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Composting behavior in Japan: an application of the theory of consumption values

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Ensuring effective and sustainable management of organic waste is a global challenge, especially in countries with limited land, such as Japan, where reducing, reusing, and recycling food waste is particularly crucial. The present research used the theory of consumption values (TCV) to investigate the main factors that encourage Japanese households to engage in composting. The hypotheses were evaluated using ordinal partial least squares structural equation modeling (OrdPLS). The model results suggest that household composting in Japan is influenced by social approval (social value), the visibility of the behavior and existing knowledge about composting (epistemic value), convenience (functional value), interest in gardening or farming, and an individual's availability to participate (conditional value). Factors such as emotions (emotional value), gender, type of housing, and household size did not significantly impact the practice of household composting. Both positive and negative functional aspects of composting were found to significantly affect perceptions of convenience, thereby indirectly influencing the decision to compost. The findings suggest that promoting ongoing training and support, improving convenience, and linking household composting with urban farming, community gardens, or public spaces could enhance participation, even among those who do not garden.

KEYWORDS

food systems, food waste, waste management, composting, Japan, behavioral models, theory of consumption values (TCV), ordinal partial least squares structural equation modeling (OrdPLS)

1 Introduction

Food production and its consequent loss and waste are major contributors to land erosion, biodiversity degradation, water pollution, and greenhouse gas emissions (Ritchie et al., 2022; Dhull et al., 2024). A significant portion of the produced food is wasted without ever being consumed. Only in 2021, 5.23 million tons of food were discarded in Japan's entire food system (MOE, 2023a). From the total amount of food wasted, the Japanese Ministry of Agriculture, Forestry, and Fisheries (MAFF) estimates that 2.44 million tons (almost half of the total amount) came from households (MAFF, 2023).

Considering the high proportion of food scraps (e.g., fruit peels) in kitchen waste (Yamada et al., 2017; Okayama et al., 2021) and the shortage of available landfill sites for disposal (Liu et al., 2016) ensuring effective and sustainable methods for managing solid organic waste from households is a critical issue in countries like Japan. One of the methods that can play an important role in managing this type of waste is composting, which has been considered a primary food recycling process in Japan (Tanaka, 1999; Takata et al., 2012; Vázquez and Soto, 2017; Kopaei et al., 2021; Mihai et al., 2023).

Despite the possibility of strong odors, adverse effects on human health, or the presence of heavy metals if not properly managed (Cerda et al., 2018; Kopaei et al., 2021; Kunszabó

et al., 2022; Mihai et al., 2023), composting, which is a biological process where microorganisms break down organic material, has the potential to reduce landfill emissions of greenhouse gases (GHGs) (Cerda et al., 2018; Kunszabó et al., 2022; Bhatia et al., 2023; Mihai et al., 2023). It can also promote local entrepreneurship, raise awareness of food waste produced, and provide nutrient-rich compost that can be used in gardens, agricultural land, and eroded soils (Cerda et al., 2018; Christie and Waller, 2019; Pai et al., 2019; Kunszabó et al., 2022; Bhatia et al., 2023; Mihai et al., 2023).

Composting systems can be large-scale, complex centralized operations or decentralized systems consisting of a network or standalone processes at a community, neighborhood, or household level (Pai et al., 2019; Bruni et al., 2020). In 2020, Japan had 100 central composting facilities (Kawai et al., 2020). Nevertheless, only about 17% of the municipalities had implemented some kind of food waste segregation system, and the actual percentage of waste delivered to composting facilities corresponded to less than 1% of the total waste generated (Kawai et al., 2020; MOE, 2021, 2023b).

On the other hand, several municipalities in Japan seem to rely on decentralized approaches, with more than half of them offering financial assistance to households to purchase electrical composting machines (Island Land Co. Ltd., 2023). Many of these cities also support the purchase of other types of household composting technologies and provide monitoring programs and training sessions (Loan et al., 2019; Edogawa City, 2022; Rare A, 2022; Go Green Kobe, 2023; Fukuoka City, 2024). Household composting, also known as home composting, involves collecting biodegradable garden waste or kitchen scraps and placing them in a container or heap, where natural decomposition breaks them down into nutrient-rich fertilizer (Purkiss et al., 2022). Notwithstanding, when looking at consumers' practice rates of different Pro-Environmental Behaviors (PEB) across Asian cities (including major Japanese cities), Phuphisith et al. (2020), Lee et al. (2013), Kurisu and Bortoleto (2011), and Aoki et al. (2010) found that home composting was among the least popular PEB. Previous findings also suggested that home composting is mostly expressed by individuals who have high environmental concerns and try to lead healthy and sustainable lifestyles (Kurisu and Bortoleto, 2011; Lee et al., 2013; Kunszabó et al., 2022; Morais and Ishida, 2024).

Based on this discrepancy between home composting incentives and their low popularity among households, and in the absence of previous research addressing comprehensively this topic in Japan, the present study aims to clarify the main drivers for Japanese households to engage in home composting. This analysis also responds to the call for further efforts to understand the mechanisms of behavior change, particularly at the consumer level (Liu et al., 2016; Kawai and Huong, 2017; Wei et al., 2017). A deeper understanding of these mechanisms, such as social norms or psychological factors, can improve the framing and messaging of behavioral interventions, which can consequently impact their success rates (Hotta and Aoki-Suzuki, 2014; Abrahamse, 2020).

Despite the growing literature about food waste generation and its prevention, it seems research about the factors pondering the adoption of alternative ways of refusing food waste, such as household composting or food waste segregation schemes, is increasing at a slower pace (Wu et al., 2019; Kopaei et al., 2021; Ladele et al., 2021; Sewak et al., 2021; Nguyen et al., 2022), particularly in Japan. Previous papers were mostly based in the U.S. (Waliczek et al., 2016; Wu et al., 2019; Niles, 2020), Canada (Taylor and Todd, 1995; Taylor et al., 1997; Mckenzie-Mohr, 2000; Sussman and Gifford, 2013; DiGiacomo et al., 2018; Pickering et al., 2020; Ladele et al., 2021), or European countries like Sweden (Sterner and Bartelings, 1999; Bernstad, 2014; Linder et al., 2018) and the U.K. (Tucker and Speirs, 2003; Tucker et al., 2003; Edgerton et al., 2009; Nomura et al., 2012; Allison et al., 2022; Purkiss et al., 2022).

Except for Tanaka et al. (2011), which focused on a specific town in Hyogo prefecture, no research could be found about the drivers of household composting in Japan. In that study, Tanaka et al. (2011) found intention to be non-significant to the actions of people who were not engaging in composting previously. These findings seem coherent with previous literature stating that despite intention being considered an important predictor of behavior adoption (Ajzen, 1991; Bamberg and Möser, 2007), an intention-behavior relationship may not always be perfect (Boldero, 1995). The intention-behavior gap has been reported by several scholars (Kollmuss and Agyeman, 2002; Hassan et al., 2016; Sultan et al., 2020; Casais and Faria, 2022), and its "size" can vary upon the analyzed behavior (Barr, 2003). Particularly, in some studies in the field of recycling and food waste management, intention-behavior relationships were found weak or even non-significant (Davies et al., 2002; Karim Ghani et al., 2013). For such reasons, authors like Bortoleto et al. (2012) have excluded intention from the analysis of waste prevention behaviors. Building on these findings, instead of using the Theory of Planned Behavior (Ajzen, 1991), which has been widely used in waste-related behavioral models (Karim Ghani et al., 2013; Kopaei et al., 2021; Savari et al., 2023), the current analysis used as a theoretical framework the Theory of Consumption Values (TCV) (Sheth et al., 1991), which does not include intention towards behavior.

TCV (Sheth et al., 1991) is a widely known marketing framework that can be used by policymakers to define, reinforce, or modify strategies that address social and environmental issues (Tanrikulu, 2021). It relies on five values (functional, social, emotional, epistemic, and conditional) to explain consumers' decisions toward a particular product/service. TCV is a robust approach comprising utilitarian and hedonic aspects of consumer behavior (Kaur et al., 2020; Tanrikulu, 2021). Therefore, it allows a straightforward inclusion of economic, psychological, situational, and social variables found relevant in previous papers into a single model.

By using this framework, the authors were also able to test under one decision model factors commonly associated with household composting, like knowledge and gardening interest (Loan et al., 2019), alongside less explored aspects such as one's self-image (Nguyen et al., 2022) or project awareness and descriptive norms (Pickering et al., 2020). Thus, it presents a comprehensive model unique in literature. Descriptive norms have been mentioned as relevant to the decision by intervention-based studies (Mckenzie-Mohr, 2000; Nomura et al., 2012; Sussman and Gifford, 2013; Bernstad, 2014; Geislar, 2017; Linder et al., 2018), but to the authors' knowledge, this is one of the few home composting behavioral models that has considered such effects. Although TCV has successfully explained and predicted behaviors across several sectors (e.g., food consumption, smoking, apparel, education, and tourism) (Tanrikulu, 2021), there is no previous research on household composting involvement.

Based on the characteristics of the collected data, the model hypotheses were tested with Ordinal Partial Least Squares Structural Equation Modeling (OrdPLS) (Cantaluppi, 2012; Cantaluppi and Boari, 2016), which is an extension of the Partial Least Squares

Structural Equation Modeling (PLS-SEM) that can handle categorical indicators (Schuberth et al., 2018). While the use of PLS-SEM has surged in recent years (Hair et al., 2018; Sarstedt et al., 2022), literature on OrdPLS remains limited. Thus, the present paper also contributes to expanding the applications of this statistical tool.

With this analysis, the authors wish: (1) to find what are the main drivers of household composting decisions in Japan; (2) understand if the Theory of Consumption Values can be used to present a comprehensive behavioral model for home composting; and (3) extend the literature concerning OrdPLS applications.

2 Literature review

The reference literature was not collected using a specific protocol. Instead, the authors used Scopus and Google Scholar as search engines to collect relevant research based on the following keywords: composting; home composting behavior; household composting behavior; food waste reduction behavior; TCV; pro-environmental behaviors in Japan, Japanese consumption patterns; Japanese consumer; Japanese recycling laws; household food waste management; household food waste segregation, PLS-SEM, and OrdPLS. After being gathered, the abstracts of the articles were read to narrow down the reference literature to those aligned with the scope of this research project. Literature from the 80s to 2023 was collected. Even though papers from the 80s and 90s might be considered old, the authors decided to collect them as, in that period, Japan had a large revival of its composting industry (Kawai et al., 2020). Additionally, some papers were added upon the analysis of the reference section of the previously gathered articles.

2.1 Japanese household's characteristics and environmental policy

Due to the low food self-sufficiency rate and lack of available landfill sites for disposal, food waste is a critical issue in Japan (Liu et al., 2016). In response to international targets, the Ministry of the Environment (MOE) and the Japanese Ministry of Agriculture, Forestry and Fisheries (MAFF) set a goal of halving the 2000 food loss and waste rate by 2030 (MAFF, 2019; Umeda, 2019). To do so, the Japanese Food Waste Recycling Law was first enacted in 2001 and has since been amended twice (in 2007 and 2015) (Joshi and Visvanathan, 2019). This Act intends to promote waste prevention and recycling loops (turn waste across the supply chain into animal feed or fertilizer) in the food industry (Liu et al., 2016; Fujii and Kondo, 2018; Umeda, 2019). In 2019, the Japanese government enacted a complementary law to reduce household food waste. According to this law, local and central authorities are to educate businesses and consumers and facilitate food re-distribution projects (Umeda, 2019).

Upon these targets and directives, each municipality implements them according to regional conditions. Several local governments in Japan rely on mechanisms centered around 3R (Reuse, Reduce, and Recycle) policies (Inaba et al., 2022). Additionally, the 'mottainai' philosophy, which implies showing gratitude for the food and a sense of regret for waste, also seems to be a popular approach (Sirola et al., 2019; Izumi et al., 2020; Setouchi City, 2021). However, it is noteworthy that a wide range of implementation strategies can be found throughout Japan (Hotta and Aoki-Suzuki, 2014; Inaba et al., 2022). These strategic nuances have been pointed out as one of the reasons for regional differences in the adoption of waste prevention behaviors from consumers (Kurisu and Bortoleto, 2011; Lee et al., 2013; Hotta and Aoki-Suzuki, 2014).

Japanese consumers have been considered more collective-oriented and risk-averse compared to other cultures (Synodinos, 2001; Ando et al., 2007, 2010), which can result in a stronger influence of social norms. Contrary to countries such as the U.S. and the Netherlands, in Japan, PEBs were positively associated with traditional education and altruistic values (Aoyagi-Usui et al., 2003; Kawasaki et al., 2022). Previous Japanese literature mentioned women being more aware of household waste generation and more engaged in waste prevention and ethical food consumption PEB (Kurisu and Bortoleto, 2011; Lee et al., 2013; Qian et al., 2020; Nakamura et al., 2022). This tendency does not appear to be exclusive to Japan (Morais and Ishida, 2024). Nonetheless, in a clustering analysis that included food waste recycling behaviors (including home composting), Morais and Ishida (2024) noted that the group with higher food waste recycling rates had a balanced gender distribution. The latter group seemed to have larger households (Morais and Ishida, 2024). This was also the case in a clustering analysis on backyard composting in Hungary (Kunszabó et al., 2022). Household size was found to be significant in curbside food waste collection by Ladele et al. (2021) and Wu et al. (2019) but not by Niles (2020).

2.2 Household composting and food waste segregation schemes literature background

Previous behavioral works on food waste recycling have focused either on household composting or curbside segregation schemes. In recent years, there has been an increase in the number of cities adopting collection schemes (Pai et al., 2019). However, food waste segregation schemes in Japan are still scarce (MOE, 2023b). As reference literature, the authors have considered decision-making models and intervention-based studies of both household composting and food waste segregation, as they both tackle food waste recycling and have been studied together in Widyatmika and Bolia (2023), Nguyen et al. (2022), Kala and Bolia (2021), Ladele et al. (2021), and Niles (2020). Despite possible differences in adoption reasons (Nguyen et al., 2022), these behaviors can be seen as complementary measures to reduce waste in landfills (Pai et al., 2019). Food waste recycling (composting, feeding animals with scraps, and so on) has also been used as part of models to explain overall food waste behavior (Parizeau et al., 2015; Abdelradi, 2018; Diaz-Ruiz et al., 2018; Pham et al., 2019; Attiq et al., 2021; Wu et al., 2023). For instance, Wu et al. (2023) found composting routines and using leftovers to feed pets can contribute to a higher food waste rate. Such findings are aligned with the idea that having a recycling option may result in a relaxation of prevention behaviors and that an increase in recycling rates may simply reflect a higher production rate (Ueta and Koizumi, 2001; Tucker and Farrelly, 2016; Ma et al., 2019; Oláh et al., 2022).

Household composting and food waste curbside segregation have often been associated with attitudes and perceptions towards behavior, knowledge, convenience and lack of control, socio-demographics, and gardening (Table 1). Despite case study evidence, only Pickering et al. (2020) and Allison et al. (2022) have considered program awareness and messaging in a behavioral decision-model. Similarly, only Nguyen et al. (2022) have included environmental self-image when studying food waste recycling behaviors.

From the studies mentioned in Table 1, only a small number are based on theoretical behavioral frameworks. This supports the call for

TABLE 1 A literature summary in household composting and food waste segregation schemes.

Paper/Country	Theoretical framework	Independent variables (1)	Dependent variable	Methodology
Widyatmika and Bolia (2023); India and Indonesia	No	Socio-demographics; laws; environmental concern; monetary incentives; and composting site.	Home composting (Yes/No); sorting (Yes/No)	Self-reported survey; logit model
Allison et al. (2022); UK	Capability-opportunity-motivation-behavior model	Income, gender, house structure, education, physical opportunity, social opportunity, reflective motivation, automatic motivation, and psychological capability. Each of them was divided into themes such as awareness, availability, and priorities.	Food waste sorting (5-point Likert scale)	Self-reported survey; ANOVA; Hierarchical multiple linear regression; and Thematic analysis
Kunszabó et al. (2022); Hungary	No	Socio-demographics; home composting; general PEB; gardening; house type; place of living; household size; children; benefits; barriers; and incentives.	-	Self-reported survey and Clustering
Leeabai et al. (2022); Thailand	No	Design, visual prompts, and experience.	Food waste sorting (5-point Likert scale)	Experimental design; self-reported survey; ANOVA; and Welch's *t*-test
Nguyen et al. (2022); Australia	No	Socio-demographics, situational factors, psychological factors, and household characteristics.	Sustainable food waste disposal (Yes/No)	Self-reported survey; factor analysis; and logit model
Purkiss et al. (2022); UK	Citizen science method	Composter type, location, item type, composting duration, certification, and compost use	Compostable plastics decomposition level (4 Levels)	Experimental design and descriptive and graphical analyses
Rahman et al. (2022); Bangladesh	TPB + DPM*	ATC*; subjective norms; PBC*; harmonious passion; and obsessive passion.	Home composting intention (7-point Likert scale)	Self-reported survey to home gardeners and PLS-SEM/ANN
Sayara et al. (2022); Palestine	No	Socio-demographics; KNG*; environmental concern; incentives; barriers; organic farming	Home composting intention (NS*)	Self-reported survey and descriptive and graphical analyses
Fernando (2021); Sri Lanka	No	Reasons to and against household composting.	Home composting (Yes/No)	Interviews and qualitative research
Kala and Bolia (2021); India	No	Socio-demographics; house type; gardening; collection system satisfaction; sorting incentives; and composting incentives.	Food waste sorting (Yes/No), Home composting (Yes/No)	Self-reported survey and binomial logistic regression
Kopaei et al. (2021); Iran	TPB + NAM*	ATC*; subjective norms; PBC*; personal norms; ascription of responsibility; awareness of the consequences; and KNG*	Home composting intention (5-point Likert scale)	Face-to-face questionnaire; clustering; PLS-SEM; and PLS-MGA
Ladele et al. (2021); Canada	No	Socio-demographics; House type; ATC*; Situational factors, Food waste rate; Planning habits; Environmental concern; KNG*, Sorting perception; Household size; and Housing tenure	Food waste sorting program support (7-point Likert scale)	Self-reported survey; univariate means standard deviation; *t*-test; bivariate correlation; and linear regression
Niles (2020); U.S.	No	Socio-demographics; ATC*; Knowledge and perception of Act 148*; and Household characteristics.	Food waste management behavior (Yes/No and 5-point Likert scale)	Self-reported survey; Telephone survey; Chi-square test; Kruskal Wallis test; and Ordered logistic regression
Pickering et al. (2020); Canada	No	Socio-demographics; NEP*; climate change uncertainty and skepticism; anthropologic origin; KNG*; benefits; messaging; and framing	Organic waste-diversion programs participation likelihood (5-point Likert scale)	Self-reported survey; logistic regression; and ANCOVA

(Continued)

TABLE 1 (Continued)

Paper/Country	Theoretical framework	Independent variables (1)	Dependent variable	Methodology
Christie and Waller (2019); Australia	No	Composting experience	Awareness of waste, green thinking, connection, and community building	Focus group; interviews and qualitative analysis
Loan et al. (2019); Vietnam	No	Socio-demographics; ATC*; KNG*; gardening; training; food waste reduction habit; and PEB adoption	Home composting (Yes/No), level of participation (1,2,3)	Self-reported survey; interviews; and logit model
Wu et al. (2019); U.S.	No	Socio-demographics; time perception; children; disabilities; household size; and working hours.	Food waste sorting (Yes/No)	Self-reported survey and logit model
DiGiacomo et al. (2018); Canada	No	Convenience (bin location)	Food waste sorting (Kg)	Experimental design and descriptive and graphical analyses
Linder et al. (2018)	No	Descriptive norms; messaging	Food waste sorting (Kg)	Experimental design; descriptive and graphical analyses; and linear regression
Nsimbe et al. (2018); Uganda	No	Socio-demographics; KNG*; perceptions; gardening; and waste sorting at home	Home composting (Yes/No)	Semi-conducted interviews and logit model
Li et al. (2017); China	No	Household composting incentives and barriers	Food waste sorting participation rate (%)	Interviews; qualitative research and descriptive analysis
Karkanias et al. (2016); Greece	No	Household composting incentives and barriers.	Home composting (5-point Likert scale)	Longitudinal self-reported survey; interviews; and descriptive and graphical analyses
Waliczek et al. (2016); US	No	Socio-demographics; composting school program (Yes/No)	KNG*; ATC*; environmental concern; locus of control (3/5-point Likert scales)	Self-reported survey; ANOVA and Pearson product–moment correlation test
Bernstad (2014); Sweden	No	Convenience: leaflet distribution	Food waste qt. (Kg)	Experimental design and descriptive and graphical analyses
Karim Ghani et al. (2013); Malaysia	TPB*	Socio-demographics; ATC*; subjective norms; PBC*; Situational factors; and composting intention.	Food waste sorting (5-point Likert Scale)	Self-reported survey; Cronbach's alpha test; T-tests; and multiple regression
Sussman and Gifford (2013); Canada	Theory of Normative Conduct	Messaging: role model person.	Food waste properly sorted (Yes/No)	Design experiment and interview and log-linear model
Nomura et al. (2012); UK	No	Social norms and intervention feedback	Program participation rate (%)	Design experiment; regression analysis
Tanaka et al. (2011); Japan	Two-Phased Decision-Making Model	Perceived seriousness; responsibility; effectiveness; feasibility; cost–benefit; social-norms; and home composting intention	Home composting (Yes/No)	Self-reported survey; factor analysis, and covariance analysis
Edgerton et al. (2009); UK	No	Environmental concern, PEB adoption, ATC*, KNG*, social diffusion, social norms, gardening, household constitution, and age	Home composting (Yes/No)	Self-reported survey; logit model
Tucker and Speirs (2003); UK	No	Gardening, ATC*, social norms, and KNG*	Home composting (composter, drop-out, does not compost)	Self-reported longitudinal survey; Chi-squared test on contingency tables
Tucker et al. (2003); UK	No	Gardening, ATC*, social norms, KNG*; drop-out reasons; adoption reasons	Home composting (composter, drop-out, does not compost)	Self-reported longitudinal survey; descriptive analysis; and Chi-squared test on contingency tables
Sterner and Bartelings (1999); Sweden	No	Socio-demographics; ATC*; gardening; and time	Home composting (Waste %)	Self-reported survey; linear, exponential, and logit model

(Continued)

TABLE 1 (Continued)

Paper/Country	Theoretical framework	Independent variables (1)	Dependent variable	Methodology
Mckenzie-mohr (2000); Canada	No	Social norms and household composting barriers	Home composting	Case study exposition
Taylor and Todd (1995); Taylor et al. (1997); Canada	TPB	ATC* (personal advantages, social advantages, complexity); subjective norms (internal and external); PBC* (self efficacy, resource facilitation conditions); and home composting intention.	Home composting (7-point Likert scale)	Longitudinal self-reported survey and diaries and CFA (structural equation model).

(1) Independent variables included in previous literature, regardless of final significance *DPM, Dualistic Passion Model; ATC, attitudes towards composting; PBC, Perceived Behavior Control; KNG, knowledge; NAM, Norm Activation Model; NEP, New environmental paradigm; NS*, Not specified in the study; Act 148 is Vermont's food waste law (place where the study took place).

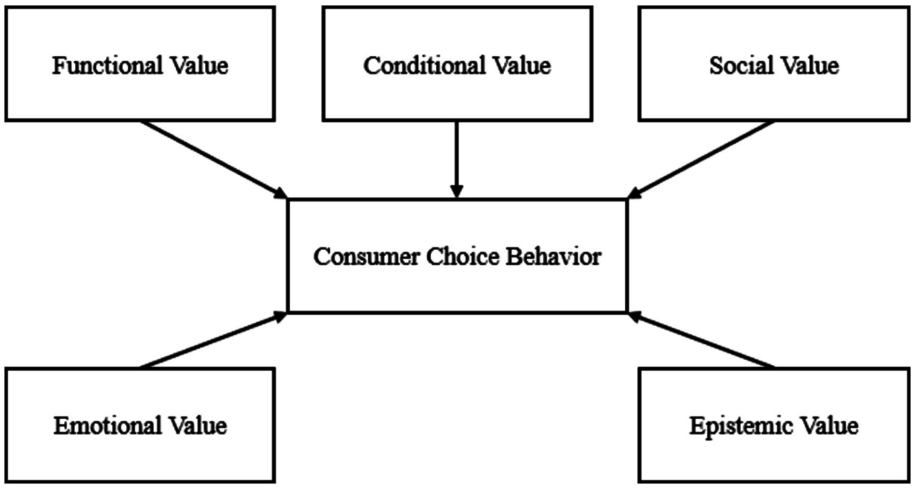

FIGURE 1
TCV as suggested by Sheth et al. (1991).

further applications of theoretical frameworks on understanding household-level food waste composting (Sewak et al., 2021). When a framework was used, the majority of articles applied integrated models based on the Theory of Planned Behavior (TPB) (Ajzen, 1991; Taylor and Todd, 1995; Taylor et al., 1997; Karim Ghani et al., 2013; Kopaei et al., 2021; Ladele et al., 2021; Rahman et al., 2022).

The time span between intention and behavior measurements has been pointed out as a limitation of frameworks like TPB (LaMorte, 2022). While authors such as Taylor and Todd (1995), Taylor et al. (1997), and Davies et al. (2002) have coped with this limitation by using data from different points in time, the present research uses data from a single point in time. In addition to allowing the inclusion of a wide spectrum of constructs and not depending on intention, the way the data was collected supports the choice of TCV as the theoretical framework for this analysis.

3 Materials and methods

3.1 Model hypotheses: TCV

In its simpler form, TCV has five main independent values (Figure 1), however, scholars often apply the framework using sub-dimensions within the values, particularly within the functional value (Tanrikulu, 2021). This analysis also incorporated sub-dimensions within the values.

3.1.1 Functional value

The functional value relates to the perceived utility acquired from the features and physical performance of a product or service (Kaur et al., 2020).

Scholars often include sub-dimensions such as price and quality under this value (Sweeney and Soutar, 2001; Lin and Huang, 2012; Gonçalves et al., 2016; Talwar et al., 2023), but factors such as efficiency (Peng et al., 2014), perceived convenience (Yang and Lin, 2017), and positive and negative features of the behavior (Sheth et al., 1991) have also been analyzed (Tanrikulu, 2021).

Given that the analysis focuses on engagement in a behavior, the authors followed the approach Sheth et al. (1991) used on the choice of whether or not to smoke and included under the functional value positive and negative features of household composting. In the present case, the items measuring positive (POS) and negative (CONS) attributes were adapted from previous literature on composting. More precisely, concerning positive attributes of composting, four items were included covering the perceptions that household composting can lower environmental impact than the mainstream disposal option, leave a better environment for future generations, reduce the amount of waste that is incinerated or ends

up in the landfills, and the fact that compost can be used on gardening and agriculture (Fernando, 2021; Kopaei et al., 2021; Kunszabó et al., 2022; Loan et al., 2019; Mihai et al., 2023; Pai et al., 2019; Sewak et al., 2021).

Meanwhile, previous studies on household composting have identified smell, attracts vermin and other animals, lack of space, lack of organic waste, and necessary effort and time as barriers to household composting adoption (Tucker and Speirs, 2003; Tucker et al., 2003; Edgerton et al., 2009; Karkanias et al., 2016; Nsimbe et al., 2018; Fernando, 2021; Sayara et al., 2022). Seven items were included regarding the latter barriers to engagement.

The current model also tested the significance of household composting in terms of perceived convenience and lack of control (CONV). Convenience/Inconvenience was found to be a significant factor in backyard composting and food waste segregation (Taylor et al., 1997; Tucker and Speirs, 2003; Edgerton et al., 2009; Bernstad, 2014; DiGiacomo et al., 2018; Ladele et al., 2021; Nguyen et al., 2022). The four measurements used were based on Yang and Lin (2017), which tested convenience factors within the TCV framework, and convenience and lack of control items from Bortoleto et al. (2012) and Kopaei et al. (2021).

Aspects like time, space, and effort have often been associated with home composting convenience and lack of control perceptions (Taylor et al., 1997; Tucker and Speirs, 2003; Nguyen et al., 2022), in addition to the direct effect of positive and negative attributes on household composting, their indirect effects through convenience were also hypothesized. When applying TCV to over-the-top media services, Talwar et al. (2023) incorporated concepts from the means-end chain framework (Gutman, 1982) and hypothesized different levels of TCV values. Under this layout, the indirect effect of functional value (quality) through functional value (price) was tested (Talwar et al., 2023). Similarly, indirect effects were also hypothesized in the current model. Nevertheless, contrary to Talwar et al. (2023) and given the majority of sustainable marketing research assumed the independence of values (Tanrikulu, 2021), the present analysis kept such assumption and only considered the indirect paths within a specific value.

> H1: PROS → CONV: perceived positive features impact home composting perceived convenience.
>
> H2: CONS → CONV: perceived negative features impact home composting perceived convenience.
>
> H3: PROS → COMP: perceived positive features impact home composting adoption.
>
> H4: CONS → COMP: perceived negative features impact home composting engagement.
>
> H5: CONV → COMP: perceived convenience impacts home composting involvement.

3.1.2 Social value

Social value (SOC) measures the perceived utility acquired from a product or service's association with one or more social groups (Sheth et al., 1991). It is related to aspects such as social approval and self-image improvement. Taylor and Todd (1995) and Taylor et al. (1997) mentioned that once household composting happens indoors, the effect of social factors such as perceived pressures and opinions from family, colleagues, or the community (subjective norms) may be weakened. On the other hand, comparison studies between Western countries and Japan have emphasized the importance of community and social cohesion in Japanese culture (Ando et al., 2007, 2010).

Previous behavioral models on household composting have mostly measurements of subjective norms, such as "people think I should compost" (Taylor and Todd, 1995; Taylor et al., 1997; Tucker and Speirs, 2003; Edgerton et al., 2009; Kopaei et al., 2021), but only Nguyen et al. (2022) have included a construct addressing self-identity in a model. Under TCV's social value, both perspectives can be captured. This analysis included four measurement items based on Kopaei et al. (2021), Khan and Mohsin (2017), and Bortoleto et al. (2012). The items are related to one's self-image as being eco-friendly, as well as pressures from peers' suggestions.

> H6: SOC → COMP: social value is significant to home composting adoption.

3.1.3 Emotional value

The concept of emotional value (EMT) pertains to the capacity of an alternative to evoke or sustain emotional or affective states (Sheth et al., 1991). These emotions can be positive, negative, or a combination of both (Kushwah et al., 2019). Research has identified a range of emotions associated with decision-making, including anxiety, anger, confidence, personal/moral obligations, playfulness, enjoyment, and satisfaction (Sheth et al., 1991; Lin and Huang, 2012; Khan and Mohsin, 2017; Yang and Lin, 2017; Teng, 2018).

Previous literature on household composting and food waste recycling behaviors found variables such as ascription of responsibility, environmental concern, harmonious and obsessive passion, and personal norms significant to behavior (Bortoleto et al., 2012; Kopaei et al., 2021; Ladele et al., 2021; Rahman et al., 2022). When studying drivers to backyard composting intention, Kopaei et al. (2021) and Rahman et al. (2022) found that ascription of responsibility, personal norms, and feelings of excitement were significant for home composting intention. Additionally, Ladele et al. (2021) mentioned that environmental concern was a driver of waste diversion behaviors.

Based on both previous research on household composting and the application of TCV (Sheth et al., 1991; Bortoleto et al., 2012; Lin and Huang, 2012; Teng, 2018; Kopaei et al., 2021), this model's emotional construct covered environmental concern, satisfaction, and personal norms with five items.

> H7: EMT → COMP: emotional value impacts composting adoption.

3.1.4 Epistemic values

Epistemic value refers the ability to composting to spark curiosity, introduce new insights, and/or satisfy the pursuit of knowledge (Sheth et al., 1991; Kushwah et al., 2019; Tanrikulu, 2021). Measurements related to this value have comprised items concerning knowledge acquisition, willingness to learn, curiosity, visibility (advertisement, example of friends), as well as novelty and current knowledge status (Sheth et al., 1991; Lin and Huang, 2012; Wen and Mohd. Noor, 2015;

Khan and Mohsin, 2017; Kaur et al., 2020). The present paper focuses on the visibility (VIS) and knowledge status (SKNG) sub-dimensions.

Researchers have often pointed out that monetary assistance and training are good strategies for increasing composting engagement (Loan et al., 2019; Pai et al., 2019; Wu et al., 2019; Kunszabó et al., 2022). Nevertheless, despite many Japanese municipalities providing incentives like financial support (Island Land Co. Ltd., 2023), household composting is among the least common PEB (Aoki et al., 2010; Kurisu and Bortoleto, 2011; Lee et al., 2013; Phuphisith et al., 2020; Morais and Ishida, 2024).

The framing of an initiative and its messaging can influence its success (Abrahamse, 2020). Based on the latter premise, previous composting intervention-based studies explored the impact of messaging based on know-how and descriptive norms (information about the behavior of others) on engagement (Mckenzie-Mohr, 2000; Nomura et al., 2012; Sussman and Gifford, 2013; Bernstad, 2014; Geislar, 2017; Linder et al., 2018). Nonetheless, when it comes to decision models, to the authors' knowledge, besides Pickering et al. (2020), there is no paper testing descriptive norms and program awareness within a decision-making model. The visibility construct of the present model addresses how visible composting programs are to respondents, considering both perceptions of the behavior of the community and awareness of ongoing programs. The measurements used were adapted from Kaur et al. (2020) and Sheth et al. (1991).

Moreover, in PEB research, knowledge has often been considered an important driver of adoption (Kurisu, 2015). Knowledge about how to compost is commonly recognized as significant for household composting adoption (Edgerton et al., 2009; Loan et al., 2019; Nsimbe et al., 2018; Pickering et al., 2020). It has even been pointed out as a possible reason why people prefer backyard composting over food waste segregation schemes (Ladele et al., 2021). Thus, in addition to the visibility construct, a variable related to the current home composting knowledge status was tested in the model. It comprised two items about home composting's process and definition based on Wen and Mohd. Noor (2015) and Loan et al. (2019).

> H8: VIS → COMP: Home composting incentives visibility is significant to household composting involvement.
>
> H9: SKNG → COMP: Knowledge about household composting impacts home composting adoption.

3.1.5 Conditional value

The conditional value is associated with the utility of a product or service as the consequence of a set of circumstances or specific situations the choice maker faces (Sheth et al., 1991; Tanrikulu, 2021). It comprises aspects like time, place, and context that enhance its functional or social value (Sheth et al., 1991; Kushwah et al., 2019; Tanrikulu, 2021). Under the conditional value, two sub-dimensions were tested.

Unlike other PEB, composting has been identified as a behavior that can be highly influenced by non-environmental factors (Edgerton et al., 2009). In particular, when analyzing simultaneously food waste segregation and household composting, Nguyen et al. (2022) and Niles (2020) mentioned that the presence of a garden is one of the factors for individuals to choose household composting over food waste segregation schemes. Moreover, several scholars have highlighted the connection between gardening/farming and the choice of home composting (Tucker and Speirs, 2003; Tucker et al., 2003; Edgerton et al., 2009; Nsimbe et al., 2018; Loan et al., 2019; Kunszabó et al., 2022; Sayara et al., 2022; Morais and Ishida, 2024). Thus, in the present analysis, one of the sub-dimensions associated with the conditional value concerns the respondents' farming/gardening (GDN) interest.

The second sub-dimension addresses the time and financial availability (AVB) of the people of the sample. The perception of a lack of time, regardless of a person's actual free time or the time required for the process, has been identified as a constraint to engagement (Edgerton et al., 2009; Wu et al., 2019). Pickering et al. (2020) also pointed out acquisition costs as a barrier. Thus, based on the latter authors, the present analysis tested three items regarding whether the respondents have the financial and time conditions necessary to engage in household composting if they wish to do so.

> H10: GDN → COMP: gardening/farming interest impacts home composting engagement.
>
> H11: AVB → COMP: availability impacts home composting engagement.

3.1.6 Control variables

Gender (GENDER), house type (HOUSE), and household size (SIZE) were used as control variables. The role of socio-demographics, such as gender or education, in PEB adoption has not been consistent in the literature (Kurisu, 2015). This extends to home composting and segregation schemes' academia. For instance, some pointed out the gender, house type, income, household size, and children to be significant to household composting and green bin schemes (Edgerton et al., 2009; Pickering et al., 2020; Kala and Bolia, 2021). On the other hand, Nsimbe et al. (2018), Sterner and Bartelings (1999), and Loan et al. (2019) found none of the latter socio-demographics and house characteristics impactful (at a 5% significance level) on household composting.

Despite previous studies mentioning residential areas (urban, rural) and age (Edgerton et al., 2009; Wu et al., 2019; Niles, 2020) as important factors in food waste recycling, these two variables were not included in this study. The percentage of respondents living in rural areas was approximately 4% of the total sample, which is lower than the national percentage in recent years (8%) (World Bank, 2024). Thus, the authors considered that including this variable would not show trustworthy conclusions about its impact on home composting decisions. Moreover, age was not included as it did not present a linear relation with the main dependent variable. Considering that having children directly contributes to a larger household, only the latter variable was analyzed in the model.

> H12: GENDER → COMP: Gender is significant to home composting engagement.
>
> H13: HOUSE → COMP: The house type (apartment or house) affects home composting involvement.
>
> H14: SIZE → COMP: The household size is significant to home composting adoption.

3.1.7 Household composting engagement

Household composting engagement has been commonly assessed either by the yes or no categorical items (Edgerton et al., 2009; Tanaka et al., 2011; Nsimbe et al., 2018; Widyatmika and Bolia, 2023) or frequency measurement like Likert scales (Taylor et al., 1997; Karim Ghani et al., 2013; Karkanias et al., 2016), but some studies have used a three-level categorical variable (yes, dropout, no) instead (Tucker et al., 2003; Tucker and Farrelly, 2016) (Table 1). Moreover, Loan et al. (2019) analyzed in separate models both backyard composting adoption (yes, no) and adoption frequency (minimal, moderate, frequent). Taking advantage of the OrdPLS analytical capabilities, the current analysis used as measurements of household composting involvement a categorical question based on Tucker and Speirs (2003) and Tucker et al. (2003), alongside a food waste composting frequency scale measured on a 6-point Likert scale.

3.2 Statistical tools: OrdPLS

As the dataset has non-equidistant categorical indicators, including an item related to the home composting dependent variable, the model hypotheses were tested using an OrdPLS. OrdPLS is an extension of PLS-SEM that can cope with categorical data by using the polychoric correlation matrix (Cantaluppi, 2012; Schuberth et al., 2018; Sarstedt et al., 2022).

PLS-SEM and its extensions are multivariate analysis techniques that allow the use of abstract concepts (latent variables) as part of the model and are able to estimate multiple dependence relationships (Hair et al., 2018). Some of the core features of PLS are its lack of distributional assumptions and sample size requirements (Cantaluppi, 2012; Schuberth et al., 2018; Hair and Alamer, 2022). However, as OrdPLS is based on polychoric correlation, which assumes normality for the latent variables, OrdPLS can no longer be considered free of distributional assumptions (Cantaluppi, 2012; Schuberth et al., 2018). This appears to be a strong assumption, but the algorithm is prepared to deal with manifest variables that derive from normality, and it can counterbalance the bias associated with the PLS techniques (Cantaluppi, 2012).

Academics also pointed out that PLS techniques are more adequate when the research has a predictive side, the goal goes beyond testing established theoretical frameworks, or the analysis comprises formative variables (Hair and Alamer, 2022). While this analysis is based on TCV, it presents some modifications to the original framework presented by Sheth et al. (1991), thus adding an exploratory side to this research.

SEM modeling consists of the estimation of two models: the outer (measurement) model and the inner (structural) model. The measurement model displays the relationships between the constructs and the indicator variables. They can be either reflective or formative. A reflective relationship implies the indicators are a "manifestation" of the latent concept (Wold, 1985). On the other hand, a formative relation implies the construct is a linear combination of its indicators (assumed not highly correlated) (Hair and Alamer, 2022). The present research uses reflective variables.

The authors of the present analysis acknowledge that PLS-SEM is a composite-based approach, so some scholars recommend the use of PLSc (in this case OrdPLSc) when the model has reflective variables (Dijkstra and Henseler, 2015; Schuberth et al., 2018; Hair and Alamer, 2022; Sarstedt et al., 2022; Henseler and Schuberth, 2023; Ringle et al., 2023). Nonetheless, due to the ongoing debate among PLS scholars about the advantages and disadvantages of using such an extension and the scarce literature available on PLS categorical applications, OrdPLSc was not used (Schuberth et al., 2018; Hair and Alamer, 2022; Sarstedt et al., 2022; Henseler and Schuberth, 2023; Ringle et al., 2023).

The inner model displays the relationships (paths) between the constructs (latent variables). These relationships can be direct or indirect depending on the existence of a mediating construct. When testing mediation effects, one can gain a deeper understanding of the causal mechanism underlying the relationship between two variables (Henseler, 2021). There may be cases of non-mediation (if the indirect effect is non-significant), full mediation (if the direct effect is non-significant), complementary partial (when the indirect and direct effects point in the same direction), or competitive partial mediation (when the direct and indirect effects have opposite directions) (Carrión et al., 2017).

Both outer and inner models should be evaluated to assess the model quality. First, the outer and then the inner. If the outer model is not scrutinized, the inner model's analysis can be compromised.

3.2.1 Evaluation of the reflective measurement model

Reflective measurement models should be evaluated regarding constructs' internal consistency reliability (Cronbach's α and Joereskog's rho, also known as ρ_c as lower and upper boundaries, respectively, $0.70 \leq x < 0.95$), indicators' reliability (loadings ≥ 0.708), convergent validity (average variance extracted (AVE) ≥ 0.50), and discriminant validity (Heterotrait-monotrait ratio of correlations (HTMT/HTMT2) < 0.85 or < 0.90 for similar concepts) (Sarstedt et al., 2022; Ringle et al., 2023).

3.2.2 Evaluation of the structural model

One should check for collinearity issues among the model constructs (VIF < 3 is uncritical, and 3 < VIF < 5 is usually uncritical) (Ringle et al., 2023). Following, the significance and relevance of the structural model relationships (p-values of path coefficients), the explanatory power, the predictive power, and model fit should be evaluated. Concerning explanatory power, a $R^2 > 0.75$ is often considered substantial, and a $R^2 > 0.50$ moderate (Hair et al., 2021). However, R^2 value depends on context, and its interpretation should be based on the research domain being examined (Hair and Alamer, 2022).

When the analysis focuses on prediction and explanation, researchers should consider the trade-off between these two aspects (Ringle et al., 2023). Thus, the present analysis assessed the standardized root mean square residual (SRMR) to address the explanatory side of the method (Schuberth et al., 2023) and compared the model prediction errors (*MAE*) of the dependent variable to the ones of a naive linear model benchmark (Shmueli et al., 2019; Hair et al., 2021). At least half of the errors should be inferior to the benchmark model (Shmueli et al., 2019), and the SRMR should be no bigger than 0.08 (Cho et al., 2020; Dash and Paul, 2021). It is important to note that under the presence of composite variables and categorical items, such cut-off values may not be accurate (Schuberth, 2022; McNeish, 2023).

3.3 Data collection

The analysis was based on the same data sample of Morais and Ishida (2024). Although the latter paper focused on the adoption patterns of PEB across the purchase, usage, and disposal of food products, it did not present in-depth information about the household composting decision-making process. By exploring household composting choice of behavior, the present research addresses one of the future research points highlighted by the previous authors. The data was collected between 2022-09-20 and 2022-09-21 through an online questionnaire, and the sample included 1,500 Japanese respondents over 30 years old who accessed the survey via a marketing research company. Not all 47 Japanese prefectures were represented in the sample. Instead, the sample included 9 highly populated prefectures: Aichi, Chiba, Fukuoka, Hyogo, Kanagawa, Kyoto, Osaka, Saitama, and Tokyo. Tokyo is the most populated area, followed by Kanagawa, Osaka, and Aichi. With a Japanese adult population of 126.146 million people in 2020, approximately 60% resided in the selected regions (Morais and Ishida, 2024).

Additionally, these prefectures were selected for their distinct approaches to waste management. For example, Aichi promoted waste reduction programs early, and at least two towns in Fukuoka made zero waste pledges (Kurisu and Bortoleto, 2011; Hirose, 2015; Life Hugger and Lee, 2023). To have a sample that closely matched the age, gender, and geographic distribution of the Japanese population, a quota sampling technique was used.

To better understand the results, three points should be addressed. First, as many young Japanese aged between 18 and 30 still live with their parents and the early twenties is a period associated with academic pursuits (Nishi, 2017; MEXT, 2019), the study focused on the population over 30 years old. Second, even though there is a marginal number of elders over 70, the quota of the elderly group, in proportion to the population composition, was based on the population between 60 and 69. This was preferred given the low percentage of elders registered for the Internet surveys. Finally, as the survey was done in Japanese, only Japanese citizens were included in the sample.

As mentioned in the above sub-sections, the survey addressed the conditional, emotional, epistemic, social, and functional values related to household composting engagement. With the exception of the questions about garden/farming interests ("I am interested in farming," "I am interested in backyard/community gardening," "I am interested in the balcony herb garden," "I have no interest in the above options"), home composting behavior (no, used to, yes), and awareness of home composting support programs ("I do not know," "I know they are available, but I do not know the details," "I know whether or not they are available"), the majority of the items were addressed on 6-point Likert scales (e.g., 1-never 6-always, 1-strongly disagree 6-strongly agree). A 6-point Likert scale was preferred over a 7-point Likert scale since Japanese respondents tend to choose "neutral" answers (Kurisu, 2015). According to Norman (2010), Likert scales yield robust results in several parametric applications, and multiple studies within PEB research have found significant results under the continuity assumption (Dorce et al., 2021; Kunszabó et al., 2022; Nguyen et al., 2022; Morais and Ishida, 2024). The present analysis also assumed Likert scale items to be continuous.

4 Results

The data were analyzed using the R (4.2.1) programming language via Rstudio (5.5.4). Regarding the analytical package, the OrdPLS results were obtained with the cSEM (0.5.0). The bootstrapping was set to 5,000 times.

4.1 Descriptive results

The initial sample had 1,500 participants, but two observations were excluded due to missing data. Among the respondents, 49.7% were female, and 50.3% were male (Morais and Ishida, 2024). The sample consisted of Japanese adults over 30 years old, where 22.3% of them were in the 30–39 age range, 29.5% were between 40 and 49 years old, 26.2% in their 50s, and the remaining 22.0% were over 60 years old (Table 2). Roughly 30% of the participants had at least one child living with them, and the most prevalent household arrangement had the respondent cohabiting with another individual, such as a parent, spouse, or child (Morais and Ishida, 2024).

Regarding education and career, 66% of individuals had a university degree or its equivalent (e.g., vocational school), 30% completed high school, and 4% held a junior high school diploma (Morais and Ishida, 2024). After their education, 41% of the participants followed the corporate career path, and 20% were housewives or husbands. The most frequently reported annual household income range was between 4 and 6 million yen (Morais and Ishida, 2024). The average household income in Japan was 5.5 million yen per year in 2021 (MHLW, 2023), thus aligning with the survey statistics.

Approximately 13% of the respondents reported having previous household composting experience, but only 6.1% were engaged. Regarding engagement frequency, the average score was 1.91 (6–always and 1–never). It is important to note that the frequency item asked if people used organic waste as a fertilizer, whereas a composting definition was given to those unfamiliar with the concept of the involvement categorical item. Therefore, if a person uses eggshells, seaweed, or coffee grounds directly in the garden as fertilizer, they may have answered no on the categorical home composting question but reported recycling organic matter as fertilizer/stabilizer.

4.2 Assessment of the measurement (outer) model

The results regarding the outer reflective model are available in Tables 3, 4 and Appendix 1. All loadings, except for CONV1, were greater than 0.7. Regardless, the item was kept in the study once removing it did not significantly increase internal consistency reliability or convergent validity (Hair et al., 2021). All the AVE values were superior to 0.50, and Cronbach's α and ρ_c bigger than 0.70. The ρ_c of the home composting and knowledge constructs were bigger than 0.95, which could imply some redundancy (Ringle et al., 2023). However, considering that Joereskog's rho (ρ_c) is seen as an upper boundary and the Cronbach's α of these variables were inferior to 0.95, the authors considered no reliability issues.

TABLE 2 Sample socio-demographics (adapted from Morais and Ishida, 2024).

Variables	Categories	*N*	*N%*
Gender	Male	754	50.3%
	Female	744	49.7%
Age	30's	334	22.3%
	40's	442	29.5%
	50's	392	26.2%
	>60	330	22.0%
Region	Saitama	166	11.1%
	Chiba	143	9.5%
	Tokyo	324	21.6%
	Kanagawa	213	14.2%
	Aichi	167	11.1%
	Kyoto	55	3.7%
	Osaka	195	13.0%
	Hyogo	122	8.1%
	Fukuoka	113	7.5%
Educational level	Junior high Sch. (or equivalent)	68	4.5%
	High Sch. (or equivalent)	448	29.9%
	College	176	11.7%
	University degree (undergraduate and postgraduate)	806	53.8%
Marital status	Single	572	38.2%
	Married	926	61.8%
Household size	1	271	18.1%
	2	685	45.7%
	3	296	19.8%
	4	136	9.1%
	> 4	110	7.3%
Living with children	Yes	447	29.8%
	No	1,051	70.2%
Yearly income (before taxes)	< 2 million yen	160	10.7%
	2–4 million yen	295	19.7%
	4–6 million yen	355	23.7%
	6–8 million yen	260	17.4%
	8–10 million yen	180	12.0%
	10–12 million yen	94	6.3%
	>12 million yen	154	10.3%
House type	Apartment	703	46.9%
	House	795	53.1%
Job	Corporate worker	610	40.7%
	Housewife/husband	296	19.8%
	Part-timer	204	13.6%
	Unemployed	170	11.3%
	Self-employed	81	5.4%
	Others*	137	9.1%

1 million yens were approximately 7,000 UDS in September of 2022 (the period when the data was collected).
*"Others" includes jobs such as public officer, lawyer, accountant, teacher, designer, and company director.

TABLE 3 Reliability measurements.

Construct	AVE	Cronbach's α	Joereskog's rho (ρ_c)
PROS	0.74	0.88	0.92
CONS	0.73	0.94	0.95
CONV	0.65	0.82	0.82
AVB	0.76	0.84	0.91
VIS	0.76	0.92	0.94
SKNG	0.93	0.92	0.96
EMT	0.59	0.83	0.88
SOC	0.72	0.87	0.91
COMP	0.93	0.93	0.97

TABLE 4 Discriminant validity: HTMT.

Construct	PROS	CONS	VIS	SOC	AVB	EMT	SKNG	CONV	COMP
PROS	1.00								
CONS	0.63	1.00							
VIS	0.18	0.14*	1.00						
SOC	0.41	0.03*	0.71	1.00					
AVB	0.46	0.09*	0.48	0.63	1.00				
EMT	0.74	0.26	0.40	0.67	0.60	1.00			
SKNG	0.39	0.05*	0.45	0.39	0.51	0.49	1.00		
CONV	0.24	0.63	0.28	0.05*	0.02*	0.02*	0.16	1.00	
COMP	0.35	0.05*	0.64	0.59	0.57	0.52	0.69	0.29	1.00

*HTMT2 was null.

All HTMT values were smaller than the maximum recommended by academia. Nonetheless, when running the model, a warning appeared regarding the HTMT/HTMT2 assumption that all intra-block and inter-block correlations between indicators must be all-positive or all-negative (Schuberth, 2022; Ringle et al., 2023). That is an issue already identified and addressed in academia (Ringle et al., 2023), but despite some software having updated versions of both HTMT and HTMT2, it is not yet the case for the cSEM package. According to Ringle et al. (2023), negative correlation patterns among indicators may often occur when measuring emotion or personality traits. However, since the HTMT aims to determine the indicators' empirical overlap, their signs are not decisive (Ringle et al., 2023). HTMT2 also has the tendency to show inadmissible solutions when the construct correlations are low (Ringle et al., 2023). In turn, small construct correlations favor the occurrence of negative indicator correlations (Ringle et al., 2023). The latter also implies that discriminant validity issues are less likely to emerge (Ringle et al., 2023). After checking the correlation values of the indicators of the constructs that triggered the warning (Appendix 2), the authors concluded that the model did not present discriminant validity issues (no correlation was bigger than modulus 0.23).

4.3 Assessment of the structural (inner) model

The variables used in the structural model had VIF values less than 3 (Table 5). The R^2adj were 0.32 for convenience and 0.68 for home composting behavior (Figure 2). One of the household composting items showed a smaller Mean Absolute Error (MAE) than the naive linear benchmark model, while the other was larger. Thus, implying a moderate predictive power (Shmueli et al., 2019). Note that one of the limitations of OrdPLS is that the predictive values of the categorical items are dependent on the calculation method used ("mean" or "median") (Cantaluppi, 2012; Schuberth et al., 2018; Schuberth, 2022). In this analysis, the approach chosen was the "mean". Moreover, the naive linear benchmark model considers all the variables continuous. The SRMR value was 0.077 (<0.08), implying a good model fit.

Not all the hypotheses were significant (p-value<0.05) to explain/predict household composting involvement. None of the control variables were significant for COMP at a 5% p-value. Nevertheless, assuming a 10% significance level, the house type would be included in the model, suggesting that living in a house rather than an apartment positively impacts the home composting decision. Within the functional values, neither PROS nor CONS had a direct impact, but both had a significant indirect impact on household composting through convenience, which was fully mediated by the latter variable (Tables 6, 7). Social and epistemic values hypotheses were accepted (Table 6, Figure 2). The model results suggest that the latter values have a high impact on composting adoption. Among the sub-dimensions of the conditional value, both gardening and availability were found to be significant. Emotional value was not found to be significant in influencing the choice of behavior (Table 6).

5 Discussion

By applying the OrdPLS algorithm to test the hypotheses of a TCV decision model on household composting, this paper presented a comprehensive analysis and identified the main drivers of this behavior in Japan. Based on these results, several social, managerial, and theoretical implications can be drawn from them.

5.1 Social and management implications

Functional aspects were impactful, both directly and indirectly, on home composting engagement. The negative attributes of household composting seemed to have a stronger effect on convenience than the positive attributes. This suggests that finding ways to alleviate these barriers can increase convenience perceptions, which will reflect on household composting engagement. For instance, Kurniawan et al. (2013) mentioned the importance of recommending the appropriate composting technology based on regional characteristics.

A relevant finding of this model is the importance of the social value and composting visibility to home composting in Japan. Aligned with the idea that the Japanese are more collectively oriented and sensitive to social norms (Ando et al., 2007, 2010), and contrary to previous findings about the weak effect of subjective norms (Taylor and Todd, 1995; Taylor et al., 1997), social value, which comprised subjective norms and self-image items, had a significant effect on home composting adoption. These results also support Nguyen et al.'s (2022) findings about the importance of environmental self-identity to home composting choice of behavior. Thus, marketing relying on one's self-image as an eco-friendly individual or as one connected with nature can be an effective strategy to foster this behavior, possibly leading to positive spillover effects in other behaviors, such as food waste prevention or waste recycling (Whitburn et al., 2020). Behavioral spillover implies that adopting one behavior may catalyze or reduce (in case it has a negative effect) engagement in others (Truelove et al., 2014; Abrahamse, 2019; Maki et al., 2019; Nash et al., 2019).

The significant effect of the home composting visibility construct also calls for raising awareness of the existing household composting support programs and the visibility of community efforts to reduce and recycle waste. In addition to having assistance available, it is important to develop effective marketing strategies so people know that such support exists. One way may pass precisely by using descriptive norms about community engagement as part of the interventions' messaging.

TABLE 5 VIF table.

VIF	CONV	COMPOST
PROS	1.49	2.78
CONS	1.49	2.23
CONV	–	1.61
AVB	–	1.73
GDN	–	1.87
SKNG	–	1.79
SOC	–	2.50
EMT	–	2.55
SIZE	–	1.17
GENDER	–	1.13
HOUSE	–	1.16

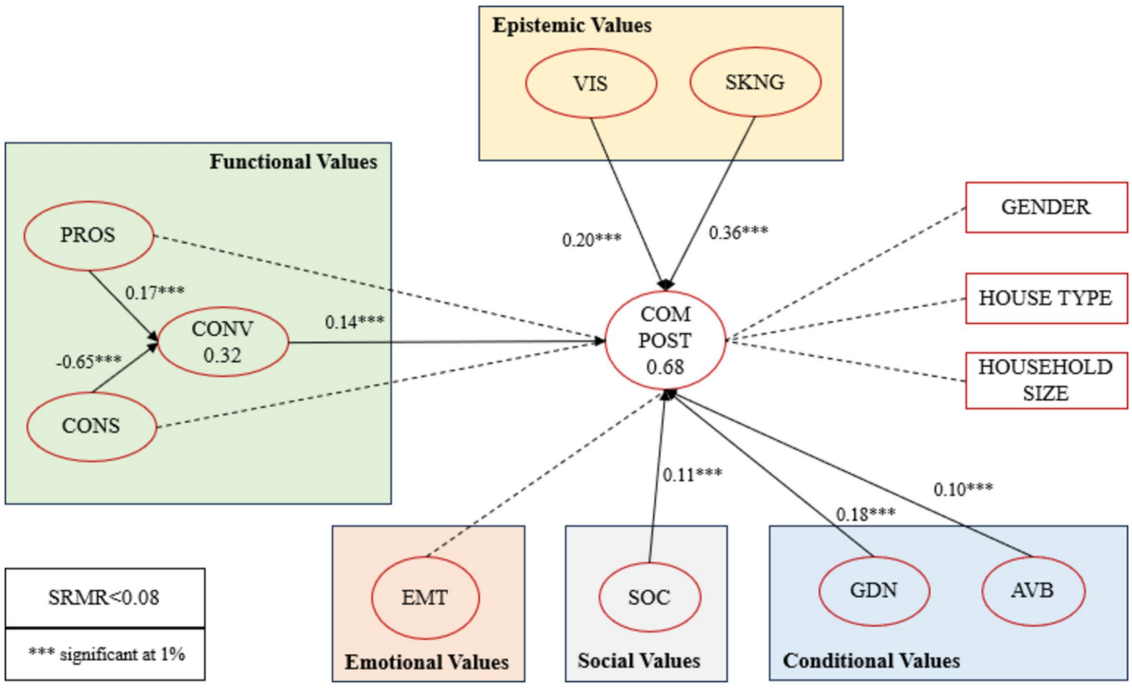

FIGURE 2
TCV model results. PROS, functional advantages; CONS, functional disadvantages; CONV, Convenience; VIS, Behavior Visibility; SKNG, Behavioral Knowledge; EMT, Emotional Value; SOC, Social Value; GDN, Gardening; AVB, Availability.

TABLE 6 Path coefficients.

	Path estimate	*t*-stat	*p*-value	Confidence interval (95%)	Hypothesis
H1: PROS → CONV	0.17	4.97	0.00	[0.10;0.23]	Accepted***
H2: CONS → CONV	−0.65	−23.11	0.00	[−0.71;−0.60]	Accepted***
H3: PROS → COMP	0.04	1.03	0.30	[−0.03;0.11]	Rejected
H4: CONS → COMP	0.00	0.11	0.91	[−0.07;0.07]	Rejected
H5: CONV → COMP	0.14	3.99	0.00	[0.07;0.20]	Accepted***
H6: SOC → COMP	0.11	2.90	0.00	[0.03;0.18]	Accepted***
H7: EMT → COMP	0.04	0.98	0.33	[−0.03;0.11]	Rejected
H8: VIS → COMP	0.20	5.43	0.00	[0.13;0.27]	Accepted***
H9: SKNG → COMP	0.36	10.72	0.00	[0.30;0.43]	Rejected
H10: GDN → COMP	0.18	5.00	0.00	[0.11;0.25]	Accepted***
H11: AVB → COMP	0.10	3.47	0.00	[0.04;0.16]	Accepted***
H12: GENDER → COMP	−0.05	−1.62	0.11	[−0.12;0.01]	Rejected
H13: HOUSE → COMP	0.06	−1.67	0.09	[−0.01;0.12]	Rejected*
H14: SIZE → COMP	0.04	1.26	0.21	[−0.02;0.10]	Rejected

*Accepted at *p*-value<10%; ** accepted at *p*-value<5%; and *** accepted at *p*-value<1%.

TABLE 7 Indirect Effects.

	Estimate	*t*-stat	*p*-value	Confidence Interval (95%)	Hypothesis
PROS → CONV → COMP	0.02	2.86	0.00	[0.01;0.04]	Accepted***
CONS → CONV → COMP	−0.09	−3.86	0.00	[−0.13;-0.05]	Accepted***

*Accepted at *p*-value<10%; ** accepted at *p*-value<5%; *** accepted at *p*-value<1%.

Naturally, the messaging should be adapted based on the type of support available. To the authors' knowledge, there is no extensive literature on waste reduction interventions or an overview of the strategies adopted by local governments in Japan. Such understanding, along with fostering 'know-how' sharing among municipalities, might be important for the effectiveness of future campaigns. For example, a food waste segregation scheme in Tsushima (Nagasaki) is being developed with the support of Osaki (Kagoshima), which is an internationally recognized successful case of food waste segregation (Morita, 2017; ISHES News, 2023; Osaki Town SDGs Council, 2024; Tsuruda, 2024).

Aligned with the idea that monetary support can be used as a strategy to foster household composting (Niles, 2020; Pickering et al., 2020; Kunszabó et al., 2022), it seems that many municipalities in Japan offer some kind of monetary assistance at the time of bin purchase (Island Land Co. Ltd., 2023). Based on the results of the current paper, framing this monetary assistance alongside technology/process information or building a network around people who were granted financial support might increase the popularity and long-term engagement of these schemes. Several researchers have emphasized the importance of practical training and continuous monitoring throughout the process (Tucker and Farrelly, 2016; Kawai and Huong, 2017; Jamal et al., 2019; Loan et al., 2019; Pai et al., 2019; Kala and Bolia, 2021; Sayara et al., 2022). Tucker et al. (2003) mentioned that unsuccessful compost production was one of the main reasons for dropout. A high dropout rate was one of the reasons Edogawa (Tokyo) stopped financing the purchase of composting bins and instead focused on investing in training and knowledge development (Edogawa City, 2022).

However, it is noteworthy that social influence may be stronger when the programs are relatively new, whereas it may not be the case once they are well-established programs and strong ideas toward the behavior have been formed (Pickering et al., 2020). This suggests that the messaging should be adapted to the intervention stage.

Financial and time availability were found to be significant to composting behavior, confirming Wu et al.'s (2019) findings on how the lack of time perception can act against home composting/segregation adoption. Moreover, in agreement with other previous scholars, gardening interest was proven to be an important condition for engaging in home composting (Tucker and Speirs, 2003; Tucker et al., 2003; Edgerton et al., 2009; Nsimbe et al., 2018; Loan et al., 2019; Kunszabó et al., 2022). Using compost in the garden/farm can reduce costs associated with soil amendments and avoid the usage of chemical products (Mihai et al., 2023). On the other hand, it poses the question of how municipalities should boost home composting when there is no gardening interest.

One solution might be to increase the integration between home composting projects and urban farms, owned community gardens, or public parks (Pai et al., 2019). For instance, in Japan, some NPOs and municipalities allow composters to give back their compost to farmers or municipal gardens (Kuchiba, 2022; Sapporo City, 2024). Another possibility may involve implementing a locality/colony-level decentralized system (Kala and Bolia, 2021) or centralized food waste collection programs, as seen in cities like Nagai City or Seattle (Kawai, 2019; Pai et al., 2019; Kawai et al., 2020). These types of systems can also alleviate the convenience constraints associated with home composting. On the other hand, by scaling up the systems, the role of the local authorities might become more prominent (Jamal et al.,

2019). It also poses additional challenges such as the quality of the input and output material, system characteristics, logistics, demand/usage of the compost, associated costs, and overall long-term sustainability of the programs (e.g., depopulation of certain regions of Japan) (Tsurumi et al., 2005; Nigussie et al., 2015; Cerda et al., 2018; Jamal et al., 2019; Kawai, 2019; Paes et al., 2019; Iacovidou and Zorpas, 2022; Inaba et al., 2022; Rathore et al., 2022; Fang et al., 2023).

5.2 Theoretical implications

The use of TCV to model consumer choices has been increasing in recent years (Tanrikulu, 2021). Notwithstanding, to the authors' knowledge, this is the first article to apply it to the choice of home composting. The results suggest that the TCV can be a resourceful tool when studying household composting, widening the scope of behaviors modeled by this theory. The present research also extended previous uses of the theory by including sub-dimensions within the values and assuming they can be related. While relations between sub-dimensions of the same value were hypothesized, no relation between values was assumed in this study. Value independence is a primary assumption of TCV, which has been upheld in the majority of studies on sustainable marketing (Tanrikulu, 2021). Nevertheless, some scholars have criticized this assumption, and studies using certain values as moderators or mediators can be found in academic literature (Khan and Mohsin, 2017; Tanrikulu, 2021; Talwar et al., 2023).

By using TCV, the authors were able to test, under the same model, multiple social components such as subjective norms, descriptive norms, and one's self-image. Thus, it provides a robust picture of the importance of social values in home composting engagement in Japan. To the authors' knowledge, this is the first study on household composting to include items on all these factors in a single model. The findings of the current model suggest that including measurements regarding one's self-image and descriptive norms can increase the explanatory power of a home composting model.

This analysis found meaningful results that align with previous work in the home composting field using OrdPLS. Given the advantages of using PLS instead of CB-SEM (Hair and Alamer, 2022; Ringle et al., 2023), the authors would expect an increase in the adoption of this technique. OrdPLS was first proposed by Cantaluppi (2012) and Cantaluppi and Boari (2016), but despite its ability to handle categorical data, its use in the social sciences remains scarce. Its low adoption rate may derive from some of the difficulties encountered on the present model, namely: (1) To the authors' knowledge, OrdPLS is only available in the cSEM R package, which does not have an HTMT index that can deal with different signs in the inter/intra-block correlation of the constructs (Ringle et al., 2023); (2) There is more literature available for its covariance-based counterpart, facilitating results assessment and methodology understanding; (3) There are still some limitations in its predictive modes (Schuberth et al., 2018); (4) The inclusion of categorical variables resulted in a considerable increase in the running time of the model when using cSEM. For a 5,000 times bootstrapping, the model running time was approximately 1 h and 23 min (on a computer with an Intel (R) Core (TM) i7-7600U CPU @ 2.80GHz 2.90 GHz processor and a 12GB RAM). The present analysis assumed the 6-point Likert scales were continuous and only modeled items with few and non-equidistant options as categorical. If the whole model were to be considered categorical, a longer running time would be expected.

5.3 Limitations and future research

Firstly, the results of this model confirm the idea that home composting can be highly influenced by non-environmental factors (Edgerton et al., 2009). Not all the values included in the research were significant at a 5% significance level. Previous authors stated that, depending on the analysis, some values may not be relevant to the choices of consumers (Sheth et al., 1991). That appears to be the case with the emotional value of household composting. Although previous research on this behavior found personal norms, harmonious passion, and obsessive passion to be significant (Kopaei et al., 2021; Rahman et al., 2022), this was not the case in the current analysis. A possible cause for this difference is that the latter studies addressed household composting intention rather than behavior adoption. As mentioned earlier, based on the intention-behavior gap identified by previous authors (Davies et al., 2002; Tanaka et al., 2011; Bortoleto et al., 2012; Morais and Ishida, 2024) and the fact that the data was collected at a single point in time, intention was not included in the model. However, analyzing such variables in a longitudinal study/intervention may show interesting findings.

Secondly, this analysis relied on self-reported qualitative data from 9 of the 47 prefectures and only considered respondents over 30 years old. While the included prefectures are among the most populated in Japan, the sample had a lower percentage of people from rural regions compared to the national average. Previous scholars noted differences between urban and rural areas in food waste generation, composting incentives, and adoption rates (Niles, 2020; Inaba et al., 2022; Nakamura et al., 2022). Therefore, further analysis of these nuances is needed.

Moreover, only the socio-demographics direct effect was studied, and age was not included in the model. According to Kala and Bolia (2021) and Widyatmika and Bolia (2023), different countries and social groups might prioritize incentives of distinct natures. Testing socio-demographics as a multigroup factor or a moderator may be helpful for future targeting of household composting campaigns.

While engagement rates can vary depending on the promotional approach (Hotta and Aoki-Suzuki, 2014; Abrahamse, 2019, 2020), it is important to understand how to sustain that engagement (Steg and Vlek, 2009). Only a small number of studies have examined home composting drop-out reasons and how people's engagement changes over time (Tucker and Speirs, 2003; Tucker et al., 2003; Karkanias et al., 2016).

Finally, adding quantitative data and gaining a deeper understanding of ongoing Japanese programs is crucial for the development of sustainable composting systems, whether decentralized or central.

6 Conclusion and future research

The model results suggest that home composting in Japan is closely linked to social approval, behavior visibility, knowledge about the process, interest in gardening/farming, convenience, and a person's availability to participate. The positive and negative functional aspects of household

composting significantly influence the perception of an individual regarding the convenience of the composting activity. Consequently, these aspects indirectly affect the decision to engage in composting. Promoting community projects alongside continuous training and support are crucial elements of successful composting programs. Moreover, enhancing the convenience of composting and promoting circular systems—by better integrating home composting with urban farms, community gardens, or public parks—could boost adoption rates, even among those who are not traditionally interested in gardening.

This study expanded the scope of analysis of the TCV and successfully identified key drivers of home composting in Japan using a categorical PLS-SEM approach. However, further exploration of food waste disposal alternatives remains an increasingly important area that scholars and entrepreneurs should address in the future.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors without undue reservation.

Ethics statement

Written informed consent was obtained from the individual(s) to publish any potentially identifiable images or data in this article.

Author contributions

AM: Conceptualization, Data curation, Investigation, Methodology, Software, Writing – original draft. AI: Conceptualization, Data curation, Methodology, Supervision, Validation, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2024.1435898/full#supplementary-material

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