



Review Article

Consumers' willingness-to-pay for dairy and plant-based milk alternatives towards sustainable dairy: A scoping review

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ARTICLE INFO

Editor: Prof. Konstantinos Tsagarakis

Keywords:

Willingness-to-pay (WTP)

Dairy

Plant-based milk alternatives (PBMA)

Sustainability

Scoping review

Thematic analysis

ABSTRACT

The dairy sector is transforming following growing concerns over sustainability, propelling innovations such as plant-based milk alternatives (PBMA). Researchers have shown increasing interest in conducting studies on consumers' willingness to pay (WTP) for dairy and PBMA. This scoping review expounds on consumers' WTP for dairy and PBMA, focusing on attributes to understand the variation across regions, value elicitation methods, driving factors, and impact on sustainable dairy. Researchers searched the literature using Web of Science, Scopus, and AgEcon databases and used descriptive statistics and thematic analysis to synthesize the findings of a scoping review of 123 worldwide studies. The reviewed studies applied stated preference (SP) and revealed preference (RP) methods, but SP methods were dominant, especially discrete choice experiments (DCEs) (42 %) and contingent valuation methods (CVM) (25 %). Consumers were willing to pay an average premium of 44 % for all attributes. Most studies were on cow milk (90 %), whereas very few investigated PBMA and other milk types. The average WTP for the attribute categories were organic (55 %), animal welfare (53 %), origin (45 %), milk quality and safety (45 %), brand (40 %), environmental (34 %), health-related (25 %), and sensory attributes (22 %). Consumers' WTP for dairy and PBMA attributes impact the sustainability of the dairy sector across regions. Moreover, income, awareness, and information consciousness influenced consumers' WTP for organic, safety, health, and environmental milk attributes. This study highlights the complexity and diversity of consumers' WTP for dairy and PBMA across regions. Our findings emphasize the need to employ multilevel strategies ranging from farm-level dairy production to processing and consumption to achieve socially, economically, and environmentally sustainable dairy. Future research should focus on consumers' WTP for PBMA and gather more evidence on how consumers in Africa and South America value sustainable dairy and PBMA.

1. Introduction

The food system is under pressure to meet the growing food demand and increase the supply of healthy, affordable, and nutritious foods (Hendriks et al., 2021). Food supply chain actors use various methods to increase productivity, lower production costs, and increase profits; however, some methods may be unethical, increase inequality gaps, damage the environment, or threaten human health. The food system is among the primary drivers of climate change, biodiversity loss, water

pollution, and scarcity, among other environmental problems emanating from unsustainable agricultural practices by the human race encroaching into preserved spaces, such as forests (Bedeau et al., 2021). Striking a healthy balance between food security and sustainable food systems is challenging (Ridolfi et al., 2020). Consumers are vital in shaping food systems towards sustainability, so their food choices and consumption behaviors matter (Vermeir et al., 2020). In 2020, the European Consumer Organization revealed that 46 % of the people who participated in their survey were concerned about sustainability.

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<https://doi.org/10.1016/j.spc.2024.09.010>

Received 13 June 2024; Received in revised form 18 September 2024; Accepted 20 September 2024

Available online 26 September 2024

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The dairy industry faces increasing pressure to meet the growing demand for dairy products. Projections indicate that the demand for dairy products will increase by 0.4 % in high-income economies, while in low- and middle-income economies, it will grow by 1.5 % per annum and 2 % per annum, respectively (OECD/FAO, 2022). The traditional dairy sector faces criticism for its substantial greenhouse gas (GHG) emissions, water usage, and land requirements that threaten biodiversity (Steinfeld et al., 2006), and consumers are interested in the production and processing of dairy products (OECD/FAO, 2020). Sustainability is the ability to meet the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland, 1987). Sustainability in the dairy sector has social, economic, and environmental dimensions (Bhat et al., 2022). Alongside traditional dairy products, plant-based milk alternatives (PBMA) are gaining popularity, driven by growing concerns about health, environmental sustainability, and animal welfare (Sethi et al., 2016). PBMA can be derived from rice, hemp, almonds, soy, and oats and are often perceived as more environmentally friendly, as dairy has a 3.3 times higher carbon footprint (CF) than soy, and the other PBMA have lower CF than dairy (Reyes-Jurado et al., 2021). However, these alternatives face sustainability challenges, such as water usage in almond cultivation and deforestation linked to soy production (Craig et al., 2023).

As an overview of the dairy sector, in 2019, over 6 billion people (80 %) regularly consumed cow's milk or other dairy products (OECD/FAO, 2020). Fresh cow milk constitutes 82.7 %, followed by buffalo milk (13.3 %), goat milk (2.3 %), sheep (1.3 %), and camels (0.4 %) (OECD/FAO, 2020). The global dairy market, valued at US\$ 330 billion, supports the livelihoods of dairy farmers and other value chain actors, encompassing more than 133 million dairy farms (OECD/FAO, 2020). Milk is a nutrient-dense product that supplies energy, proteins, and micronutrients, including calcium, magnesium, riboflavin, selenium, and vitamins B5 and B12 (Berardy et al., 2022). In 2013, dairy milk production reached approximately 770 billion liters, ranked third by production tonnage (OECD/FAO, 2020).

There is diverse literature from research articles on consumers' WTP for dairy and PBMA focusing on consumers' WTP for various attributes such as organic (Scozzafava et al., 2020), traceable (Hossain et al., 2023), sustainable (Gao et al., 2020), organic soy PBMA (Yue et al., 2013) and cooperatively produced (Kaliyeva et al., 2021) only to mention a few. The currently available literature reviews and meta-analyses have focused on a specific attribute of a wide range of food products or milk, but also on a particular attribute of milk, which did not provide more comprehensive coverage of consumers' WTP for dairy and PBMA. For example, there have been systematic literature reviews on the organic attributes of different food products (Katt and Meixner, 2020; Li et al., 2020), sustainable attributes of diverse kinds of food products (Li and Kallas, 2021), health attributes (Alsubhi et al., 2023), and traceability attributes (Tran et al., 2024; Vriezen et al., 2022), and only a few studies on dairy and PBMA cannot provide a holistic view of consumers' WTP.

Given this evolving dairy sector landscape, a comprehensive understanding of consumers' WTP for attributes associated with both dairy and PBMA is necessary. Products of focus in this study include fluid or powdered dairy milk consumed as raw or processed milk. Dairy milk includes Ultra Heat Treatment (UHT), fresh or pasteurized cow, goat, or buffalo milk, and infant formulas. PBMA derived from soya, rice, almonds, hemp, or oats are part of the products under review. Consumers in this study are individuals above 18 who buy milk or PBMA for consumption by family members. Consumers' WTP is a crucial indicator of what value they place on specific product attributes, and this is important because consumers pay for products that align with their preferences and values. WTP denotes the maximum amount an individual can spend to procure a good or service reflecting the utility derived from the product subject to their budget constraints. Understanding WTP for sustainable attributes in both dairy and PBMA can provide valuable insights for producers, policymakers, and marketers

aiming to cater to the evolving demands of a conscious consumer base.

This scoping review is part of the proactive measures that provide evidence to advocate for approaches that promote food safety, environmental sustainability, and the well-being of consumers (Adegbeye et al., 2024). This paper is an inquiry that seeks to understand the milk attributes consumers are willing to pay high premiums for, which is helpful to policymakers in crafting strategies that shape the dairy sector towards sustainability. Moreover, this scoping review provides locally relevant research insights to policy makers in various regions (Tricarico et al., 2020), which is crucial for sustainable intensification and informs the need for various regulatory and policy frameworks through analyzing consumers' WTP for various milk attributes. A recent systematic review of sustainable food consumption revealed that future studies should include sociodemographic factors influencing consumers' WTP (Ruppenthal, 2023). Again, this is also a follow-up to a review article by Bimbo et al. (2017), which highlighted a need to expand the pool of countries when evaluating consumer preferences for dairy products and to include PBMA (Bimbo et al., 2017). Bimbo et al. (2017) also indicated that future work could focus on methods to improve the realism of choice experiments discussed in the methodological trends. Besides, Andersen, 2007 stated the importance of documentation of the diversity of dairy milk products (Andersen, 2007). This scoping review generates new information to enhance decision-making, promote market competitiveness, foster innovation, and match consumers' milk needs by consolidating and synthesizing information from different studies, countries, and regions.

2. Materials and methods

The study used the search, selection, and data extraction methods in the Cochrane Handbook for systematic reviews of interventions (Higgins et al., 2019). The protocol development and the report followed the preferred reporting items for systematic literature reviews and meta-analyses (PRISMA) guidelines and checklists to promote transparency, comprehensiveness, reproducibility, and reduce bias (Moher et al., 2009). A protocol for this review was registered on the 14th of April 2023, and is available on the link doi:10.17605/OSF.IO/DS3CJ. The review followed the Population, Context, Concept (PCC) framework.

Unlike systematic literature reviews, which are narrow and specific, the scoping review method suits mapping the breadth and depth of literature on a particular topic, embracing various study designs and methodologies (Arksey and O'Malley, 2005). The inclusivity of scoping reviews is essential for capturing the multifaceted nature of consumer behavior and preferences related to sustainable milk attributes to capture relevant evidence. This approach is valuable in areas where evidence is complex or heterogeneous, as it allows the inclusion of a wide range of study designs and methodologies. The primary aim of this study was to explore the diverse landscape of consumers' WTP for dairy and PBMA, ranging from milk types and attributes, geographic distribution, and methods used to research gaps. A scoping review is well suited for this purpose as it highlights areas lacking evidence, providing a foundation for targeted studies and informed decision-making in sustainable agriculture and consumer behavior. Researchers did not use a meta-analysis approach because the study designs were heterogeneous, and the outcome milk attributes were diverse.

2.1. Study aim and research questions

The scoping review aims to identify global published literature on consumers' WTP for dairy and PBMA, identify commonalities in the studies, factors affecting consumers' WTP, and the knowledge gaps. The scoping review maps the available literature with a broader view, explores the methods used, evaluates milk attributes, and determines the socioeconomic factors affecting consumers' WTP. The specific objectives of the scoping review included (1) identifying milk products and explored attributes, (2) assessing how consumers' WTP differ across

regions and for different milk attributes, (3) identifying factors that affect consumers' WTP for dairy milk and PBMA, (4) exploring the methods used to elicit consumers' WTP, and (5) identifying the research gaps for future research. The research questions answered by this scoping review are: (i) What dairy and PBMA have been explored in consumers' studies on WTP? (ii) What methods elicit consumers' WTP for dairy and PBMA? (iii) How does consumers' WTP differ across regions and for different attributes? (iv) How do consumers' WTP for dairy and PBMA impacts the sustainability of the dairy sector? (v) What factors affect consumers' WTP for dairy and PBMA? (vi) What research gaps exist in eliciting consumers' WTP for dairy and PBMA?

2.2. Search strategy and databases

The search process began on the 15th of April 2023, using the Web of Science, Scopus, and AgEcon databases. The choice of the three databases, Scopus, Web of Science, and AgEcon, corresponded to the quest to conduct a comprehensive and rigorous scoping review. These databases have unique strengths and are essential for reviewing consumers' WTP for dairy and PBMA. Web of Science is a multidisciplinary database with journals offering extensive coverage of high-quality, peer-reviewed studies in various fields, including agriculture and environmental sciences, which are essential to this review. Scopus has wide-ranging sources of information from vast disciplines, including the social sciences, which helps to understand consumer preferences and WTP.

$$\text{WTP} = \frac{\text{WTP for milk product with the desired attribute} - \text{regular milk price}}{\text{Regular milk price}} \times 100$$

Advanced article search functionalities in the Scopus database are essential to explore studies relevant to scoping reviews. The AgEcon database specializes in agricultural economics which provides access to niche publications. Including these three databases minimizes the risk of publication bias, ensures the robustness of findings, triangulates data sources, and gives authors a high-quality and well-balanced representation of literature on consumers' WTP for milk attributes key to providing perspectives critical for a sustainable dairy.

In this study, researchers obtained search terms on consumers, WTP and milk from previous systematic literature review studies on consumers (Alsubhi et al., 2023; De Steur et al., 2017), WTP (Alsubhi et al., 2023; De Steur et al., 2017; Olum et al., 2020) and milk (Diniz Lagueza, Mocellin, Nunes, & Ribas, 2023; Zeltzer et al., 2022). The search terms for milk were adopted as milk and soymilk since the search term milk omitted other articles on soymilk. The search strings included in the protocol available on the link doi:10.17605/OSF.IO/DS3CJ were applied.

2.3. Study selection, screening, and reference management

The selected studies were limited to peer-reviewed public research articles using primary data because of the nature of the study, which included many studies. The researchers also performed citation searches on relevant peer-reviewed studies, systematic reviews, and meta-analysis studies to identify additional articles to include in the scoping review. Eligible studies in the review were (1) peer-reviewed original public research articles published in scientific journals, (2) used primary data, (3) written in the English language, and (4) reporting consumers' WTP for dairy milk or PBMA. We excluded non-peer-reviewed articles, conference papers, and book chapters. Studies focusing on other dairy products, such as cheese, were also excluded. The review did not apply geographic and time boundaries. Researchers used the stated exclusion and inclusion criteria to identify relevant studies for this review through

title, abstract, and full-text screening. They retrieved all relevant studies and imported the search results into Endnote X20, where they verified references and eliminated duplicates.

2.4. Data charting, extraction, and analysis

Data extraction was performed on the articles that met the full-text screening requirements. Different studies used different formats to report the consumers' WTP for the investigated attributes. The mean incremental WTP was reported in the study, and where the study did not report it, the researchers calculated the mean incremental WTP by subtracting the difference between the regular product and the price that consumers are willing to pay for the milk attribute. A standardized Microsoft Excel data extraction form developed from the concepts and nature of the study topic was used to extract relevant information from each eligible study. The review captured study information such as authors, country, region, type of milk, sample size, study setting, value elicitation methods, number of attributes, main attribute, mean WTP, and analytical methods. Other studies directly reported the percentage price premium for the investigated milk attributes. The willingness to pay is the additional money expressed as a percentage of the price of a regular product and sometimes the conventional milk product that the consumer would be willing to pay given the presence of the desired milk attribute. When the WTP was not directly given in the manuscript, the mean % WTP was calculated as follows:

This transformation to obtain the marginal WTP enables the comparison of consumers' WTP prices for different milk attributes across regions. Researchers used the WTP values for the milk attribute with the highest WTP reported in the selected studies. The average price premium consumers were willing to pay for a milk attribute was expressed as a percentage of the price of the regular milk product for that same year in the same currency, accounting for inflation and currency adjustments to give a uniform metric (Turner et al., 2019). Descriptive statistics and thematic analysis were presented using tables and figures. The findings were reported and synthesized in the Results and Discussion sections.

3. Results

The results include six subsections covering search results, literature trends observed in the 123 included studies, milk types studied and their geographic distributions, value elicitation methods employed in estimating consumers' WTP for milk attributes, consumers' WTP for milk attributes, and the factors affecting consumers' WTP. The search results obtained from the three databases, Web of Science, Scopus, and AgEcon, are shown in the PRISMA flow chart (see Fig. 1) in Section 3.1 and the data has been published in Mendeley data (Madududu et al., 2024). The literature spans from 1994 up to the most recent studies conducted in the year 2023, indicated in Section 3.2. Subsection 3.3 illustrates the milk types studied and the geographic regions. The value elicitation methods employed, including the study settings, are shown in Section 3.4, while Section 3.5 delves much into the milk attributes and consumers' WTP values. The last section, Section 3.6, provides the factors influencing consumers' WTP for milk attributes.

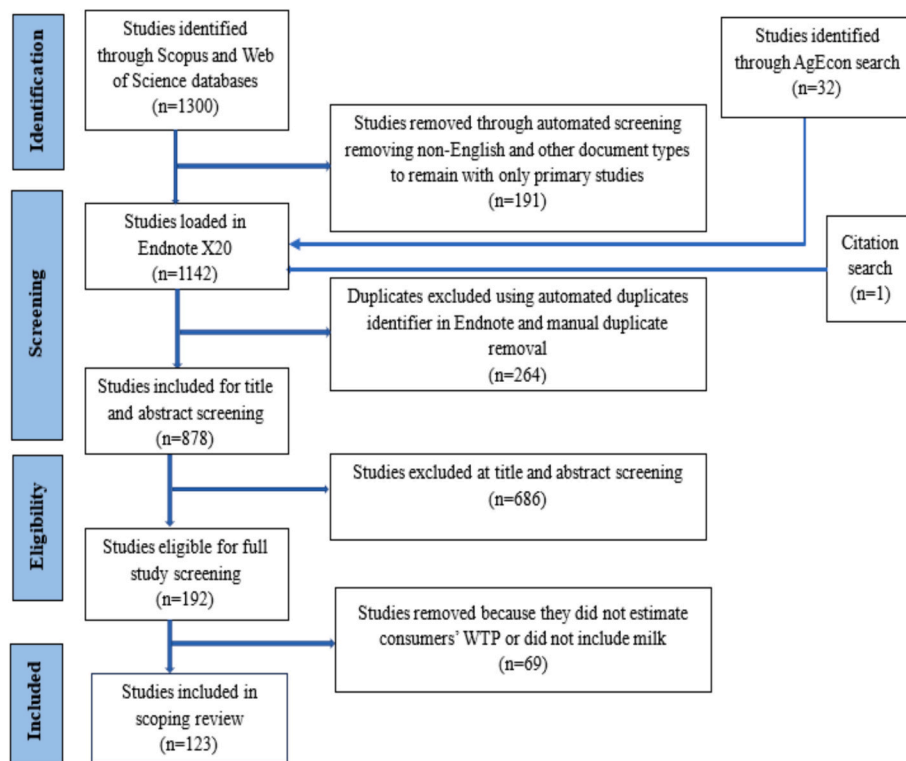


Fig. 1. PRISMA flow chart of the consumers' WTP for milk studies from identification to inclusion.

3.1. Search results

The electronic database search yielded 1300 articles in Scopus and Web of Science, where 191 studies were removed through automated screening, removing non-English studies and other study types to keep primary studies. An additional 32 articles were identified through the AgEcon search. A single article was added through a manual reference search to come up with 1142 studies. Duplicates were removed through Endnote and manual method, leaving 878 studies. Title and abstract screening removed 686 studies, and 192 were eligible for full screening. Finally, 123 studies were included in the scoping review in total (see supplementary file SI). The PRISMA flow chart shows the steps and stages involved in the review, showing how screening was done at each stage (see Fig. 1).

3.2. Literature trends

The earliest article on consumers' WTP for milk attributes was published in 1994 (Fox et al., 1994). The studies cited by this earliest paper indicate that market research had already started with laboratory experimental auctions and CVM. The trends in the number of studies indicate growing interest among researchers in investigating consumers' WTP for milk attributes (See Fig. 2). The moving average for the ten-year periods 1994–2003, 2004–2013, and 2014–2023 were calculated as 0.3, 3, and 9 articles per year, respectively. The last five years, 2018–2023, have accounted for 60 studies, which is 48.7 % of all the studies included, showing a rapid increase in the literature on consumers' WTP for milk attributes. There was a decline in the number of studies in 2010 and 2012, 2018 and 2022. The sharp decline in 2022 might be due to Covid-19. Notably, the number of studies is rising, as shown by the trendline corresponding to the number of studies.

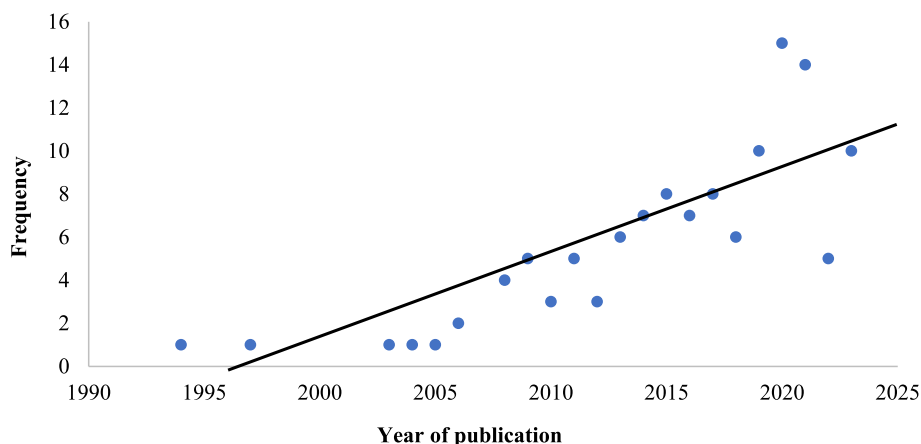


Fig. 2. Trendline showing number of consumers' WTP for milk studies published from 1994 to 2023.

Table 1
Milk type investigated and regions of the included studies (n = 123).

Characteristics	Number of studies	Percentage (%)
Milk type		
Cow milk	111	90.2
Infant formula	7	5.7
Soya PBMA	5	4.1
Oat PBMA	1	0.8
Rice PBMA	1	0.8
Camel milk	1	0.8
Regions		
Asia	46	37.4
North America	33	26.8
Europe	30	24.4
Africa	8	6.5
South America	6	4.9

3.3. Milk types and geographic distribution

Most papers, constituting 89.4 % of the 123 studies, were on cow milk, highlighting its widespread popularity across regions (see Table 1). Infant formula, representing 5.7 %, emerged as the second most studied milk type among the studies, 6 out of 7 conducted in China. A small proportion of the studies were on PBMA, which investigated consumers' WTP for the attributes of dairy alternatives from soy, rice, and oat (Laassal and Kallas, 2019) and soy (McCrickerd et al., 2020). In Table 1, other studies had more than one type of milk, for example, investigating consumers' WTP for cow milk and a PBMA from soy. Therefore, the total percentage by milk type does not add up to 100 % as such studies were counted in both cow milk and PBMA studies. For example, a study in Catalonia, Spain, investigated consumers' WTP for cow milk and PBMA from soya (Yokessa and Marette, 2019). Studies on PBMA from soya were 4.1 %, which may indicate a potential for soya PBMA, although there are still few studies.

The geographic distribution of studies in the scoping review reveals notable patterns in research focus across different regions. Asia emerged as the region with the highest representation, accounting for 37.4 % of the included studies. Following closely behind, North America and Europe demonstrated considerable research activity, with 26.8 % and 24.4 % of the studies originating from these regions, respectively. This distribution highlights the substantial contributions of Western research contexts to the body of knowledge on the topic. Africa and South

Table 2
Data collection location and value elicitation methods included in studies (n = 123).

Characteristics	Number	Percentage
Data collection location		
Online	38	30.8
Supermarkets	24	19.5
Laboratory	23	18.6
Not given	10	8.1
Consumer homes	7	5.7
Market places	8	6.5
Public places	7	5.7
Others (University, telephone, special stores)	7	5.7
Value elicitation		
Stated preference (hypothetical value elicitation)		
DCEs	51	41.5
CVM	31	25.2
Direct elicitation	13	10.6
Revealed preference (non-hypothetical value elicitation)		
Hedonic pricing	3	2.4
Auctions	19	15.4
Direct elicitation	2	1.6
Mixed methods		
Hypothetical & non-hypothetical	4	3.3

America had 6.5 % and 4.9 % of the studies from these regions, respectively.

3.4. Study setting and value elicitation methods

The data collection platforms and value elicitation methods reviewed encompass diverse approaches to understanding consumers' WTP for milk attributes (see Table 2). Regarding data collection platforms, online surveys were the most used, with 38 (30.8 %) studies, but they differed in respondent response rates, and their respondent rates are generally lower than the face-to-face surveys. For example, an online survey was rolled out to 4000 households in the US, and 1691 were completed (Brooks and Lusk, 2010). Face-to-face surveys with consumers at supermarkets (Echeverría et al., 2014; Merlino et al., 2020) and auctions in laboratories (McCrickerd et al., 2020; Paterson and Clark, 2020) were also common data collection points, comprising 24 (19.5 %) and 22 (17.9 %) studies, respectively.

Various other platforms were utilized to collect data, including consumer homes, marketplaces (Linhai et al., 2014), and public areas (Vroegindewey et al., 2021).

Regarding value elicitation methods, stated preference methods (hypothetical value elicitation) were the most commonly used in 95 (82.1 %) studies. The second highest was revealed preference methods (non-hypothetical elicitation) with 24 (19.5 %) studies and then 4 (3.3 %) manuscripts mixed hypothetical and non-hypothetical methods. In the category of stated preference methods, discrete choice experiments (DCEs) dominated with 51 (41.5 %) studies. DCEs involved researchers presenting participants with a series of hypothetical choice scenarios and asking them to select their preferred option, allowing researchers to estimate WTP for different attributes. In the US, consumers were given choice scenarios for milk with varying packaging, organic attributes, fat content levels, and price (Kim et al., 2018). Within DCEs, best-worst scaling had only two studies where, in one instance, the multi-profile case 3 was applied with consumers choosing between milk with different animal welfare attributes, such as cow-calf contact and dehorning with varying formats of information (Boaitey et al., 2022).

The CVM was also commonly employed in 31 (25.2 %) studies (Chancharoenchai, 2017; Neill and Williams, 2016). The direct elicitation method was also used, where participants were asked about their WTP for a specific attribute or product, often through surveys, and 13 (10.6 %) studies were conducted. Revealed preference methods used were auctions (Akaichi et al., 2012; Goldberg et al., 2009), direct elicitation (Britwum and Bernard, 2018), and hedonic pricing (Loke et al., 2015). Direct elicitation was used in both hypothetical and non-hypothetical value elicitation. For example, in hypothetical elicitation, consumers were asked in a survey how much they would be willing to pay for milk with specified attributes without the actual product made available. In non-hypothetical scenarios, for example, in an auction, consumers were asked to choose the amount of money they wanted to pay for milk with a given set of attributes.

An analysis of the trends of the value elicitation methods shows that early studies from 1994 to 2003 were few and used CVM (Maynard and Franklin, 2003), direct elicitation (Wang et al., 1997), and auction (Fox et al., 1994). From 2003 to 2013, CVM, DCEs, and auctions recorded almost a similar number of studies, excluding studies that employed mixed methods (Zhao et al., 2020), using both stated and revealed preference methods (see Fig. 3). However, the last decade of 2014–2023 indicates a surge in the studies using DCEs compared to CVM and auctions, almost doubling the number of studies using CVM. It can be seen in the trend lines that studies using DCEs are increasing at a higher rate compared to the CVM and auctions (see Fig. 3).

It is also essential to note that the number of studies using CVM and auctions was increasing, though they cannot be compared to the expansion of studies using DCEs. The best-worst scaling study among reviewed studies was first recorded in 2015 (Costanigro et al., 2015), and another study used the method in 2022 (Boaitey et al., 2022). The

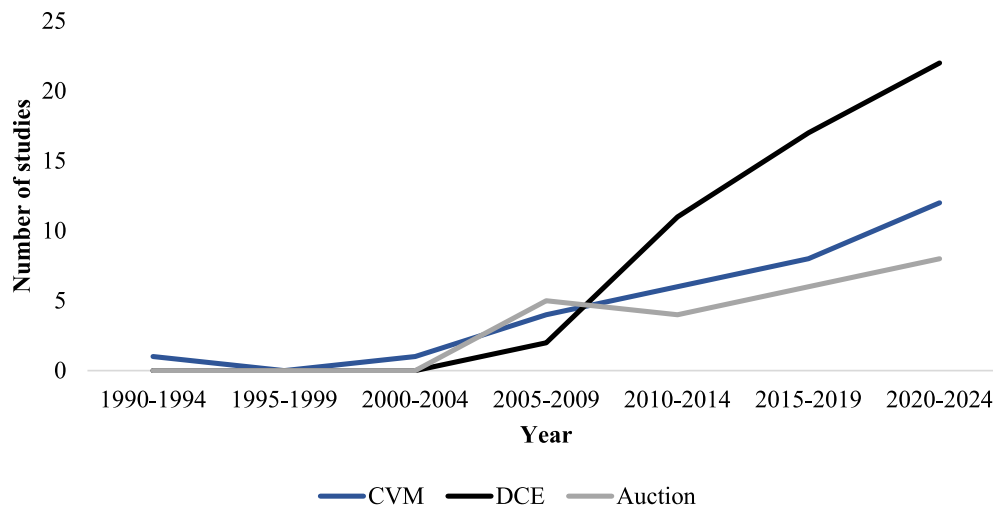


Fig. 3. Trend of value elicitation methods used in studies to elicit consumers' WTP for milk attributes.

WTP estimates for the hypothetical methods (DCEs, CVM, BWS) were higher than those for non-hypothetical methods (auctions and hedonic pricing).

3.5. Consumers' WTP for milk attributes and their regional patterns

The analysis of consumers' WTP for milk attributes reveals distinct patterns in consumer preferences, particularly concerning attributes associated with higher consumers' WTP. This section compares consumers' WTP for various milk attributes across different regions. The objective is to understand the regional variations in WTP for the various dairy and PBMA attributes. The attributes were put into categories for comparison purposes. The identified categories and the number of studies reported per group were organic (29), safety and quality (29), environmental (17), health-related (9), animal welfare (13), origin (10), brand (4), sensory attributes (3) and other (9). The groups reported in this section have studies above five: organic, safety and quality, environment, animal welfare, origin, and health-related attribute groups. The sensory and brand categories with fewer studies below five could not proffer meaningful regional patterns worth comparison. The

category named “other” was not explained since it includes all the attributes that could not be put into the specified categories, and meaningful comparisons of WTP values could not be made.

The attributes grouped as “other attributes” were gene editing, cooperative, ownership, education label, redundant, improved, irradiated, and units purchased, described in the following statements. The gene-editing attribute was used to describe milk from cows, which went through a process aimed at altering targeted DNA, thereby improving the breeding process and progress rate (Kilders and Caputo, 2021). The cooperative attribute was used to solicit if consumers are willing to pay for milk produced by smallholder farmer cooperatives in Kazakhstan (Kaliyeva et al., 2021). Ownership attribute is a farmer-owned milk label, and consumers are willing to pay more for the farmer-owned label in the Netherlands (Grashuis, 2021). Irradiated milk is treated with ionization to reduce or eliminate microorganisms and improve its safety (Liaukonyte et al., 2015). In the context of the study by Yue et al. (2015), the improved milk attribute refers to the milk produced from organically fed cows grazing on pasture. Also, the milk is free from hormones and antibiotics and has a certification label (Yue et al., 2015). The redundant label used two or more qualities of milk; in this case, consumers were

Table 3
Regional distribution of milk attributes included in the studies (n = 123 studies).

Attributes	Asia	North America	Europe	Africa	South America	Studies no. (%)	Min %	Max %	SD %	Average WTP (%)
Organic	10	12	6	0	1	29 (23.6)	7	132	37.3	54.9
Safety & Quality (pasteurized, safety, traceability, quality, smell, fresh, aflatoxin free, HACCP, certification, mycotoxin free, 100 % fresh, shelf life, rBST free, GMO-free, antibiotic-free)	17	4	2	5	0	29 (23.6)	3	117	36.9	44.5
Environmental (climate impact, green, mountain product, packaging, carbon footprint, sustainable, linseed cow milk, local feed)	6	2	9	0	1	17 (13.8)	3	85	23.5	34.2
Animal Welfare (animal welfare, cow-calf contact, pasture-raised, non-cloning, cloned cow milk, ban tie stall, fair milk, and grazing)	1	7	4	0	1	13 (10.6)	0	102	35.9	52.7
Brand	2	0	1	0	1	4 (3.3)	7	76	28.6	40.3
Origin (origin, local milk, imported)	3	3	4	0	0	10 (8.1)	10	147	42.3	44.6
Health-related (fat content, nutrition, A2 milk, functional milk, CLA)	4	2	1	1	1	9 (7.3)	3	73	23.9	25.4
Sensory (Aroma, flavor, enhanced sensory)	1	0	1	1	0	3 (2.4)	3	45	21.2	22.3
Other (milk type, irradiated, ownership, improved, education label, co-operative, redundant, gene editing, units purchased)	2	3	2	1	1	9 (7.3)	4	80	27.8	38.3
Studies No. (%)	46 (37)	33 (27)	30 (24)	8 (6)	6 (5)	123 (100)	Global Min	Global Max	Global SD	Global average
Average WTP (%) SD%	46 (34)	52 (39)	37 (26)	35 (40)	29 (22)	43.6 (33.9)	0	147	33.8	43.6

willing to pay more for the redundant label, showing that the milk is non-GMO and was produced using animal-friendly methods (Ufer et al., 2021). The unit attribute indicates that consumers were willing to pay more when buying a single unit of milk, and the more units, the lower the willingness to pay (Akaichi et al., 2012). The education label was used to sell milk to promote the education of low-income students with high academic potential (Rajo et al., 2016). The individual groups with studies above 5 per group exhibited some regional patterns with different values of consumers' WTP, which are explained in the following sub-sections (also see Table 3).

3.5.1. Organic

The organic attribute in milk has been shown to command a high premium recorded in 29 reviewed studies spanning Asia (10), North America (12), and several European countries (6), South America (1), with WTP ranging from 7 % to 132 % and an average global WTP of 55 % (SD37.3 %). The results of the consumers' WTP for the organic attribute in dairy and PBMA reveal significant variation across different regions, showing an interplay of diverse preferences, economic drivers, and cultural perceptions towards organic products among consumers. The WTP for organic attributes in Asia varies widely. For example, Zhu et al. (2023) found a WTP as high as 178 % in China, although this is considered an outlier in this study for better estimations of the regional average values of WTP. Similarly, an even higher WTP of 200 % in Saudi Arabia has been reported, which stands out as an outlier (Almarri and Al-Mahish, 2021). In contrast, a lower WTP of 14 % in Iran, showing a moderate interest in organic products, has been solicited (Rafiee et al., 2023). Additionally, a substantial WTP of 126 % in China for organic infant formula shows that Chinese consumers are willing to pay more for organic products for children, which may be driven by food safety and quality concerns (Yin et al., 2018). Other studies in China, such as Linhai et al. (2014) and Xu et al. (2014), reported 70 % and 60 % WTP values, respectively, indicating a consistently high interest in organic dairy.

In North America, the WTP for organic attributes also shows variability. Kim et al. (2018) found a WTP of 90 % in the United States of America (U.S.), indicating a strong preference for organic products, which is consistent with the health-conscious consumer base in the country. Schroeter et al. (2016) and Schott and Bernard (2015) found WTP values of 71 % and 95 %, respectively, further supporting the notion that American consumers place a high value on organic dairy products. Interestingly, Liu et al. (2013) reported an even higher WTP of 132 %, suggesting that organic attributes are particularly valued for some consumer segments. However, there are lower WTP values as well, such as the 7 % reported by Tonsor & Wolf (2012) and the 19 % by Bernard et al. (2006), indicating that the demand for organic products is not uniform across the country and might be influenced by factors such as income, education, and regional differences.

The WTP for organic attributes varies in Europe but tends lower than in Asia and North America. Hasselbach and Roosen (2015) found a WTP of 75 % in Germany, showing a strong but not extreme preference for organic dairy products. In Denmark, Denver and Christensen (2014) reported a WTP of 35 %, indicating a more moderate interest, possibly due to the already high availability and consumption of organic products in the region, which might reduce the premium consumers are willing to pay. Akaichi et al. (2012) in Spain found a WTP of 49 %, and Yokessa and Marette (2019) in France reported a WTP of 83 % for organic soy in PBMA, suggesting that while there is interest in organic dairy, it varies across different European countries. In South America, Rodríguez et al. (2009) reported a WTP of 14 % in Argentina, which is on the lower end of the spectrum. The findings for South America suggest that organic products may not be as highly valued in this region, potentially due to economic factors or lower awareness of the benefits of organic farming.

3.5.2. Safety and quality

Safety and quality attributes were reported by 29 studies, with the

highest number from Asia (17), Africa (5), North America (4), and Europe (2), showing a more consistent distribution across regions, which can indicate a universal emphasis on dairy products' safety and quality standards among consumers. The premiums range from 3 % to 117 % and an average of 45 % (SD 37 %). The attributes under this category include safety, quality, HACCP, pasteurization, traceability, mycotoxin-free, rBST-free, antibiotic-free, GMO-free, and fresh. Some Asian countries had exceptionally high WTP for safety attributes, reflecting acute concerns over food safety. For example, a WTP of 117 % was reported in Thailand for 100 % fresh milk, showing that Thai consumers are concerned about the freshness of milk (Chancharoenchai, 2017). Similarly, Zhou et al. (2010) reported a WTP of 217 % for traceability, reflecting their sensitivity to food safety from food scandals in China. It is important to note that safety attributes and contexts vary across regions. For example, Abedullah et al. (2023) found a WTP of 238 % for aflatoxin-free milk in Pakistan, indicating severe concerns over contamination, while Anjum et al. (2021) found a much lower WTP of 8 % for pasteurized milk.

Interestingly, 5 African studies had safety and quality attributes that were mainly preferred to other milk attributes. The findings show that WTP for safety attributes in Africa can be relatively high, reflecting the critical importance of food safety in regions where foodborne diseases may be more prevalent. For instance, Habiyaremye et al. (2023) reported a WTP of 92 % for milk with safety and quality assurance in Rwanda, showing a strong consumer preference for safe and high-quality dairy products, possibly driven by limited access to consistently safe food. Similarly, Oyekale et al. (2013) found a WTP of 92 % for pasteurized milk, which indicates a significant consumer demand for safer milk products in a region where raw milk consumption might still be common. On the lower end, Bekele et al. (2017) found a WTP of only 4 % for pasteurized milk in Ethiopia.

The WTP for safety attributes in North America is moderate and lower than in other Asian countries. For example, Endara et al. (2023) reported a WTP of 44 % in the U.S. for milk with an extended shelf life, suggesting a concern for both safety and convenience. Wolf et al. (2011) found a WTP of 43 % for rBST-free milk, indicating a strong consumer preference for hormone-free products, likely driven by health concerns and the desire for more natural food options. Interestingly, Jensen et al. (2021) reported a lower WTP of 16 % for pasteurized milk, which may suggest that pasteurization is so standard in the U.S. that consumers do not see it as a premium attribute worth paying extra money. In Europe, WTP for safety attributes is generally moderate. Consumers were willing to pay 29 % for mycotoxin-free milk in Italy, reflecting a specific concern for contamination that can affect dairy products (Sckokai et al., 2014). In Germany, a high WTP of 85 % was reported for quality-assured infant formula, indicating that European consumers are willing to pay a premium for safety and quality regarding products for vulnerable populations such as infants (Goldberg et al., 2009).

3.5.3. Animal welfare

Animal welfare can mean different things to politicians, consumers, farmers, or veterinarians. Generally, when an animal's body and physical environment, mainly feed and shelter, is enough for a healthy and productive life, then an animal is faring well (Hewson, 2003). Animal welfare falls under the social sustainability aspect of the dairy sector. In this review, different studies investigated consumers' WTP for various animal welfare attributes presented in multiple dimensions, such as animal welfare, pasture-raised grazing, cow-calf contact, non-cloning, and banning the use of tie stalls. The average consumers' WTP for animal welfare attributes was 53 % (SD35.9 %), ranging from 0 % to 102 %. North America had the highest number of studies on animal welfare, followed by Europe. Single studies were recorded in South America and Asia, whereas no study was recorded for Africa, indicating that animal welfare might not be as prioritized or publicly discussed in these regions with fewer studies than in Europe and North America.

In North America, especially the U.S., the WTP for animal welfare is

significantly higher than in other regions. [Boaitey et al. \(2022\)](#) reported a WTP of 102 % for maintaining cow-calf contact, indicating a strong consumer preference for specific welfare practices. Another study by [Brooks and Lusk \(2010\)](#) found a WTP of 93 % for non-cloning practices, while [Robbins et al. \(2019\)](#) reported a WTP of 68 % for banning tie stalls. In Europe, the results vary, but generally, the WTP is lower than in North America. [Waldrop and Roosen \(2021\)](#) reported a WTP of 0, indicating no additional willingness to pay for animal welfare attributes in a broad European context. However, other studies in Germany showed varying results, with [Markova-Nenova et al. \(2018\)](#) and [Höhler & Schreiner \(2020\)](#) reporting WTP values of 32 % for general animal welfare and 32 % for Fairmilk and grazing practices, respectively. [Kuhl et al. \(2017\)](#) found a higher WTP of 74 % for pasture-raised dairy cows.

3.5.4. Environmental

Overall, 17 studies reported on environmental-related attributes, and 9 were conducted in Europe, 6 in Asia, 2 in North America, and then 1 study in South America. The WTP for the environmental attributes ranges from 3 %–85 %, with an average of 34 % (SD23.5 %). The attributes in this category are climate impact, green production, sustainable practices, biodegradable packaging, mountain milk production, carbon footprint, local feed, and use of linseed feed. The consumers' WTP values for environmental-related attributes vary across different regions. In Europe, the WTP for environmental attributes differs widely. For example, in Germany, [Sonntag et al. \(2023\)](#) found a WTP of 43 % for climate impact attributes, while [Wägeli et al. \(2016\)](#) reported a higher WTP of 77 % for local feed in supermarkets, which reduces the environmental impact through local sourcing. A lower % WTP value of 22 % was reported in Italy for mountain products ([Staffolani et al., 2022](#)), and [Cammarelle et al. \(2021\)](#) found a WTP of just 7 % for environmentally friendly packaging in the same country. These lower figures suggest that Italian consumers might prioritize different aspects of environmental sustainability or are less willing to pay for these attributes. However, [Marette et al. \(2017\)](#) in France reported a relatively high WTP of 85 % for linseed cow milk to reduce enteric methane emissions.

The WTP for environmental attributes also varies in Asia, particularly in China. [Li et al. \(2023\)](#) reported a WTP of 40 % for green production, while [Zhang et al. \(2019\)](#) found an outlier WTP of 200 for sustainable practices, indicating a very high valuation in some contexts. However, [Zhao et al. \(2020\)](#) reported a very low WTP of 3 % for reducing the carbon footprint, suggesting that Chinese consumers do not value all environmental attributes equally. [Nam et al. \(2020\)](#) in Korea reported a WTP of 36 % for mountain products, indicating a moderate preference for ecological sustainability. The differences in WTP across Asian studies might reflect varying levels of environmental concern, economic development, and consumer trust in sustainability claims. In North America, [Paterson and Clark \(2020\)](#) reported a WTP of 14 % for environmentally friendly packaging in the U.S., while [Neill and Williams \(2016\)](#) found a WTP of 19 % for the same attribute. These WTP values suggest consumers are willing to pay for environmentally friendly attributes, though it is not as high as in other regions like Europe. In South America, Chile, a WTP of 29 % for reducing the carbon footprint was found ([Echeverría et al., 2014](#)), but we could not make judgments based on a single study on environmental attributes, though it may reflect a growing concern for environmental impacts of the dairy sector in the region.

3.5.5. Origin

Origin-related attributes, such as local and imported milk, exhibited significant regional variation, with 3 studies recorded for Europe and 3 studies each for Asia and North America. The average WTP of the origin attributes ranges from 10 % to 147 %, averaging 45 % (SD42.3 %). Different regions have shown varied interests in the origin attribute, although this attribute has not been reported to have a consumer WTP in the African and South American regions.

In Asia, consumers show a moderate to strong preference for the

origin attribute in dairy products, with a notable preference for imported milk due to safety concerns and a desire for foreign products. [Zhang et al. \(2021\)](#) found a WTP of 59 % in China for origin labeling, while [Quan et al. \(2018\)](#) reported a lower WTP of 25 % for imported infant formula. These results indicate that while origin is essential, there may be a different premium placed on foreign products, particularly in infant formula, where safety and quality are paramount. [Li et al. \(2017\)](#) reported a WTP of 37 % of imported milk from Europe, further cementing the notion that Chinese consumers value the origin of their dairy products, possibly due to trust issues with domestic products.

North America has a solid but varied interest in the origin attribute. [Osburn et al. \(2020\)](#) found a very high WTP of 147 % in the U.S., indicating that American consumers place significant value on knowing the origin of their dairy products, possibly due to a combination of national pride, support for local agriculture, and concerns over food safety and sustainability. However, [DeLong et al. \(2020\)](#) reported a much lower WTP of 12 %, suggesting that while origin is vital to some, it may not be a priority for all American consumers, perhaps depending on demographic factors or product types. [Forbes-Brown et al. \(2016\)](#) found a WTP of 81 % in Canada, which also points to a strong preference for origin labeling, likely reflecting a desire to support local producers and ensure product quality.

In Europe, the WTP for the origin attribute tends to be lower compared to North America and Asia. [Tempesta and Vecchiato \(2013\)](#) reported a WTP of 36 % in Italy, indicating a moderate interest in the origin of dairy products, which might be linked to Italy's rich culinary traditions and the importance placed on local food products. [Emberger-Klein et al. \(2016\)](#) found a WTP of 10 % in Europe, which further reflects a lower priority on origin compared to other attributes. [Schroder et al. \(2005\)](#) in Germany found a WTP of 24 % for local origin labeling, suggesting that while there is some interest, it is not as strong as in other regions, possibly due to the already high standards of local products that reduce the need for additional origin labeling.

3.5.6. Health-related

Health-related attributes are the attributes associated with the qualities of milk enhanced to benefit consumers with specific health needs. The health-related attributes were high conjugated linoleic acid (CLA), A2 milk, functional properties, improved nutrition, and fat content. A functional food can be defined as a dietary item that, besides providing nutrients and energy, beneficially controls one or more targeted functions in the body by improving specific physiological responses and reducing the risk of diseases ([Nicoletti, 2012](#)). Animal science studies have shown that milk with high conjugated linoleic acid (CLA) inhibits many cancers ([Maynard and Franklin, 2003](#)). A2 milk is a variety of cows' milk that mostly lacks a form of β -casein proteins, and it has increased protein, better digestibility, and natural health benefits ([Bentivoglio et al., 2020](#)). Diabetes milk has been described as milk with functional properties that help diabetes patients and is bone-healthy milk ([Van Tra et al., 2011](#)). The average WTP for these attributes was 25 % (SD23.9 %), ranging from 3 %–73 %. The WTP values vary across regions, and 4 studies were recorded in Asia, then 2 in North America, while Europe, Africa, and South America had single studies on this category.

Varied responses were found in Asia since other attributes had moderately lower WTP values and others were extremely high. For example, in Singapore, [McCrickerd et al. \(2020\)](#) observed a higher WTP of 40 % for the "Healthier Choice" label in soymilk, indicating a strong preference for health-related attributes, but Vietnam showed a high WTP of 300 % for diabetes milk in the study by [Van Tra et al. \(2011\)](#), which stands out as an outlier. In China, [Xu et al. \(2020\)](#) reported a high WTP of 470 % for milk with enhanced nutrition, which is another outlier. In North America, [Maynard and Franklin \(2003\)](#) reported a WTP of 73 % for CLA-enriched dairy products in the U.S., showing a strong interest in health-related benefits, but [Kazi et al. \(2022\)](#) found a lower WTP of 12 % for fat content, showing that while some health attributes

are valued, others might not be as significant to American consumers. In Africa, [Bekele et al. \(2016\)](#) found that Ethiopian consumers had a very low WTP of 3 % for low-fat content in dairy products, indicating that health-related attributes might not be a significant factor for most consumers in this region. In South America, a single study was conducted in Brazil, where consumers were willing to pay 20 % for A2 milk ([Oliveira et al., 2022](#)). [Bentivoglio et al. \(2020\)](#) reported a low WTP of 11 % for A2 milk in Italy, indicating a moderate interest in this health-related attribute, similar to findings in Brazil.

3.5.7. Plant-based milk alternatives (PBMA)

Very few studies have investigated consumers' WTP for PBMA. A study conducted in Singapore showed that consumers were willing to pay more for PBMA from soya with front-of-package health and nutrient-related labels. However, when the labels were unavailable, consumers would go for taste intensity and consume larger portions for

Table 4
Factors affecting consumers' WTP for dairy and PBMA attribute classes.

Attribute class	Positive factors (number of studies reporting the factors)	Negative factors (number of studies reporting the factors)	References
Animal welfare	Education (1), women (1), liberals (1), income (1)	–	(Boaitey et al., 2022 ; Robbins et al., 2019)
Environment	Consumer awareness (6), attitudes towards the environment (3), perception about own impact on the environment (3), age (2), income (2), female (2)	Age (3), expenditure share (2)	(Cammarelle et al., 2021 ; Echeverría et al., 2014 ; Gao et al., 2020 ; Li et al., 2023 ; Marette et al., 2017 ; Profeta and Hamm, 2019 ; Staffolani et al., 2022 ; Xia and Zeng, 2013 ; Zhang et al., 2019 ; Zhao et al., 2020)
Health	Income (3), education (3), milk use (2)	Age (2)	(Bekele et al., 2016 ; Kazi et al., 2022 ; Van Tra et al., 2011)
Organic	Income (5), awareness (4), health consciousness (4), education (4), environmental consciousness (3), age (2)	Age (2)	(Akaichi et al., 2012 ; Almarri and Al-Mahish, 2021 ; Amirnejad and Tonakbar, 2015 ; Britwum et al., 2021 ; Loke et al., 2015 ; Rafiee et al., 2023 ; Wu et al., 2020 ; Yormirzoev et al., 2021)
Origin	Local food preferences (3)	Age (2)	(Delong et al., 2020 ; Emberger-Klein et al., 2016 ; Li et al., 2017 ; Zhang et al., 2021)
Safety	Income (8), milk safety risk perception and information consciousness (8), education (5), male (5), safety awareness (4), age (3), employment (2), having children (2)	Higher raw milk consumption (2), having more children (3), Age (3)	(Anjum et al., 2021 ; Bekele et al., 2017 ; Bozoglu et al., 2019 ; Chen et al., 2013 ; Cheng et al., 2015 ; Endara et al., 2023 ; Habiyaremye et al., 2023 ; Hossain et al., 2023 ; Oyekale et al., 2013 ; Schell et al., 2023 ; Sckokai et al., 2014 ; Wang et al., 1997 ; Zhang et al., 2012)
Sensory	Shopping expenditure on dairy alternatives (2)	–	(Laassal and Kallas, 2019)

tastier soya PBMA ([McCrickerd et al., 2020](#)). An investigation conducted in the U.S. on the organic attribute of soybean in soya PBMA revealed that consumers placed more value on the U.S.-certified organic attribute than the Chinese-certified ([Yue et al., 2013](#)). A study in Catalonia, Spain, showed that price was the major driving factor for WTP for non-dairy alternatives, and consumers were willing to pay €0.89/unit for the original flavor. Also, consumers prefer soya PBMA over rice and oat PBMA ([Laassal and Kallas, 2019](#)). In France, consumers would pay more for soya PBMA than cow milk if all the milk products were produced under an organic process ([Yokessa and Marette, 2019](#)).

3.6. Factors affecting consumers' WTP

Consumers' WTP for milk attributes is influenced by various factors, which range from socioeconomic factors, perceptions, attitudes, information, and market orientations, only to mention a few ([Table 4](#)). Firstly, most studies revealed that consumers' WTP for the organic milk attributes was driven mainly by income ([Almarri and Al-Mahish, 2021](#); [Amirnejad and Tonakbar, 2015](#)), awareness ([Almarri and Al-Mahish, 2021](#); [Rafiee et al., 2023](#)), education ([Britwum et al., 2021](#); [Rafiee et al., 2023](#); [Xu et al., 2023](#)), health and environmental consciousness ([Xu et al., 2020](#); [Yormirzoev et al., 2021](#)). Factors such as age ([Britwum et al., 2021](#)), lack of information about organic farming ([Akaichi et al., 2012](#)), and the perception of high costs pose challenges to consumers' WTP for organic milk. Information consciousness about milk safety potential risks ([Endara et al., 2023](#); [Hossain et al., 2023](#)), higher income levels ([Cheng et al., 2015](#)), and education ([Anjum et al., 2021](#); [Schell et al., 2023](#); [Sckokai et al., 2014](#)) positively influence WTP for safer products. Conversely, higher consumption of raw milk ([Bekele et al., 2016](#)), more children ([Bekele et al., 2016](#)), and purchasing milk at open-air markets ([Bozoglu et al., 2019](#)) negatively affect WTP for safe milk.

Consumers' WTP for environmental attributes such as climate impact, carbon footprint and green production methods were influenced by consumers' awareness ([Cammarelle et al., 2021](#); [Li et al., 2023](#); [Xia and Zeng, 2013](#)), perceptions regarding sustainability ([Marette et al., 2017](#); [Xia and Zeng, 2013](#)) and attitudes towards the environment ([Cammarelle et al., 2021](#); [Li et al., 2023](#)). The worldwide climate change concerns around greenhouse gas emissions from intensive dairy farming are among the reasons other consumers are willing to pay premiums for milk with low carbon footprints. Factors such as age were positive ([Li et al., 2023](#); [Staffolani et al., 2022](#)) or negative ([Profeta and Hamm, 2019](#); [Xia and Zeng, 2013](#); [Zhang et al., 2019](#)) in different studies; therefore, it is not conclusive that age effectively drives WTP for environmentally friendly milk. Also, expenditure share on milk emerges as a potential barrier ([Echeverría et al., 2014](#)). Regarding factors affecting consumers' WTP for animal welfare attributes, this review shows that individuals with higher levels of education ([Boaitey et al., 2022](#)), women, liberals, and higher-income consumers are more inclined to prioritize animal welfare concerns, though these are few studies ([Boaitey et al., 2022](#); [Robbins et al., 2019](#)). However, there is limited knowledge of the specific negative factors impacting consumers' WTP for animal welfare, warranting further investigation. In terms of health-related attributes, income ([Kazi et al., 2022](#); [Van Tra et al., 2011](#)), milk use ([Bekele et al., 2016](#)), and education level ([Van Tra et al., 2011](#)) emerge as primary drivers influencing consumers' WTP for milk with perceived health benefits.

The literature revealed that age ([Bekele et al., 2016](#)) and taste preferences ([Bekele et al., 2016](#)) negatively influence consumers' WTP for milk with health benefits. Factors such as willingness to support the local economy ([Emberger-Klein et al., 2016](#)), perceived quality benefits ([Delong et al., 2020](#)), and cultural value ([Zhang et al., 2021](#)) influence WTP for locally sourced products. However, another study showed that consumers with experience from abroad might have a reduced preference for local products ([Li et al., 2018](#)). Lastly, a study has reported that residence in low-density areas ([Laassal and Kallas, 2019](#)) positively influences WTP for sensory attributes such as aroma, flavor, and taste. In

contrast, having no children may negatively affect consumers' WTP for the sensory characteristics of milk. Not all papers included the factors as others used models which did not accommodate factors influencing consumers' WTP but focused only on the WTP value elicitation.

4. Discussion

The scoping review shows an overwhelming focus on cow milk in most studies. This finding underscores the dominant position of cow milk in the market and its significant role in meeting dietary needs. The few studies on other milk types, such as PBMA, show that they are still new to the market, though their use is prevalent in the global north compared to the developing countries (Bojovic and McGregor, 2023). A study on camel milk was conducted in Kenya (Emukule et al., 2011), but this shows that these other milk types, including goat milk and buffalo milk, may not have obtained much research attention on this subject. Another notable pattern in the number of publications was a plunge in the number of studies published in 2010, 2012, 2021, and 2022. The decline in the number of studies in 2010 and 2012 might have resulted from the 2008 global financial crisis, which caused many governments to reduce research funding, causing a subsequent decline in research studies. The decline in 2021 and 2022 might have resulted from the covid-19 pandemic, limiting researchers' flexibility in doing their work. The number of studies in Asia was higher compared to other regions, which may emanate from the fact that about a quarter of the world's residents are Asian, although other factors, such as the availability of resources to carry out research and research interests in a region, also matter.

4.1. Applied methods to evaluate consumers' WTP for milk attributes

There is a notable shift towards online platforms in data collection platforms, with internet-based research accounting for 30.1 % of the studies reviewed using surveys. This trend highlights the increasing prevalence and accessibility of online surveys in contemporary research endeavors, primarily in developed countries where Internet services are functional. For example, there was no single online study among the African studies since this would introduce bias if not including other consumers without internet connectivity. Additionally, face-to-face interviews conducted at supermarkets (19.5 %) and laboratory settings (17.9 %) emerged as common data collection points for surveys and auctions. The utilization of diverse platforms such as consumer homes (Anjum et al., 2021), marketplaces, public places (Vroegindewey et al., 2021), and universities stress the multifaceted approach researchers adopt to capture a representative sample of consumer perspectives. Consumer studies targeting food products are challenging to get a sampling frame; therefore, researchers have the flexibility to determine the data collection platforms that maximize the representativeness of their targeted consumers, and this is why other researchers then choose to focus on a particular group of consumers, for example, university students (Abedullah et al., 2022; Zhao et al., 2020) or the general public (Li et al., 2023).

Stated preference methods, particularly DCEs, were the most frequently employed approach, constituting 82.1 % of the reviewed studies compared to CVM, with 25.2 %. Revealed preference methods, including auctions, direct elicitation, and hedonic pricing, were also used, highlighting the diversity of techniques employed to elicit WTP values for milk attributes. The last decade of 2014–2023 saw a near doubling of the studies using DCEs, which suggests the flexibility of DCEs in exploring several attributes or it is less complex, or it is a much better approach to provide respondents with more information relating to product functionality compared to other methods. Again, the emergence of BWS as a methodological approach shows the ongoing methodological innovation within the field (Aizaki and Fogarty, 2019). The WTP estimates from the hypothetical methods, DCEs, and CVM were higher than for the non-hypothetical techniques, and this is in line with

the findings of other researchers suggesting that estimating WTP using hypothetical methods results in high WTP estimates (Dolgopolova and Teuber, 2018).

Implications of these findings on using different methods extend beyond methodological preferences to broader considerations for research practice and policy formulation. The prevalence of online surveys brings out the need for researchers to adapt to evolving technological landscapes and leverage online platforms to reach diverse consumer populations efficiently. Moreover, the dominance of stated preference methods, also known as hypothetical elicitation methods, especially the DCEs, may be due to various reasons, such as the inappropriateness of other methods or higher complexity of different methods that can be used, such as the hedonic pricing in eliciting consumer preferences. However, findings from hypothetical scenarios require validation against real-world behavior where feasible. Comparative analyses across geographical contexts and product categories, such as comparisons between dairy and PBMA, can elucidate underlying drivers of consumer behavior and inform evidence-based policies and market strategies. Moreover, efforts to integrate emerging methodologies such as best-worst scaling and hybrid approaches using hypothetical and non-hypothetical value elicitation can enrich the methodological toolkit available to researchers and enhance the depth and breadth of insights gleaned from WTP studies.

4.2. Consumers' WTP for dairy and PBMA attributes

There were notable patterns based on the attribute class frequencies that suggested tailoring milk products to align with regional preferences, such as emphasizing organic certification in Asia and North America. Environmental sustainability and animal welfare attributes are primarily preferred in Europe, which are opportunities for consumerism, market-based voluntary certification programs, and the need for dairy farmers to adjust their production methods to suit consumers' preferences. Willingness to pay for origin attributes mostly in European countries such as local milk (Emberger-Klein et al., 2016; Forbes-Brown et al., 2016) aligns with supporting circular economies and regional producers. The findings align with the high WTP values for organic and locally produced milk due to high environmental awareness, health consciousness, and cultural attitudes towards sustainability attributes of food (De-Magistris and Gracia, 2016; Khalili et al., 2024). The findings are also vital in providing the information needed to guide policy actions and strategies for transforming the livestock farming systems to improve animal welfare and health (Ducrot et al., 2024). The researchers found it difficult to make generalizations using the studies in Africa and South America since there were few. Few studies in the regions may indicate gaps in research focus, a lack of research interest, or research funding in the subject matter, suggesting avenues for further exploration and collaboration to address regional disparities in research coverage.

The varying price premiums across different attributes of milk show the differences in consumer preferences and priorities, which dairy producers, marketers, and policymakers can leverage. The high WTP for organic attributes, particularly in Asia and North America, signals a growing consumer demand for sustainable food products. The findings align with the increasing consumer demand for sustainable food products, driven by concerns for health, environmental sustainability, and animal welfare (Li and Kallas, 2021; OECD/FAO, 2022). High WTP for organic attributes presents an opportunity for dairy producers to capitalize on the premiumization trend by investing in organic certification and sustainable farming practices. Similarly, the substantial WTP premiums for animal welfare attributes, predominantly in North America and Europe, highlight the increasing importance of ethical considerations in consumer purchasing decisions, urging dairy producers to prioritize ethical, human treatment of animals and transparent dairy supply chain practices.

Safety and quality attributes show consistent numbers across regions, reflecting universal emphasis on product standards and trust in

the dairy supply chain. The importance of safety milk attributes necessitates ongoing investments in food safety protocols and quality control mechanisms to meet evolving consumer expectations and regulatory requirements in dairy supply chains. The studies in China on the safety of infant formula and cow milk were likely stimulated by the deadly milk melamine scandal, which happened in 2008 and poisoned 300,000 children (Chen, 2009). WTP for health-related and sensory attributes was lower than other milk attributes, which may indicate a difference in how they receive attention from different consumer segments. However, this may highlight the need for targeted marketing strategies and product innovation efforts to enhance consumer awareness and perceived value. For example, consumers were willing to pay more for tastier soya PBMA when there was no front-of-package health and nutritional information, but when the information was available, they would choose soya PBMA with health and dietary benefits.

The emergence of studies on PBMA (Laassal and Kallas, 2019; Yue et al., 2013) highlights shifting consumer preferences in the global north (Bojovic and McGregor, 2023). This finding underscores the growing popularity of PBMA, driven by healthier choice considerations and environmental concerns in the global north, which can be an opportunity for producers and marketers in this region (McCrickerd et al., 2020; Yokessa and Marette, 2019). The attributes investigated in the PBMA studies are like the ones of cow milk, such as organic (Yokessa and Marette, 2019; Yue et al., 2013) and flavor (McCrickerd et al., 2020), which make it possible to make comparisons between the products. Sensory attributes of PBMA, such as taste and flavor, are essential as other consumers prefer the original flavor to different flavors. Taste matters, and manufacturers must understand their targeted consumers before producing products in bulk to circumvent losses. On the contrary, there are concerns that PBMA may not provide sufficient amino acids compared to cow milk, which may limit its use for infant consumption (Vitoria Miñana, 2017). In certain instances where the benefits of PBMA outweigh cow milk, such as allergies to cow milk, PBMA fortified to enhance nutritional value can be used for feeding children instead of cow milk (Reyes-Jurado et al., 2021).

The comparative analysis revealed distinct regional patterns in consumers' WTP for milk attributes. Organic and animal welfare attributes received higher premiums in North America and Europe, reflecting strong consumer preferences and higher income levels. Safety and quality attributes are valued uniformly across regions, indicating a universal concern for product standards. Environment-related and origin-related attributes showed significant regional variation influenced by local environmental awareness and cultural factors. Important health-related and sensory attributes exhibit lower WTP, suggesting that these factors are less critical than others in driving consumer choice.

4.3. Drivers of consumers' WTP for milk attributes

Our analysis sheds light on various positive and negative socio-economic factors influencing consumers' WTP and the different milk attributes driven by multiple factors. Notably, other studies did not report socio-economic factors in their empirical analysis design; therefore, some milk attributes did not get sufficient evidence on the socio-economic factors that drive their WTP by consumers. Discussed here are the positive and negative socioeconomic factors influencing consumers' WTP for various milk attributes ranging from household demographics and consumer attitudes to knowledge and awareness. The intricate interplay of these socio-economic factors indicates the complex nature of understanding what shapes consumers' WTP for different milk attributes.

Positive factors associated with dairy and PBMA attributes provide dairy producers valuable insights into consumer preferences and behaviors. For example, investing in animal welfare initiatives, such as promoting cow-calf contact (Boaitey et al., 2022) and transitioning away from tie stalls (Robbins et al., 2019), can appeal to consumers who prioritize ethical and humane production practices. The findings imply

that in regions where animal welfare is an issue in Europe, availing the information about animal welfare can drive up consumers' WTP. Similarly, implementing environmentally sustainable practices, such as biodegradable packaging (Cammarelle et al., 2021), green production (Li et al., 2023), reducing greenhouse gas emissions, and lowering carbon footprints in dairy production can cater to the growing segment of eco-conscious consumers.

Moreover, identifying positive factors related to health, organic production, origin, safety, and sensory attributes offers product differentiation and market segmentation opportunities. Dairy producers can leverage these attributes to develop niche products targeted at specific consumer segments, such as environmentally conscious consumers or those who prefer locally sourced (DeLong et al., 2020) and sustainably produced foods (Gao et al., 2020). By offering a diverse range of milk products that cater to different consumer preferences and values, producers can expand their market reach and capture new market segments, thereby driving growth and profitability. Furthermore, recognizing negative factors helps marketers acknowledge the importance of addressing potential barriers to consumers' WTP for some milk attributes. For example, addressing concerns about taste preferences for milk with health benefits can help enhance consumers' WTP (Akaichi et al., 2012). Improving the sensory properties, such as taste, flavor, and texture, may involve investing in product innovation, taste profiling, and consumer education initiatives to enhance liking and inform consumers about the benefits of health attributes of milk (Bekele et al., 2016).

In addition, the price of organic foods is a deterrent to low-income earners, who would instead go for cheaper conventional foods, so another study revealed the consumers' high-cost perception of organic milk (Akaichi et al., 2012). The findings indicate the need for targeted educational campaigns to educate consumers about the differences between conventional and organic foods so that they can make their purchasing decisions with knowledge. Marketers can also use proportional pricing strategies that favor first-time buyers. Purchasing milk in open-air markets was found to be negatively associated with consumers' WTP for safety attributes, indicating potential health-related concerns among other consumer segments (Bozoglu et al., 2019). The negative association with WTP for safe milk among households with more children who buy cheaper, uncertified, and less safe milk products threatens children's health and is vital for policymakers.

Moreover, consumers with experience from abroad were not willing to buy local milk products, which may emanate from the perceptions that foreign products have better quality and high safety standards, or it may highlight the importance of cultural factors in shaping consumption patterns (Li et al., 2017). By highlighting the positive attributes that resonate with target consumers, marketers can craft compelling messaging and branding strategies that appeal to consumer values and preferences. Strategies may involve leveraging certifications, eco-labels, and storytelling to convey messages of sustainability, health, and ethical production practices, thereby fostering consumer trust and loyalty. From a policy standpoint, the findings accentuate the importance of supporting sustainable and ethical production practices within the dairy industry. Since the WTP for environmentally friendly attributes is generally low, policymakers can create programs to raise awareness and educate consumers on sustainable consumption patterns that support sustainable production. Policies promoting transparency, traceability, and food safety can also enhance consumer confidence and trust in the dairy supply chain, fostering a more resilient and competitive dairy industry ecosystem that is key across regions.

4.4. Implications of the study and recommendation for future studies

This scoping review provides concrete understanding of the existing knowledge on consumers' WTP for dairy and PBMA by providing a detailed analysis of consumer preferences for milk attributes that are key to shaping the dairy sector towards sustainability across various regions.

Previous review studies often focused on specific attributes such as organic (Katt and Meixner, 2020), traceable (Tran et al., 2024), or sustainable (Li and Kallas, 2021) on a wide range of food products, but our review offers a broader perspective by incorporating data from 123 studies on consumers' WTP for milk and PBMA. The scoping review integrates individual studies that highlighted higher WTP for various attributes such as organic by consumers in specific countries like Iran (Rafiee et al., 2023), Germany (Hasselbach and Roosen, 2015), and many other attributes contextualizing these findings within a global framework, demonstrating that organic milk is a highly valued attribute across diverse geographic areas, including North America (Bernard and Bernard, 2009; Kanter et al., 2009). Moreover, the review's comparative analysis of attributes such as safety, quality, and environmental sustainability provides a nuanced understanding of how consumer priorities vary by region, contributing to more targeted and effective policy and marketing strategies.

Additionally, this review highlights emerging trends and less-explored areas in consumer preferences, thereby identifying gaps and opportunities for future research. For example, while previous studies have predominantly examined WTP for traditional dairy attributes, this review also includes an analysis of consumer preferences for PBMA, a growing segment in the market. Findings from studies in Singapore (McCrickerd et al., 2020) and the U.S. (Yue et al., 2013) indicate a significant WTP for health and nutrient-related labels on PBMA, underscoring the importance of functional and health-related attributes in consumer decision-making. Furthermore, by including a diverse range of attributes, such as animal welfare and environmental impact, the review underscores the multidimensional nature of consumer preferences and the increasing importance of sustainability in the dairy sector. This comprehensive approach consolidates existing research and sets the stage for future investigations into consumer behavior and sustainability in the dairy industry.

A meta-analysis of consumers' willingness to pay for sustainable food products revealed that organic food attributes had the highest WTP (38 %), followed by fairtrade (30.5 %), animal welfare (29.5 %), environmentally friendly (21.3 %), and local (21.1 %) (Li and Kallas, 2021). This study has similar findings of having the highest WTP for organic milk attributes (54 %), followed by animal welfare (53 %), safety and quality (45 %), and country of origin (48 %). The differences between the WTP values may be because this scoping review only captured a single attribute with the highest consumers' WTP from a study, which might have driven the average values higher than those reported in meta-analyses and other systematic review papers. Other studies have also shown that the organic attribute tops the WTP values for different food attributes. For example, a review of consumers' WTP for sustainable seafood in Europe revealed that organic attributes had the highest WTP, followed by animal welfare and local (Zander and Feucht, 2018). A review of consumer perceptions and behavior towards organic foods found that consumers are willing to pay a premium for organic products ranging from 0 %–105 % with an average of 30 % because of perceived health benefits and environmental considerations (Aschemann-Witzel and Zielke, 2017). Our review corroborates these findings, mainly through studies done in China (Yin et al., 2018), the U.S. (Liu et al., 2013), and Germany (Hasselbach and Roosen, 2015), where organic milk commands high premiums of 126 %, 132 % and 75 % respectively. This consistency across studies highlights the growing consumer demand for organic dairy products.

Furthermore, our review's focus on different sustainable milk attributes, including safety and quality attributes, aligns with the findings of Yang and Fang (2021), who conducted a meta-analysis study of food safety attributes. Their meta-analysis only included studies conducted in China, and they found that dairy products had the highest willingness to pay value, followed by pork and crop products (Yang and Fang, 2021). These findings show how important food safety is in dairy products. The high WTP for food safety measures, such as traceability and certification, are also highly valued by consumers in this scoping review, with

consumers' WTP as high as 92 % in Rwanda (Habiyaremye et al., 2023), 85 % in Germany (Goldberg et al., 2009) and 89 % in China (Ortega et al., 2011). The universal emphasis on safety and quality across various regions underscores the fundamental importance of these attributes in the consumer decision-making processes.

Regarding environmental sustainability attributes, our findings resonate with the multi-country study conducted by Van Loo et al. (2017) with consumers in Germany, the United Kingdom, the Netherlands, and Belgium. They reported that attributes such as a low carbon footprint and sustainable production practices increasingly influence consumer choices, particularly in developed countries, which is driving consumers to plant-based diets perceived as healthy and sustainable (Van Loo et al., 2017). Our review found a strong WTP for environmentally friendly milk attributes, especially in Europe, where consumers are willing to pay 65 % for milk with low carbon footprints in Italy and 85 % in France for milk from cows fed with linseed, which lowers methane emissions. In Asia, consumers were also willing to pay 40 % for sustainably produced milk with low environmental impact (Gao et al., 2020). This review highlights a broader trend towards environmental consciousness among consumers and suggests a converging global awareness of sustainability issues.

Moreover, our inclusion of PBMA extends the analysis of consumer preferences beyond traditional dairy products, which is lacking in previous reviews. Studies such as those by McCrickerd et al. (2020) and Yue et al. (2013) illustrate a growing interest in WTP for PBMA driven by health and sustainability concerns. This addition broadens the scope of our review and reflects the evolving landscape of consumer preferences in the dairy and non-dairy sectors.

This scoping review identified several research gaps worth considering in the future. Most studies often omit the effectiveness of different marketing tactics in influencing consumers' WTP for milk attributes, as marketing strategies may play a huge role. Again, with the increasing concern among consumers about healthy eating, investigating the impacts of one health message and interventions on diverse populations in China and beyond is required (Xu et al., 2023). Dairy farmers may be willing to deliver milk with the desired attributes to the consumers, such as reducing antibiotic use. However, these decisions can increase costs to the farmer or reduce productivity, making it essential to determine if farmers remain profitable after adjusting to attain new labels (Schell et al., 2023).

This review has shown that consumers are willing to pay varied premiums for different milk attributes certified by various food chain actors in other countries; therefore, understanding how consumers trust different certifying agencies is crucial to research (Yormirzoev et al., 2021). Providing consumers with varied information regarding sustainable milk is vital to identifying effective advertising strategies and knowing which dairy sustainability attributes they are willing to pay for (Li et al., 2023). Also, understanding the interplay between socioeconomic and non-agricultural factors affecting consumers' WTP is vital. For example, using a protected eco-origin product (PEOP) label has been found to emphasize the local culture and the importance of maintaining the agricultural environment in China, but this may be a different narrative in other regions (Zhu et al., 2023).

There is a need for more techniques to reduce hypothetical bias in estimating consumers' WTP in stated preference methods and use ways that mimic real-life market situations (Li et al., 2023). Certainty follow-up questions minimize hypothetical bias (HB) (Zhu et al., 2023). The use of experimental auctions in conjunction with hypothetical methods is another way to deal with HB as they simulate more realistic consumption scenarios (Abedullah et al., 2022; Canavari and Coderoni, 2019; Yormirzoev et al., 2021). A study in Rwanda on consumers' WTP for milk safety and quality indicated the scarcity of studies focusing on dairy sector settings in developing countries. It emphasized the need for studies implementing strategies to reduce hypothetical bias through field experiments or multiple rounds (Habiyaremye et al., 2023). Investigating psychological factors was also emphasized in future

research to understand how external and internal factors influence consumer behavior on labeled products (Zhao et al., 2020). In addition, sample sizes should be large and represent the sampled population to avoid self-selection and bias (Canavari and Coderoni, 2019). Following consumers in stores in a field experiment is another way researchers can verify the effects of social pressure on product choices (Kim et al., 2018). In addition to the research gaps, cow milk dominates in studies, and only a few studies have focused on PBMA, which might be because PBMA are not as long on consumer markets and have been gaining importance recently compared to cow milk. Therefore, future research may consider investigating how the introduction of the PBMA on the markets influences the dairy marketing landscape and consumers' WTP for milk, which may include comparing consumers' WTP for dairy and PBMA. Cross-regional studies exploring consumers' WTP over time in response to changing market trends are lacking.

4.5. Impact of consumers' willingness-to-pay on sustainable dairy

Consumers' WTP for sustainable milk attributes is critical in shaping the dairy sector towards sustainability. Sustainability comprises three main pillars: economic, social, and environmental. Consumers will always pay for attributes that they consider necessary to them. Consumers' WTP for attributes depends on their values, awareness, attitudes, and incentives that influence their choices, which is essential to policymakers in shaping production and consumption towards sustainability and achieving sustainable development goals. This paper analyses how consumers' WTP for dairy and PBMA impacts sustainability's economic, social, and environmental dimensions.

4.5.1. Economic sustainability

Economic sustainability of the dairy sector means remaining in business and ensuring competitiveness, innovation, profitability, and efficiency after considering the social and environmental aspects (Zul Azlan et al., 2024). For dairy farmers to remain economically sustainable, they need to provide consumers with milk produced in a manner that matches their social and environmental values. There are instances where consumers cannot pay high premiums for sustainably produced milk, and policymakers can assist farmers through incentives to remain viable while conserving the environment. In cases where production levels are still low enough to reach an environmentally detrimental threshold, farmers can continue raising their productivity under the guidance of environmental experts to provide their societies with sufficient milk while adhering to socially acceptable dairy production practices. The strong preference for organic milk in regions such as Asia (Managi et al., 2008; Rafiee et al., 2023), North America (Bernard and Bernard, 2009; Kanter et al., 2009), and Europe (Akaichi et al., 2012; Hasselbach and Roosen, 2015) demonstrates consumers' WTP higher prices, which can enhance farmers' profitability and support the economic viability of small and medium-sized farms in these regions. Again, high premiums for safety and quality attributes, such as HACCP certification (Wang et al., 2008), traceability (Hossain et al., 2023; Zhou et al., 2010), and mycotoxin-free milk (Sckokai et al., 2014) across regions further drive economic sustainability of safe and quality milk. These premiums encourage dairy producers to implement stringent safety measures and quality controls, leading to safer and higher-quality products that command better prices in the market.

4.5.2. Environmental sustainability

Overall, environmental sustainability involves conserving the natural resources of soil, air, water, and forests to balance the environmental, societal, and economic goals (Dong and Hauschild, 2017). The environmental sustainability attributes identified in the papers included in this review include organic, low climate impact, carbon footprint, use of green production methods, sustainability, use of linseed in feeding cows, and use of local feed. A higher WTP for environmentally friendly dairy products promotes adopting practices that reduce the environmental

impact of dairy farming. Europe and Asia value attributes such as low climate impact (Sonntag et al., 2023), low carbon footprints (Canavari and Coderoni, 2019; Zhao et al., 2020), and sustainable production methods (Gao et al., 2020; Zhang et al., 2019). These preferences push producers towards sustainable practices that reduce greenhouse gas emissions and enhance resource efficiency. Consumers' WTP for locally produced (Profeta and Hamm, 2019) and green-produced milk (Li et al., 2023; Xia and Zeng, 2013) supports environmentally sustainable practices. Local production reduces transportation emissions, whereas green production emphasizes environmentally friendly farming techniques. Additionally, linseed-fed milk (Marette et al., 2017) and mountain-produced milk (Nam et al., 2020; Staffolani et al., 2022) align with sustainable farming practices, which are less detrimental to the environment.

4.5.3. Social sustainability

Social sustainability in the dairy sector deals with the well-being of communities, acceptance of farming practices in society, quality of life for farmers, and animal welfare (Segekvist et al., 2020). The attributes related to social sustainability in this review include animal welfare, cow-calf contact, support of cooperatives, supporting farmer-owned labels, fair milk, acceptance of gene-editing, origin, pasture-raised, ban use of tie stalls, GMO-free, rBST free, which all depends on consumers' views and acceptability. Consumers' emphasis on animal welfare and ethical production practices enhances the dairy industry's social sustainability. High premiums for attributes related to animal welfare, such as cow-calf contact (Boaitey et al., 2022), adherence to animal welfare standards (Markova-Nenova et al., 2018; Tavárez and Álamo, 2021), cow housing (Waldrop and Roosen, 2021), and pasture-raised milk (Kuhl et al., 2017), demonstrate a strong consumer preference for the ethical treatment of animals. Premiums for animal welfare encourage dairy producers to improve their livestock living conditions, leading to more humane farming practices. Consumers' willingness to pay more for milk that follows ethical production standards, such as fair compensation for farmers and transparent labeling, supports social equity in the dairy industry. By prioritizing products that ensure better treatment of animals and fair wages for farm laborers, consumers can help promote ethical standards and social responsibility in dairy production.

4.6. Study limitations

While the scoping review provided valuable insights into the WTP for milk attributes across different regions, it is important to acknowledge several limitations inherent in the methodology and data sources. Firstly, few studies in Africa and South America made it difficult for researchers to generalize the findings in these regions. Also, China dominated studies in the Asian region, while the U.S. dominated the studies recorded under North America, which skews the generalizations in these regions towards individual country population preferences for milk attributes. Again, this review included only the manuscripts written in English that were publicly available, and this may have introduced selection bias of studies emanating from publication, language, or availability bias. This review may have excluded useful literature from non-English countries in Europe, Canada, and South America. The publicly available academic research in the three databases excluded grey literature and market research conducted by industry consultants, creating a bias to include research from educational institutions.

Additionally, the heterogeneity of methodologies and measurement techniques across studies may have made it challenging to compare WTP values between regions directly. Moreover, the scoping review focused primarily on the WTP value for the attribute with the highest WTP in a study and did not delve into other attributes with lower WTP. Finally, as with any review, there is the potential for information overload and the omission of relevant studies despite efforts to conduct a comprehensive search. For example, we omitted the studies that only investigated consumer preferences but did not estimate the WTP, but they may have

provided helpful information on most preferred milk attributes. These limitations highlight the need for caution when interpreting the scoping review findings and the importance of further research to address these gaps and enhance our understanding of consumers' WTP for milk attributes across different regions. Another limitation is that in calculating the mean WTP, we use a percentage, and this could not account for the currency differences but indicate how much more, as a percentage, the consumers are willing to pay for milk with the targeted attributes. Again, there were some cases where one attribute would have different WTP values. For example, in a study conducted in China, consumers were willing to pay different premiums for organic milk with Chinese, USA, and European labels (Zhu et al., 2023).

5. Conclusions

In conclusion, this study reveals various opportunities and challenges associated with shaping consumers' WTP for dairy and PBMA with sustainable milk attributes, which have implications for public health and the promotion of a sustainable dairy sector. The consumers' WTP values for the different milk attributes go beyond mere consumer preferences, including potential consumer health and safety risks through purchasing cheaper uncertified dairy products and lack of complete knowledge of dairy products consumed without proper labeling to show all ingredients and processing procedures. Numerous vital messages have been drawn from this scoping review that can benefit various stakeholders in the dairy sector. Dairy farmers have to note that consumers are highly willing to pay for organic milk and attributes related to sustainability, such as animal welfare and reducing negative environmental impact. Adopting sustainable dairy farming practices can significantly increase the market value of the farmers' milk products. Again, consumer demand for safe milk certified by the entities trusted by the consumers is essential since consumers show that their trust varies among different certifying agents. As a result, farmers implementing and communicating stringent safety and quality measures can attract a premium price, enhancing their competitive advantage. Policymakers need to know that incentivizing sustainable practices in dairy farmers can help meet the growing consumer demand for these attributes, which can fast-track the transition towards sustainable food systems. Also, creating robust safety and quality certification systems is vital to enhancing consumer trust and protecting the public's health. Moreover, through awareness campaign programs about the benefits of sustainable dairy products, consumer education can raise their awareness and then increase their WTP for sustainable dairy products.

Retailers are encouraged to offer a diverse range of milk products in their shops since consumers are willing to pay for various milk attributes such as organic, health-related, and sensory properties so that they can cater to the varying consumer preferences. Again, retailers can enhance consumer trust by displaying various certifications and quality labels and educating consumers about sustainability to drive sales. In addition, they can ensure that sustainable products with these desired labels are easily accessible, offer customer loyalty discounts, and run promotions. Dairy processors need to adopt processing methods that maintain the sustainable attributes of milk that consumers value. Another critical issue is investing in innovative processing methods to improve milk's health benefits by fortifying sensory properties such as aroma, flavor, and texture that attract higher consumer WTP. We emphasize transparency in food processing and proper labeling of ingredients to safeguard consumer safety.

Further research is still needed to mitigate hypothetical bias, understand the consumers' WTP changes over time, and explore consumers' WTP in regions such as Africa and South America. Another critical area requiring attention is more studies on the consumers' WTP for PBMA, as there are still few studies. Collaborative efforts among stakeholders such as researchers, dairy industry players, and policymakers in different regions are vital to shaping the dairy sector towards sustainability. This study underscores the urgency of installing proactive measures to shape

dairy production and consumption towards social, economic, and environmental sustainability in the dairy sector and promote food safety, planetary health, and the well-being of communities.

CRediT authorship contribution statement

Pamela Madududu: Writing – original draft, Visualization, Project administration, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Damien Jourdain:** Writing – review & editing, Visualization, Validation, Supervision, Methodology, Formal analysis, Data curation, Conceptualization. **Duc Tran:** Writing – review & editing, Validation, Methodology. **Margo Degieter:** Writing – review & editing, Validation, Methodology. **Selma Karuaihe:** Writing – review & editing, Validation, Supervision. **Herbert Ntuli:** Writing – review & editing, Validation, Supervision. **Hans De Steur:** Writing – review & editing, Validation, Supervision, Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no competing interests.

Acknowledgments

The authors sincerely thank the Global Minds - Vliros committee for opening an opportunity for North-to-South collaborations and strengthening the research capacity of PhD students. The manuscript was conceptualized during the Global Minds Short Research Stay by Pamela Madududu at Ghent University in Belgium.

Funding

Global Minds Scholarship supported this review as part of Pamela Madududu's PhD short research stay at Ghent University. The scholarship code is DOZA/IL/DDC/MVDW.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Appendix A. Supplementary data

S1 File. Contains information for the 123 retained articles used for analysis. Supplementary data to this article can be found online at <https://doi.org/10.1016/j.spc.2024.09.010>.

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