



Perfectly imperfect: Embracing sub-optimal vegetables in Coimbatore farmer's market

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Abstract

India is one of the largest producers of vegetables globally, consistently ranking among the top countries in terms of production. However, post-harvest losses continue to be a major problem in the food sector because of poor handling, storage and transportation. Despite these losses, customers frequently ignore vegetables that are not at their best but still have nutritional value due to their aesthetic flaws. This is because consumers and retailers have high expectations in purchasing vegetables. The study explores factors that influence purchasing behavior and consumer preferences in sub-optimal vegetables. Using a well-structured questionnaire data was collected from 250 respondents in Coimbatore farmers market and analyzed by using factor and conjoint analysis. A total of four factors such as buying expectations, attitudes, benefits and price were identified on purchasing behaviour of sub-optimal vegetables. Combination of fresh, firm, without spots with a price discount of 50-75 % has a higher utility score and it is a highly preferred attribute of the consumer in buying sub-optimal vegetables. This study contributing to food waste reduction and supporting sustainable practices.

Keywords: farmers market; food reduction; preference; purchasing behaviour; sub-optimal vegetables; sustainability

Introduction

Food waste is considered a major issue in the food sector that affects sustainability in the social, economic and environmental domains (1). One of the main causes of food waste, especially in developing nations like India. Consumer behaviour influenced by preferences for aesthetically perfect produce. Understanding the elements affecting consumers perceptions and behaviors about food waste is essential to effectively reducing consumer-related food waste.

The production of vegetables has been steadily rising over time worldwide, reaching 1.1 billion tonnes in 2021 (2). India is the second-largest producer of vegetables in the world with around 200 million tonnes produced yearly, after China, which accounts for more than half of worldwide production. Post-harvest losses continue to be a major problem globally despite this outstanding yield. Approximately 14 % of the world's food is lost after harvest before it reaches consumers (3). Since vegetables are perishable, they account for a significant portion of this loss. Between 4.6 million and 15.9 million tonnes of vegetables are lost after harvest each year in India, which is a startlingly high rate.

The term *sub-optimal* refers to products that deviate slightly from the standard or ideal appearance. This variation could be caused by unusual shape, size, or weight or they could be related to the product's approaching expiration date. In certain situations, the packaging could also be flawed or broken (4). It can be described as food that is still edible but not

at its best in the eyes of the consumer (5). When choosing foods, most consumers prioritize flawless shape and appearance, packaging and a long shelf life; this leads to less-than-ideal food that is not marketable (6). Fig. 1 illustrates how sub-optimal is categorized based on its degree of deviation from the normal.

Even if the fundamental quality and food safety of these sub-optimal foods are the same, they are thought to provide fewer benefits in some areas than the optimal ones. Additionally, it may just seem less appealing, which could have a negative impact on its perceived worth according to the "what beautiful is good" (6) equation. In terms of perceived value and some quality aspects, the sub-optimal is less valuable than the effort in terms of time or money. One of the studies looked at how consumers reacted to fruit that was aesthetically flawed, including cucumbers that were deformed (7). It discovered that aesthetic faults had a big impact on consumers' decisions to buy.

A browning banana that requires additional care to carry home or a bent cucumber that is challenging to peel are two examples of poor-quality food that can be viewed as uncomfortable to handle during transportation, storage and cooking. When food is no longer fresh, it may be expected to lose its nutritious qualities or to taste less appetizing (8). A sub-optimal food may be presumed to be less healthy when it is lowered in price (9). Sub-optimal vegetables identified in farmers market tabulated in the Table 1.

Table 1. Sub-optimal vegetables in Coimbatore farmer's market

S. No	Characteristic	Image	Reason
11	Appearance (Shape, size, weight)		
			
			Occurs naturally due to poor water supply, bird damage, poor soil health, overuse of fertilizer. These vegetables are perfectly suitable for consumption; they only differ in size.
22	Breakage/Crack		
			
			
			Mechanical or minor damage due to handling, harvesting, transporting and storage

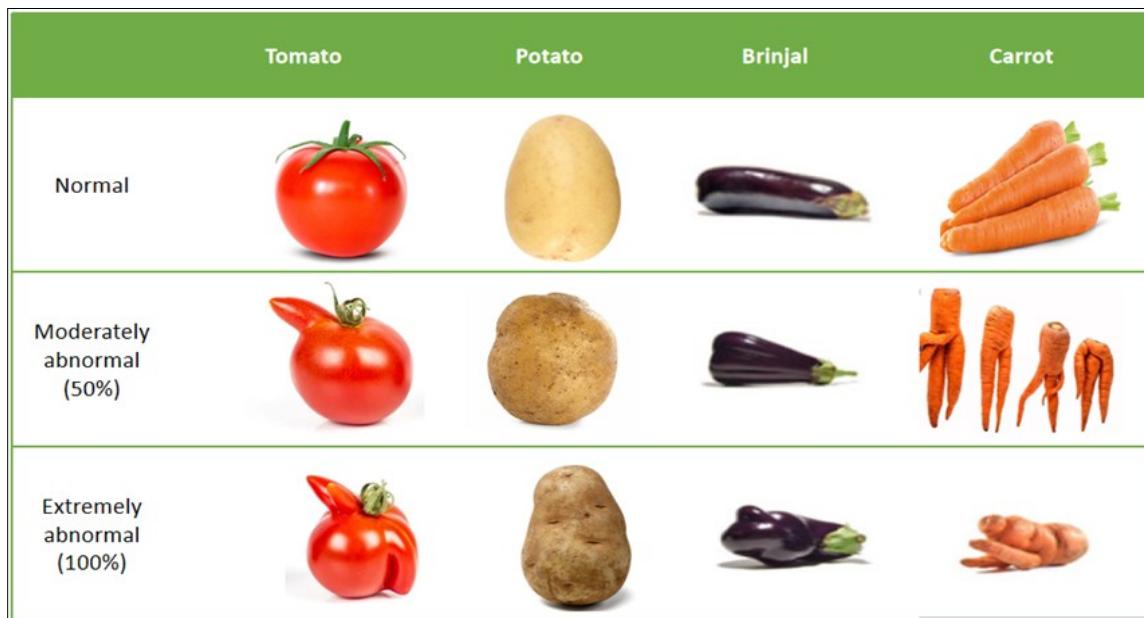


Fig. 1. Normal Vs abnormal.

The main causes of vegetables that are not at their best can frequently be linked to agricultural and environmental problems, including unhealthy soil, a contaminated or inadequate supply of water and bad weather. Degradation of the soil, brought on by erosion, the loss of organic matter, or excessive use of chemical fertilizers, results in crops that are low in nutrients and may not be up to par. Water scarcity or contaminated irrigation water sources can also cause agricultural stress, which can lead to poor growth, lower yields and degraded quality. Furthermore, the development and storage of agricultural products are further impacted by extreme weather events like droughts, floods, or temperature variations, which increase their vulnerability to damage and consumer rejection.

Consumer preferences and purchasing behaviors towards sub-optimal vegetables play a major role in addressing food waste and promoting sustainability. General objectives like Zero Hunger, sustainability and the reduction of food waste, suboptimal vegetables can be made a beneficial part of the food system by concentrating on improving accessibility, cost and consumer education. The main objectives of the study is to find out the factors that influence the purchase of sub-optimal vegetables and to know the consumer preference towards the purchase of sub-optimal vegetables.

According to its characteristics, sub-optimal food is classified into three groups (10). These groups include: the food marked expiration date (e.g., food that is nearing or past its expiration date), the packaging (e.g., food packaging exhibiting visually damage, such as a dented can or a torn wrapper) and appearance standards (e.g., weight, shape and size are required to meet suitable standards). Retailers' influence over the quality of products standards and specifications is the primary cause of fruit and vegetable waste (11). However fresh produce offered at open market is less applicable to the above criteria. Instead, these products are judged more by their visual freshness and overall appearance, which may vary naturally and are influenced by factors such as weather exposure and handling.

When the quality or safety of sub-optimal food is comparable to optimal food, only a small percentage of consumers will select sub-optimal food (12) and (13) discover that visual imperfections like unusual forms, broken packaging, or products that are about to expire, have negative effects on the decisions made by customers. These factors often lead consumers to reject sub-optimal food, even when its quality and safety remain intact. Due to their potential to decrease food waste and enhance sustainability, suboptimal vegetables that are safe and nutritious despite having flaws in size, shape, or appearance have drawn attention. Less-than-ideal produce into food systems, cutting down on food waste and lowering greenhouse gas emissions all have positive environmental effects (14).

The significance of creative marketing techniques and consumer education in enhancing acceptance of purchasing veggies that are not at their best. Price reductions and the use of less-than-ideal produce in processed foods are two tactics that are becoming more and more successful in changing consumer behavior and lowering post-harvest losses. Interestingly, the issue of appearance-based rejection is also relevant in the case of organic produce vegetables. Because organic farming does not use synthetic fertilizers or pesticides to enhance visual appeal, organic fruits and vegetables are often perceived as visually "sub-optimal" despite being healthy and safe (15). To maintain their quality and marketability, technological advancements such as sorting systems and controlled storage conditions have been adopted. According to these results, integrating less-than-ideal veggies into the mainstream food chain requires a multi strategy that combines consumer awareness, technological innovation and supportive policy.

Study area and sampling method

Sometimes vegetables are not bought because they are thought to be less-than-ideal, which leads to food waste. Offering at lower prices in the store or market is one of the methods to prevent this aspect from producing sub-optimal results. In those situations, customers are likely to select such food, but it is still not well studied. The city of Coimbatore was chosen for this study purposively because it is a major trading

center for fruits and vegetables. This resulted in a total size sample of 250 consumers from farmer's market in Coimbatore city.

This study aims to understand the purchasing behaviour and preferences of sub-optimal vegetables. For which, a five-point Likert scale was used, with 5 representing "Strongly agree" and 1 representing "Strongly disagree". The questionnaire was developed based on the following 11 attributes identified from previous studies, as shown in Table 2.

The data was analyzed using Exploratory Factor Analysis (EFA), which grouped the qualities into a limited number of factors. IBM SPSS version 22 was used to conduct the EFA. Conjoint analysis was used to analyze the consumer preferences towards purchasing sub-optimal vegetables in farmer market in Coimbatore city. The attributes used in the survey and their levels are given in Table 3.

Table 2. Attributes considered for making the questionnaire

S.No	Attributes	Sources
1	Taste and texture	(29)
2	Appearance	(30)
3	Wide variety	(31)
4	Nutritional concerns	(32)
5	Convenience	(33)
6	Quality concerns	(34,35)
7	Health and safety concerns	(36)
8	Sustainability	(37)
9	Prior knowledge	(38)
10	Price discounts	(39)
11	Ease of availability	(40)

Table 3. Attributes and levels used in conjoint analysis

Freshness	Texture	Appearance	Price discount
Fresh	Firm	With minor spots	Less than 50 %
Stale	Soft	With major spots	50-75 %
		Without spots WS	Above 75 %

In conjoint analysis, a full factorial design ($3 \times 2 \times 2 \times 3 = 36$ cards) that can be derived from the parameters that correspond to the main effects. The interviewer is unable to answer all the 36 combinations. Giving participants too much information could make them disinterested and negatively impact the caliber of their responses. The conjoint orthogonal design is a useful technique for minimizing the number of options when predicting participant preferences (16). This method offers an efficient estimate of all significant effects, but it assumes that all current interactions in stimuli may be overlooked (17). Because of this, fractional designs which are less than full factorial designs are used. Thirty-six card combination was reduced to ten by using orthogonal design in SPSS result are presented in the Table 4.

In this way, the ten combination cards as shown in Table 4 were generated and aimed at measuring the preference of buying sub-optimal vegetables by presenting them to the respondents. The task of the participant is to make rank the combination from one to ten and run in SPSS to get result.

Table 4. Orthogonal-design result

Card	Freshness	Texture	Appearance	Price discount
I	Fresh	Firm	With minor spot	Above 75 %
II	Stale	Soft	With major spot	50-75 %
III	Fresh	Firm	With major spot	Less than 50 %
IV	Stale	Soft	With minor spot	Above 75 %
V	Stale	Firm	Without spot	Less than 50 %
VI	Fresh	Soft	Without spot	50-75 %
VII	Stale	Firm	With major spot	Less than 50 %
VIII	Stale	Soft	With minor spot	50-75 %
IX	Fresh	Firm	Without spot	Above 75 %
X	Fresh	Soft	With major spot	Less than 50 %

Results and Discussion

The demographic profile of consumers who purchase vegetables at Farmer's markets, highlighting key attributes such as gender, age and purchasing frequency are represented in the Table 5. This data helps in understanding the underlying trends and preferences of the target audience in this market segment.

The demographic data reveals significant insights purchasing behavior of sub-optimal vegetables at Farmer's markets. A higher percentage of male consumers (54.58 %) visit these markets compared to females (45.42 %), suggesting that men might be actively involved in household or personal vegetable shopping. This trend aligns with previous findings, who said that male participation in grocery purchasing is increasing and active involvement more than women reflecting changing gender roles in consumer behavior (18). In terms of age, the largest group of consumers falls within the 36-50 age (34 %), followed by those above 51 years (29.6 %). Studies have found that older adults tend to consume more fruits and vegetables than younger individuals, driven by health considerations and a desire for better nutrition (19). When analyzing purchase frequency, nearly 40.4 % of the respondents buy vegetables once a week, while 32.8 % of the consumers shop 2-3 times a week. This behavior aligns with the need for the perishability of fresh produce and necessitates more frequent purchases, especially among consumers with limited resources who aim to reduce waste (20). In terms of location, Farmer's markets attract 46.8 % of consumers, making them the most preferred purchase location compared to departmental stores or mixed options. Similarly, studies revealed that majority of the consumers were willing to pay more at farmers' markets for the quality and freshness, pricing and the desire to support local farmers rather than at nearby retail outlets or supermarkets (21). Sub-optimal vegetable consumption is common, people are buying with 38.4 % of respondents consuming them often, driven by the affordability of these vegetables compared to premium options and awareness of reducing food waste (8).

A significant portion, 43.06 %, indicated that were purchased for Hotels or Hostels, highlighting the demand for bulk consumption. 35.42 % of respondents stated that special occasions (family functions, marriage, temple) suggesting that

Table 5. Demographic profile

S.No	Sample	Content	Frequency	Percentage
1	Gender	Male	131	54.58
		Female	119	45.42
		18-25	29	11.6
2	Age	26-35	62	24.8
		36-50	85	34.0
		Above 51	74	29.6
3	Frequency of purchase of vegetables	2-3 times a week	82	32.8
		once a week	101	40.4
		2 times a month	67	26.8
4	Purchase Location	Farmer's market	117	46.8
		Departmental Store	62	24.8
		Mixed others	37 24 10	14.8 9.6 4.0
5	Frequency of sub-optimal purchase	Rarely	83	33.2
		Often	96	38.4
		Always	71	28.4
6	Quantity of buying sub-optimal vegetables	Smaller	106	42.4
		Larger	144	57.6
7	Larger quantity of purchase	Family size is big	9	6.25
		Hotel/Hostel	62	43.06
		Special occasions	51	35.42
		Value-added products	17	11.81
		Others	5	3.47

these events create opportunities for utilizing sub-optimal vegetables effectively. Another 11.81 % purchased value-added products (chips, sauce) showing the growing trend of repurposing imperfect vegetables for processed or alternative products. A study highlights that restaurants/hotels consider the priority of buying and using relatively suboptimal foods, or foods that have been produced for a longer time, as these are usually priced lower, thereby reducing operational costs (22). Among the participants, 57.6 % reported purchasing sub-optimal vegetables in larger quantities, while 42.4 % opted for smaller quantities. Finally, primary reasons behind buying sub-optimal vegetables in larger quantities decisions.

Additionally, 6.25 % of buyers cited a big family size as the driving factor, emphasizing the role of household consumption needs. Finally, 3.47 % mentioned other reasons, which may indicate that social capital, encompassing networks and community engagement, contributes to food security by facilitating knowledge and product sharing among community members (23). This communal approach can lead to increased acceptance and utilization of sub-optimal. By leveraging farmer's market to promote their benefits and normalizing their inclusion in regular farmers'-optimal vegetables can contribute to reducing food waste and fostering a more sustainable food system.

Reliability analysis

To assess the reliability of the data and the adequacy of the sample size, the attributes were analyzed using exploratory factor analysis and Cronbach's alpha was calculated. The statistics are presented in Table 6.

The values of Cronbach's alpha (0.789) and KMO (0.752) are both above the acceptable limit (41), which indicates that the data is reliable and the sample size is adequate. The results of exploratory factor analysis on purchasing decision on sub-optimal vegetables in Coimbatore farmers' market are tabulated in Table 7

Table 6. KMO and Bartlett's test of sphericity

Statistic	Value
Kaiser-Meyer-Olkin measure of sampling adequacy	0.752
Approx. Chi-Square	434.775
Bartlett's test of sphericity	df
	55
	Sig.
	.000

Note: Cronbach's α is acceptable higher than 0.7; value of KMO above 0.6 being acceptable; Bartlett's test of sphericity is significant, hence acceptable (41)

Using SPSS, the Rotated Compound Matrix analysis revealed four unique characteristics that affect consumer behavior towards sub-optimal vegetables. Taste and texture (0.872), appearance (0.721) and wide variety (0.645) are the most important factors, according to Factor 1. However, positive taste experiences can mitigate negative perceptions associated with suboptimal appearance, enhancing overall acceptance (24). Followed by practical and nutritional considerations (0.845) and quality concerns (0.684) and convenience (0.735) emerge as important characteristics and falls on Factor 2. Factor 3 includes consumer perceptions regarding the broader benefits, with a focus on health and safety concerns (0.843) and sustainability (0.785). Positioning not ideal products in sustainability narratives might increase customer willingness to buy since it reflects their beliefs and helps reduce waste (25). Finally, Factor 4 underscores the role of prior awareness, where prior knowledge (0.871) and price discounts (0.674) drive decisions with ease of availability (0.612) being critical. Offering financial incentives and educating consumers about the feasibility of may greatly boost the suboptimal vegetables acceptance and purchase intent (26). The contribution of each factor is listed out in the Table 8.

Table 7. Results of exploratory factor analysis on purchasing decision

Variables	Rotated Compound Matrix			
	Factor 1	2	3	4
Taste and texture	0.872			
Appearance	0.721			
Wide variety	0.645			
Nutritional concerns		0.845		
Convenience		0.735		
Quality concerns		0.684		
Health and safety concerns			0.843	
Sustainability			0.785	
Prior knowledge				0.871
Price discounts				0.674
Ease of availability				0.612

Table 8. Component contribution and factors

Factors	Character	Variance	Attributes
F1	Buying Expectations	52.6 %	Taste and texture Appearance Quality concerns
F2	Attitudes	29 %	Nutritional concerns Convenience Wide variety
F3	Benefits	10 %	Health and safety concerns Sustainability
F4	Price	7.3 %	Price discounts Ease of availability Knowledge

The factors influencing consumer behavior toward suboptimal vegetables emphasize the importance of buying expectations (52.6 %), where consumers place a high value on taste, texture, appearance and quality. They frequently conclude that sub optimal produce lacks visual appeal, which is a significant consideration when purchasing fresh produce. By purchasing sub-optimal produce, consumers can help to reduce food waste and protect the environment. Consumers learned about the environmental benefits of buying suboptimal food, they were more responsive, according to the same study (27). Followed by attitudes with (29 %) preferences influenced by convenience, a large range of options and nutritional concerns. Consumers who are more knowledgeable about sub-optimal produce are more likely to purchase it. As a result, it is critical to inform customers about the advantages of sub-optimal produce and to increase its affordability and accessibility. It was supported the notion that sensory attributes significantly influence consumer behavior (24). Benefits (10 %) like sustainability, safety and health are becoming more widely acknowledged, but affordability and cost (7.3 %) are still crucial, with price breaks acting as major inducements. If sub-optimal produce is priced far lower than average, consumers are more likely to purchase it. Consumers are more likely to buy sub-optimal produce if it is priced significantly less than normal produce. This implies that availability and price reductions are inherently incompatible. Among the four factors buying expectations and attitudes plays a major role in purchasing sub-optimal vegetables.

Consumer preference towards sub-optimal vegetables

The study aimed to analyze consumer preferences for sub-optimal vegetables using the responses collected from participants. The data was analyzed using SPSS software to determine the utility scores and the importance values for each attribute. The results were interpreted to understand the significance of individual features like freshness, texture, appearance and price discount in influencing consumer choices.

Important values

To determine the utilities allocated to each level of the attribute, Table 9 presents the utility scores obtained by each attribute. It represents the utilities and the average importance score of consumer preference of sub-optimal vegetables in the Farmers Market. Based on the average importance, scores appearance was the most important attribute for consumers, followed by texture, freshness and price discount.

Combining the importance scores (Appearance > Texture > Freshness > Price Discount), this table understands how much weightage is given by the respondents for purchasing sub-optimal vegetable features and predicts which combinations are most likely to be appealing. Similarly, the study highlighted that abnormal appearance, Price and expiration dates were key barriers to acceptance, further reinforcing the importance of visual and quality attributes over economic incentives (28).

Table 9. Contribution values by each attributes

S. No	Attributes	Values
1	Freshness	18.704
2	Texture	20.642
3	Appearance	41.069
4	Discount Price	9.585

Total utility

According to the researchers, a more desirable combination of features is indicated by a higher utility score. Utility is the key score for each combination and is determined by adding the utility scores of each individual feature level within that combination. The total utility of sub-optimal vegetables is shown in Table 10.

From the above Table 10, Combination card VI achieves the highest utility score of 1.793. This indicates that consumers highly prefer sub-optimal vegetables that are fresh, have a firm texture, are without spots and come with a moderate price discount (50-75 %). Food waste can be decreased and purchase increased if farmers and sellers live up to these consumer expectations in sub optimal vegetables. Other combinations that were given lower utility scores draw attention to areas that require improvement. A study conducted on suboptimal fruits where, consumers place greater emphasis on freshness indicators and appearance (26). This suggests that while visual imperfections can be a barrier, appropriate pricing strategies can mitigate this effect. Improved freshness, texture, appearance, or price reductions should all be attempted to better suit customer preferences. This could promote a wider acceptance of vegetables that aren't the best, which would help reduce food waste and promote sustainable farming methods. The marketing tactics that highlight the "tasty but ugly" appeal of these vegetables have

Table 10. Total utility

Combination cards	Freshness	Texture	Appearance	Price discount	Utility
I	0.43	0.25	0.574	-0.487	0.929
II	-0.43	-0.25	-0.429	0.325	-1.091
III	0.43	0.25	-0.429	-.162	-0.074
IV	-0.43	-0.25	0.574	-0.487	-0.431
V	-0.43	0.25	0.946	-.162	0.273
VI	0.43 (Fresh)	0.255 (Firm)	0.946 (Without spot)	0.325 (50 %-75 %)	1.793
VII	-0.43	0.25	-0.429	0.162	-0.44
VIII	-0.43	-0.25	0.574	0.325	0.056
IX	0.43	0.25	0.946	-0.487	1.139
X	0.43	-0.25	-0.429	0.162	-0.078

improved consumer perceptions and lessened the stigma attached to flaws (29). When consumers are made aware of the environmental and social benefits of consuming imperfect produce, their willingness to buy such items increases significantly especially when paired with economic incentives (5).

Conclusion

The study revealed that the purchasing behaviour and consumer preference of sub-optimal vegetables in farmers market is shaped by a mix of economic, practical and sustainability considerations. Consumers are increasingly inclined to purchase visually imperfect, that are good as standard ones in terms of taste and nutritional value. The findings underscore the importance of consumer segments and usage of sub-optimal vegetables in farmer's market. Based on the findings, Men were slightly more likely to visit the farmer's market than women, due to their role in household vegetable purchases. Middle-aged people were the most frequent customers, likely due to health consciousness or a preference for fresh produce. Most consumers shopped vegetables weekly in farmers market reflecting the need to consume fresh produce. A substantial portion frequently purchased sub-optimal vegetables, driven by affordability and waste reduction awareness. Targeting buyers like Hotels/ Hostel, households with larger family sizes and markets for value-added products can significantly enhance the acceptance of these vegetables, contributing to food waste reduction and supporting sustainable practices. Four different factors such as buying expectations, attitudes, benefits and price has been identified that influenced the consumers to purchase sub-optimal vegetables in farmer's market. Among the four factors buying expectations and attitudes plays a major role in purchasing sub-optimal vegetables. These factors contribute to the growing acceptance of purchasing and consuming sub-optimal vegetables in markets. Finally, to know the consumer preference in buying sub-optimal vegetables, ten different combination card is identified. Where, one of the combinations such as (fresh, firm, without spots, with 50-75 % price discount) is highly preferred by the consumer. The above combination is purchased and meeting out the consumer expectations, thus reducing food waste. For the remaining combination cards which is not meeting out the needs, extra focus may be given on improving accessibility and affordability and educating consumers about the benefits of sub-optimal produce. Marketing strategies promoting the "ugly but tasty" appeal of these vegetables have positively influenced consumer perceptions, reducing the stigma associated with imperfections.

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Authors' contributions

SKN contributed to collecting data, writing and original draft preparation. UK helped in guiding for preparing the manuscript, reviewing and supervision. MM helped in summarizing and revising the manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

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Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used Chatgpt in order to assist in refining structure, language editing, summarizing content. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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