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A Simulation Approach for Waste Reduction in the Bread Supply Chain

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Abstract: *Background*: Bread, a basic need for the survival of human beings, is highly perishable, has a short shelf-life, and loses its quality and potency after its date of expiry. This leads to a considerable amount of bread waste and loss in the economy. This study explores and analyses the most common causes of wastage in the bread supply chain and proposes key strategies for waste mitigation in bread-producing industries in the context of Indian bakeries. *Methods*: Based on a systematic literature review and pilot studies, Monte-Carlo simulation techniques were applied to conduct the analysis. *Results*: The results indicate that bread should be recalled from the market after three days rather than the usual six, and the strategy used by companies A and E (in this study) is recommended. *Conclusions*: These tactics ensure that any bread returned to the company is in great condition, giving us two to three days to transform the bread into some by-products. It will help managers, decision makers, and specialists create a successful waste-reduction strategy.

Keywords: wastages; mitigation strategies; simulation approach; bread supply chain; food industry

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1. Introduction

The increase in food waste in our technologically sophisticated age is receiving attention from both social and natural standpoints. Food wastage is a key problem in supply chain inefficiencies [1,2]. According to FAO estimations, the global volume of food wastage is 1.6 gigatons of "primary product equivalents", while the total wastage for the edible part of foods is 1.3 gigatons [3,4]. Food shortages affect the assets used in the supply chain [5]. The United Nations estimates that approx. 33% of food is wasted or thrown away, which can feed nearly 800 million people [5,6]. About 40% of food in India is consistently wasted because of unproductive inventory systems and structures [7]. Due to increasing food demand and daily food waste, issues related to food scarcity, inflation, the scarcity of fossil fuels, and natural resources are also increasing. Bread, a large part of global food waste, is an essential part of our daily diet, and bakery wastage is nearly 7–10% of total production [8]. The complexity of this issue connects it to the three pillars of favorable outcomes: financial, social, and environmental [9,10], involving production and post-harvest handling and storage losses. Therefore, a comprehensive waste mitigation strategy is required to address the bread waste problem while also considering selling bread across the whole supply chain. Furthermore, the previous methodologies for reducing bread waste and their findings are mentioned in the literature review. The aim of this research is achieved by answering three specific research questions (RQs):

- *RQ1*—What are the sources of bread waste?
- *RQ2*—What effective strategies can mitigate bread waste?
- *RQ3*—To propose a mitigation strategy to minimize bread wastage throughout the bread supply chain.

This research aims to contribute to the normative literature by developing a research approach to answering these RQs. A search was conducted in Jalandhar city from September 2021 to December 2021 to identify major bread waste-related research articles [11]. Among the articles collected, the bread waste rate was analyzed, along with locations in the bread supply chain that had been shared in previous years, and waste reduction techniques were proposed. The subject's connection to our present discussion about optimal bread waste and strategies was the foundation for evaluating a particular writing source. Because articles reflect multiple factors (for example, waste from diverse sources, bread waste rate, which waste records are supplied, complicated waste reduction techniques, etc.), the author used systematic meditation to establish the valid portion of the debate. The systematic literature review carried out in this paper followed three phases:

- Phase I—Planning for the bread loss percentage and source.
- Phase II—Concerning the texture of the bread.
- Phase III—Discussing the bread waste mitigation strategies.

1.1. Phase I

This phase pertains to addressing RQ1, i.e., identifying the sources of bread waste, including where it originates from and how much is generated. The various stages of the supply chain exist in Table 1.

Table 1. Bread waste type and its source.

S. No	Source	Bread Waste Type
1	Consumers	• Not used bread • Expired bread
2	Retailers	• Not sold bread
3	Distributors	• Return from retailers
4	Agency Holders	• Return from distributors
5	Manufacturers	• Bread scrape (from manufacturing processing) • Return from agency holders

In continuation of RQ1, Table 2 shows the bread loss from different waste sources, together with information on the accounts from which the bread waste is produced. Figure 1 graphically displays the wastage figures from Table 2.

Table 2. Information on bread wastage.

Country	Source of Waste	Bread Waste %	Waste on the Account of	Reference
Sweden	Bakery	5.2%	Total production	[12]
Switzerland	Bakery	5.1%	Total production	[13]
Sweden	Retail Bake-off	8.5%	Total mass delivered	[12]
Sweden	Retail Bake-off	27%	Total waste mass	[14]
Sweden	In-store	3%	Total waste mass	[14]
Austria	In-store	2.8%	Sales in cost price	[15]
Sweden	TBA	8.8%	Total mass delivered	[12]
Sweden	TBA	5–14%	Mass supplied	[10]
Sweden	TBA	30%	Supplied bread loaves	[16]
Austria	TBA	12.5%	Sales in cost price	[15]
Unknown	Not specified	0.5–8%	Sale value	[17]
Italy	Not specified	30.6%	Total waste mass	[18]
Sweden	Restaurants	16%	Avoidable waste	[12]
Sweden	Schools	10%	Avoidable waste	[12]
Italy	Schools	12%	Total waste mass	[19]
Finland	Schools	3%	Plate leftovers	[20]
Sweden	Households	13%	Avoidable waste mass	[12]
Norway	Households	27%	Edible food waste mass	[21]

Figure 1. Bread loss (percentage) from Table 2.

The above chart (Figure 1) clearly shows that the highest waste is in the retail bake-off and TBA, as well as in households and unspecified sources. For this study, only retail bake-off and TBA are focused on due to the infeasibility of tracking households and unspecified sources.

1.2. Phase II

This phase is concerned with the quality and texture of the bread. Authors [8] compared the physical properties of bread crumb extrudates with wheat flour extrudates produced under the same extrusion conditions and found that the extrudates of the bread crumbs had a higher radial expansion index, lower bulk density, and better textural characteristics. Ref. [22] evaluated the physical and chemical changes during the delayed consumption of croissants and doughnuts at three different storage times (days 0, 1, and 2). The result of the comparison was that a doughnut had a higher hardness of 175.63% (from day 0 to day 2) than that of croissants, and croissants were slightly higher in carbohydrate (52.42 $\pm$ 0.29%) than doughnuts. Doughnuts contained more protein (9.78 $\pm$ 0.28%) and fat (17.64 $\pm$ 0.65%) than croissants. Croissants showed more moisture (26.29 $\pm$ 0.33%) and ash (1.49 $\pm$ 0.01%) than doughnuts.

In [23], the physical, texture, color, and sensory aspects of wheat flour, as well as its interaction with amaranth flour (AF), were investigated at three different levels (5, 10, and 15%) for making bread. To compare the means of characteristics such as moisture, protein ash, fat, and crude fiber content, a one-way analysis of variance (ANOVA) and Duncan's multiple range test were used. The results showed that AF application enhanced the moisture (31.06–33.24%), ash (0.92–1.51%), protein (12.17–13.11%), fat (2.16–2.77%), and crude fiber content (1.11–1.72%) of the bread. AF also increased toughness, chewiness, gumminess, juiciness, and compactness. Ref. [24] further investigated the effect of heat and drought on bread wheat's successional growth and productivity. Wheat genotypes were examined over two years in four conditions, i.e., control, heat, drought, and combined heat and drought. The yield loss assessment throughout the control studies revealed that combined stress produced the most significant loss (55.96%) followed by drought (41.11%) and heat alone (4.77%).

1.3. Phase III

This phase addresses RQ2, where various waste mitigation policies/strategies have been defined that reduce the waste of bread and bread products. Authors [12] used a two-sample t-test to investigate bread loss proportions at the supplier–retailer interface and discovered that TBA contributed 39% of the total share of waste; production, 30%; bake-off goods, 24%, and not subjected to TBA, 7%. This demonstrates that TBA should not be used.

A case study model was developed by [25] of surplus food creation and management (named the availability surplus recoverability waste model) to analyze and measure food surpluses at the industry and country levels. Furthermore, the variable "degree of recoverability" (a lens for better analyzing surplus food management and food waste) indicates mitigating the loss at every level of the bread supply chain. Different technologies for treating and valorizing the surplus bread through life cycle assessment resulted in source reduction; donation; and the production of ethanol, beer, and feed favored over anaerobic digestion and incineration because it is not an optimum option for environmental impacts [5].

Packaging can play a critical role in reducing food loss and waste, and it is part of businesses' new reporting circular economies and sustainability agendas [26]. Ref. [27] said that developed countries have reduced food loss and waste by raising the awareness of staff; increasing the sensitization of consumers; promoting collaboration among stakeholders; and by educating, training, and increasing collaboration between farmers and small-scale suppliers in low-development countries. Ref. [4] estimated the scale of food losses in the bread and confectionery industry, determined the causes of losses, and identified ways to reduce them to prevent food losses, resulting in 2.39% (in 2017) and 2.63% (in 2018) of manufactured products. The highest loss level was for the production section at 1.56% (2017) and 1.85% (2018), and this needs to be reduced by raising awareness and developing guidelines for individual enterprises [4].

A survey was conducted to determine the quantity of avoidable household food waste and mitigation strategies. Monte Carlo simulations were performed to quantify the final uncertainty resulting in a proportion of avoidable household food waste of 56%. Household food waste generation can be reduced by following the 3Rs (reduce, reuse, recycle) and improvements in consumer behaviors, consciousness, and attitudes [28]. There are daily losses indicated at 9.7–14.4% of production volume, including 10.4–13.4% of bread losses and 6.8–24.4% of fresh pastry losses, that decreased with careful packing, being alert to mistakes, planning equipment, utilizing clean dough, conducting routine inspections, etc. [29]. In [30], the author said that the SI model (Food Banks model) reduces operational costs and allows us to work with stakeholders who can tackle food waste. According to [31], investigating surplus food prevention was the best scenario, followed by any management, including redistribution and use-as-feed. The authors [32,33] presented how disruptive technologies help revamping the food supply chain operations.

These studies have produced a way of illustrating numerous bread waste reduction strategies. The authors demonstrate via these approaches how wastes and losses from a particular system might be identified and minimized across the various supply chain phases to extract their greatest value. By using waste-utilization strategies that are advantageous to the environment and the economy in this research, the author has taken a step toward sustainable practices. Some gaps remain in the literature review presented in this study, including approaches:

- To tackle the bread returned from the retailer and TBA (take back agreement) problem.
- To maintaining the quality of returned bread waste for making some by-products.
- To achieving a negligible amount of bread wastage from the bakery.
- To creating a hygienic and secure environment for society.

Therefore, this study explores and analyses the most favorable causes of bread wastage in the form of RQ1, RQ2, and RQ3 and the key sources of waste generation, as well as offering mitigation strategies in the Indian bakery industry.

2. Methods and Analysis

After a comprehensive literature assessment of bread waste and its mitigation strategies, an attempt was made to tackle the bread wastage problem. For that purpose, data were collected daily from the retailers regarding the breads placed on shelves and the number sold. Then after analyzing the data, probabilities of selling bread on days 1, 2, 3, 4, 5, and 6 were calculated (Appendix A). Then, using random numbers and these probabilities of selling, it was decided to apply Monte Carlo simulation to simulate the bread sold and the wastage resulting after the end of its useful life. However, strategies and their impacts (in Table 3) on waste percentage from companies A, B, C, D, and E supported the research gaps and reinforced the findings of this study. Here, the authors identified and analyzed the strategies bread companies chose for reducing waste in their supply chains and understanding the impact on sales. The additional strategies refer to tactics used beyond the companies' existing plans.

Table 3. Waste concerning the additional strategies.

Company	Additional Strategies	Impact on Sell	Wastage
Company-A	Giving agency holder (AH) a task to carry very little return by offering an extra discount of 4–5% on the bill. Similarly, AH gives 2–3% to distributors and 1–2% to retailers on the bill.	Wastage percentage is minimized, and less space is required to return inventory to the manufacturer.	4–6%
Company-B	Giving material to AH according to his demand, the company is ready to take back all returns (if produced). The company produces various types of bread.	Wastage percentage is higher, and more space is required to return inventory to the manufacturer. Due to various types, customers are more attracted to this company.	10–12%
Company-C	The company is ready to take back all returns (if produced), and companies do not need AH, dealing directly with distributors. Producing small packets of bread at a low price for low-budget customers.	Wastage percentage is more, and there is no AH, so the company's time for selling is increased. Due to small packs of bread, wastage is less, and sales are good.	8–10%
Company-D	The company is targeting small towns and villages to sell bread because they assume that people there are not too quality-conscious.	This creates less wastage.	4–5%
Company-E	The company is also targeting small towns and villages to sell bread because they assume that people there are not too quality-conscious. Producing small packs of bread at a low price for low-budget customers.	This creates less wastage, and sales are good due to small bread packets.	3–4%

Data Collection and Simulation Procedure

The authors conducted an offline market survey in Jalandhar city to determine bread loss by interviewing randomly selected bread retailers from various companies asking the following questions:

- How much is the demand per day for a retailer?
- How many losses per day are from the retailer's end?
- Which strategy do retailers follow to minimize waste?
- What is done with bread waste by the bakery?
- Which strategy does the bakery follow to minimize waste?

As we know, Table 1 shows the many types and sources of bread waste, whereas Table 2 details information regarding bread waste and points us in the direction of critical areas for intervention. Consequently, the authors collected data and used simulations to determine our findings. The data collection was designed to offer further knowledge on the researched phenomena and suggest ways of reducing bread losses. It concerns data from retailers and companies A, B, C, D, and E (in Table 3). It aims to collect retailer sales data per day per cycle and find the probabilities of selling bread on day 1 (D1) and day 2 (D2) ... and day 6 (D6) in every cycle (in Appendix A). Retailers always need some inventory stock on hand to propagate the supply chain. Figure 2 demonstrates the simulation procedure used in this paper.

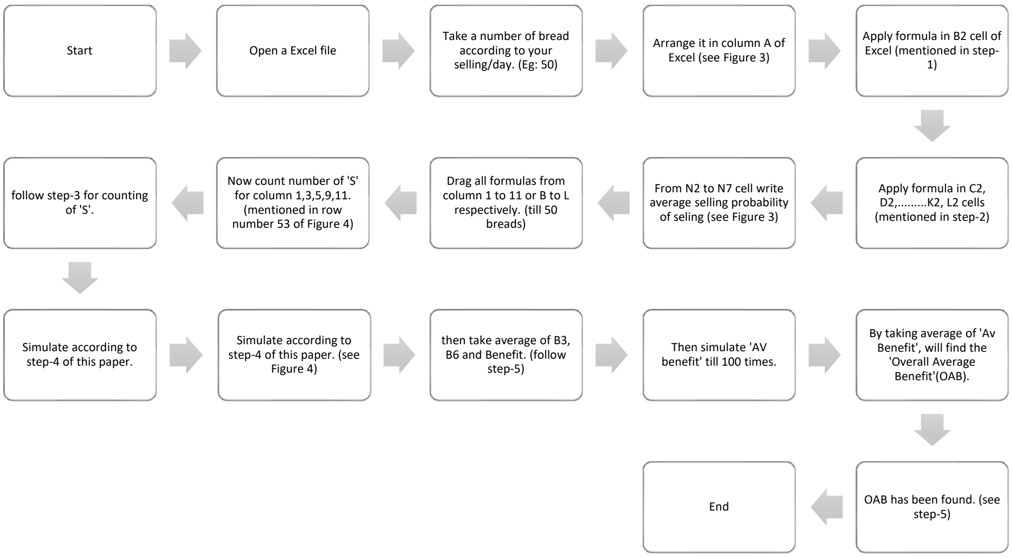
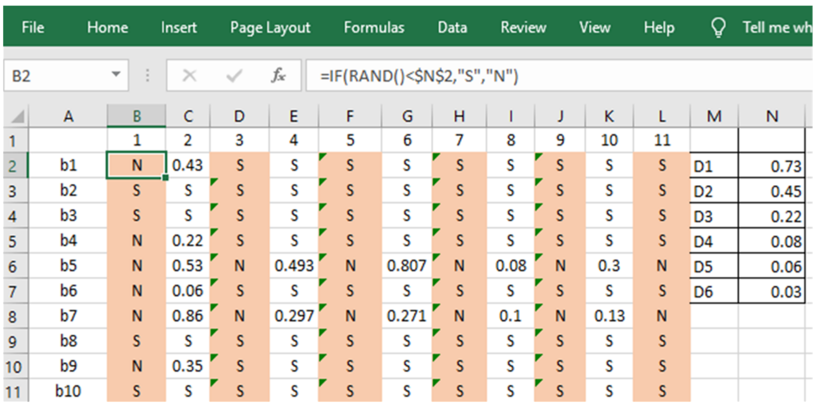


Figure 2. Flowchart of simulation procedure used in this study.

Step-1 In an Excel sheet, for example, 50 bread packets (b1, b2, b3, . . . , b50) are taken because the lot size that retailers prefer varies from 30 to 70 bread packets generally (someone can take any possible number of breads according to his per day selling, but he has to apply further steps). With the help of the average selling probability of bread selling per day per cycle (Appendix A), we apply some formulas as column B of the Excel sheet, [=IF(RAND()<N2,"S","N")], shown in Figure 3 (displays only ten pieces of bread) where S represents that the bread has sold and N denotes that the bread has not sold. Column N in the Excel sheet represents the average selling probability of bread per day per cycle (Appendix A).

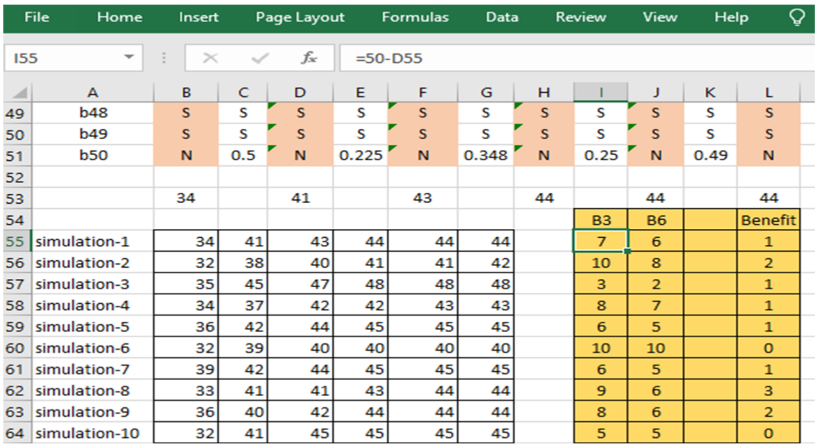


	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1		1	2	3	4	5	6	7	8	9	10	11		
2	b1	N	0.43	S	S	S	S	S	S	S	S	S	D1	0.73
3	b2	S	S	S	S	S	S	S	S	S	S	S	D2	0.45
4	b3	S	S	S	S	S	S	S	S	S	S	S	D3	0.22
5	b4	N	0.22	S	S	S	S	S	S	S	S	S	D4	0.08
6	b5	N	0.53	N	0.493	N	0.807	N	0.08	N	0.3	N	D5	0.06
7	b6	N	0.06	S	S	S	S	S	S	S	S	S	D6	0.03
8	b7	N	0.86	N	0.297	N	0.271	N	0.1	N	0.13	N		
9	b8	S	S	S	S	S	S	S	S	S	S	S		
10	b9	N	0.35	S	S	S	S	S	S	S	S	S		
11	b10	S	S	S	S	S	S	S	S	S	S	S		

Figure 3. Formula used in column B of Excel sheet.

Step-2 There are various formulas used for the next columns: [=IF(B2="S","S",RAND())], [=IF(C2="S","S",IF(C2<N3,"S","N"))], [=IF(D2="S","S",RAND())], [=IF(E2="S","S", IF(E2<N4,"S","N"))], [=IF(F2="S","S",RAND())], [=IF(G2="S","S",IF(G2<N5,"S","N"))], [=IF(H2="S","S",RAND())], [=IF(I2="S","S",IF(I2<N6,"S","N"))], [=IF(J2="S","S",RAND())], [=IF(K2="S","S",IF(K2<N7,"S","N"))], used in column C, D, E, F, G, H, I, J, K, L (Figure 3) respectively.

Step-3 Now count the number of S from column 1 or column B, using the formula [=COUNTIF(B2:B51, S)]) and similarly for the following columns (3,5,7,9,11). It will give the selling of bread on day 1, day 2, day 3, day 4, day 5, and day 6 are 34, 41, 43, 44, 44, and 44 out of 50 (all counting is mentioned in row number 53 of Figure 4).



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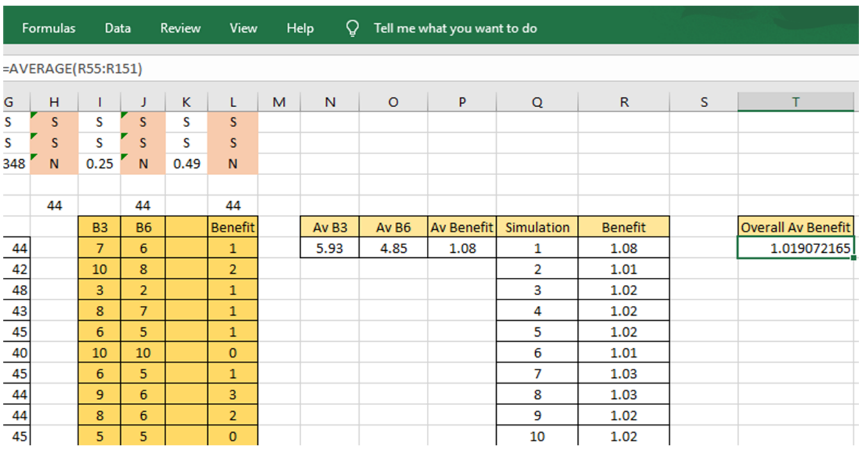
I55 =50-D55

	A	B	C	D	E	F	G	H	I	J	K	L
49	b48	S	S	S	S	S	S	S	S	S	S	S
50	b49	S	S	S	S	S	S	S	S	S	S	S
51	b50	N	0.5	N	0.225	N	0.348	N	0.25	N	0.49	N
52												
53		34		41		43		44		44		44
54									B3	B6		Benefit
55	simulation-1	34	41	43	44	44	44		7	6		1
56	simulation-2	32	38	40	41	41	42		10	8		2
57	simulation-3	35	45	47	48	48	48		3	2		1
58	simulation-4	34	37	42	42	43	43		8	7		1
59	simulation-5	36	42	44	45	45	45		6	5		1
60	simulation-6	32	39	40	40	40	40		10	10		0
61	simulation-7	39	42	44	45	45	45		6	5		1
62	simulation-8	33	41	41	43	44	44		9	6		3
63	simulation-9	36	40	42	44	44	44		8	6		2
64	simulation-10	32	41	45	45	45	45		5	5		0

Figure 4. Formula used in column I of Excel sheet to find B3.

Step-4 Further, simulate the selling of bread 100 times (someone can simulate until any number according to their choice) with the help of a data table and then find B3 (bread balance after 3 Days) and B6 (bread balance after 6 days). For more clarity, B3 is the number of breads remaining after three days out of 50 breads found by the [=50-D55], and B6 is the number of breads remaining after six days out of 50 [=50-G55]. To find benefits (bread sold in the last three days), given by using the [=B3-B6] (Figure 4). Then drag till 100 simulations.

Step-5 Now take an average of B3, B6, and benefit, simulate the average of benefit (Av Benefit) 100 times with the help of the data table, and take the average to find out the overall average benefit (It is defining the number of bread has been sold in last three days) by the formula [=AVERAGE(R55:R151)]. The overall average benefit nearly equals 1 out of 50 bread packets (Figure 5). Therefore, the sale of bread in the last three days is almost one out of fifty, which has a very low probability.



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=AVERAGE(R55:R151)

G	H	I	J	K	L	M	N	O	P	Q	R	S	T
S	S	S	S	S	S								
S	S	S	S	S	S								
348	N	0.25	N	0.49	N								
	44		44		44								
		B3	B6		Benefit		Av B3	Av B6	Av Benefit	Simulation	Benefit		Overall Av Benefit
44		7	6		1		5.93	4.85	1.08	1	1.08		1.019072165
42		10	8		2					2	1.01		
48		3	2		1					3	1.02		
43		8	7		1					4	1.02		
45		6	5		1					5	1.02		
40		10	10		0					6	1.01		
45		6	5		1					7	1.03		
44		9	6		3					8	1.03		
44		8	6		2					9	1.02		
45		5	5		0					10	1.02		

Figure 5. Overall average benefit (OAB) for average benefit of bread.

3. Result and Discussion

This section aims to address RQ3, i.e., to describe the proposed strategy for reducing bread waste throughout the bread supply chain. It begins with a discussion of the study to concentrate on bread waste reduction because there is a high incidence of bread loss at the supplier–retailer interface. Agents from many companies have reported that leftover bread is sold to cow or pig yards for 2 to 3 rupees per kg. It is heard that companies often do not utilize excellent materials for creating bread, which means they combine materials (fresh and returned bread) for making rusk and breadcrumbs. It is hazardous to one's health.

If there is a way to reduce bread waste and have a minimum return, there is no need to sell to pig yards or cow yards; combine fresh and returned bread because this situation is not optimum. As a result, it was decided to collect data (in Appendix A) from randomly chosen retailers of the different bakeries, and the average likelihoods of selling bread from days 1, 2, 3, 4, 5, and 6 were 73%, 45%, 22%, 8%, 6%, and 3%, respectively. It means that 73% of bread is sold on day 1 (D1), and the next day (D2), 45% of that same bread is sold, and on the third day (D3), 22% of that same bread, etc. It indicates a progressive decline in the chance of selling bread from day one to day six.

The approach for using the Monte Carlo simulation method is described in the research methodology for this study. Following step 5 of the simulation process, the overall average benefit (OAB) indicated that the sale of bread over the previous three days was nearly one out of every fifty bread packets. Therefore, it is obvious that if any retailer keeps bread for more than three days, it will not be advantageous for any bakery since the likelihood of OAB is only around 2% (or 1/50%), which is extremely low and not an optimal situation. Therefore, it is advised to recall bread three days after it has been sold rather than the customary six days and to imitate Company A's and Company E's strategies as they have the most effective additional strategies and the lowest waste percentage.

Bread returned to the bakery or business will not be an expired product if any bakery uses the above-provided tactics. The bread that has been returned is edible, of high quality, and requires less new flour to make rusk, breadcrumbs, etc. because this may be achieved with returned bread. Through the more effective use of raw materials, packaging, and technology, we may save time and money by preventing the need to sell leftovers to pig or cow yards and avoiding the costs associated with purchasing flour, labor, shipping, maintenance, etc.

4. Conclusions

Unlike most other members of the bread supply chain, retailers are likely to be eager to decrease bread wastage since it costs them money and cuts into their already thin profit margins. In this study, we looked at data on bread sales from ten randomly selected retailers in Jalandhar city. This research looked at the different proportions of the retailer's bread waste and found that the probability of selling bread is highest on day one and drops progressively. According to the findings, nearly one bread package out of fifty was sold in the last three days. It also shows some strategies companies A, B, C, D, and E used. It is recommended that bread be recalled after three days of selling by retailers or delivery to retailers rather than six days from the market. On the other hand, companies A and E's strategy of offering supply chain members an additional discount on bill invoices by assigning them tasks, such as returning fewer bread packets, producing small packets of bread at low prices to attract low-budget customers, and targeting small towns and villages for increased bread sales through retailer contact, can be followed to reduce waste and consequent business loss.

The findings indicate that a comprehensive approach against bread waste at the bakery level may evolve along certain lines: (i) If any bakery follows these practices, the chances of expired bread are fewer, and recalled bread will have enough quality and time to be turned into breadcrumbs, rusk, pastry, and other baked items. In turn, there will be no need to sell expired bread to cow or pig yards because there will be nothing to sell. (ii) If extra discounts are offered to supply chain members on bill invoices by assigning them tasks, it is obvious that they will work hard to sell most bread packets. (iii) If retailers target small towns and villages for higher bread sales since they are less quality concerned, sales may grow as well, and making small packets of bread at cheap costs to attract low-budget customers will play an essential part in bread sales. To achieve the best outcomes, each bakery or bread manufacturing firm must use the abovementioned strategies.

This study uses information provided by the retailer only, and future research may consider the selling/waste data in the bread supply chain taken directly from the bakery. Since it was discovered that there is greater wastage in the summer than in the winter, researchers should aim to collect data throughout the summer for optimality.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Stock and sell data of bread per cycle per retailer.

		CYCLE-1						CYCLE-2						CYCLE-3					
	DAY	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
R1	STOCK	20	6	3	2	1	1	26	8	5	3	2	2	22	7	4	3	3	3
	SELL	14	3	1	1	0	0	18	3	2	1	0	0	15	3	1	0	0	0
	PROB	0.7	0.5	0.333	0.5	0	0	0.69	0.38	0.4	0.33	0	0	0.68	0.43	0.3	0	0	0
		CYCLE-1						CYCLE-2						CYCLE-3					
	DAY	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
R2	STOCK	25	7	4	3	3	3	27	7	4	3	2	2	25	10	6	4	4	4
	SELL	18	3	1	0	0	0	20	3	1	1	0	0	15	4	2	0	0	0
	PROB	0.72	0.43	0.25	0	0	0	0.74	0.43	0.25	0.33	0	0	0.6	0.4	0.3	0	0	0
		CYCLE-1						CYCLE-2						CYCLE-3					
	DAY	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
R3	STOCK	30	9	5	3	3	2	29	10	6	6	5	5	31	9	5	3	2	2
	SELL	21	4	2	0	1	0	19	4	0	1	0	0	22	4	2	1	0	0
	PROB	0.7	0.44	0.4	0	0.33	0	0.66	0.4	0	0.17	0	0	0.71	0.44	0.4	0.333	0	0
		CYCLE-1						CYCLE-2						CYCLE-3					
	DAY	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
R4	STOCK	29	7	3	2	2	2	24	7	3	3	2	2	29	10	7	5	5	4
	SELL	22	4	1	0	0	0	17	4	0	1	0	0	19	3	2	0	1	0
	PROB	0.7586	0.57	0.333	0	0	0	0.71	0.57	0	0.33	0	0	0.66	0.3	0.3	0	0.2	0
		CYCLE-1						CYCLE-2						CYCLE-3					
	DAY	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
R5	STOCK	22	5	3	2	2	2	18	1	0	0	0	0	18	6	2	1	1	1
	SELL	17	2	1	0	0	0	17	1	0	0	0	0	12	4	1	0	0	0
	PROB	0.7727	0.4	0.333	0	0	0	0.94	1	0	0	0	0	0.67	0.67	0.5	0	0	0
		CYCLE-1						CYCLE-2						CYCLE-3					
	DAY	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
R6	STOCK	34	8	4	4	4	4	34	10	4	2	2	2	36	6	4	4	4	4
	SELL	26	4	0	0	0	0	24	6	2	0	0	0	30	2	0	0	0	0
	PROB	0.7647	0.5	0	0	0	0	0.71	0.6	0.5	0	0	0	0.83	0.33	0	0	0	0

Table A1. *Cont.*

		CYCLE-1						CYCLE-2						CYCLE-3					
	DAY	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
R7	STOCK	28	6	3	2	1	1	31	7	3	2	2	2	29	8	4	3	3	3
	SELL	22	3	1	1	0	0	24	4	1	0	0	0	21	4	1	0	0	0
	PROB	0.7857	0.5	0.333	0.5	0	0	0.77	0.57	0.33	0	0	0	0.72	0.5	0.3	0	0	0
		CYCLE-1						CYCLE-2						CYCLE-3					
	DAY	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
R8	STOCK	20	4	2	1	1	1	14	5	3	3	2	2	21	7	5	4	3	3
	SELL	16	2	1	0	0	0	9	2	0	1	0	0	14	2	1	1	0	0
	PROB	0.8	0.5	0.5	0	0	0	0.64	0.4	0	0.33	0	0	0.67	0.29	0.2	0.25	0	0
		CYCLE-1						CYCLE-2						CYCLE-3					
	DAY	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
R9	STOCK	20	4	3	2	2	2	22	6	3	3	3	2	22	7	4	3	3	3
	SELL	16	1	1	0	0	0	16	3	0	0	1	0	15	3	1	0	0	1
	PROB	0.8	0.25	0.333	0	0	0	0.73	0.5	0	0	0.33	0	0.68	0.43	0.3	0	0	0.3
		CYCLE-1						CYCLE-2						CYCLE-3					
	DAY	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
R10	STOCK	20	6	3	2	2	2	26	6	3	2	2	2	20	6	3	2	2	2
	SELL	14	3	1	0	0	0	20	3	1	0	0	0	14	3	1	0	0	1
	PROB	0.7	0.5	0.333	0	0	0	0.77	0.5	0.33	0	0	0	0.7	0.5	0.3	0	0	0.5
		CYCLE-4						CYCLE-5						CYCLE-6					
		D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
R1		25	7	4	3	3	3	22	6	3	2	2	2	24	7	4	3	3	3
		18	3	1	0	0	0	16	3	1	0	0	0	17	3	1	0	0	0
		0.72	0.43	0.25	0	0	0	0.73	0.5	0.333	0	0	0	0.71	0.43	0.3	0	0	0
		CYCLE-4						CYCLE-5						CYCLE-6					
		D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
R2		30	8	4	3	2	2	23	6	3	2	2	2	28	9	5	4	4	4
		22	4	1	1	0	0	17	3	1	0	0	0	19	4	1	0	0	0
		0.73	0.5	0.25	0.33	0	0	0.74	0.5	0.333	0	0	0	0.68	0.44	0.2	0	0	0
		CYCLE-4						CYCLE-5						CYCLE-6					
		D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
R3		28	2	1	1	1	1	24	7	4	4	3	3	33	10	6	4	3	3
		26	1	0	0	0	0	17	3	0	1	0	0	23	4	2	1	0	1
		0.93	0.5	0	0	0	0	0.71	0.429	0	0.25	0	0	0.7	0.4	0.3	0.25	0	0.333
		CYCLE-4						CYCLE-5						CYCLE-6					
		D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
R4		27	7	4	3	3	3	26	9	5	4	4	4	29	7	3	3	3	2
		20	3	1	0	0	0	17	4	1	0	0	0	22	4	0	0	1	0
		0.74	0.43	0.25	0	0	0	0.65	0.444	0.2	0	0	0	0.76	0.57	0	0	0.33	0
		CYCLE-4						CYCLE-5						CYCLE-6					
		D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6

Table A1. *Cont.*

R5	23	8	5	3	3	2	20	6	3	3	3	2	21	6	4	4	4	4
	15	3	2	0	1	0	14	3	0	0	1	0	15	2	0	0	0	0
	0.65	0.38	0.4	0	0.33	0	0.7	0.5	0	0	0.33	0	0.71	0.33	0	0	0	0
				CYCLE-4						CYCLE-5						CYCLE-6		
	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
R6	30	8	3	2	2	2	38	10	5	3	3	2	32	7	6	6	6	6
	22	5	1	0	0	0	28	5	2	0	1	0	25	1	0	0	0	0
	0.73	0.63	0.33	0	0	0	0.74	0.5	0.4	0	0.33	0	0.78	0.14	0	0	0	0
				CYCLE-4						CYCLE-5						CYCLE-6		
	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
R7	32	9	5	5	4	4	30	9	5	3	2	2	32	10	5	4	4	4
	23	4	0	1	0	0	21	4	2	1	0	0	22	5	1	0	0	0
	0.72	0.44	0	0.2	0	0	0.7	0.444	0.4	0.333	0	0	0.69	0.5	0.2	0	0	0
				CYCLE-4						CYCLE-5						CYCLE-6		
	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
R8	16	6	2	1	1	1	20	1	1	1	1	1	11	2	2	2	2	1
	10	4	1	0	0	0	19	0	0	0	0	0	9	0	0	0	1	0
	0.63	0.67	0.5	0	0	0	0.95	0	0	0	0	0	0.82	0	0	0	0.5	0
				CYCLE-4						CYCLE-5						CYCLE-6		
	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
R9	23	2	2	2	2	1	17	4	2	2	1	1	25	6	4	4	4	3
	21	0	0	0	1	0	13	2	0	1	0	0	19	2	0	0	1	0
	0.91	0	0	0	0.5	0	0.76	0.5	0	0.5	0	0	0.76	0.33	0	0	0.25	0
				CYCLE-4						CYCLE-5						CYCLE-6		
	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
R10	26	7	3	2	2	2	21	6	3	2	2	2	25	8	4	3	3	3
	19	4	1	0	0	0	15	3	1	0	0	0	17	4	1	0	0	1
	0.73	0.57	0.33	0	0	0	0.71	0.5	0.333	0	0	0	0.68	0.5	0.3	0	0	0.333

Table A2. Probability of selling of breads per cycle per retailer.

			CYCLE-1						CYCLE-2						CYCLE-3		
	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
R1	0.7	0.5	0.33	0.5	0	0	0.692	0.375	0.4	0.333	0	0	0.682	0.429	0.25	0	0	0
R2	0.72	0.43	0.25	0	0	0	0.741	0.429	0.25	0.333	0	0	0.6	0.4	0.33	0	0	0
R3	0.7	0.44	0.4	0	0.333	0	0.655	0.4	0	0.167	0	0	0.71	0.444	0.4	0	0	0
R4	0.759	0.57	0.33	0	0	0	0.708	0.571	0	0.333	0	0	0.655	0.3	0.29	0	0.2	0
R5	0.773	0.4	0.33	0	0	0	0.944	1	0	0	0	0	0.667	0.667	0.5	0	0	0
R6	0.765	0.5	0	0	0	0	0.706	0.6	0.5	0	0	0	0.833	0.333	0	0	0	0
R7	0.786	0.5	0.33	0.5	0	0	0.774	0.571	0.333	0	0	0	0.724	0.5	0.25	0	0	0
R8	0.8	0.5	0.5	0	0	0	0.643	0.4	0	0.333	0	0	0.667	0.286	0.2	0	0	0

Table A2. *Cont.*

R9	0.8	0.25	0.33	0	0	0	0.727	0.5	0	0	0.33	0	0.682	0.429	0.25	0	0	0
R10	0.7	0.5	0.33	0	0	0	0.769	0.5	0.333	0	0	0	0.7	0.5	0.33	0	0	1
AVERAGE	0.75	0.46	0.32	0.1	0.033	0	0.736	0.535	0.182	0.15	0.03	0	0.692	0.429	0.28	0	0.02	0
	CYCLE-4						CYCLE-5						CYCLE-6					
	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6	D1	D2	D3	D4	D5	D6
	0.72	0.43	0.25	0	0	0	0.73	0.5	0.33	0	0	0	0.708	0.429	0.25	0	0	0
	0.73	0.5	0.25	0.33	0	0	0.74	0.5	0.33	0	0	0	0.679	0.444	0.2	0	0	0
	0.93	0.5	0	0	0	0	0.71	0.429	0	0.25	0	0	0.697	0.4	0.33	0.25	0	0.33
	0.74	0.43	0.25	0	0	0	0.65	0.444	0.2	0	0	0	0.759	0.571	0	0	0.333	0
	0.65	0.38	0.4	0	0.333	0	0.7	0.5	0	0	0.333	0	0.714	0.333	0	0	0	0
	0.73	0.63	0.33	0	0	0	0.74	0.5	0.4	0	0.333	0	0.781	0.143	0	0	0	0
	0.72	0.44	0	0.2	0	0	0.7	0.444	0.4	0.33	0	0	0.688	0.5	0.2	0	0	0
	0.63	0.67	0.5	0	0	0	0.95	0	0	0	0	0	0.818	0	0	0	0.5	0
	0.91	0	0	0	0.5	0	0.76	0.5	0	0.5	0	0	0.76	0.333	0	0	0.25	0
	0.73	0.57	0.33	0	0	0	0.71	0.5	0.33	0	0	0	0.68	0.5	0.25	0	0	0.33
	0.75	0.45	0.23	0.05	0.083	0	0.74	0.432	0.2	0.11	0.067	0	0.728	0.365	0.12	0.03	0.108	0.07

Table A3. Average probability of selling of breads per cycle per day.

CYCLE	**DAYS**					
	D1	**D2**	**D3**	**D4**	**D5**	**D6**
CYCLE-1	0.75	0.46	0.32	0.1	0.033	0
CYCLE-2	0.736	0.535	0.182	0.15	0.03	0.736
CYCLE-3	0.692	0.429	0.28	0	0.02	0
CYCLE-4	0.75	0.45	0.23	0.05	0.083	0
CYCLE-5	0.74	0.432	0.2	0.11	0.067	0
CYCLE-6	0.728	0.365	0.12	0.03	0.108	0.07
AVERAGE	**0.73**	**0.45**	**0.22**	**0.08**	**0.06**	**0.03**

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