience

5. How aware are you of food waste occurring in the cafeteria?
6. From your experience or observation, what are the main reasons food gets wasted here? (→ Addresses Objective 1: understanding existing waste patterns and causes.)

B.1.3 Section 3: Food Choice and Decision Process

7. When choosing food in the cafeteria, what factors influence your decision the most — taste, price, portion size, healthiness, convenience, or something else?
8. Do information such as nutritional details or sustainability indicators affect people's meal choices? Why or why not? (→ Addresses Objective 2: identifies behavioral and contextual factors.)

B.1.4 Section 4: Feedback on Smart Menu Prototypes

9. What is your first impression of these menus? Which seems most practical or appealing to use, and why?

10. What specific features — such as waste data, nutritional info, or visuals — stand out to you?

11. Is there anything unclear or unnecessary in any of the menu designs? (→ Addresses Objectives 3 & 4: explores usability, clarity, and visual appeal.)

B.1.5 Section 5: Perceived Impact and Adoption

12. If the menu showed information like "10 percent of this dish was wasted yesterday," how might that influence food choices?

13. Do you think such a smart menu could help reduce food waste? Why or why not?

14. How likely do you think students, staff, or vendors would be to use or support this menu system if implemented? (→ Addresses Objectives 4 & 5: explores expected behavioral impact and adoption.)

B.1.6 Section 6: Implementation and Suggestions

15. What challenges or barriers might arise if this smart menu system were introduced?

16. What would make it easier or more enjoyable for everyone to use regularly?

17. Do you have any other ideas or features you'd like to see in a cafeteria menu? (→ Addresses Objective 6: focuses on feasibility, ease of adoption, and improvement suggestions.)

B.2 Participant Demographics and Codebook

Table B.1: Demographic Table of Interview Participants

ID	Age	Gender	Usage Frequency	Key Insights
P1	21	F	Daily	Food waste from unmet expectations re: taste, freshness.
P2	20	M	Rarely	Waste from inconsistent quality, social trends (rejecting food is "cool").
P3	27	F	Daily	Waste from over-prep; values health, believes nutrition info helps.
P4	22	M	Few times/week	Aware of waste; pricing and nutrition influence decisions.
P5	20	F	Few times/week	Waste from impulse; prefers nutrition over taste, values portions.
P6	19	F	Weekly	Large portions cause waste; prefers waste data, nutrition info.
P7	22	M	Regular	Food safety concerns; supports transparency, better standards.
P8	21	M	Regular	Frustrated with safety; supports quality control, waste reduction.
P9	23	M	Regular	Hygiene issues; supports transparency, accountability.
P10	32	F	Daily	Waste from inaccurate prep, over-prep; values nutrition info.
P11	20	F	Occasionally	Waste from time constraints; wants clearer menus, nutrition.
P12	22	M	Few times/week	Aware of waste; values nutrition over taste, pricing is barrier.
P13	19	M	Rarely	Portion size, taste issues cause waste; wants waste data.
P14	38	F	Regular	Waste from low turnout; wants clearer info, skeptical.
P15	21	F	Daily	Waste from poor quality, unappetizing portions.
P16	23	M	Regular	Quality, price concerns; better portions reduce waste.
P17	25	M	Few times/week	Excessive portions cause waste; portion control key.
P18	30	F	Daily	Waste during rush hours; needs better prep forecasting.
P19	29	F	Weekly	Waste from unappealing meals, mismatched expectations.
P20	42	M	Rarely	Quality, trust concerns; supports food tracking system.

Table B.2: Thematic Codebook

Subtheme	Code	Operational Definition	Example Quote	Participant
Theme 1: Expectation–Reality Mismatch				
Hygiene & safety concerns	ER-HYGIENE	Concerns about cleanliness or contamination	"The object was clearly not supposed to be present."	P06
Quality dissatisfaction	ER-QUALITY	Food rejected due to taste or presentation	"The portion sizes were too big and the food was unappealing."	P16
Portion mismatch	ER-PORTION	Portion sizes not matching hunger level	"Rice looks small but it's too much."	P13
Food freshness concerns	ER-FRESH	When food quality does not match expectations	"I once took a sandwich but later realized it was not fresh."	P01
Theme 2: Social and Operational Friction				
Fixed serving limitation	PC-FIXED	Lack of ability to adjust portion sizes	"Allowing customers to choose portion sizes could reduce waste."	P02
Overestimation of hunger	PC-HUNGER	Taking more food than necessary due to misjudgment	"Sometimes I feel full after only a few bites."	P03
Theme 3: Decision Timing and Cognitive Pressure				
Pre-decision habit	DM-HABIT	Food choices made before reaching the counter	"I usually decide what to eat before I reach the counter."	P07
Queue & speed priority	DM-SPEED	Choosing quickly due to time pressure	"Students focus on speed rather than reading menu details."	P04
Cognitive overload	DM-OVERLOAD	Difficulty processing too much information quickly	"Too much information at once becomes overwhelming."	P05
Theme 4: Information as Awareness and Control				
Waste awareness trigger	IN-WASTE	Influence of waste-related information on behavior	"Seeing waste statistics made me more conscious."	P06
Nutritional influence	IN-NUTRI	Impact of nutritional labels on choices	"I choose healthier options when I see calorie info."	P03
Visual engagement	IN-VISUAL	Preference for icons, colors, and visuals	"The visuals made it easier to choose food."	P10