

# Food Labelling and Producer Responsibility: Implications for Food Waste Behaviour

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## Abstract

This study examines food labelling as a strategic mechanism influencing consumer behaviour and producer responsibility, with a particular focus on reducing food waste. It investigates the extent to which the interpretation of date labels, the use of visual cues, and trust in smart packaging technologies shape food waste behaviour, highlighting the gap between information provision and actual consumer decision-making. The research adopts a quantitative approach based on an online survey (N =217). Cognitive, psychological, and technological determinants of food waste behaviour were analysed using correlation analysis and multiple linear regression to test the relationships between food label literacy (FLL), cognitive barriers (CB) risk aversion (RA) trust in smart packaging (SP), and food waste behaviour (FWB). The results indicate a limited explanatory capacity of the model ( $R^2 = 0.095$ ), suggesting that food waste behaviour is influenced by additional contextual factors beyond the variables included in the analysis. Among the predictors, only risk aversion was statistically significant and positively associated with food waste behaviour, indicating that subjective risk perceptions outweigh purely informational factors in shaping disposal decisions. The study proposes an exploratory model integrating cognitive, psychological, and technological dimensions, challenging the assumption that increased information alone automatically leads to more responsible and sustainable consumer behaviour. The findings suggest that effective food labelling strategies should combine clear visual communication, educational interventions, and interactive technologies to better manage consumer risk perception. Strengthening collaboration between producers, public authorities, and consumers may support informed decision-making and contribute to food waste reduction within the circular economy.

## Keywords

Food date labels; producer responsibility; food waste behaviour; food label literacy; cognitive barriers; food risk aversion; smart packaging visual cues

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## Introduction

Food labelling has evolved considerably, reflecting the dynamic nature of information and regulatory requirements, shifting from a purely informative role to a strategic one capable of influencing consumer behaviour and producer responsibility. Within the European Union, Regulation (EU) No. 1169/2011 marked a turning point by consolidating the label as an essential instrument of economic transparency and consumer protection (Regulation (EU) No. 1169/2011, 2011). The importance of informational mechanisms, such as food labelling, in shaping consumer behaviour is further reinforced by Directive (EU) 2025/1892, which establishes clear food waste reduction targets to be achieved by 2030 (European Parliament & Council of the European Union, 2025).

A central dimension of extended producer responsibility concerns the prevention of food waste. Food date labels, such as the “use-by” date and the date of minimum durability or “best before”, must be properly

understood by consumers to prevent premature disposal of products (Ray et al., 2024). Specific information campaigns implemented and adopted by major producers may provide effective solutions through simple visual cues that transfer part of the decision-making responsibility to the consumer (Patra et al., 2026).

Digital technology and smart packaging enable the transition from static labels to dynamic interactions, providing real-time information on product freshness and storage conditions (Salume et al., 2026). In parallel, the adoption of dual food labelling is essential for harmonising communication and reducing confusion surrounding the terms “use by” and “best before” (European Commission, 2024, 2025). Consequently, producer responsibility extends beyond the point of sale, encompassing consumer education and the adoption of innovative solutions that support informed and sustainable decision-making. A gap can be identified in the existing literature, which highlights consumers’ difficulty in correctly interpreting the date of minimum durability and the resulting food waste behaviour, thereby creating a relevant research opportunity.

This study investigates how the interpretation of food date labels, the adoption of visual labels, and the integration of smart packaging may reduce the phenomenon of premature disposal and promote responsible food consumption behaviour, thereby contributing to food waste reduction with implications for sustainability and the efficiency of the circular economy. The quantitative research is based on an online-administered questionnaire that evaluates the extent to which the misinterpretation of food date labels influences food waste behaviour (FWB), thus quantifying information asymmetry and the mechanisms through which producer transparency may act as a catalyst for sustainable food-related decisions.

The paper is structured as follows: after the Introduction, Section 1 reviews the theoretical framework, Section 2 details the applied research methodology and formulates the research hypotheses, while Section 3 presents primary results and discusses the empirical findings, highlighting the theoretical and practical implications and limitations. The final section summarizes the main findings and proposes future research directions.

## **1. Review of the scientific literature**

### **1.1. Labelling as a pillar of producer and consumer responsibility**

The role of the label has been fundamentally redefined, evolving from a simple support for information and promotion into a pillar of economic transparency and consumer protection, establishing the direct responsibility of producers to ensure the presence, accuracy, and neutrality of information, while contributing to the standardisation of communication with consumers (Regulation (EU) No. 1169/2011, 2011). From an economic perspective, producer responsibility extends beyond legal compliance, with the label becoming an instrument of corporate social responsibility through which producers reduce information asymmetry and influence purchase decisions (Marchini et al., 2021). In this context, informational transparency becomes a strategy of competitive differentiation and a key driver of consumer trust (Sansome et al., 2025). Within the framework of European food waste reduction targets established by Directive (EU) 2025/1892, food labelling acquires a strategic role in shaping consumer FWB and reducing premature product disposal (European Parliament & Council of the European Union, 2025).

A critical direction in the evolution of producer responsibility concerns the proactive approach of food waste through the clarification and innovation of shelf-life indicators. Although Regulation (EU) No. 1169/2011 established a rigorous semantic framework to distinguish between the “use-by” date (an indicator of microbiological safety) and the date of minimum durability or “best before” date (an indicator of sensory quality), empirical evidence shows that consumers’ cognitive barriers persist, limiting the effectiveness of these indicators. This cognitive resistance is reflected in the phenomenon of information overload, whereby the large volume of data displayed on the label exceeds the individual’s processing capacity, leading to decisions based on simplified heuristics or safety-related cues (Szenderak et al., 2025). Many consumers continue to perceive the date of minimum durability as a strict safety threshold, which significantly contributes to food waste. This reality compels producers to adopt extended responsibility through strategies that support consumers’ correct interpretation of product shelf life (Toma et al., 2020).

An emerging trend is represented by the implementation of Look, Smell, Taste campaigns, initially launched by Too Good To Go, integrated directly into the label alongside the date of minimum durability, as an innovative form of extended producer responsibility. This initiative represents a direct and effective approach for mitigating the problem of premature food disposal (Too Good To Go, n.d.; Wallnoefer et al., 2024).

By adding a visual cue next to the date of minimum durability (“best before” date), consumers are encouraged to evaluate products using their senses: Look – checking the appearance, Smell – detecting unpleasant odours, and Taste – tasting only if the previous stages do not indicate any issues.

From an economic perspective, the campaign functions as an instrument that reduces consumers’ information costs and shifts part of the decision-making responsibility to them, while producers assume the validation of food safety beyond the calendar date (Patra et al., 2026), thereby influencing FWB. The adoption of the voluntary pictogram operates as a signal of transparency and social responsibility, strengthening consumer trust and loyalty and extending producer responsibility into the post-consumption stage. In this way, a bridge is created between the traditional model of informative labelling and the emerging model of participatory labelling, in which responsibility for a sustainable food system is more equitably shared between producers and consumers.

## **1.2. Active and smart labels for sustainable food behaviour**

In recent years, at the level of the European Commission, there has been an ongoing discussion regarding the introduction of dual food labelling, a concept that involves displaying two distinct but complementary dates on food labels, namely the “use-by” date and the date of minimum durability (“best before”), with the aim of clearly distinguishing food safety risks from sensory quality degradation. This initiative responds to evidence showing that the misinterpretation of these indicators significantly contributes to FWB and suboptimal consumption decisions, which is why the European Commission is exploring ways to improve and reform the labelling system to support more informed and sustainable choices (European Commission, 2024, 2025).

Consumer confusion often results from overlapping label information, and dual food labelling seeks to distinguish the sell-by date from “use-by/best before” indicators, which are frequently misinterpreted as safety thresholds. Although this clarification may improve transparency and influence FWB, consumers still associate minimum durability dates with food safety, leading to premature disposal (Secondi, 2019), while attention remains focused mainly on the date itself rather than explanatory information (Badiger et al., 2023). Thus, labelling becomes more effective when complemented by visual cues and contextual messages that support informed decisions, improve FWB, and reduce food waste (Majer et al., 2022).

The future of dual food labelling is moving toward the integration of printed (static) and digital (dynamic) systems. Producers increasingly use QR codes to provide updated information on product freshness based on storage conditions rather than only expiration dates, reducing packaging information overload while supporting post-purchase responsibility. In parallel, the digital transition accelerates the adoption of Smart Packaging solutions using sensors, freshness indicators, and interactive digital codes to deliver real-time information, improving transparency, consumer trust, and product management efficiency. This dynamic approach addresses the rigidity of printed expiration dates, which are often conservatively estimated to limit legal risks and may lead to unnecessary food waste (Salume et al., 2026).

A major barrier identified in the literature is the need for standardisation of dual labelling through clear labelling policies aimed at reducing food waste and protecting public health. Consequently, producer responsibility is expressed through continuous collaboration with regulatory authorities to establish a common language. A harmonised dual labelling system can influence FWB, as consumers develop the necessary trust to no longer perceive the date on the label as a simple expiration switch (Alaybek et al., 2025). The transition from static, purely informative labelling towards interactive solutions and simplified visual cues represents not only a logistical innovation but also an economic necessity.

## **2. Research methodology**

The aim of the present research is to highlight the expansion of the role of food labelling from a legal compliance element to an economic instrument capable of correcting misperceptions regarding food safety and quality, by reducing information asymmetry and clarifying food date labels, while investigating the extent to which cognitive, psychological, and technological determinants associated with food labelling influence decision-making processes and food waste behaviour.

The research objectives are structured to provide a comprehensive understanding of the interaction between the regulatory framework, producer responsibility, and consumer perception. The first objective aims to assess consumers’ level of knowledge regarding the differences between food date indicators, namely the “use-by” and “best-before” labels, to determine the impact of this knowledge on FWB. The second objec-

tive investigates cognitive barriers in processing food date information and examines the impact of simplified visual cues on consumer decision-making processes. Third, the study aims to analyse consumers' openness toward labelling innovations, with a particular focus on dual food labelling systems. Fourth, the study examines the effect of integrating labelling information with smart packaging on FWB, to assess the potential of innovative technologies to reduce food waste.

Food labelling literacy is defined as the consumer's ability to process and use label information to make safe and efficient consumption decisions (Llagas et al., 2025), a competence that is crucial for preventing food waste. The study conducted by Schanes et al. (2018) identified low understanding of food date labels as the main barrier to reducing household food waste. Another study examined the direct relationship between food literacy and premature disposal behaviour in the context of food price instability (Natali et al., 2026). Consequently, we propose hypothesis H1:

H1: Consumer level of food label literacy regarding label terminology ("Best Before" and "Use-By") shapes food waste behaviour.

Digital and physical decision architecture uses visual cues to simplify the complex cognitive processes of the modern consumer (Majer et al., 2022). Recent studies have shown that intuitive pictograms, such as Look, Smell, Taste, are more effective in changing FWB than traditional textual warnings (Wallnoefer et al., 2024). Moreover, Szenderak et al. (2025) demonstrate that reducing cognitive effort through simplified design increases product retention in consumption. Accordingly, we formulate hypothesis H2:

H2: Consumer ability to process food date labels is associated with a preference for simplified visual cues over complex textual instructions, influencing food waste behaviour.

Food risk perception is a psychological construct that often overrides economic rationality in evaluating freshness, as fear of health consequences leads consumers to devalue still viable food products and treat date labels as absolute safety signals, disregarding sensory quality (Buttlar et al., 2021; Secondi, 2019). This cognitive barrier is particularly evident among younger consumers, who rely more on printed package information than on sensory assessment (Natali et al., 2026). As a result, the date of minimum durability is often interpreted as a strict threshold, beyond which food is considered unsuitable even in the absence of spoilage signs. Therefore, we propose hypothesis H3:

H3: Consumer risk aversion level is positively associated with food waste behaviour, as the interpretation of the date of minimum durability as a rigid safety threshold increases the likelihood of premature food disposal.

Smart packaging represents a technological solution that provides real-time information on the interaction between the product and its external environment, thereby reducing information asymmetry. This technology replaces static dating with continuous quality monitoring (Hossain et al., 2023; Rahman et al., 2026). Thus, we propose hypothesis H4:

H4: Trust in information embedded in smart packaging is associated with food waste behaviour, reducing the tendency to consider food as unfit for consumption.

This approach enables the quantification of consumer perceptions and the assessment of food labelling literacy by analysing the interdependencies among the variables presented in Table no. 1.

**Table no.1. Research variables**

| <b>Ipoteză</b> | <b>Independent variables</b>                                                                   | <b>Dependent variable</b>                                                                   |
|----------------|------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| <b>H1</b>      | Level of consumer food label literacy regarding terminology ("Best Before" and "Use-By") (FLL) | Food Waste Behavior (FWB) (understanding sustainability indicators for reducing food waste) |
| <b>H2</b>      | Capacity to process food date information (cognitive barriers) (CB)                            | Food Waste Behavior (FWB) (preference for visual labelling cues to reduce food waste)       |
| <b>H3</b>      | Consumer risk aversion level (RA)                                                              | Food Waste Behavior (FWB) (increase in the likelihood of premature food disposal)           |
| <b>H4</b>      | Trust in information embedded in smart packaging (SP)                                          | Food Waste Behavior (FWB) (reducing the tendency to consider food unfit for consumption)    |

The exploratory conceptual model of the study proposes the analysis of FWB as a dependent variable, explained through cognitive, psychological, and technological determinants. Thus, consumer food label literacy and cognitive barriers reflect the cognitive dimension of information processing, while risk aver-

sion captures the psychological dimension of decision-making behaviour. At the same time, trust in information embedded in smart packaging represents the technological component, associated with innovations in the communication of food date information.

Methodologically, the research is grounded in deductive logic and in the operationalisation of abstract concepts into measurable variables (Ghanad, 2023). Data were collected through an online questionnaire consisting of 34 items, structured into four sections: legislative knowledge, perceptions of producers, food waste behaviour, and consumer profile in the context of sustainability, followed by socio-demographic information. Data collection was conducted between 1 January and 10 March 2026 via Social Media Apps, targeting individuals over 18 years of age, resulting in 217 responses, which were subsequently processed in Excel. For data interpretation, descriptive statistics were employed, while hypothesis testing was conducted using correlation analysis and multiple linear regression, and the results were discussed in relation to the specialized literature.

### 3. Results and discussion

Descriptive data analysis provides an overview of the sample characteristics and the variables included in the research model. The sample structure, according to the main demographic characteristics, is presented in Table no. 2.

**Table no. 2. Socio-demographic profile of respondents**

| Variables                         | Percentage (%) | Variables             | Percentage (%) |
|-----------------------------------|----------------|-----------------------|----------------|
| <b>Age</b>                        |                | <b>Gender</b>         |                |
| 18-24 years                       | 44.7           | Female                | 60.8           |
| 25-34 years                       | 16.6           | Male                  | 31.8           |
| 35-44 years                       | 20.3           | Prefer not to answer  | 7.4            |
| 45-54 years                       | 10             | <b>Residence Area</b> |                |
| Over 55 years old                 | 8.3            | Urban                 | 75.6           |
|                                   |                | Rural                 | 24.4           |
| <b>Highest Level of Education</b> |                | <b>Monthly Income</b> |                |
| Secondary school studies          | 2              | Below 3.000 RON       | 39.6           |
| High School                       | 40             | 3.001-5.000 RON       | 30.9           |
| University studies                | 43.8           | 5.001-7.000 RON       | 18             |
| Postgraduate studies              | 15             | Over 7.000 RON        | 11.5           |

The study highlights several relevant trends regarding consumer behaviour in relation to food labelling and food waste. First, it is noteworthy that approximately 46.5% of respondents report checking food labels before consumption; however, this practice is primarily focused on identifying food date labels and, to a much lesser extent, on other relevant information. For example, only 25.3% of respondents indicate that they also examine other label elements, such as the list of ingredients or storage conditions. This selective focus suggests the presence of behaviour oriented toward reducing perceived risk.

Regarding the level of understanding of label-specific terminology, the results indicate a heterogeneous distribution of responses, with approximately 53.9% of respondents demonstrating a correct understanding of the difference between “Best Before” and “Use-By”, while 16.1% either confuse these concepts or are unable to clearly distinguish between them. This conceptual ambiguity is reflected in subsequent consumption behaviours, as 45.2% of respondents report discarding products immediately after reaching the food date labels regardless of their actual condition. Respondents’ reported behaviour regarding products approaching or exceeding the food data labels further confirms this tendency. Thus, approximately 68.2% of respondents avoid consuming products even when they do not exhibit obvious signs of spoilage. Among the main reasons cited for discarding food are the expiry date, doubts regarding product safety, and lack of confidence in personal evaluation.

Perceptions of food labels also reveal the presence of information-processing difficulties. Approximately 17.05% of respondents consider labels to be overly information-dense, while 43.31% perceive them as difficult to interpret. In this context, a clear preference for simplified visual elements can be observed, with 47% indicating that they would prefer graphical symbols or colour codes over text-based information. Regarding attitudes toward innovative solutions, the results indicate a high level of openness to the use of

smart packaging. Accordingly, approximately 64.1% of respondents report that they would trust such solutions, while 41.9% state that they would be willing to use them on a regular basis. This finding suggests a significant potential for the adoption of innovative technologies aimed at reducing food waste.

The correlation analysis reveals variations in the degree of association between the predictors and FWB, providing an exploratory perspective on the bivariate relationships within the model. Regarding H1, the relationship between food label literacy and food waste behaviour is characterised by an almost null coefficient ( $r = 0.01$ ), indicating the absence of a linear association between the two dimensions within the analysed sample, thereby leading to the rejection of H1. This result suggests that mere knowledge or the ability to process label information does not have a direct impact on the quantity of food wasted.

A similar situation can also be observed in the relationship between cognitive barriers and preference for visual cues, where the correlation coefficient is very low ( $r = 0.10$ ). Although the value is positive, the strength of the association between the two variables is insufficient to demonstrate a meaningful effect, suggesting that difficulties in information processing do not significantly determine a reliance on the visual design of indicators, thereby leading to the rejection of H2.

In contrast, with regard to H3, a weak to moderate positive association is observed between risk aversion and food waste behaviour ( $r = 0.29$ ), indicating a tendency for co-variation between the two variables. This result supports H3 and suggests that a higher level of caution or fear of uncertainty is associated with more pronounced food waste behaviour. This relationship highlights the determining role of psychological factors: consumers with higher levels of risk aversion tend to discard products more quickly in order to avoid potential hazards, such as exceeding the labelled shelf life, even when the products remain safe for consumption.

With respect to H4, the relationship between trust in information embedded in smart packaging and food waste behaviour shows a weak correlation ( $r = 0.11$ ). Although packaging technologies are designed to assist consumers, our data suggest that their presence is not sufficiently associated with either a reduction or an increase in food waste within this sample, which leads to the rejection of H4.

The analysis highlights that, among all determinants, only the psychological dimension related to risk exerts a predictable influence on FWB. The correlation analysis suggests that the structure of bivariate relationships is generally weak, which justifies further investigation using multivariate models to assess the simultaneous effects of the independent variables on FWB. To test the combined impact of the predictors on FWB, a multiple linear regression model was estimated. This approach allows for the examination of how FLL, CB, RA, and SP jointly explain variation in FWB, providing an overall perspective on the phenomenon under study.

The multiple regression analysis indicates that the model is statistically significant ( $F = 5.568$ ,  $p < 0.001$ ), suggesting that the independent variables, considered jointly, are associated with FWB. However, the explanatory power of the model is low ( $R^2 = 0.095$ ; adjusted  $R^2 = 0.078$ ), indicating that only a limited proportion of the variance in behaviour is explained by the included predictors. Although modest, this result highlights the complexity of consumption behaviour, which is also shaped by additional external variables not captured in the present model.

Regarding individual coefficients, RA is the only statistically significant predictor ( $\beta = 0.533$ ,  $p = 0.0004 < 0.001$ ), indicating a positive association between perceived risk and FWB. This finding suggests that individuals with higher levels of risk aversion tend to report higher levels of food waste. CB shows a positive coefficient ( $\beta = 0.189$ ), but the effect does not reach statistical significance ( $p = 0.074$ ), exceeding the 0.05 threshold, suggesting that its influence becomes secondary in the presence of other factors and indicating a potential direction for future research. FLL and SP exhibit weak and statistically non-significant effects, with  $p$ -values of 0.105 and 0.264 respectively ( $p > 0.05$ ), suggesting that, within this model, these variables are not significantly associated with FWB.

FWB is weakly influenced by cognitive and informational determinants, such as FLL or difficulties in processing label information (CB), and to a limited extent by technological determinants, such as information embedded in smart packaging (SP). RA emerges as the only statistically significant predictor, being positively associated with FWB, suggesting that consumer decisions are shaped more by subjective perceptions of safety than by the level of information available.

This study contributes to the literature on consumer food waste behaviour by highlighting the limitations of models based exclusively on informational rationality. In contrast to traditional assumptions that increased information automatically leads to more efficient decisions, the study emphasizes the role of psychological mechanisms, particularly risk aversion, in explaining food waste behaviour. Accordingly, the

proposed model integrates three dimensions: cognitive (FLL and CB), psychological (RA), and technological (SP), which interact in explaining food waste behaviour, thereby offering methodological originality. From a practical perspective, the study examines consumers' willingness to cooperate with producers within a circular economy framework, where food labels should become a tool of sustainability. Effective strategies should address risk perception through intuitive visual communication, educational messages, and interactive technologies, while standardising food date indicators would enhance economic efficiency and reduce food waste.

Our research presents certain methodological limitations, due to the exploratory nature of the model, the use of a convenience sample, and its limited explanatory power, which restrict the generalisability of the findings and the formulation of strong causal inferences. Therefore, the results should be interpreted with caution, as they are specific to the analysed context. Future research based on more diverse and representative samples could strengthen the external validity and relevance of the model.

## Conclusions

Food labelling emerges as a strategic communication and persuasion instrument at the intersection of public policy, corporate strategy, and consumer experience, whose design, terminology, and structure function as nudging mechanisms that may contribute to reducing food waste by clarifying information on product shelf life. From an information economics perspective, the mere presence of food date labels is not sufficient to shape food waste behaviour, as the effectiveness of labelling depends on how consumers process and interpret quality-related information. In this context, producer responsibility extends beyond legal compliance, becoming an ethical and technological commitment aimed at developing intelligent labelling systems. Thus, label design reduces information asymmetry and functions as a quality signalling mechanism, facilitating the transition toward interactive and personalised digital labelling within the logic of the circular economy.

Our research provides an integrated overview of the effectiveness of labelling systems and their potential to influence food waste behaviour. The analysis confirms that premature food disposal decisions are not solely based on economic rationality but are also influenced by cognitive and emotional barriers and risk perception, which limits the rational evaluation of food date labels.

The study highlights the complex and multidimensional nature of consumption behaviour, in which psychological factors play at least as important a role as informational ones, underscoring the need to extend analytical models beyond strictly cognitive variables. Future research should incorporate additional determinants, such as social norms, consumption habits, and economic constraints, to enhance the explanatory power of the models. Furthermore, a deeper investigation of the mechanisms influencing food waste behaviour is required through experimental and longitudinal research designs aimed at testing causal relationships and the effectiveness of interventions. In this way, integrated strategies can be developed among producers, authorities, and consumers, oriented towards decision-making transparency and the reduction of food waste.

## Generative Artificial Intelligence (GenAI) usage statement:

ChatGPT (version 5.0) was responsibly used for language improvement. After this process, the authors reviewed and edited the content as needed and take full responsibility for the content of the present article.

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