Consumer perceptions of QR code technology for enhanced fluid milk shelf-life information provision in a retail setting

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Graphical Abstract

Summary

We assessed consumer acceptance of quick response (QR) code technology to communicate (1) product shelf-life and (2) shelf-life dependent pricing, by offering identical half-gallon fluid milk with both traditional printed best-by dates and with QR codes to convey best-by dates over an 8-wk time period in a retail setting. The study included 2 phases to determine (1) consumers’ receptiveness to using QR codes to access shelf-life information and (2) if offering a discounted price based on shelf-life would change consumers' willingness to use QR codes and would increase sales of milk nearing its best-by date. Our findings indicate that at least some consumer segments are likely to accept QR code technology to access shelf-life information. Hence, this technology represents a strategic opportunity to better communicate shelf-life information and to reduce food waste (e.g., by encouraging sales of products close to end of shelf life through reduced prices, using dynamic pricing approaches).

Highlights

- Novel technologies can be used to communicate fluid milk shelf-life in a retail setting.
- Consumers accept use of QR code technologies to display best-by dates.
- Hassle costs to identify discounted products may impede dynamic pricing acceptance.
Consumer perceptions of QR code technology for enhanced fluid milk shelf-life information provision in a retail setting

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Abstract: There is increasing awareness of the impact of food waste and the large role best-by or sell-by dates play in consumer food waste. To address this issue, predictive models have been developed that can not only provide more accurate best-by dates for fluid milk but could also be used to dynamically predict shelf-life (e.g., based on distribution data such as storage temperatures) and adjust prices for products closer to the end of shelf-life. However, limited information is available on strategies to communicate this type of information to consumers. Here we assessed the consumer acceptance of (1) quick response (QR) code technology to communicate product shelf-life and (2) shelf-life dependent pricing based on QR codes by offering both half-gallon fluid milk with traditional printed best-by dates and identical products with QR codes to convey best-by dates over an 8-wk time period in a retail setting. Overall, 62% of half-gallon containers sold over this time frame featured QR codes and 48% of QR code scans were linked to subsequent sales, suggesting the possibility of substantial consumer acceptance of novel technologies to display and communicate best-by dates. Preliminary data based on a small number of sales also showed that consumers did purchase QR code-labeled products offered at a reduced price due to limited remaining shelf-life. Our data suggest that at least some consumer segments would adopt QR code-based shelf-life labels, which presents an opportunity to better manage and communicate “best-by” dates and use dynamic pricing strategies to reduce food waste that occurs when an end-of-shelf-life product is either not sold or is discarded by consumers. Overall, QR codes represent a strategic opportunity for the dairy industry to achieve greater sustainability and to foster stronger connections with customers through enhanced provision of information that highlights sustainability practices implemented across the whole supply chain.

Environmental, social, and economic concerns have increased regarding food waste as nearly 1.3 billion tons of food have been reported to be lost or wasted globally every year (Gustavsson et al., 2011). Along the supply chain, the retail sector and consumers are estimated to be responsible for 31% of food waste (Buzby et al., 2014). Here, we refer to this as “food waste,” consistent with the Food and Agriculture Organization of the United Nations (FAO) definition of food waste as “the decrease in quantity or quality of food resulting from decisions and actions by retailers, food services, and consumers” (FAO, 2019; p. 5). In 2010, dairy products were estimated to contribute to approximately 25.4 billion pounds of food waste at retail and consumer levels in the United States, with fluid milk making up of 32% of the dairy product waste (Buzby et al., 2014).

Even though food labeling can provide important information to consumers, in some cases it can also create confusion and therefore drive food waste. Importantly, there is limited regulatory guidance in the United States related to best-by dates and expiration dates (USDA Food Safety and Inspection Service, 2019), including the phrasing used (e.g., best-by; use-by), how the expected shelf-life should be determined, and even if date labeling is required, which can cause consumer uncertainty about interpretation of shelf-life labels (Hall-Phillips and Shah, 2017). Indeed, Wilson et al. (2018) found that consumers differ in their interpretation of “best by” and “use by” dates and may misinterpret these terms. Roe et al. (2018) evaluated the discard rate of fluid milk of consumers and also found that consumer responses differed depending on whether they were given milk with or without date labels. When given milk without a date label, consumers were reliant on their senses to evaluate the milk and, thus, even when milk was past its sell-by date, there was a lower discard rate for these samples (Roe et al., 2018). On the other hand, even when milk that had 3 more days until its sell-by date, consumers were more likely to discard unspoiled milk with date labels present (Roe et al., 2018). While these authors concluded that innovative date labeling and education around date labels could reduce milk waste, we are not aware of published consumer studies that evaluated innovative date labeling approaches for milk in commercial retail establishments.

While one approach to address the confusion around date labels is the use of a standardized label such as a “best if used by” label (S.3324–Food Date Labeling Act of 2021; Congress, gov, 2021), technology-enabled solutions, such as quick response (QR) technology, offer a novel solution to address food waste and specifically address the best-by-date issue. For example, QR code labels coupled to a computer model that predicts shelf-life (i.e., best-by dates) of fluid milk using lot-specific input data would enable provision of more precise spoilage information to consumers, which could help reduce food waste that results from consumers discarding unspoiled milk prematurely.

QR codes were first developed for the auto industry to track manufacturing and distribution for car parts (Denso Wave, 2022) and have since been used in other industries such as education
Greatly expanded the use of QR code technology by consumers for payments and dining in response to the COVID-19 pandemic has findings indicate that consumers have a positive attitude toward using a QR code to understand the food traceability system, and their findings indicate that consumers have a positive attitude toward using QR codes as a tool. Furthermore, increased use of contactless payments and dining in response to the COVID-19 pandemic has greatly expanded the use of QR code technology by consumers.

The purpose of this study was to evaluate consumers’ acceptance of QR code technology and explore its use as a replacement for traditional best-by dates for dairy products. We conducted a 2-part pilot study in a university retail location that sells fluid milk and other dairy products. All research activities were reviewed by Cornell’s Institutional Review Board for Human Participants (IRB) and were approved and granted exemption under protocol number IRB0143820. For phase 1 (wk 1–4), the objective was to first determine consumers’ receptiveness to using QR code technology to access information about product shelf-life (using HTST-pasteurized fluid milk in half-gallon containers as a model). For phase 2 (wk 5–8), the objective was to determine if offering a discounted price schedule based on shelf-life for half-gallon fluid milk would (1) change consumers’ willingness to use the QR code technology (relative to the phase 1 baseline) and (2) increase sales of milk near its best-by date thereby reducing potential food waste.

This pilot study took place at the Dairy Bar at Cornell University in Ithaca, New York, between January and March 2022. The Dairy Bar sells 3 different sizes of fluid milk products: individual (8 oz), half gallon, and quart. We used fluid milk in half-gallon containers as a model for this study as the smaller serving sizes (e.g., 8 oz and quart) are often consumed immediately or soon after purchase, possibly making product shelf-life a less important factor in purchase decisions. For phase 1 and phase 2 of the study, the half-gallon milk products were offered for purchase with 2 labels: (1) the traditional printed “best-by” date with no alteration to the half-gallon carton (referred to as “static label milk”) and (2) a QR code that allowed consumers to access shelf-life information as well as (for phase 2 only) pricing information (referred to as “QR code milk”). For the QR code milk, the best-by date was concealed with white tape and replaced with a statement sticker. During phase 1 the sticker stated “Scan the QR code for the best-by date,” and during phase 2 the sticker stated “Scan the QR code for a potential discount and best-by-date.” We disclose the discount first in the phase 2 label to help mitigate possible customer inattention when interacting with the label (Loewenstein et al., 2014). The QR code corresponding to the best-by date was placed on the upper left corner of the milk container above the existing product label (Figure 1A).

To control the variables in the pilot study, we placed the half-gallon milk products on the same shelf and maintained a shelf placement similar to what the Dairy Bar has used in the past. Historically, the Dairy Bar has 2 rows of each milk fat type (i.e., skim milk, reduced fat, whole milk) with 5 half-gallons per row; from left to right, the order of the half-gallon milks is skim milk, reduced fat, and whole milk. For this study, we maintained a total of 2 rows of each milk fat type, with the left 3 rows used to display static label milk and the right 3 rows used to display the QR code milk. The milk was placed in the following order: skim static label, reduced fat static label, whole static label, skim QR code, reduced fat QR code, and whole QR code (Figure 1C). Additional measures taken to control the variables of the study included a daily check (at the start of each day) to ensure that an equal number of half-gallons containers with static labels and QR codes were present. Stockouts never occurred during the duration of the study, and Dairy Bar employees were instructed to maintain at least 3 half-gallon containers of milk per row throughout the day and restock if necessary. Dairy Bar employees were also specifically instructed not to remove any of the half-gallon milks from the shelf until the end of the day of the printed best-by date.

To inform potential customers of the new QR code labels, we placed an 8.5” by 11” color sign on the front of each display case with instructions to scan the QR code on the half-gallon milk container to get the best-by date. There was also a statement on the bottom of the sign that stated, “Help reduce food waste by choosing the carton with a best-by date that best fits your needs.” During phase 2 of the study, customers saw the same sign on the display case with the addition of a statement mentioning the potential discount and instructing them to show their screen to the cashier at checkout (see Figure 1B). For the QR code milk, the best-by date and price of the milk was communicated with the use of the QR code. During phase 1 of the study, when a customer scanned a QR code, it directed them to a website with a display that showed (1) the date and time at which the customer scanned the QR code, (2) the best-by date, and (3) a statement “Thank you for your contribution in helping reduce food waste.” During phase 2 of the study, customers saw the same display with the addition of a shelf-life dependent price displayed below the best-by date and above the “thank you” statement (see Figure 1C). For phase 2, we used 4 different price levels: the original price (i.e., the same price displayed on the static label milk) and 3 discounted prices. The discounting schedule was determined based on the following information. From a previous paper, the mean milk consumption for milk consumers per capita was approximately 9.82 fluid oz per day (Lau et al., 2022b). A half-gallon is approximately 64 fluid ounces so an average milk consumer would finish a half-gallon milk in 7 d. We therefore assumed that consumers would not consider the possibility of spoilage or waste when buying a half-gallon of milk unless the best-by date was less than a week away. Thus, the discounting began when there was less than 7 d from the best-by date, and we subdivided that into 3 periods: 5 to 6 d, 3 to 4 d, and less than 3 d from the best-by date. For each price level, we doubled the discount rate such that greatest discount would be in the fourth price level. The corresponding discount rates were 10%, 20%, and 40%, with the final prices being $2.87, $2.55, and $1.91, respectively.

Overall, our study showed broad consumer acceptance of QR code-based shelf-life labeling of milk as 62% of product sales, or a total of 79 QR code milk sales, across the 8 wk were half-gallon containers with QR codes. The proportion of QR code sales was slightly lower in phase 2 (32/61 or 52% of sales) as compared with...
This could indicate the existence of a novelty effect: as the novelty of the QR-code-based labeling “wore off,” consumers were less interested in using QR codes. Studies suggest that consumers’ perceptions of a new technology are strongest at the initial stages and will decay unless there is substantial variation between iterations of the technology (Hopp and Gangadharbatla, 2016). Similarly, it could be possible that the novelty of the waste reduction message could have worn off. The decreased proportion of QR code sales in phase 2 may also be an unintended consequence of dynamic pricing: The increased purchase complexity introduced in phase 2 (when discounts were implemented) may have deterred consumers from using the system, despite the potential savings.

Interestingly, despite a substantial number of QR code milk sales, the number of customer QR code scans was consistently lower than the number of sales. The overall proportion of QR code scans to QR code sales was 34% (27 QR scans/79 QR code milk sales), and a lower number of QR code scans than QR code sales was observed for each of the 8 wk of our study (Figure 3). In addition to the number of half-gallon containers sold with QR codes, we were also able to identify transactions in which a single customer purchased more than one half-gallon container at a time. Among all QR code containers sold, we only identified one such transaction (in this case 2 QR code containers were purchased, as supported by 2 QR code sales at the same time, in hours and minutes). Therefore, the substantially lower number of QR code scans as compared with QR code sales cannot be explained by events in which a consumer purchased multiple QR code milk products but only scanned one QR code, possibly under the misconception that such information would be representative of all containers purchased.

The observation of a greater number of QR code sales compared with QR code scans indicates that some consumers opted to purchase QR code milk without scanning the QR code on the half-gallon container. One possible reason for this occurrence is the existence of perceived value and trust around the QR code label. Shin et al. (2012) showed that perceived interactivity, the
ability of the QR code to provide information with minimum lag time, has an influence on the trust, behavior, and social support for consumers when using QR codes. Kim and Woo (2016) found both a positive effect on consumer attitudes in using QR codes and an understanding among consumers of the importance of QR codes in agriculture and food industries. Another possible explanation for this observation could be customer inattention. This is consistent with research that has shown that many consumers cannot recall the price of the items they placed in the shopping cart accurately or are inattentive to price changes (Dickson and Sawyer, 1990; Clerides and Courty, 2017). Despite the fact that signs were placed on both the retail refrigerator door and the half-gallon milk informing customers about the discount opportunity, customers may still have overlooked this information. Other possible reasons for the QR code scans and sales discrepancy may include a greater inherent trust of the half-gallon milk at this retail setting or that customers intended to drink the half-gallon milk in a period of time where the best-by date would not be of concern.

Despite the economic incentive offered in phase 2 of the pilot study, using the Mann-Whitney U test in R v 4.0.3 (R Core Team, 2020), there was no significant difference in the proportion of QR code scans \( (P = 0.54) \) or in the proportion of QR code sales \( (P = 0.88) \) between phase 1 and phase 2. Only 4 QR code milk sales from phase 2 of the study (12.5% of QR code sales during this phase) were purchased with a discount. It is important to note that the Dairy Bar staff was instructed to only apply a discount if the customer showed their phone screen to the cashier. Thus, some of the QR code milk sold may have qualified for a discount, but it may not have been applied due to a lack of customer participation. Customers also may not have taken advantage of the shelf-life dependent pricing in phase 2 of the study because of the additional effort required to scan each of the QR codes to determine the discount for each product. For example, Hansen et al. (2021) observed that having a reduced purchase price displayed on the shelf itself, without the need for customers to do additional work to determine the discount, was effective in increasing sales of aging item. They conducted a field study in a European grocery retail store that used electronic shelf label price tags and barcodes to facilitate price discounts of perishable products (e.g., breaded chicken, raw chicken, pre-cooked dishes) closer to the end of shelf-life. Even though the discounts increased the sales of aging items, they did find that the “hassle cost” of having to check multiple sell-by dates plays a role in customer purchase decisions. For example, when there were fewer items on the shelf, customers would choose the newer product due to a decreased hassle cost of inspecting all the products (Hansen et al., 2021). Overall, these findings suggest that dynamic shelf-life based pricing can increase sales of aging products, but the hassle costs of having to scan multiple packages to identify discounted products may impede its acceptance by consumers, particularly for low-cost items.

As our study collected separate time stamps for both QR code sales and QR code scans, we used these data to identify QR code scans that led to actual sales. We assumed that the sale of a QR code milk product within 5 min of scanning a particular QR code represented sales of that scanned product, which suggests that 48% (13/27) of QR code scans led to QR code milk sales. Conversely, this implies that 52% (14/27) of QR code scans did not lead to a subsequent sale, suggesting the need for follow-up studies to assess why some QR scans do not convert to sales.

Our study provides valuable initial evidence that some consumer segments are likely to accept QR code technology, which supports the potential of broader use of QR codes to provide information such as the best-by date in retail settings. This finding is also supported by at least one previous study that indicates that customers will pursue additional information about a product through a QR code (Li and Messer, 2019). Nonetheless, the customer base in our study (predominantly younger college students, as well as faculty and possibly university employees) may be more willing to use...
these technologies (and may be more concerned about food waste reduction) than the general public. Due to the nature of our study, we were unable to collect individual sociodemographic information to explore these potentially confounding factors. Substantial additional work is therefore needed in this area to confirm our results and explain those nuances. In particular, future studies in traditional retail setting with different customer segments are necessary to further characterize consumer reception to QR code technology for providing shelf-life related information. Importantly, our study also reinforces the need for further development of models that predict fluid milk shelf-life (Buehler et al., 2018; Lau et al., 2022a), as these models will be needed to provide dynamic shelf-life information that can be disclosed via QR codes.

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Notes

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