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# Emergence of Milk Dispensing Machines as a Retail Innovation in Kenya: Trends and Consumer Patterns

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## ABSTRACT

African food systems are transforming due to rapid urbanization, growing food demand, and shifting dietary patterns reflected in increased consumption of processed foods. In the informal–formal African market system, shifting consumption trends are linked to various food marketing innovations. This study investigated the emergence of processed milk dispensing machines (“milk ATMs”) in Kenya as a marketing innovation and their effect on consumption trends. Data was collected through surveying 162 ATM operators and 352 consumers and interviewing key informants. Findings indicate exponential growth of milk ATM enterprises, most (79%) of which are small, sole proprietorships. ATM milk is mostly purchased by low- and middle-income consumers, driven by affordability and convenience. ATM milk is 46% cheaper than packaged milk, but 15% more expensive than raw milk. However, perceived safety concerns deter some consumers from buying ATM milk. The study recommends scaling this inclusive business innovation but ensuring it delivers quality milk.


## KEYWORDS

ATM milk; consumer preferences; food environment; food system transformation; formal market; product safety

## Introduction

Over the past few decades, developing countries have experienced significant transformation of their food systems. A characteristic of this transformation is the changing food environment, reflected in reorganization of supply chains and efforts to expand and modernize agri-food retail markets to meet growing food demand and shifting consumption patterns toward more processed foods (Debela, Demmler, Klasen, & Qaim, 2020; Khonje & Qaim, 2019; McCullough, Pingali, & Stamoulis, 2010). According to Turner et al. (2018), the food environment is the interface that mediates people’s access to and consumption of food, indicated by key supply dimensions

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such as availability, price, vendor and product characteristics; and consumer dimensions such as affordability, desirability of food products, accessibility, and convenience. This is tied to socioeconomic factors such as household characteristics, including income levels and gender dimensions that influence decisions about food purchase and consumption.

Transformation of food systems in developing countries, characterized by diverse models and levels of modernized marketing, is driven by innovations that are both technological and institutional in nature (Blake et al., 2021; Constantinides et al., 2021; Hagen, 2003; Klerkx & Begemann, 2020). It has long been recognized that the evolution of and innovation in food retail marketing is an important contributor to economic growth in developing countries, reducing high cost of food and even shaping consumption patterns (Danse, Klerkx, Reintjes, Rabbinge, & Leeuwis, 2020; Hagen, 2003), for example through inclusive business models that pay attention to low-income market segments (Danse et al., 2020). The changing food environments are driven by trends such as demographic shifts, urbanization, rising incomes for some people even as poverty and food insecurity persist, changing dietary patterns, increased consumer concerns about food safety issues in the supply chain, and growing recognition of the importance of inclusive food systems (Danse et al., 2020; Gómez & Ricketts, 2013; Khonje & Qaim, 2019; Maestre, Poole, & Henson, 2017; Morgan, Hawkes, Dangour, & Lock, 2019). In the context of an informal–formal food market continuum, structured markets—such as supermarkets and other modern retailers—expand and seek to capture a growing share of the market, while traditional chains remain important. The traditional (informal) market system is characterized by fragmented supply chains operating in conditions with limited infrastructure, while the modernized, structured (formal) retail system is governed by more rules and regulations and features improved infrastructure (Berger & van Helvoirt, 2018; Maruyama, Wu, & Huang, 2016). Therefore, policies and regulatory frameworks will play a vital role in influencing consumer decisions about food selection, including those related to food safety (Muunda et al., 2021; Ralston, 1999).

Trends in food retail innovations, and how they relate to shifting consumption patterns and influence food systems transformation, are of increasing research interest but are still little understood in the African context. The argument is that to promote inclusive food systems that create food security and healthy diets for everyone, it is important to understand the linkages between the changing food environment, retail innovations and the emergent food business ecosystems, the related enabling and regulatory environment, and the effects on consumers (Khonje & Qaim, 2019; Nwuneli, 2021; Turner et al., 2018). The business ecosystem is the various organizations that come together and co-evolve their capabilities around

new innovations (Rinkinen & Harmaakorpi, 2018). Moreover, there is increased research and policy interest in the dynamic interplay of the expanding role of small and medium enterprises (SMEs) and large businesses in driving food systems transformation in the continent (Nwuneli, 2021; Reardon et al., 2021).

The vibrant Kenyan dairy industry is an interesting case for exploring such transformation of the food environment, especially related to shifts in milk marketing and effects on milk access and consumption. Kenya's per capita consumption of milk and dairy products is five times higher than the average of sub-Saharan African countries, and the demand is projected to double by 2030 compared to 2010 (Kenya Dairy Board [KDB], 2016; Ministry of Agriculture, Livestock & Fisheries [MoALF], 2010). About 70% of the marketed milk is traded through informal channels, mostly as raw milk, which raises food safety concerns (KDB, 2016). The remaining 30% is processed into milk and dairy products and is traded through formal markets. The formal channel has grown slowly, although the ambition expressed in key sector policies is to expand the formal market share (KDB, 2016; MoALF, 2013). This has resulted in calls for diverse approaches to an inclusive upgrade of the informal sector that will expand quality and safety-driven development with appropriate safeguards, although there are competing perspectives on the best approach to realize this ambition (Alonso & Grace, 2018; Makoni, Mwai, Redda, van der Zijpp, & van der Lee, 2014). Ongoing efforts to accelerate the transition toward a competitive, formal and quality-driven industry has stimulated exploration of innovation and investment opportunities for sustainable and inclusive sector development around supply chain organization, product development, and enterprise and marketing innovation (Kariuki, Kihoro, & Iravo, 2018; Ndambi et al., 2018).

One emerging retailing innovation is the milk-dispensing machine (popularly known as "milk ATM"). Milk ATMs are placed in strategic market locations and sell chilled, pasteurized milk (Bebe, Van der Lee, & Kilelu, 2020; Kariuki et al., 2018; Kosgey, Shitandi, & Marion, 2018; see photos with examples of milk ATMs in [supplementary material 1](#)). The use of milk-dispensing technology has been noted in other regions, especially Europe, as a retail option for shortening the milk supply chain and promoting environmental sustainability (Mikulec et al., 2019; Pannella et al., 2019; Pereira, Villanueva-Rey, Vence, Moreira, & Feijóo, 2018). According to the Kenya Dairy Board (KDB), milk ATM businesses have grown exponentially from 3 in 2005 to 1,550 in 2018 across various regions in the country (KDB, 2016). The spread of milk ATMs in Kenya has provided business opportunities to entrepreneurs in peri-urban and urban locations, providing consumers with an additional option of accessing processed milk. This emerging market is regulated by KDB but gaps in standards and

regulations exist, highlighting the need for evidence-based insights on how to address them. In Kenya, there are regulations and guidelines on milk safety, exclusive sale of pasteurized milk, required temperature of ATM milk, machine standards, and skills of ATM operators (the people who run the daily operation of ATMs such as refilling, cleaning, dispensing) (Smallholder Dairy Commercialisation Program, 2018). However, there has been limited coordination and surveillance over these businesses, leading to poor compliance with operating standards by operators (Kevin, Njue, & Abong, 2021; Kosgey et al., 2018).

Recent studies highlight the growth of this retail market, indicating the opportunities and limitations of innovation in contributing to the growth of the formal milk market share. Bebe et al. (2020) point out that price, consistent availability, hygienic premises and traceability attract consumers to purchase ATM milk. Bebe et al. (2020) and Nyokabi et al. (2021) stress that quality of milk in all retail channels needs to be more strictly enforced. Across various retail channels in Kenya, adulteration is a common problem in milk marketing (Bebe et al., 2020; Wanjala, Mathooko, Kutima, & Mathara, 2017). According to Nyokabi et al. (2021), adulteration affects the composition and processing quality of milk, with implications for its hygienic and nutritional quality.

However, there is limited systematic analysis looking at how or whether this growing retail innovation has affected milk marketing, consumer perceptions, and consumption patterns. In response to this gap, this study aimed to assess how the evolving ATM milk supply chain is shaping the food environment with regard to milk access and consumption patterns in the Kenyan market.

## **Materials and methods**

The study used a cross-sectional research design to assess the current trends, purchasing patterns, and food safety issues in the milk ATM supply chain. Data was collected using a mixed-methods approach, including key informant interviews and two surveys targeting consumers and milk ATM operators.

### **Study area**

The study was conducted in the six Kenyan counties with the highest density of registered milk ATMs, according to data supplied by the KDB for 2018: Nairobi County (48% of all ATMs), Kiambu County (15%), Nakuru County (11%), Kajiado County (7%), Uasin Gishu County (6%), and Machakos County (5%). The remaining counties not included in this study accounted for 9% of the ATMs.

### ***Sampling of ATM operators***

As a first step, the target sample proportion was set at 20% of all ATM businesses (i.e., businesses that sell milk using a dispenser, sometimes also selling other commodities) in the selected counties as noted above. Secondly, within the selected counties, towns with high ATM concentrations were selected, based on KDB data for 2018. Thirdly, the towns were subdivided into location clusters, considering a general distribution of consumers based on their income status (low, medium, and high income). A medium-income location was assumed to have most of its residents earning Kenyan shilling (KES) 20,000–49,999 (approx. USD 200–500) per month, while most residents in low-income and high-income locations earned less or more than the middle-income earners respectively. The income bands were derived from an overview of salary guidelines provided by Kenyan labor laws and regulations of wages (The Labour Institutions Act, 2007).

### ***Sampling of consumers***

The sampling of consumers followed a multistage sampling technique based on the sampled milk ATMs in Section “Sampling of ATM operators.” From the 162 sampled milk ATMs, consumers were sampled proportionate to the number of sampled milk ATMs in each county. Finally, consumers were randomly selected at the milk ATM business premises (the building where an ATM business is run) by picking every fifth consumer regardless of the type of milk being bought, until the target sample size was attained. Across all the counties, 490 consumers agreed to be interviewed. From 490 interviews, 352 responses (where respondents were household heads) were retained for further analysis due to data completeness, especially about financial information and household management decisions. The sample distribution is presented in Table 1.

### ***Identification of key informants***

Thirty-eight key informants were identified and interviewed using interview guides. They were purposively selected through snowballing, based on their

**Table 1.** Sample size distribution.

Counties	No. of registered milk ATM* businesses	No. of sampled milk ATM businesses (20%)	Number of household heads interviewed
Nairobi	420	84	231
Nakuru	101	20	34
Kajiado	58	12	14
Machakos	45	9	18
Uasin Gishu	49	10	18
Kiambu	132	27	37
Total	805	162	352

\*Registered with the Kenya Dairy Board

involvement in various aspects of the milk ATM supply chain, business operations and regulatory issues. The key informants interviewed were suppliers of milk to ATMs ( $n=17$ ), suppliers of ATM machines ( $n=9$ ), KDB inspectors at county level ( $n=5$ ), KDB officials at the headquarters ( $n=1$ ), and county public health officials ( $n=6$ ). Regional coverage was taken into consideration during the identification of the interviewers.

### **Data collection and analysis**

The survey for ATM operators had five sections: the business characteristics (ownership, location, rental arrangement, operation duration, products sold, etc.), the ATM machine (acquisition, cost, capacity, technologies, after-sales services, etc.), milk sale (quantities, prices, peak and off-peak periods, etc.), milk handling (cleaning method, detergents, etc.), and operation practices (milk sourcing, pasteurization, maintenance of milk, etc.) (see [supplementary material 1](#) for the detailed questionnaire). The survey for consumers also had five sections: respondent characteristics (age, gender, education level, occupation, etc.), household characteristics (family members), milk consumption (purchase quantities, purchase frequency, purpose of purchase, etc.), ATM milk purchase (frequency, volumes, etc.) and perceptions about ATM milk and licensing (see [supplementary material 2](#) for the detailed questionnaire). The Open Data Kit platform, a mobile (Android) phone application, was used for quantitative data collection. Prior to data collection, tools were pretested by well-trained enumerators and relevant corrections made. Statistical analysis was conducted using Stata 16 and Excel 2013 software for the consumer and milk ATM operator surveys. The analysis included descriptive (percentages, means, minimum, maximum) and inferential statistics (F-stat, *Chi-square*). Data were disaggregated by gender and income groups.

Qualitative data from the key informant interviews was recorded and transcribed. The interview covered a wide range of themes related to ATM operations, the business ecosystems that have emerged, drivers of growth and regulatory and policy issues. The transcripts were all coded in Excel using thematic coding and then analyzed using NVIVO.

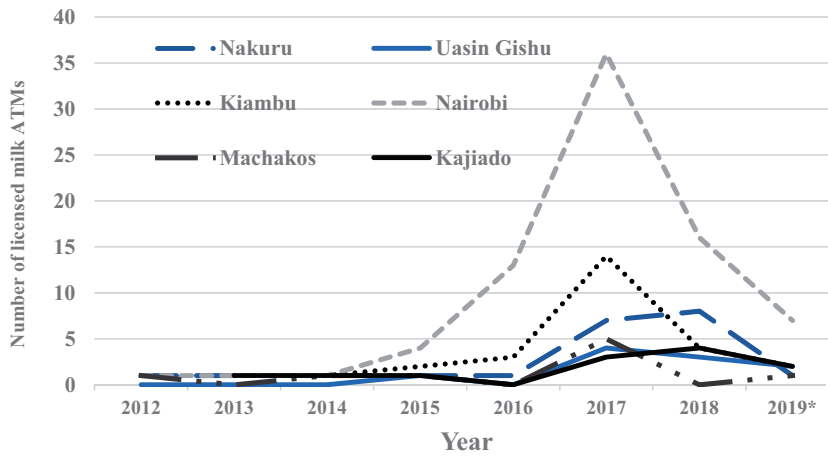
## **Results**

### **ATM market trends**

#### **ATM spread over time and space**

Survey data indicates growth in establishment of milk ATM businesses across the major urban centers in Kenya ([Figure 1](#)), confirming the trend noted by the KDB. There were few ATMs in Kenya until 2012, then from 2015 onwards their numbers steadily increased. According to the KDB,





**Figure 1.** Annual trends in newly licensed milk ATMs per county across Kenya. *Source:* ATM operators' survey.

based on key informant interviews, the number of ATM businesses fell from 2018. This was linked to a suspension in annual operating licenses being issued, to address some regulatory gaps and challenges that were observed in the operation of some businesses.

#### ***Types of ATM business models***

About 21% of ATMs were located in supermarkets and 79% in other business premises (either stand-alone or as part of a mixed retail shop). The majority (86%) of ATMs operated from rented premises, while 7% operated from their own premises and 7% were anchored in business premises (mainly supermarkets) and paid a commission on sales volume to the anchor business. The ownership structure of milk ATM businesses was diverse, with most (79%) owned by sole proprietors as small enterprises, 17% owned by companies, 3% by partnerships (an arrangement between two or more people who run the ATM business and share profits and liabilities), and 1% by dairy cooperatives. A minority of milk ATM owners (18%) operated several machines in different locations, but most (82%) ran a single machine. Of the sampled ATM businesses, 34% employed only female milk ATM operators, 47% employed only male operators, and 19% employed both male and female operators.

#### ***ATM milk pricing across regions and compared to other milk products***

ATM milk was priced differently across the geographical regions, with the average retail price per liter ranging from KES 60.5 (approx. USD 0.6) (Kajiado) to KES 70.6 (approx. USD 0.7) (Machakos) with a mean of KES 63.4 (approx. 0.6 USD) (Table 2), with differences being significant



**Table 2.** ATM average purchasing and selling milk prices (KES/liter) across regions and distance to milk supplier ( $n = 162$ ).

	Nakuru	Uasin Gishu	Kiambu	Nairobi	Machakos	Kajiado	Overall	F statistics
Price of ATM milk (a)	63.2 (4.1)	62.5 (4.2)	61.8 (3.7)	63.9 (4.0)	70.6 (3.5)	60.5 (5.6)	63.4 (4.5)	2.12*
Purchasing price of ATM milk from main supplier (b)	49.7 (8.2)	49.2 (8.5)	52.9 (8.6)	52.5 (3.5)	57.1 (3.4)	50.1 (6.2)	50.9 (6.1)	4.37**
ATM business margin (a – b)	13.5 (6.6)	13.3 (7.6)	8.9 (7.1)	11.4 (4.1)	13.5 (4.6)	10.4 (2.2)	12.5 (5.4)	4.00*
Distance to main milk supplier (driving minutes)	41.2 (23.5)	25.0 (15.2)	61.3 (49.6)	90.4 (47.0)	210.0 (34.6)	106.7 (54.0)	78.3 (47.4)	8.51**

\* and \*\* indicate a statistical difference at the  $p < 0.05$  and  $p < 0.01$  levels respectively. Figures in parentheses are standard deviations. 100 KES  $\approx$  1 USD.

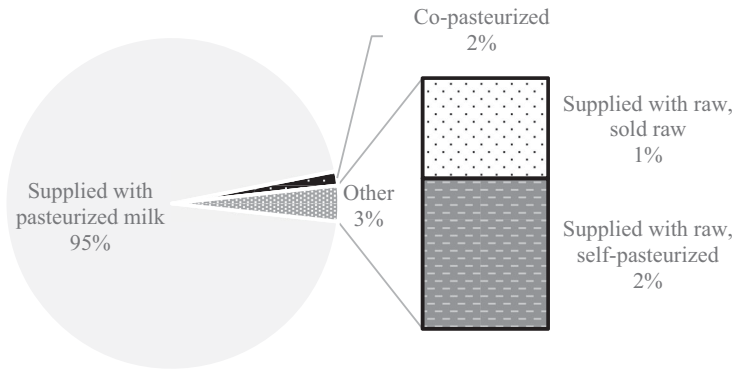
**Table 3.** Price comparison between ATM milk and other milk market segments.

	Mean	SD	Minimum	Maximum
Price of UHT milk per liter ( $n = 162$ )	109.7	12.0	94.0	150.0
Price of packaged pasteurized milk per liter ( $n = 46$ )	92.9	17.1	88.0	120.0
Retail price of raw milk per liter ( $n = 34$ )	53.8	10.4	35.0	70.0
Price of ATM milk per liter ( $n = 162$ )	63.4	4.5	50.0	80.0

Source: ATM operator survey and Key Informant Interviews. 100 KES  $\approx$  1 USD.

( $p < 0.1$ ). ATM operators purchased milk from suppliers at an average price of about KES 51, with the highest price in Machakos (KES 57.1) and lowest in Uasin Gishu (KES 49.2). The ATM business margin also differed significantly ( $p < 0.1$ ), with higher margins per liter recorded in Machakos and Nakuru, at KES 13.5. In terms of distance between the ATMs and their main milk supplier, the longest distance was in Machakos (210 driving minutes), while the shortest was in Uasin Gishu (25 driving minutes). The distance was measured in driving minutes to capture the differences in road infrastructure and traffic conditions between the business premises and the milk pasteurizing facilities. Machakos County—which had the highest mean retail price for milk—also had the most driving minutes to main supplies, and their businesses made the highest profit margin.

Table 3 presents the average retail price of ATM and other different milk products in the market. The average price of ultraheat-treated (UHT) milk was highest (KES 109.7 per liter), approximately 73% more expensive than milk sold through ATMs (KES 63.4), while that of pasteurized packaged milk was KES 92.9, approximately 47% more expensive than ATM milk. On the other hand, raw milk, that is sold informally by traders was priced at an average of KES 53.8, which is 15% cheaper than ATM milk.



**Figure 2.** Nature of milk supplied to ATM operators, as percentage of ATM operators ( $n = 162$ ).

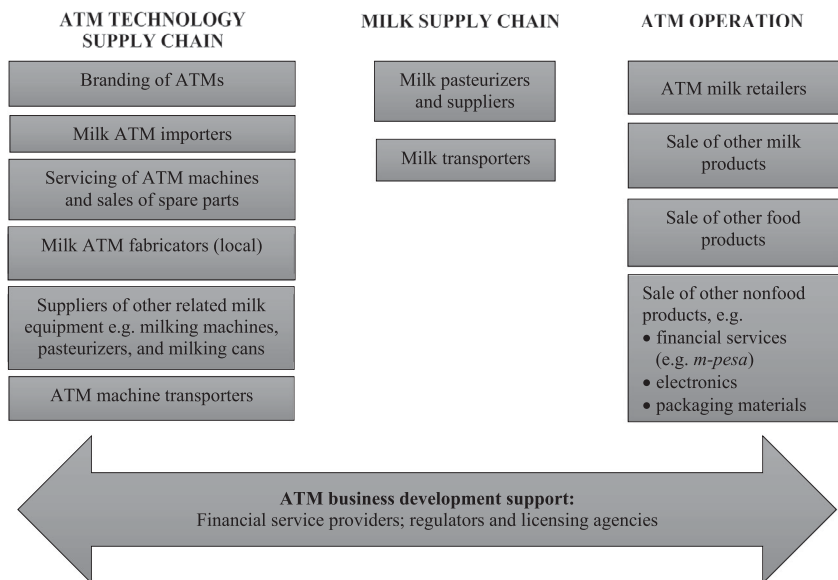
### ***ATM milk supply chains***

According to the survey, ATM operators sourced milk through different channels (Figure 2). Most operators (95%) purchased already-pasteurized milk from various sources. These sources included mini-dairies/processors (40%), major processors (26%) and farmer cooperatives (29%). The major processors are large dairy firms with extensive penetration of the national domestic market, while mini-processors are small firms with limited penetration, concentrating their business in local markets. Four percent of ATM operators sourced raw milk and pasteurized it themselves or hired the services of an independent pasteurizer (called co-pasteurization). New milk pasteurization businesses have emerged that offer independent pasteurization services at KES 5–6/liter. A very small percentage (1%) of ATM operators indicated that they sold their milk raw, which is against regulations.

According to interviews with ATM milk suppliers, pasteurized milk is typically delivered to ATM businesses in 50 liter cans. The operator survey findings indicated that 84% of suppliers used sealed aluminum cans to ensure quality of milk, while the remaining 15% used unsealed aluminum cans. Findings further revealed that only 1% of the businesses received milk using the recommended tamperproof milk cans that were recently introduced in the Kenyan market. The tamperproof cans have seals that safeguard the milk's integrity from any compromise. Operators' survey results further indicate that 31% of operators stored ATM milk at temperatures higher than 4 °C.

### ***Business ecosystem around ATM milk***

The emergence of the ATM retail model has triggered the evolution of a dynamic business ecosystem around it (Figure 3). Based on key informant interviews, this ATM milk business ecosystem has three facets: ATM technology supply, milk supply to the ATM operators, and ATM operations (retail level). On the ATM technology supply side, the main business



**Figure 3.** Business ecosystem of milk ATMs. *Source:* Key Informant Interview data.

development has been around local manufacturing of milk ATMs, the sale of ATMs to ATM businesses, servicing of the ATM machines at intervals of 2–5 months, branding of the ATMs, sale of other milk equipment and milk cans (including tamperproof cans), and sale of milk pasteurizing equipment to pasteurization businesses.

At the ATM operator level, a few (16%) sold ATM milk only, but most (84%) also sold other milk products (e.g., yogurt and buttermilk, known locally as *mala*), nondairy food products (e.g., eggs and bread), and non-food products and financial services such as mobile financial services, known locally as *m-pesa*, and small electronic devices. On the milk supply side, businesses have developed around milk supply, transportation, and pasteurization services.

### **Consumption patterns and perceptions related to ATM milk**

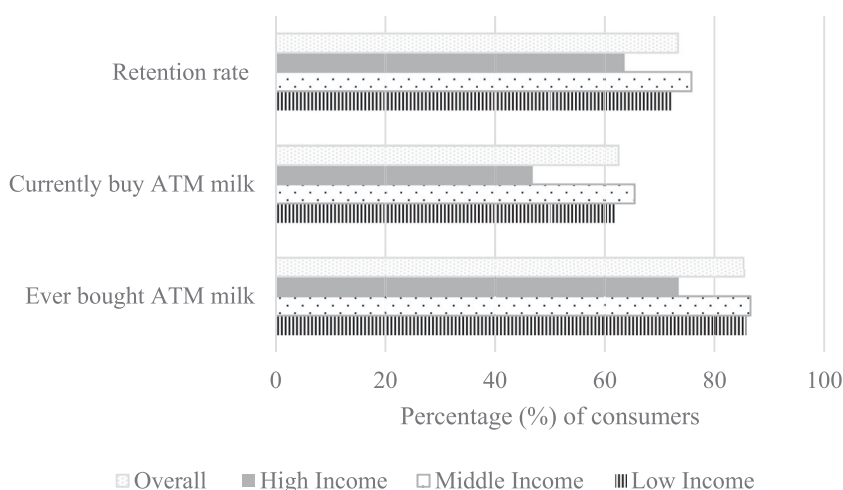
#### **Consumer purchase patterns by income level**

In terms of income, 52% of the 352 consumers interviewed were low-income earners, 42% were middle-income earners, and 6% were high-income earners. The high number of low- and middle-income consumers is linked to them being most likely to purchase ATM milk and therefore more commonly found around the ATM businesses. Table 4 presents results of purchasing patterns for different types of milk by households in these income categories, based on if they had ever purchased raw, ATM and packaged milk in the previous year (multiples responses possible). People categorized as high-income earners only purchased packaged and

**Table 4.** Type of milk purchased in the past year (%) by income category ( $n = 352$ ).

	Low income	Middle income	High income	Overall	Chi <sup>2</sup>	Pr
Raw milk	22.3	23.6	13.3	22.6	0.81	0.668
Packaged milk	83.5	85.5	80.0	84.1	0.38	0.826
ATM milk	85.6	86.4	73.3	85.2	1.82	0.404

Source: Consumer survey.

**Figure 4.** Consumer purchasing patterns of ATM milk (%) ( $n = 352$ ).

ATM milk, while those in low- and middle-income categories purchased all milk types. In all income categories, ATM milk was purchased alongside packaged milk. From the overall sample, about 17% of consumers purchased raw milk. No differences were observed in raw milk purchasing between low- and middle-income groups.

The consumer purchasing patterns of ATM milk were broken down by income bands. Figure 4 shows that the number of consumers reporting that they currently purchase ATM milk is lower than those who have ever purchased it, across all income brackets, resulting in an average retention rate of 73%.

#### *Consumer purchase patterns by gender and education level*

The consumer survey revealed that milk purchasing decisions were made mostly by women (56%). Approximately 95% of all households purchased milk regularly (daily or at least once every two days), with female decision-makers in the households purchasing milk slightly more regularly than male decision-makers (97% vs. 92%).

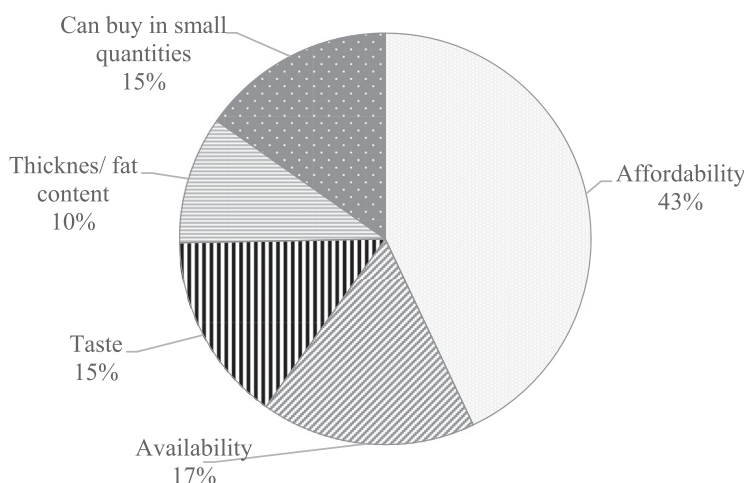
The purchasing pattern of milk types varied, based on the gender of the decision-maker (Table 5), with men buying more raw milk than women. About 25% of households with male decision-makers purchased raw milk,

**Table 5.** Type of milk purchased in the past year (%) by gender of decision-maker ( $n = 352$ ).

	Male	Female	Overall	Chi <sup>2</sup>	Pr
Raw milk	25.0	18.9	21.6	1.92	0.165
Packaged processed milk	79.5	86.2	83.2	2.83	0.093
ATM milk	76.3	85.2	81.3	4.54	0.033*

Source: Consumer survey.

Note: \* indicates significance at 5%.

**Figure 5.** Drivers for consumers' purchase of ATM milk ( $n = 286$ ).

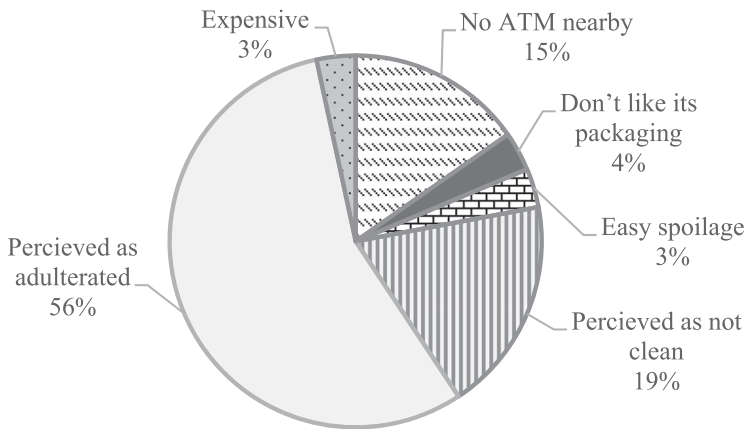
compared to 19% in households with female decision-makers. Further, 85% of households with female decision-makers did purchase ATM milk in the past year, compared to 76% of households with male decision-makers. There was a significant relationship between the gender of the decision-maker and purchase of ATM milk at 5% significance level.

#### **Main drivers for ATM milk purchase decisions**

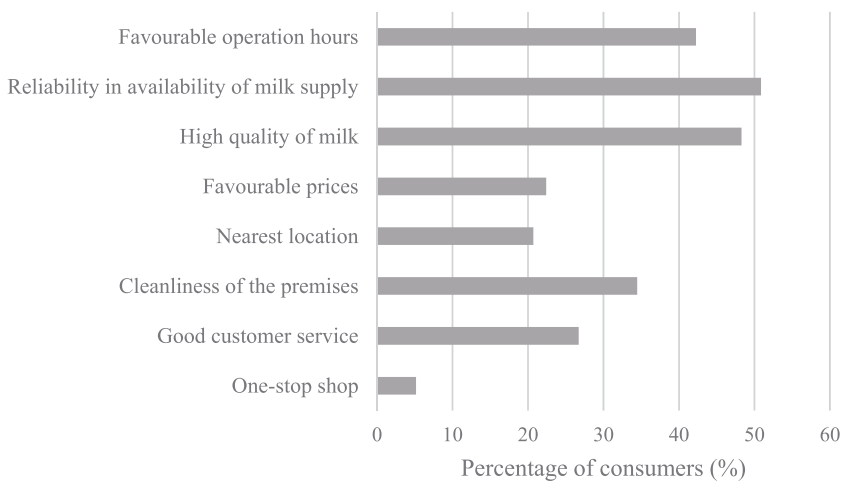
For consumers currently purchasing ATM milk, the most notable driver (multiple responses were not possible) for this purchase decision was affordability (43%) (Figure 5). Other reasons were its availability (17%), flexibility in quantity purchasable (15%), consumer preference for the taste of ATM milk (15%), and perception of its thickness/fat content (10%).

Several reasons were noted by consumers who do not purchase or stopped purchasing ATM milk (Figure 6). The majority (56%) perceived ATM milk to be adulterated, 19% of the consumers considered it not clean, while 15% were deterred by not having an ATM nearby.

Figure 7 presents factors that consumers consider when choosing which ATM point to purchase milk from. Most consumers consider reliability in



**Figure 6.** Reasons consumers do not purchase ATM milk ( $n = 66$ ).



**Figure 7.** Factors consumers consider when choosing the point of ATM milk purchase ( $n = 352$ ).

the availability of milk (51%) (i.e., the ATM always has milk in stock) and perception of quality (48%).

Table 6 presents the main quality concerns consumers expressed about ATM milk. Adulteration of milk with water was the most reported concern (28%); then cleanliness of the ATM machines, premises and milk handler (22%); hygiene in milk handling (16%); and adulteration of ATM milk with preservatives and other chemicals (15%). Based on the key informant interviews, the most common form of adulteration reported was the addition of water to milk to increase its volume, hence increasing the profit margin of the business.

**Table 6.** Quality issues consumers perceive about ATM milk ( $n = 352$ ).

Quality concern	Percentage
ATM milk easily gets spoiled	5
ATM milk has a bad taste	7
ATM milk has preservatives and chemicals	15
ATM milk is adulterated with water	28
Cleanliness of ATM machine, premises and handler	22
Lack of trust (not knowing milk source, not trusting operators)	6
Unhygienic handling	16
Uncertainty if ATM milk is pasteurized	1

## Discussion

### *Milk ATM business expansion and an emerging business ecosystem*

The number of milk ATM retail businesses in Kenya has exponentially increased over the last decade. The general trend shows earlier onset and growth—and hence higher concentration—of ATMs in Nairobi, the densely populated capital city, and neighboring Kiambu County. The business model is steadily spreading to towns in other counties. ATM milk has a price advantage over other processed milk products, but raw milk has the lowest price and is the main competitor that can impede growth of ATM business. Bebe et al. (2020) attributed the relatively lower price of ATM milk to the elimination of the packaging costs and reduced sales monitoring costs because of automated business transactions. Differences in ATM milk prices across different counties can be mostly attributed to the distance between the production area and the sales point. In Machakos, milk sold within the county was produced and processed outside the county, as reflected by a high supply price of KES 57 per liter and the longer distances (210 driving minutes) to ATM milk suppliers. Operators' proximity to suppliers has been associated with reduced food miles linked with shorter supply chains (through transportation, storage, and energy), so it can be argued that milk ATMs are enhancing environmental benefits in the sector (Pereira et al., 2018).

The increase in demand for milk ATMs is spawning a business ecosystem for the assembly, supply and maintenance of the machines themselves and the pasteurization of milk and its supply to milk ATM retail businesses. The growth of the milk ATM market has also led to a shift from the initial reliance on imported technology toward more locally fabricated machines. These are assembled with imported parts like sensors and ATM dispensing pads, while the main frame—which is the cooling chamber—is built with locally manufactured material. This price of production and hence the purchase price of these machines has fallen, an important factor in the growth of milk ATM businesses. It has also stimulated the development and expansion of a fabrication and manufacturing industrial cluster. In addition to fabrication of milk ATMs, other businesses that have



emerged include milk pasteurization, transportation, cooling systems, milk-handling equipment, servicing of the machines and sale of spare parts. Network structures are evolving within the milk ATM ecosystem that are important in influencing the supply chain performance and development. Examples include co-pasteurization, ATM machine support services, and supply of milk to ATM enterprises. Thus, a self-organizing network of businesses is emerging and building different capacities that anchor the milk ATM retail innovation (Rinkinen & Harmaakorpi, 2018). Bonamigo, Ferenhof, and Forcellini (2016) note that such network structures and interactions between actors are important in co-creating value and growing a business platform.

The KDB is responsible for regulating the milk industry in Kenya. This study indicates that compliance with the regulation that all ATM milk must be pasteurized is very high. However, the lack of standards regulating ATM machine fabrication has resulted in locally fabricated machines being of low quality. All ATM enterprises need a number of licenses: a county government operating license, a public health certificate, an operator food-handling certificate, and a KDB permit. These are intended to assure the safety of milk and a good business operating environment, but ATM owners have found them too onerous. As a result, the KDB suspended its issue of annual operating licenses for ATM businesses so it could urgently address a gap in its regulation of this sector. Previous studies (Muunda et al., 2021; Ralston, 1999) linked policy and regulatory frameworks to food prices and food distribution, alongside influencing food safety and affecting consumer awareness, which affects consumer food choices.

### ***Consumer perspectives and influence of ATM milk growth***

ATM milk is being purchased by consumers with different income levels, although the majority of those sampled were from low- and middle-income groups. The main value proposition for ATM milk relates to affordability, convenience, and flexibility. However, for consumers who had stopped purchasing ATM milk, the decision was attributed to perceptions around quality of ATM milk, including spoilage, and observed poor hygiene practices of the ATM operator. High-income earners had the lowest retention rate of ATM milk purchasing, while the highest retention rate was observed among medium-income earners. Mtimet and Karugia (2020) also found that milk ATMs provide low- and middle-income consumers with access to processed milk in urban and peri-urban areas in Kenya because of the relatively lower prices.

Food safety and quality concerns are increasingly important considerations for consumers and increasingly influence food enterprises and

markets when food systems transform (Ortega & Tschirley, 2017). Next to affordability and convenience factors, this study showed that milk quality and cleanliness of premises are important factors in choice of milk outlet (28% and 22% respectively). This confirms the findings of previous studies (Gido, Ayuya, Owuor, & Bokelmann, 2016; Godic Torkar et al., 2017; Ortega & Tschirley, 2017) in which product quality influenced consumers' food and milk purchase decisions in other European and African countries. Some consumers (6%) were concerned that they did not know or trust the milk source, implying that providing information on the supplier could boost consumers' confidence of ATM milk. Bekele, Beuving, and Ruben (2017) also found that many consumers did not trust the quality of milk from retail outlets in Ethiopia, and therefore most consumers boiled the milk before consumption. Considering that the ATM milk sector is growing, building trust among stakeholders can help increase milk demand.

An important aspect of food safety for milk is the storage temperature, which is recommended to be 4 °C (Pannella et al., 2019; Porcellato et al., 2018). However, 31% of milk operators stored ATM milk at higher temperatures than recommended. Storing milk at temperatures above 4 °C favors microbial growth and increases enzymatic activities (Mikulec et al., 2019; Pannella et al., 2019; Porcellato et al., 2018). As temperature is an important determinant for milk safety, Godic Torkar et al. (2017) recommend temperature readings are displayed in retail outlets and consumer awareness created on the effect of uncontrolled milk temperature. Policy and regulatory frameworks in Kenya could adopt such recommendations.

## Conclusions

This study has shown how the increase in milk ATMs as a retail innovation is altering the food environment in relation to access to milk, thus shifting consumer trends in Kenya. Milk ATM businesses provide an alternative for consumers to access milk that is relatively cheaper than other pasteurized milk products. Urbanization is an important driver of the growth of ATMs, linked to the spread of these businesses from the main capital city to its peri-urban regions and other growing towns. This study shows that the ATM milk market segment is mainly attractive to low- and middle-income consumers, with gender being an important factor, as more women than men purchase ATM milk. The sampled consumers reveal that consumer purchase decisions of ATM milk are affected by affordability, availability, and convenience; as well as by concerns about quality, especially adulteration, cleanliness of the ATM machines and premises, and hygiene in milk handling along the ATM milk supply chain. The milk ATM market segment has the potential to be a game changer in the expanding and

inclusive formal milk market if supported with relevant policy and regulations. The Government of Kenya could fast-track policy and regulations to guide the sector and improve consumer confidence. This study shows that ATM milk sells at a lower price than packaged milk and, just as in other retail channels, food safety hazards occur along the supply chain. To enhance safe milk handling along the ATM milk supply chain, the ATM business operators—supported by the Government of Kenya, consumer organizations and other stakeholders—need to enhance responsible behavior along the supply chain. This may be bolstered by labeling and effective traceability systems, which will require the development and deployment of standard operating procedures at the different nodes of the supply chain. Sensitizing consumers and assuring them of quality would improve the market prospects for ATM milk while ensuring a lower price of ATM milk along the supply chain. This can be enhanced by building sustainable network structures that self-regulate the ATM business ecosystems. KDB needs to strengthen its capacity in terms of enforcement officers, data management systems, ATM milk traceability systems, and appropriate systems for registering and monitoring ATMs.

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## Disclosure statement

No potential conflict of interest was reported by the author(s).

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