

REVIEW

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Pathways towards food sector sustainability: the case of vending

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Abstract

This paper reviews the literature on sustainability in the food vending industry to understand whether: (1) the topic of sustainable development is addressed at the academic level when it comes to the sector; (2) whether or not the industry is on the right track towards sustainability, considering only academic knowledge; and (3) what might be useful topics for its development. To this end, 71 articles were analysed using Scopus as a database. The results indicate a rather fragmented situation and a clear prevalence of studies focussed on social and nutritional issues, leaving little room for environmental or circular economy-related issues. However, the analysis also revealed that the field holds potential for sustainable transformation in the agri-business sector. Future studies could use this review as a springboard for further investigation.

Keywords: Vending, Sustainable development, Sustainability, Circular economy, Food

Introduction

In 2015, the largest-ever study and action programme on environmental, social and economic problems, Agenda 2030, was formalised in New York (United Nations 2015). Still ongoing, the programme aims to reframe current economic and industrial models by redesigning them by 2030 with consideration given to Earth's biological and ecological cycles, efficient and equitable organisation and distribution of resources, and people's social needs in attaining a sustainable and equitable life (Daly & Farley 2011; Raworth 2018). One of the economic sectors that urgently needs a new model aligned with these principles is food (FAO 2018). Rising obesity levels (Abdeen et al. 2017), persistent poverty, inequality and unemployment (ILO 2018), increased scarcity and diminished quality of land and water resources (Amundson et al. 2015; Notarnicola et al. 2017) contribute to the entire food sector's high unsustainability level (FAO 2018), which is why such sustainability issues are at the core of Agenda 2030 and are addressed in the United Nations' Sustainable Development Goals (SDGs) (FAO 2017). To prepare the food sector for a sustainable transition, it is imperative to identify industrial sectors that have the potential to make significant environmental and social impacts, then redesign and adapt them to sustainability principles. Vending is one such sector that ought to be reconsidered and redesigned for the future.

The vending sector is nested within food supply chains, and its role is to provide low-cost food and beverages for immediate consumption. Although other retail services exist (e.g. supermarkets, small grocery stores, and coffee shops), vending has two unique characteristics: It is widespread within public, private and hybrid spaces, and it provides, through vending machines, quick and easy access to different types of food and beverages while meeting consumer needs. The vending sector's ability to reach any geographic region to provide people with what they want, when they want it, has created considerable economic gains. It is estimated that total food vending industry revenue in Europe and the USA in 2019 reached €17 billion (EVA 2020) and \$24 billion (Montano 2021), respectively. Hot beverage sales represent the driving force in Europe, accounting for nearly €11 billion in revenue, followed by cold beverages, snacks and other food (EVA 2021). The statistics are different in the USA, where the driving force is the sale of cold beverages, followed by snacks, candies, confections, health products, other food, hot beverages, ice cream and other consumables (Montano 2021). Overall, in less than 10 years (from 2011 to 2019), both the European and US markets significantly expanded their offerings in a higher number of public and private sites, increasing, in turn, their respective revenues by 21% and 24%. However, the COVID-19 pandemic heavily affected the entire sector through closure of sales channels, eliciting significant decreases in sales and profits. It is estimated that in 2020, total revenue in Europe and the USA dropped by 30% (VendingMarketWatch 2021) and 45% (Montano 2021), respectively, compared with 2019.

This severe blow inflicted on the sector has forced many vending companies to scale back their activity temporarily and set up a new business model capable of cushioning crises further, thereby transforming them for the future. A topic that recently has emerged in Europe (EVA 2021) and globally is the greater attention paid to business aspects related to sustainability. Despite past implementation of several initiatives, the role that vending can play in societal sustainable development remains uncertain and little discussed at the academic level. Therefore, this paper aims to analyse the existing scientific literature on the topic and answer the following questions:

- QA Is the academic community addressing the topic of sustainability in the vending industry?
- QB Is the vending industry on the right track for sustainable development?
- QC What issues should be examined to help facilitate the vending industry's sustainable development?

The first question aims to provide an exploratory overview of the academic interest in sustainability within the sector, identifying areas that have been investigated. The second question's objective is to discuss, in depth, various aspects related to the areas that emerged in the first question and try to reconstruct the logical and conceptual thread that unites various studies and provide a summary of what has been accomplished so far. Finally, the third question identifies some thematic areas that merit further examination in the future to help develop the sector.

Materials and methods

This study followed Denyer and Tranfield’s (2009) systematic literature review (SLR) approach. An SLR adheres to the basic principles of being systematic, transparent, replicable and synthesisable, (Tranfield et al. 2003) and includes five consecutive steps (Fig. 1):

- (1) Research question formulation
- (2) Study detection
- (3) Study selection and evaluation
- (4) Data synthesis and analysis
- (5) Results reporting and application

After formulating the research questions presented above, scientific papers were screened in 2023 to identify relevant studies in vending sector fields. The Scopus database was used as the main resource for the articles.

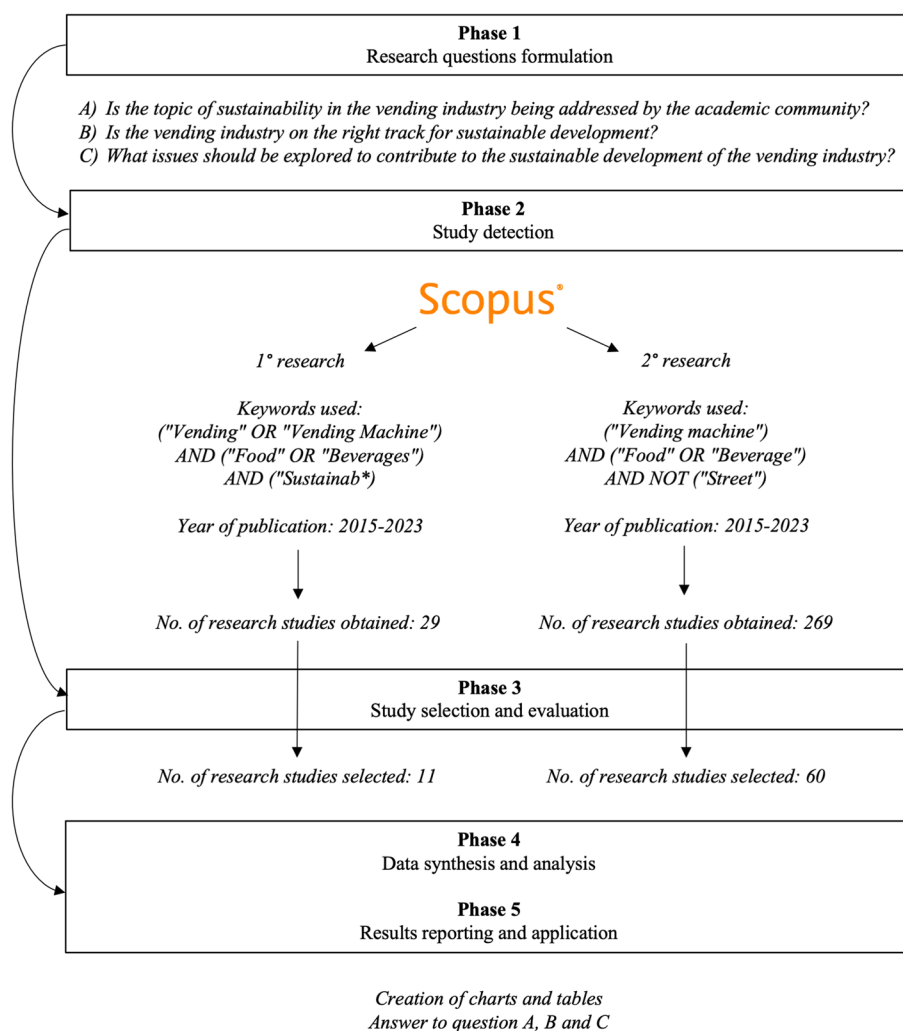


Fig. 1 Flowchart of the search procedure used

To identify the most relevant documents efficiently and effectively, five search keywords were used: ('Vending ' OR 'Vending Machine ') AND ('Food ' OR 'Beverages ') AND ('Sustainab*'). These search criteria yielded an initial sample of 49 documents. To reduce the number of sources, only scientific articles published during the 2015–2023 period were selected, while conference papers, reviews and book chapters were excluded, thereby reducing the sample size to 29. In the next step, all abstracts from the 29 selected articles were read to ensure that the scientific studies dealt with sustainable development and vending machines. Only articles that directly analysed vending machines' role in certain sustainable aspects were considered. Thus, all articles that dealt with other topics—such as mobile vending, technological innovations in vending machines, development of reverse vending machines or policy interventions that included services other than vending machines (e.g. cafeterias)—were eliminated. The final sample comprised 11 scientific articles.

Considering the small number of articles obtained from this first search, a second search was conducted to determine whether any other studies discussed the evolution of the vending sector towards sustainability indirectly, i.e. without an explicit reference to the concept of sustainable development. Again on Scopus, the following four keywords were used for this second search: ('Vending machine ') AND ('Food ' OR 'Beverage ') AND NOT ('Street '). The term 'vending' often is used in a general way, so the elimination of the keywords 'Vending' and 'Street' made it possible to consider only articles that mentioned vending machines, reducing the possibility of including other sectors, such as street vendors. The search yielded an initial sample of 729 articles. As with the first search, the field was restricted to scientific articles published during the 2015–2023 period, resulting in a sample of 269 articles. Of these, 60 were selected, excluding all those concerning the clinical effects of food and drink on human health, food products' microbiological quality, technological innovations and those that did not directly consider vending machines in their analysis.

Thus, the final sample comprised 71 scientific articles (see Appendix for details). Steps 4 and 5 are addressed in the following sections.

Results and discussion

QA—Is the academic community addressing the topic of sustainability in the vending industry?

The topic of sustainable development is addressed in the literature, but not uniformly. The analysis revealed a clear preponderance of scientific studies developed around a particular social problem, namely the continuous increase in cases of malnutrition and obesity in developed countries, to which the vending industry seems to contribute significantly due to the type of food sold. The latter aspect is why many similarities were found among the analysed studies in terms of theoretical background, research objectives, analytical mode and, often, results. For example, 21 out of 71 articles conducted analyses of snacks and beverages' nutritional content, sometimes assessing whether their nutritional profiles were in line with national/international guidelines (e.g. Faris et al. 2021; Lasala et al. 2022; Raposo et al. 2016; Vine et al. 2021). However, 34 articles examined the use of behavioural, policy or structural interventions to elicit healthy food consumption in different contexts (e.g. Blake et al. 2021; Bos et al. 2018; Clarke et al. 2020; Griffiths et al.

2020; Hua et al. 2017; Hua & Ickovics 2016; Kehm et al. 2018; Rose et al. 2018; Vehmas et al. 2019; Viana et al. 2018); Finally, five articles examined consumers and their drivers for buying healthier foods (Hasan et al. 2021; Mengarelli et al. 2021; O’Hara & Haynes-Maslow 2015; Raposo et al. 2018; Rauzon et al. 2020). The scientific community’s interest in these topics has remained almost constant over the years (Fig. 2), and many of these studies have been published in journals specialising in nutrition, human health and non-communicable diseases (Table 1).

Only a small portion of the analysed sample (n = 11) touched on different topics, steering academic knowledge development in other directions as well. Specifically, four articles conducted life cycle analyses to calculate the environmental impact of certain types of products (Costa et al. 2022; Potting & van der Harst 2015; Wong et al. 2022) or short supply chain distribution systems (Pereira et al. 2018), three articles focussed on consumers and their predisposition towards purchasing innovative products or local foods (Bertossi et al. 2023b; Koutsou and Sergaki 2020; Sabău et al. 2023), one article examined the topic of sustainable communication through packaging (Bertossi et al. 2022), one article discussed energy recovery from coffee grounds (Bottani et al. 2019), one article examined the topic of financing to make the vending industry more sustainable (Bertossi et al. 2023a) and one article discussed sustainable initiatives in an Italian context (Henke & Sardone 2020). Although one of these articles dates back to 2015, the scientific community only recently has begun to examine this environmental sustainability perspective (Fig. 2), publishing studies in journals specialising in sustainable production, life cycle analysis or environmental management (Table 1).

QB—Is the vending industry on the right track for sustainable development?

Referring solely to the analysis of the articles considered, the vending industry is on the right path to sustainability, but the results seem to suggest that this transformation

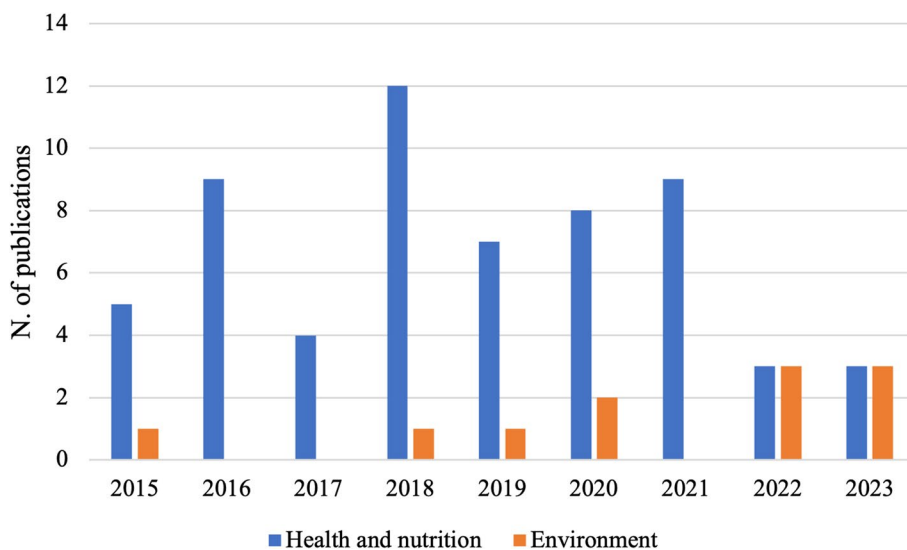


Fig. 2 Temporal distribution of the studies considered

Table 1 List of scientific journals

Scientific journal	No. of research studies published
British Food Journal	6
Appetite	5
Health Promotion Practice	3
Journal of the Academy of Nutrition and Dietetics	3
International Journal of Behavioral Nutrition and Physical Activity	3
International Journal of Environmental Research and Public Health	3
Journal of American College Health	3
Journal of Public Health Management and Practice	2
Foods	2
American Journal of Health Promotion	2
Preventive Medicine Reports	2
Sustainability (Switzerland)	2
Economia Agroalimentare/Food Economy	1
Canadian Journal of Dietetic Practice and Research	1
Italian Review of Agricultural Economics	1
Food Policy	1
Nutrients	1
Journal of Policy Analysis and Management	1
Nutrition	1
Health Promotion Journal of Australia	1
Public Health Nutrition	1
PLoS ONE	1
Journal of Food and Nutrition Research	1
Journal of Nutrition Education and Behavior	1
Rivista di Studi sulla Sostenibilità	1
Journal of Health, Population and Nutrition	1
Current Psychology	1
Public Health	1
Atencion Primaria	1
High Blood Pressure and Cardiovascular Prevention	1
Corporate Social Responsibility and Environmental Management	1
International Journal of Life Cycle Assessment	1
Food Quality and Preference	1
Sustainable Production and Consumption	1
Italian Journal of Food Science	1
Journal of Public Health Research	1
Nutrition and Dietetics	1
Frontiers in Nutrition	1
BMC Public Health	1
Journal of School Health	1
Canadian Journal of Public Health	1
Paediatrics	1
Journal of Public Health Policy	1
Australian and New Zealand Journal of Public Health	1
Preventing Chronic Disease	1
Journal of Hunger and Environmental Nutrition	1
American Journal of Preventive Medicine	1
Total	71

is taking place rather slowly, not always uniformly and privileging some issues at the expense of others.

First, as mentioned earlier, most of the literature reviewed in this study focussed on nutritional and health aspects. The distribution of food and beverages is the main function of vending services, so it seems rather obvious that to be sustainable, its offerings should be directed towards foods that are as healthy and nutritious as possible to help accomplish Goals 2 and 3 of Agenda 2030. Unfortunately, many studies in the sample found a significant presence of foods of rather poor nutritional quality in many contexts (particularly schools and universities). For example, Faris et al. (2021) reported that the Nutritional Quality Score (i.e. the average of the 'nutrients to maximise' score divided by the 'nutrients to minimise' score) of almost all vending foods and beverages was less than 100, thereby indicating that the nutrients to minimise (i.e. saturated fat, cholesterol, sodium and total sugars) are present in greater amounts than the nutrients to maximise (i.e. vitamin A, vitamin C, protein, dietary fibre, iron and calcium). This is in line with what other authors also have pointed out, such as Champ et al. (2019), Grech et al. (2017), Lasala et al. (2022), Martin Payo et al. (2020), Martinez-Perez and Arroyo-Izaga (2021), Ng et al. (2019), Park and Papadaki (2016), Rahi et al. (2022), Raposo et al. (2016), Rozman et al. (2020) and Samuel et al. (2023). Thus, present conditions indicated a substantial disparity between the nutritional recommendations and objectives that international organisations put forth (e.g. WHO and UN) and governments and their practical implementation in real-world contexts (Mann et al. 2017; Orava et al. 2016; Vine et al. 2021). Thus, the vending sector seems to be unresponsive to the nutritional challenge of our times—a continuous increase in cases of malnutrition, obesity and, consequently, non-communicable diseases (e.g. diabetes). Although this suggests a direct negative influence from vending products on health, insufficient scientific evidence exists at present to support it. The only study that has addressed the topic is Park and Papadaki (2016), who did not find a significant relationship between vending machine use and an increase in people's body mass index (BMI).

One reason for these findings seems to be concern (on the part of the service operator and the administration of the public or private sites where the vendor operates) about possible profit losses from selling healthier foods (Green et al. 2021). Despite this, several case studies in the literature regarding initiatives have been effective in bridging this gap and overcoming economic barriers (Blake et al. 2021; Griffiths et al. 2020; Grivois-Shah et al. 2018; Hua & Ickovics 2016; Narain et al. 2016; Pharis et al. 2018; Rosi et al. 2017; Roy & Liu 2022; Viana et al. 2018; Wickramasekaran et al. 2018; Yan et al. 2019). For example, Blake et al. (2021) discussed the Deakin University Food Charter, a university policy aimed at providing healthy and sustainable food to meet the needs of the community and the service manager while promoting new lifestyles. According to the authors, the policy has elicited important positive nutritional, economic and commercial effects, motivating the service manager to adopt, improve and implement similar interventions in other settings. However, Viana et al. (2018) presented results from some of the most common interventions in the literature when it comes to vending, namely increasing the quantity of healthier products, labelling them and increasing prices on less healthy foods. This initiative has been effective not only at increasing sales and consumption of healthier products, but also at maintaining profit margins. Although

economic expectations have not been met fully in some cases (Pharis et al. 2018; Wickramasekaran et al. 2018), the scientific community seems to have realised that leadership involvement, business partnerships with shared goals, healthy contracting and proper communication are needed to achieve desired economic and nutritional outcomes (Green et al. 2021; Lane et al. 2019; Volpe & Marchant 2020). This is a key aspect of sustainable development, addressed by Goal 17 of Agenda 2030.

A second reason for unhealthy foods' continued presence concerns consumer behaviour. Although some research has detected growing demand for healthier products (Hasan et al. 2021; Mengarelli et al. 2021; Park & Papadaki 2016), nudging consumers towards healthier foods is not so simple because vending machine decisions often are dictated by impulse, lack of time or essential needs, such as hunger (Hasan et al. 2021). An important hurdle to overcome is finding the most effective, fastest and least-intrusive way possible to stimulate such purchases (Bos et al. 2018) while simultaneously minimising offsetting side effects (e.g. relying on other services, such as cafeterias or various food stores) (Capacci et al. 2018; Godin et al. 2018). The most common interventions found in the literature and programmed for this purpose include rearranging products and replacing all or part of unhealthy foods with more nutritious solutions (Boelsen-Robinson et al. 2017; Griffiths et al. 2020; Grivois-Shah et al. 2018; Marinelli et al. 2020; Pechey et al. 2019; Roy & Liu 2022; Viana et al. 2018; Yan et al. 2019), using labels/information on packaging or posters (Carrad et al. 2015; Clarke et al. 2020; Dingman et al. 2015; Roberto et al. 2016; Seah et al. 2018; Shi et al. 2018; Stöckli et al. 2016; VanEpps & Roberto 2016), utilising price manipulation and employing promotional messages (Bos et al. 2018; Calabro et al. 2023; Hua et al. 2017; Hua & Ickovics 2016; Kirchoff et al. 2021; Lambert et al. 2023; Pharis et al. 2018; Rosi et al. 2017). However, current opinions in the scientific community on which intervention is best are not homogeneous. As Bos et al. (2018) noted, much depends on the intervention's level of intrusiveness and how consumers respond. Furthermore, it is difficult for vending companies to predict consumption trends, which depend not only on sociodemographic characteristics, but also on the place of consumption and, most importantly, on healthier products' seasonality and shelf life.

While nutritional and health issues have been addressed widely in the literature for a long time, the same cannot be said for others that are part of the sustainability concept, such as those related to the environment or circular economy. The vending industry operates within the distribution phase of food and beverages, most of which are produced by multinational corporations using raw materials of international origin, generating various environmental impacts, particularly during the transportation phase. Although at first glance, it may seem that vending companies have no alternative but to operate in this way (mainly for economic reasons), Koutsou and Sergaki (2020), Pereira et al. (2018), Sabău et al. (2023) and Bertossi et al. (2023a) demonstrated that vending also can help develop short and more sustainable supply chains by favouring local products (in these cases, milk and sweet snacks). In the first three case studies, encouraging results were obtained both from a consumption (Koutsou and Sergaki 2020; Sabău et al. 2023) and environmental impact (Pereira et al. 2018) perspective, setting a precedent for the development of the vending market in this direction, as well as helping achieve several SDGs, including Nos. 2, 11 and 12. However, Bertossi et al. (2023a) examined

extensively the barriers that companies may face as a result of developing local products using an Italian sweet snack as a case study, as well as the need for funding aimed at reducing the geographic distance between various actors in the supply chain. What emerged prominently from these four studies is vending's enormous, yet untapped, potential, as well as the managerial, economic and market obstacles that make the industry's orientation towards local dynamics quite complex and deserving of more attention from the scientific community. Henke and Sardone (2020) also mentioned such complexities when discussing the Clementine Project, an Italian initiative with the aim of supplying vending machines with locally produced clementines.

Clearly, to align with sustainability principles, the vending industry must focus primarily on supply and try to prioritise foods produced in such a way so that environmental impacts are minimised as much as possible. The only three studies in the literature on this topic are Potting and van der Harst (2015), Costa et al. (2022) and Wong et al. (2022), who took a life cycle approach in their analyses to estimate environmental impacts, but their objects of study differed. Potting and van der Harst (2015) considered various constituent materials used to make hot beverage cups (e.g. polystyrene, polylactic acid and biopaper), a hotly debated issue in recent years due to awareness of pollution from single-use plastics (the material used most often to make hot beverage cups). However, Costa et al. (2022) assessed a frozen meal vending machine's environmental impact, and Wong et al. (2022) examined the production of a new carbonated beverage to meet the climate challenges of our times. Along with low environmental impact, it is critical that the products offered communicate sustainable characteristics to consumers in some way to influence their purchasing choices. Bertossi et al. (2022) was the only study in the literature sample that analysed whether products sold to retailers somehow communicate sustainable information through verbal or visual statements, finding a significant lack of such elements on packaging. This aligned with Park and Papadaki (2016) and Prowse et al. (2019), who found that nutrition labelling is not always adequate. Nevertheless, several initiatives have aimed to reduce the information gap between producers and consumers, including 'Fresco benessere' and 'Percorso salute', which offer a wide selection of fresh and 'healthy' Italian products advertised and enhanced in vending machines by means of specific labels or stickers (Henke and Sardone 2020). Speaking of communication, Bertossi et al. (2023a; b) helped develop knowledge on the topic of hot beverage cups from a consumer perspective, according to which, cups should be biodegradable, recyclable or reusable, as well as communicate their ecological characteristics (e.g. 100 per cent recyclable or 'environmentally friendly'). Although adapting the supply is a priority, the post-consumer phase should not be forgotten. Currently, the only work that has focussed on this phase has been Bottani et al. (2019), who discussed business models based on alternative and more sustainable ways of producing energy using spent coffee grounds taken from vending machines in northern Italy.

QC—What issues should be examined to help facilitate the vending industry's sustainable development?

Answering this question is not easy, as the vending world is broader than it appears to be at first glance, and every aspect of it plays a key role in its transformation towards more

sustainable dynamics. However, this section briefly will present five themes also chosen on the basis of their potential large-scale effects.

True cost accounting and true price

True cost accounting (TCA) and true price (TP) are two tools for assigning the right price to food by considering its impact on the biosphere (e.g. pollution) and society (e.g. malnutrition) throughout its life cycle (Hendriks et al. 2021; Marangon et al. 2023; Minotti et al. 2022). The goal is to create agri-food markets in which food is produced with respect for the environment, and workers and consumers enjoy lower and more affordable prices than food produced in conditions that ignore externalities. This is critical to achieving SDGs and represents a call to duty for all agribusiness sectors (Marangon et al. 2023), including vending. Based on this review's findings, most foods sold in vending machines today seem to possess rather poor nutritional quality, though priced significantly cheaper than healthier alternatives, thereby attracting consumers' immediate attention and purchase power. Although price manipulation is one of the most widely implemented interventions for steering consumers towards healthier products, it usually occurs in the absence of any real supporting methodology, and its effectiveness is not always guaranteed. The use of TCA and TP in future studies could be one of the necessary thrusts in the transformation of the industry towards more sustainable dynamics and a means of promoting healthier diets in environments still characterised by unhealthy foods' presence. Furthermore, implementing TCA and TP in analyses also would shed light on various foods' actual environmental impacts—a topic that remains unexamined and deserves academic attention.

Development of short supply chains

The scientific community has long been aware of the large externalities associated with international food supply chains (Crippa et al. 2021; Li et al. 2022), urging a decisive strengthening of shorter supply chains due to their indisputable environmental, economic and social benefits (Enjolras and Aubert 2018; Galli & Brunori 2013; Food and Land Use Coalition 2019). Furthermore, recent years have seen major changes in distribution and purchasing patterns, with consumers increasingly demanding local products and relying on faster distribution services (e.g. e-commerce). Vending is a service that can satisfy both speed and local proximity, although at first glance, one would not think so (Pereira et al. 2018). We all have become accustomed to viewing vending as a service for distributing only high-calorie foods produced by large multinational corporations that we know nothing about—so much so that the very idea of a vending machine with food produced by local, well-known farms seems rather extraordinary. However, as this review indicated, such a market can be a viable alternative to traditional supply chains, with several benefits for consumers, local producers and the environment (Bertossi et al. 2023a; Koutsou and Sergaki 2020; Pereira et al. 2018; Sabău et al. 2023). Nevertheless, parallel to the undeniable benefits, numerous organisational, managerial and economic obstacles also can lead to these initiatives' failure if not addressed properly (Bertossi et al. 2023a; Pereira et al. 2018). Academic research on this topic remains in its infancy, but future research could help develop it through real-world case studies and by examining vending's potential as a gateway to rural and more sustainable markets.

Consumption of sustainable products

The consumption phase is the main activity of the vending business, and stimulating the purchase of more environmentally and socially sustainable products is a sensitive issue that deserves deeper examination and understanding. Indeed, vending machines aim to supply mainly food and beverages to satisfy temporary and impulsive consumer needs. Hunger (an essential need) can deter consumers from choosing sustainable products due to its influence on taste evaluation and preferences for specific foods (Hoffmann et al. 2019). Moreover, consumers often rely on their past experiences when making food selections (Ogundijo et al. 2021); therefore, consumers may tend to choose 'conventional' vending machine products that they already know will satisfy their cravings versus a new product—even if the new product is viewed as environmentally and socially sustainable. To plan effective behavioural interventions, appropriate surveys are needed to gauge personal (e.g. attitudes, values, knowledge, perceptions, and emotions) and contextual (e.g. social pressure) factors that might elicit or discourage purchases of more sustainable foods. Particularly useful would be studies conducted using the most common behavioural theories developed for this purpose, such as the theory of planned behaviour (Ajzen 1991), value belief norm theory (Schwartz 1977), goal-framing theory (Steg et al. 2014), theory of consumption values (Sheth et al. 1991) or the more recent 'stage model of self-regulated behavioural change' (Bamberg 2013). The latter in particular has been used to explain the reasons why people abandon disposable cups for reusable ones (Keller et al. 2021), a key issue in vending.

Post-consumer phase management

Effective management of the post-consumer phase is of crucial importance to achieving a circular economy in any agribusiness sector, but in the vending sector, several obstacles seem to hold it back. Degano (2023; not included in this review) addressed this topic for the first time, highlighting how small Italian vending companies have numerous difficulties valorising food waste, mainly due to outdated legislation that is out of step with the times. The author found that while surpluses are redistributed for human consumption through specific associations (e.g. BancoAlimentare) or distributed to employees, food waste by law must be treated as waste and sent to landfills. Although the companies interviewed stated their interest in becoming more virtuous and sustainable when it comes to waste management, non-innovative legislation, excessive bureaucratisation and the absence of specialised companies still prevent a circular and virtuous recovery of this commodity, greatly limiting possibilities. Nevertheless, there are case studies that have shown how careful planning of this post-consumer phase can lead to not only environmental but also economic benefits. In their study, Bottani et al. (2019) demonstrate the profits that can result from the effective management of spent coffee grounds converted back into pellets to produce energy. The topic of recovering food waste to produce energy or high-quality fertilisers is central to the realisation and implementation of a circular economy but requires considerable investment and a certain degree of creativity. Future studies that address the issue of food management in the post-consumer phase by focusing on foods other than coffee and that help solve the various problems identified by Degano (2023) to contribute to the development of circular supply chains would be of great value and usefulness. Particularly interesting and highly topical would

be to investigate whether and how artificial intelligence could contribute to food waste management. Current vending machines are very technologically advanced, and this could be a good starting point to test artificial intelligence-based operating systems' potential in predicting generation of surpluses and waste well in advance, providing valuable information for their timely management.

Analysis of different markets

In their work, Henke and Sardone (2020) examined the Italian vending sector in some detail, analysing its structure, consumption dynamics and sustainable initiatives with regard to healthier food supply and waste management. However, the literature review did not reveal other works with the same objective and approach in different markets (e.g. France and Germany, to remain within the European context). Thus, more studies that investigate the sector's evolution in terms of structure, dynamics and sustainable development in other European and non-European countries are needed for a better understanding of the topic. This could lead to: (1) mapping of all existing initiatives, projects and programmes, allowing for a clearer picture of how each market, with its own peculiarities, is responding to today's climate challenges; (2) an analysis of whether and how various vending operators worldwide in the public sector align themselves with the EU's Green Public Procurement requirements; and (3) a comparison among such markets on a cultural and value basis, which are fundamental aspects that contribute, in one way or another, to both supply and demand. Regarding the last point, as an example, one could investigate whether the dynamics of production and consumption in countries with a long and important culinary tradition (e.g. Italy and France) are influenced by such values and differ from other, less-virtuous countries in this respect. Similarly, whether being a country historically recognised worldwide for its attention to the environment and sustainable culture (e.g. Norway and Sweden) elicits a greater supply and consumption of sustainable food products (e.g. organic, fair trade) can be examined.

Conclusions

This literature review is the first attempt to shed light on whether and how far the vending industry has moved towards more sustainable dynamics. In some respects, the vending industry still appears to be poorly understood and associated with the stereotype of a service that sells mostly junk food. Several studies included in this review seem to support this notion, revealing the poor nutritional value of food currently found in many vending machines. Thus, the vending sector seems to be failing to meet the nutritional challenges of our times, despite the huge amount of scientific evidence indicating a steady increase in malnutrition and obesity cases. However, the review also shed light on instances in which the industry has brought its services in line with community needs, providing low-fat, high-fibre or high-vitamin foods, as well as local products with limited environmental impact while preserving economic revenues. Thus, vending has the potential to become an industry that can provide healthy and environmentally sustainable foods, but presently, this potential has not yet been fully studied, understood, and incentivised. Moreover, while issues related to nutritional and health aspects have been investigated for a long time, those related, for example, to the development of short supply chains, the study of life cycle impacts or the minimisation and management of

food waste have received little attention in the literature. Thus, this paper serves as a springboard for future studies that can help develop the sector by validating its versatility and usefulness, as it puts forth proposals for sound arguments that can serve as a path towards sustainability.

Despite the present study's interesting results, it contains one main limitation: It considered only the scientific literature, purposely ignoring many companies' laudable initiatives in the sector. Future studies can fill this literature gap by aligning theoretical and academic aspects with practical and industrial ones.

Appendix

References	Scientific journal	Aim of the research
Bertossi et al. (2023a, b)	British Food Journal	Investigating the sustainable attributes of hot beverage cups and consumer preferences
Bertossi et al. (2023a, b)	Food Economy/Economia Agroalimentare	To discuss financing for the vending sector from a sustainable perspective
Calabro et al. (2023)	Current Psychology	To observe beverage consumption choices based on images on vending machines
Costa et al. (2022)	Sustainability (Switzerland)	To evaluate the environmental impacts associated with producing hot food directly from a vending machine
Lambert et al. (2023)	Journal of American College Health	To examine the effectiveness of three strategies to increase consumption of healthy products among students
Sabău et al. (2023)	Foods	To investigate the willingness of Romanian consumers to buy raw milk from vending machines
Samuel et al. (2023)	Journal of Public Health Research	Evaluate the nutritional quality of snacks and drinks
Bertossi et al. (2022)	Rivista di Studi sulla Sostenibilita	Examine whether the products sold at a university communicate sustainable aspects in any way
Lasala et al. (2022)	Nutrients	Evaluate the nutritional quality of snacks and drinks
Rahi et al. (2022)	British Food Journal	Evaluate the nutritional quality of snacks and drinks
Roy and Liu (2022)	Journal of American College Health	Analyse the sales of a healthy vending machine vs. an unhealthy one
Wong et al. (2022)	Corporate Social Responsibility and Environmental Management	Evaluate the environmental impacts associated with the production of a carbonated drink sold in vending machines
Blake et al. (2021)	Journal of the Academy of Nutrition and Dietetics	Evaluate the economic effectiveness of a university policy oriented towards the healthiness of the vending system
Faris et al. (2021)	British Food Journal	Evaluate the nutritional quality of snacks and drinks
Green et al. (2021)	Health Promotion Practice	Evaluate policies created for a healthy vending system in 4 cities

References	Scientific journal	Aim of the research
Hasan et al. (2021)	Foods	Examine consumption trends and motivations of university students regarding vending products
Kirchoff et al. (2021)	Journal of American College Health	To examine the effectiveness of some strategies to increase the consumption of healthy products among students
Martinez-Perez and Arroyo-Izaga (2021)	International Journal of Environmental Research and Public Health	Evaluate the nutritional quality of snacks and drinks
Mengarelli et al. (2021)	Frontiers in Nutrition	Listen to the opinions of university students regarding the type of offer to distributors
Rozman et al. (2021)	Journal of Health, Population and Nutrition	Evaluate the nutritional quality of snacks and drinks
Vine et al. (2021)	International Journal of Environmental Research and Public Health	Examine whether products sold were aligned with school food policies in 2 regions of Canada
Carrillo-Álvarez et al. (2020)	Public Health	Compare the nutritional values of foods and beverages sold in health VMs and conventional VMs
Clarke et al. (2020)	Appetite	Examining the effectiveness of labels on snack consumption
Griffiths et al. (2020)	PLoS ONE	Evaluate the effectiveness of an intervention that involves the complete replacement of unhealthy products with healthier solutions
Henke and Sardone (2020)	Italian Review of Agricultural Economics	To analyse the most significant initiatives to assess whether they could contribute to the reinforcement of the role of agriculture and to the definition of new criteria within the selection procedures for vending services
Koutsou and Sergaki (2020)	British Food Journal	Analyse the economic feasibility and consumer response to a short milk supply chain
Marinelli et al. (2020)	British Food Journal	Extend current knowledge on the factors that influence consumer purchasing decisions. In particular, explore the role of planograms and time
Martin Payo et al. (2020)	Atencion Primaria	Evaluate the nutritional quality of snacks and drinks
Rauzon et al. (2020)	Preventive Medicine Reports	To explore the relationship between the presence of VMs selling sugary drinks and their consumption by school staff
Rozman et al. (2020)	International Journal of Environmental Research and Public Health	Evaluate the nutritional quality of snacks and drinks
Volpe and Marchant (2020)	High Blood Pressure and Cardiovascular Prevention	Illustrate the case study "a little car for a friend" in Italy
Bottani et al. (2019)	Sustainability (Switzerland)	Examine the recovery of spent coffee from vending machines as a raw material for the production of pellets for domestic (industrial) use
Champ et al. (2019)	Nutrition	Evaluate the nutritional quality of snacks and drinks
Lane et al. (2019)	Preventive Medicine Reports	Examine differences between the nutritional quality of products sold in snack and beverage vending machines in contracted and non-contracted establishments

References	Scientific journal	Aim of the research
Ng et al. (2019)	Health Promotion Journal of Australia	Evaluate the nutritional value of foods and drinks, their price and consumer characteristics
Pechey et al. (2019)	International Journal of Behavioral Nutrition and Physical Activity	To study the impact of changing the absolute and relative availability of more or less healthy cold foods and drinks in vending machines
Prowse et al. (2019)	Canadian Journal of Dietetic Practice and Research	Evaluate whether product health labels align with government nutritional guidelines
Vehmas et al. (2019)	British Food Journal	Evaluate the effectiveness of a distributor producing fresh health food on site
Yan et al. (2019)	American Journal of Health Promotion	Examine whether implementing a 100% Healthy vending machine impacts revenue, employee satisfaction, and the amount of fat and sugar included in snacks and beverages
Bos et al. (2018)	Food Policy	To evaluate the effectiveness of 4 types of interventions and the effect of their level of intrusiveness on acceptance of students
Capacci et al. (2018)	Journal of Policy Analysis and Management	To evaluate the effectiveness of the vending machine ban in France on snack consumption and morning sugar intake of school children
Godin et al. (2018)	International Journal of Behavioral Nutrition and Physical Activity	To evaluate whether and to what extent the availability of SSB differs between schools belonging to different districts with different policies
Grivois-Shah et al. (2018)	American Journal of Health Promotion	Examine whether replacing unhealthy products with healthier choices leads to reduced calorie, sugar, fat and sodium intake and decreased income
Kehm et al. (2018)	Journal of Hunger and Environmental Nutrition	Examine the effect of policies and practices within rural school settings in the provision of vending products
Pereira et al. (2018)	Sustainable Production and Consumption	Assess the environmental and economic feasibility of selling milk through vending machines
Pharis et al. (2018)	Public Health Nutrition	Evaluate the feasibility of an intervention aimed at increasing the proportion of healthy products, decreasing the portion size of drinks, manipulating the price and their effect on sales and total revenues
Raposo et al. (2018)	Journal of Food and Nutrition Research	Examination of consumption frequency, body weight, satisfaction and eating habits of vending machine users in both Spain and Portugal
Rose et al. (2018)	Health Promotion Practice	To determine the impact of milk vending on milk and calcium intakes in college students
Seah et al. (2018)	International Journal of Behavioral Nutrition and Physical Activity	Evaluate the effectiveness of using tax or incentive messages on sales of sugary drinks
Shi et al. (2018)	BMC Public Health	Detect improvements in the availability of healthy products after implementing the labelling system, their cost and compliance with guidelines

References	Scientific journal	Aim of the research
Viana et al. (2018)	Appetite	Evaluate the feasibility and effectiveness of replacing products sold while maintaining total revenue
Wickramasekaran et al. (2018)	Journal of Public Health Management and Practice	Evaluate whether a policy requiring 100% healthy vending machines impacts calorie, sugar, fat, and sodium intake and total revenue
Boelsen-Robinson et al. (2017)	Appetite	To examine the change in consumer purchase of healthy and unhealthy foods and beverages from vending machines, following the introduction of a healthy vending machine policy
Grech et al. (2017)	Nutrition and Dietetics	Evaluate the nutritional quality of foods and drinks sold by vending machines in schools
Hua et al. (2017)	Journal of the Academy of Nutrition and Dietetics	To examine how healthier product availability, price reductions, and/or promotional signs affect sales and revenue of snack and beverage vending machines
Rosi et al. (2017)	Food Quality and Preference	To evaluate whether replacing unhealthy items with healthy products and providing nutritional information increased the purchase of healthy products
Cisse-Egbuonye et al. (2016)	Journal of School Health	To examine the availability of foods sold in vending machines and associations of availability with students' food purchases and consumption
Hua and Ickovics (2016)	Journal of the Academy of Nutrition and Dietetics	To describe intervention and case studies designed to promote healthier vending purchases by consumers and identify which manipulations are most effective
Narain et al. (2016)	Journal of Public Health Management and Practice	Evaluate the effectiveness of a healthy policy on modifying the nutritional values of vending drinks
Orava et al. (2016)	Canadian Journal of Public Health	To identify, describe and categorise beverages and snacks available for purchase in school vending machines according to legislative nutritional standards
Park and Papadaki (2016)	Appetite	To evaluate the nutritional value of foods sold in vending machines at a UK university. The secondary objective was to conduct a cross-sectional survey to investigate differences in food intake and body weight
Raposo et al. (2016)	Italian Journal of Food Science	To determine the nutritional composition of the food dispensed in vending machines to compare not only the nutritional profiles of various foods, but also the consumption of such foods in the Gran Canaria population
Roberto et al. (2016)	Paediatrics	To test whether warning labels can effectively educate consumers about the health harms associated with SSB intake. Furthermore, the study also aimed to evaluate how warning labels influence parents' intentions to purchase SSBs

References	Scientific journal	Aim of the research
Stöckli et al.(2016)	Appetite	To explore whether environmental cues can influence the preference for healthy or unhealthy food
VanEpps and Roberto (2016)	American Journal of Preventive Medicine	To measure the extent to which warning labels influence adolescents' beliefs and hypothetical choices
Carrad (2015)	Australian and New Zealand Journal of Public Health	To investigate the feasibility of introducing vending machines for healthier food into public places, and to examine the effectiveness of two front-of-pack labelling systems in the vending machine context
Dingman (2015)	Journal of Public Health Policy	To test the effect of providing nutrition information and 'healthy' designations to consumers where vending machines were located in college residence halls
Lillehoj et al. (2015)	Health Promotion Practice	To assess the effectiveness of healthy interventions on 4 workplaces
Mann (2015)	Preventing Chronic Disease	To examine the nutritional quality of competitive foods and beverages before implementation of the US Department of Agriculture's Smart Snacks in School standards
O'Hara (2015)	Journal of Nutrition Education and Behavior	To estimate the association of school vending machine availability and BMI among subgroups of children based on gender, race/ethnicity, and socioeconomic status
Potting and van der Harst (2015)	International Journal of Life Cycle Assessment	To evaluate the environmental impacts associated with different hot drink cups

Abbreviations

EVA	European Vending and Coffee Service Association
SLR	Systematic literature review
WHO	World Health Organisation
UN	United Nations
BMI	Body mass index
TCA	True cost accounting
TP	True price

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Declarations

Competing interests

Sustainability in agri-food systems; consumers' behaviour; circular economy.

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