Applied Mathematics and Computational Intelligence
Volume 12, No. 3, Oct 2023 [83-90]

Carbon Footprint Calculator for Food Waste to Support Behaviour Change

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Received: 27 Oct 2022
Accepted: 13 Sept 2023

ABSTRACT

Carbon emission is carbon gas that is released every time food is produced. Food waste is food that completes the food supply chain until the final product and suitable for human consumption but discarded regardless of whether it is rotten or expired. Wasting food means that greenhouse gas emissions that is released during food production are being wasted. Bakery is the biggest contributor in the food industry that contributes to food waste. Therefore, this project developed a carbon footprint calculator for bakery to effectively monitor carbon released from food waste. User interface design for the web application using persuasive techniques which are reduction, suggestion, conditioning, self-monitoring, and surveillance. The effectiveness of the system is decided by evaluation that consists of monitoring their carbon footprint and behaviour change that is conducted to three bakery owners for three weeks. Two phases of testing were conducted that involved pre-evaluation and post-evaluation. As a conclusion, web-based carbon footprint calculators with persuasive technology techniques manage to motivate bakery owners to change their behaviour in reducing food waste.

Keywords: Carbon footprint, carbon emission, food waste, bakery, persuasive techniques

1 INTRODUCTION

Malaysia discards 4,005 tonnes of food waste daily, or 24% of which is edible. Food waste is one of the largest contributors to global greenhouse gas emissions, accounting for 11% of total greenhouse (GHG) emissions. The terms “food waste” or “wasted food” is a food that completes the food supply chain until the final product is of good quality and suitable for human consumption, but it is not eaten because it is discarded regardless of whether it is rotten or expired [1].

Food production, including the bakery sector, contributes to the greenhouse effect throughout the food supply chain, and food waste indicates that such emissions are wasted. The total amount of greenhouse gases including carbon dioxide and methane produced by food waste, is called the carbon footprint. According to [2], carbon footprint calculator is important to calculate the number of carbon emissions emitted. However, there is lack of up-to-date research and systems on the carbon footprint of food waste in the bakery sector, even though bakeries are one of the major contributors to food waste [4]. The bakery industry can start making a big difference by making small changes to their actions, such as reducing food waste by limiting the number of ingredients, especially the ones with

high carbon. Carbon footprint acts as a medium and plays a significant role in raising awareness and motivating people in reducing activities that can lead to the release of carbon [5]. The Carbon Footprint Calculator allows users to effectively monitor carbon waste by taking steps to avoid food waste based on suggestions given by this application. To use this web-based carbon footprint calculator, users need to input data and information such as the weight of food wasted (kg) and the food waste emission factor (kgCO2e).

This project uses persuasive technology [5], and interactive information technology designed to motivate changes in user's attitudes or behaviour in the field of human-computer interaction. Techniques are developed according to persuasive design principles. Five techniques that are being applied in this project are reduction, suggestion, self-monitoring, conditioning, and surveillance. In this project, technology refers to the use of computers involving websites or web-based and technical social persuasive psychology in the art of persuasion (changes in behaviour and attitudes in various areas of human endeavor. All these applications are considered persuasive technologies, potentially influencing consumer attitudes and behaviors through persuasion or social influence [6].

2 LITERATURE

2.1 Bakery Waste

As bakery is one of the world's major food industries, the industry is highly to be one of the biggest contributors to food waste [7]. These foods are often wasted as baked goods are ultra-fresh products with a typical shelf life of one day, and the properties of the associated products are uniform. Bread and pastries are one of the retailers' most frequently discarded foods. Without considering households, retail is the supply chain stage in which the most bakery food waste is generated [7],[8].

2.2 Persuasive Technology

Persuasive technology is interactive information technology designed for changing user's attitudes or behavior in human-computer interaction [9]. Techniques developed according to compelling design principles. Such technologies are regularly used in distribution, diplomacy, politics, religion, military training, public health, and government, and may be used in all human-human or human-computer interaction areas. Most self- proclaimed research on compelling technologies focuses on interactive computing technologies such as desktop computers, internet services, video games, and mobile devices, which include experimental psychology, rhetoric, and human-computer interaction. The design of a compelling technique can be seen as a special case of intentional design [10][11][12].

2.3 Persuasive Techniques

There are five techniques that are applied in this project which are reduction, suggestion, self-monitoring, conditioning, and surveillance [13]. Firstly, reduction technologies that make a complex task simpler, usually by eliminating some of the steps of a sequence required to achieve a certain goal. Next is by giving suggestions on how to improve. Thirdly, self-monitoring technologies allow people to monitor themselves to modify their attitudes or behaviours to achieve a pre-determined goal or outcome. Fourth, conditioning technologies that make use of operant conditioning, often in the form of positive reinforcement, to reinforce target behaviours when they occur. Lastly surveillance refers to the collection of data on behavior and performance outcomes.

2.4 Bahaviour Change

Behavioural change can be temporary or permanent effects that are considered changes in a person's behaviour compared to previous behaviour [14]. This change is generally characterized by changes in thoughts, interpretations, emotions, or relationships. These changes may be good or bad, depending on the behaviour involved. Behavioural changes are very beneficial to humans. Two such theories on this subject are behaviour modification theory and cognitive behavioural theory. Both are aimed at helping users engage in positive behavioural changes. According to Frothingham, it takes 18 to 254 days for a person to adopt a new habit [14]. Therefore, this study took three weeks, which is about 21 days to monitor bakery waste behaviour change.

3 METHODS

This web application concentrates on creating a carbon calculator using persuasive techniques such as reduction, suggestion, self-monitoring, conditioning, and surveillance in the design of the user interface. The formula [15] for the carbon footprint calculator for food waste is total waste (kg) multiplied by total waste multiplied by carbon emissions for each type of food (Table 1). To support behaviour change effectiveness, three bakeries (Remaja Purba Café and Bakery (Bakery1), Cakes by KakSyam (Bakery2), and Akmam Bakes Cakes (Bakery3)) in Ipoh, Perak, Malaysia were involved during the evaluation process that took three weeks to monitor the changes in their behaviour. Their carbon footprint is recorded throughout the assessment process.

Table 1: Carbon Footprint for Food

Variable	Carbon Footprint Formula	Notes
Carbon Footprintfor Daily Food Waste	[Carbon Emissions(CO_2eq) x Consumption (kg)] =kgCO_2e-	1 kg of food releases around 1.9 kg CO_2-eq(Source: Watch My Waste)

4 RESULTS AND DISCUSSION

In this paper, researchers discussed behaviour change progress that involved three bakeries around Ipoh, Perak (Figure 1). During evaluation phase, all bakeries enter data on their food waste for three weeks that were tested in the pre and post evaluation questionnaire. The evaluation questionnaire comprises of bakery details and the bakery's understanding of carbon emission, carbon footprint, and the food waste to environment. In the third week, bakeries are required to fill out their behavioural change. This can be temporary or permanent changes in a person's behaviour when compared to previous behaviour. Changes in thoughts, interpretations, emotions, or relationships are typical of this change. Depending on the behaviour, these changes may be positive or negative. Results show that all bakery carbon footprint changes every week (Table 2, Table3 and Table4). It is caused by the festival factor and the new year celebration that took place when this study was conducted. Food waste data is obtained from the bakery owner. The data collection process is carried out one day a week.

Figure 1: Evaluation session conducted for three bakeries

4.1 Pre-Questionnaire

Pre evaluation is a stage in the development of a questionnaire that determines the questionnaire's potential effectiveness. Before distributing the questionnaire to the target population, a pre-test was conducted [16]. Respondents are required to fill in a questionnaire that consists of the primary objective to learn as much as possible about the subject's prior knowledge and experience before the test begins. The subject's history will have a significant impact on their behaviours and perspectives as they engage with system. During pre-evaluation, all respondents agreed that they know about carbon emissions. Their response to carbon emissions is the use of carbon in industry, which can contribute to heat pollution, and carbon emission is carbon that has been released from waste. They are also aware that when people reduce carbon emissions, it helps to ensure cleaner air, water, and food for our generation and for generations to come. All the respondents agree that they are aware of carbon footprints. Their response to the carbon footprint is the reduction of carbon waste that includes carbon footprint refers to waste carbon emissions. Finally, the carbon footprint is one of the ways to measure the effects of human-induced global climate change where users also agree with the statement that it is critical to reduce food waste in situations of what they are doing to protect the environment and reduce waste.

Table 2: Carbon Footprint for Bakery1

Week	Total of Carbon Footprint (kgCO2eq)	Reasons of Increase/Decrease of Food Waste (Behavior Change)
Week 1	689.78	Bakery1 has a lot of waste due to many demands of cakes and pastries every day.
Week 2	878.75	The wastage of second week is quite high compared to the first week due to wastage when celebrating the new year.
Week 3	427.42	Third week wastage is low compared to first week and second week as bakeries reduce the quantity of cake production.

Table 3: Carbon Footprint for Bakery2

Week	Total ofCarbon Footprint (kgCO2eq)	Factor of Increase/Decrease of Food Waste (Behavior Change)
Week 1	48.01	Bakery2 using marketing strategy by giving promotional price of buy one free one of their products to avoid waste.
Week 2	48.01	Bakery2 maintains amarketing strategy to ensure food waste remains or reduced.
Week 3	18.74	Many cake orders because of many weddings. Food waste successfully reduced.

Table 4: Carbon Footprint for Bakery3

Week	Total ofCarbon Footprint (kgCO2eq)	Factor of Increase/Decrease of Food Waste (Behavior Change)
Week 1	65.70	Waste is caused by the fruits that are used as decorations on the cake.Fruits have a short shelf life. Therefore, the fruits had to be thrown away.
Week 2	63.90	A small amount of waste is reduced. Encouraged response as a result of numerous events and weddings.
Week 3	63.90	Waste remains low, as it was in second week.

4.2 Post-Questionnaire

On the third week, respondents were given post-questionnaire to fill out. The purpose is to collect data that explains why users make certain choices while navigating the tasks that have been assigned to them. It is indeed possible that the test is very interactive, in which the user was required to share their thoughts during the process as they finish each step. On the other hand, it could be completely silent, with users working on their own and responding to questions following each individual task or section.

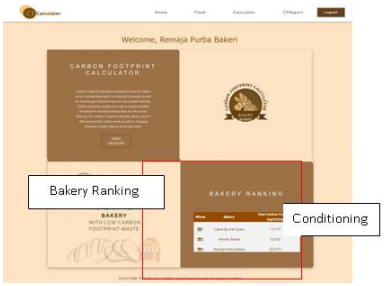

Figure 1: Conditioning Persuasive Technique

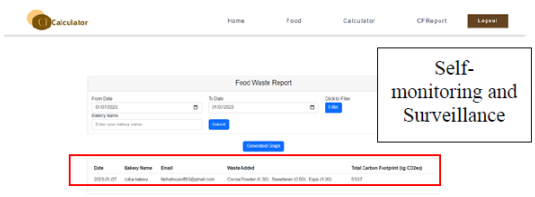

Figure 2: Self-monitoring and Surveillance Persuasive Technique

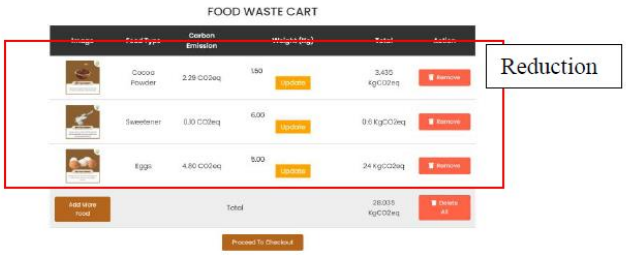

Figure 3: Reduction Persuasive Technique

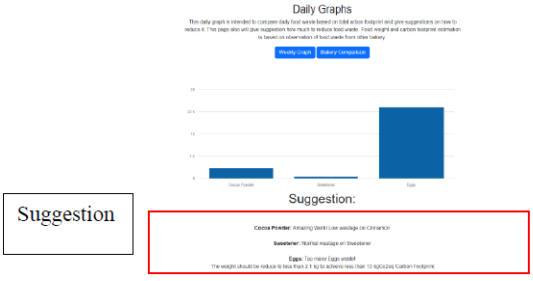

Figure 4: Suggestion Persuasive Technique

Next section of the questionnaire focused on behaviour change. The first element in persuasive technique is conditioning which is applied on the main page as displayed in bakery ranking (Figure1). This application has bakery ranking to make sure each bakery update food waste every day. This is because with position that they obtained by looking into others progress to the extent that they are motivated to contribute less carbon emission to the environment. In addition, they also feel motivated to compete with other bakeries after seeing the rankings display their total carbon footprint. This is supported by bakery ranking features that can encourage bakeries to contribute to the environment as well as raise the spirit of competition between bakeries to reduce food waste.

While in self-monitoring technique (Figure 2), is useful incorporated in the carbon footprint report page, where it can monitor bakery food waste details based on filtered date. They can view the amount of carbon footprint from previous days and weeks. The results of their carbon footprint that is shown in a form of graph conveys important data more vividly and encourages them to set the goal for next outcome. Besides with the displayed result also they can make comparison among them by monitoring their food waste and can motivate user to reduce waste from time to time. Surveillance alternatively refers to the collection of data on behaviour and performance outcomes. Web-based carbon footprint calculator serves to keep a record of updated carbon footprint of bakery food waste daily and weekly. With the updated details information is easier for the bakery to monitor the amount of food waste so that they are aware of the carbon emissions released.

Consequently, persuasive technique is reduction (Figure 3). This applies to the food and calculation pages. Reduction aims to make calculation of the carbon footprint of food waste much easier. To use the carbon footprint calculator, user can simply add raw materials for food and update the weight on the calculation page. A Food Waste Report is generated every time a user calculates carbon footprint [17]. This food waste report is equipped with a date filter to improve user experience. With the date filter, bakeries can monitor their food on a daily, weekly, or monthly basis.

Lastly, are suggestions and tips (Figure 4). It aims to give suggestions on how much to reduce food waste weight. It is applied in the daily graph page on the suggestion section. Bakeries agreed that the weight of each ingredient for food is fixed in the web application. Hence, they suggested that at the same time, reducing the weight of certain food is quite difficult. Overall, bakeries agreed that the development of the web application is a good platform, efficient and provides many advantages especially to new users or public generally who are not aware of carbon emission. On top of that, in the Tips tab, users are given suggestions on reducing daily food waste. Hence, based on the graph, bakeries can compare the carbon emissions resulting from which food waste and take the initiative to reduce materials with a high carbon footprint.

5 CONCLUSION

Web-based carbon footprint calculators with persuasive technology techniques aim to motivate bakery owners to change the behaviour in reducing food waste. The application also is significant reducing operating costs and increasing profits by reducing the amount of unsold and perishable foods and increasing the production of high-demand, durable food. By measuring food weight, bakeries can determine the amount of carbon footprint generated by non-preferred foods. Moreover, this project also supports in increasing awareness of preserving the environment. The carbon footprint calculator for food waste opens opportunities to advocate for the long-term protection and

conservation of the environment, thereby improving the lives of all living things, including humans. By analysing the carbon dioxide emissions of waste, bakeries owners can develop strategies to ensure the earth's sustainability whereby carbon emissions contribute risks to climate change.

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