

Improving the public's willingness to purchase near-expired food to reduce food waste: The case of milk products in China

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Abstract: The near-expired food (NEF) is a significant opportunity to reduce food waste, while consumers often associate NEF with safety issues, which results in a large amount of safe and healthy food being wasted globally. This research focuses on food date labelling (FDL) and explores how consumers' label cognition impacts their willingness to purchase NEF. Using a random sampling method online, we obtain 2 113 valid samples from China and conduct an information intervention 'quasi-natural experiment' to obtain participants' FDL cognition and willingness to purchase the near-expired milk (NEM) before and after the intervention and evaluate the impact of the intervention through the difference-in-differences model. The results show that consumers' initial purchase willingness for NEM is low, and their FDL cognition has a positive effect, especially in Eastern China and higher education consumers. Information intervention increases consumers' willingness to purchase NEM by changing their label cognition, and the intervention has a more pronounced impact among older, male, and higher education consumers. Considering the pressure on resources and the environment caused by food waste has become an impediment to sustainable development, the findings expand the application of the Knowledge, Attitude, and Practice (K-A-P) theory in the NEF field and clearly reveal the important role of eliminating consumer prejudice of FDL in reducing food waste to achieve the United Nations Sustainable Development Goal 12.3 'Halve food waste.'

Keywords: difference-in-differences; experimental economics; food date labelling; food industry; food waste

With the rapid development of the economy and urbanization, global food waste has been further aggravated (Thyberg and Tonjes 2016), and near-expired food (NEF) waste has become an important compo-

nent. According to the Food and Agriculture Organization of the United Nations (FAO), about one-third of the food (about 1.3 billion tons) is lost or wasted during production and consumption each year globally

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(Gustavsson et al. 2011), threatening global food security (Kuiper and Cui 2021). At the retail and consumer stages, a large amount of edible food is discarded (Melbye et al. 2017). About 28% of foods in Austria go unsold because they pass the best-before or use-by date (Lebersorger and Schneider 2014). In the United States, more than 90% of Americans throw away food prematurely because they regard date labels as food safety indicators (2012), which brings about 20% of food waste to the consumer stage (FDA 2019). At present, only a few developed economies have paid attention to this issue, and the current status of in transition economies is still unknown.

The consumption of suboptimal food is a vital opportunity to improve the utilization efficiency of resources and reduce food waste (Bai et al. 2022), especially the NEF (Zhang et al. 2023). NEF refers to food about to reach the restriction date on food packaging (still within the date). However, consumers are reluctant to purchase the NEF (Aschemann-Witzel et al. 2018). Although the NEF can reduce food enterprises' turnover and management costs and enable consumers to benefit from lower prices, 'Bad quality' is consumers' inherent impression of the NEF (Xu 2013). Nearing expiration date makes consumers feel that food safety will not be up to their expectations (Aschemann-Witzel et al. 2018), and existing research points out that 69% to 84% of consumers believe that the quality of perishable products decreases over time (Tsiros and Heilman 2005). In addition, price is an external cue, and product features (such as the expiration date approaching) are an internal cue, influencing consumers' willingness to purchase the NEF. Although reducing the price can increase the market attractiveness and is the most direct way to improve consumers' purchase willingness of NEF, they often infer the quality level

based on the price and reinforce the cognition of the declining quality (Aschemann-Witzel et al. 2017; Theotokis et al. 2012), while this price reduction may just aim to reduce pressure on the stock.

Food date labelling (FDL) is the criterion for defining the near-expired state, while the definition of NEF has yet to be unified globally. In China, NEF has yet to be unified nationwide, and only a few local governments have made preliminary regulations (see Table 1). FDL in China consists of manufacturing date and quality guaranteed duration, collectively referred to as 'quality guaranteed date label,' which is an indicator of food quality. NEF is the medium of FDL, and consumers' understanding of FDL mainly determines their willingness to consume NEF. However, evidence from advanced economies suggests that many consumers do not know the difference between the various expressions of FDL on the market (Milne 2012), and they often misunderstand FDL as an indicator of food safety (Newsome et al. 2014; Verghese et al. 2015), directly leading to the wrong cognition of the NEF and resulting a large amount of safe, healthy, and high-quality food being wasted (Hall-Phillips and Shah 2017). There is a severe information asymmetry in the market's understanding and use of FDL, and the FDL has an important role in reducing food waste (Kavanaugh and Quinlan 2020). Food manufacturers use FDL to indicate the quality and freshness of food products to consumers, while consumers mistakenly believe that FDL is intended to convey food safety information.

Based on such information asymmetry, it seems understandable that consumers resist NEF for food safety to avoid the risk of foodborne diseases. The theory of Knowledge, Attitude, and Practice (K-A-P) is mainly used to explain the effects of individual knowledge and original beliefs on changes of individual behaviours,

Table 1. The definition of NEF in China

No.	Duration of quality guaranteed	Criterion	Example
1	More than one year	45	cans, candy, cookies
2	More than six months but less than one year	20	instant noodles, aseptically packaged milk and juice
3	More than 90 days and less than six months	15	some vacuum-packed and refrigerated cooked food
4	More than 30 days and less than 90 days	10	some sterilised packaged meat and fresh eggs
5	More than 16 days and less than 30 days	5	yogurt, some dessert
6	Less than 15 days	1–4	unsterilised cooked food, boxed soy products

The criterion column means 'X days before the quality guaranteed date'

Source: According to the different quality guaranteed duration of different foods, the NEF is classified into six situations, which is the most widely recognised standards of 'The food date label critical' issued by the Beijing Bureau of Industry and Commerce

and is the theoretical basis for formulating behaviour intervention strategies (Pärna et al. 2005), which has been widely used in areas such as waste reduction (Liu et al. 2023) and adaptation to climate change (Cai et al. 2024). This theory divides individual behaviour transformation into three stages: acquiring knowledge of information, forming beliefs and changing behaviour. Specifically, 'Knowledge' refers to the acquisition and understanding of some common-sense knowledge, 'Attitude' refers to the correct consciousness and positive attitude toward something, and 'Practice' refers to the transformation of individual behaviour after the acquisition and understanding of knowledge and producing corresponding beliefs. Consumers will only change their existing consumption behaviour if they aware that it harms their health, and changing it can reduce the risk (Contento and Murphy 1990). Based on the above theoretical analysis, random intervention experiments in experimental economics can achieve the realization of a certain stimulus to consumers to achieve the change of their 'knowledge'. By informing the meaning of the FDL, we conduct the FDL information intervention on consumers to change their cognition of NEF food to complete the cognitive change process of the first stage ('knowledge'). After the information intervention, this stimulus gives consumers a new cognition and understanding of the FDL and NEF ('Attitude') and is expected to influence their subsequent food consumption decisions ('Practice'). A further explanation is when consumers realize that NEF will not pose food safety or health hazards, the corresponding willingness to consume NEF may increase.

Many studies have focused on the marketing methods of suboptimal food, mainly on the impact of price discounts on consumers' purchase willingness and the role of information intervention in improving consumers' perceived quality. On the one hand, merchants attract consumers' attention to different types of suboptimal food by setting price discounts to satisfy their utility at a lower price (Aschemann-Witzel et al. 2018). On the other hand, providing positive information about food while lowering prices can ensure consumers' perceived quality of suboptimal food and sell successfully. Aschemann-Witzel et al. (2019) use the cost-saving information label 'Lower price, save money' and the waste reduction label 'Do not waste food' to interfere with consumers' purchase willingness for suboptimal food and find that both intervention information improves the perceived quality and purchase willingness for suboptimal food. Giesen and Hooge (2019) use 'Accepting defective food: Joining the fight

against food waste' and 'It is an apple (carrot) in a special shape: Do not waste them' information interventions to change consumers' purchase willingness for foods with appearance defects, and they find that information works well. Although information intervention as an effective tool has been widely used in food waste mitigation, the existing information intervention is mainly descriptive language (European Commission 2018 United States Environmental Protection Agency 2019; FAO 2020) and indicates product attributes (Aschemann-Witzel et al. 2019; Giesen and Hooge 2019; Schneider and Ghosh 2020) to inform consumers to reduce food waste. However, there is a relative lack of statistical analysis on suboptimal food through non-price or non-declarative statement intervention methods. For NEF, the relationship between consumers' cognition of FDL and their willingness to consume NEF has not been empirically tested, and studies of informational interventions based on the meaning of FDL are rare. In particular, quasi-natural experiments that can simulate real consumption scenarios can be used to obtain more realistic data, while avoiding potential endogeneity problems. Notably, the existing studies are mostly from developed economies, and there is a lack of relevant studies from transition economies.

Our study aims to empirically test the relationship between consumers' cognition of FDL and their NEF purchase willingness, and then through conducting FDL information intervention to reduce their misunderstandings about FDL to explore the influence of information on their purchase willingness of NEF. Finally, we attempt to discern the heterogeneity among different groups and contribute new ideas to reduce food waste from transition economy.

MATERIAL AND METHODS

Sampling and data. Considering that consumers may be more sensitive to the safety of perishables, our research focuses on near-expired perishables, which is representative in the NEF research field. In this study, we take milk (perishable, dairy products), which has a large impact on the environment, a representative of perishable food purchased by consumers daily and also a common focus in food waste research (Blondin et al. 2017; Connors and Schuelke 2022), as our research object. We obtain the *per capita* milk consumption data from the last five years from the China Statistical Yearbook (The National Bureau of Statistics of China, 2016–2020) and selects six provincial capitals according to the rank

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of the *per capita* milk consumption, *per capita* gross domestic product (GDP), and regional distribution characteristics.

We conduct an online questionnaire survey from the professional and well-known Chinese online survey platform, 'Questionnaire Star' (<https://www.wjx.cn>, a platform similar to Synata) in China in 2023 with random sampling. The 'Questionnaire Star' has over 6.2 million registered users, including over three million active users, covering 31 provincial administrative divisions in China (excluding Hong Kong, Macao, and Taiwan). The survey company consistently provides qualified survey distribution and collection services through screening participants with an integrity score system (Lin and Guan 2021). The process is voluntary and participants can stop answering and exit anytime. Before the start of our survey, we make it clear to all participants that the questionnaire is entirely anonymous, the collected data will only be used for scientific research, and there is no right or wrong in all questions. Participants must be at least 18 years old, and each participant is allowed to submit only once. Since the sample groups of the 'Questionnaire star' have their unique corresponding codes, the number of answers for each participant is restricted strictly. Participants are randomly assigned to either the intervention group or the control group. When the number of questionnaires collected reaches the expected number, the questionnaire collection automatically stops.

To ensure the quality of the online questionnaire, we set up multiple attention test questions and repeated questions in different places of the questionnaire to verify the participants' seriousness in answering the questionnaire. In addition, we exclude samples with response times that are too long or too short to ensure the intervention's effectiveness. After validity screening, we obtain 2 209 survey data from six cities, and the samples are evenly distributed among regions. To avoid the influence caused by the consumers' dietary preferences, we delete the samples that do not consume milk and obtain 2 113 valid samples. The descriptive statistical characteristics of the samples are shown in Table 2, which details the general individual and family characteristics of our participants, and differences in place of residence. We also illustrate the variations of the core variables in the study here. Only 17.56% of Chinese consumers understand the meaning of the FDL correctly initially, collectively referred to as 'quality guaranteed date' in China, which means consumers' cognition of labels is generally low, and the information transmission function of FDL is seriously damaged. In addition,

compared to mean 4, consumers' initial purchase willingness for NEM is negative. However, after the information intervention, the corresponding values change.

Information intervention experimental design.

Before the information intervention experiment, we require the participants to identify whether the quality guaranteed date label is a quality or a safety indicator to obtain their initial label cognition, initial purchase willingness for the NEM, and the corresponding demographic characteristics. Then we conduct an information intervention on the meaning of the quality guaranteed date label for the intervention group, which displays the text '*Quality guaranteed date label – A quality indicator indicating optimal food taste and flavour, which will decline beyond this date but is edible*' (in Chinese). For the control group, the screen displays the following content: '*This page is intentionally left blank*' (in Chinese). Finally, we obtain their cognition of the quality guaranteed date label and their willingness to consume the NEM again to construct the panel data before and after the information intervention experiment to identify the effectiveness of the intervention. The whole process takes place on participants' phones or computer screens, and they cannot go back or revise any questions they answered.

Model setting. Firstly, we use ordinary least square (OLS) regression to explore the effects of the label cognition on consumers' purchase willingness of NEM, the specific formula in Equation (1):

$$Y_i = \beta_0 + \beta_1 X_i + \varepsilon_i \quad (1)$$

where: Y_i – the consumers' self-reported willingness (Likert seven-level scale, $Y = 1, 2, 3, \dots, 7$) to purchase NEM before receiving the information intervention; the index = 1, ... I – the participant; X_i – contains 0–1 variable of the label cognition that characterize whether the consumer answers the meaning of quality guaranteed date label correctly and a set of control variables in Table 2; ε_i – the constant term; β_1 – the regression coefficient of the variable.

Second, we use difference-in-differences (DID) regression to evaluate the net effect of the information intervention on consumers' willingness to purchase the NEM. Among the methods to evaluate the effect of policy implementation, the difference-in-differences model is the most prevalent and the oldest quasi-experimental research method widely used in recent years (Feng et al. 2021; Wang and Ge 2022), which can not only test the effectiveness of the policy or intervention,

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Table 2. Descriptive statistics

Control variables	Descriptions	Definitions	Mean	SD	Min.	Max.	Obs.
Age	the age of the participants	year	30.24	7.44	18	69	2 113
Gender	gender of participants	male = 1; female = 0	0.42	0.49	0	1	2 113
Education	education level of participants	bachelor degree or above = 1; below bachelor degree = 0	0.78	0.41	0	1	2 113
Risk attitude	risk attitude of participants	risk aversion = −1; risk neutral = 0; risk preference = 1	−0.45	0.85	−1	1	2 113
Health state	the health state of participants' family members	all healthy = 1; someone unhealthy = 0	0.76	0.43	0	1	2 113
Disposable income	<i>per capita</i> household disposable income	USD/month	640.22	505.61	46.89	2 816	2 113
Family size	the number of the participant's family members	people	2.97	1.33	1	8	2 113
Sample locations	Eastern region	Beijing city	—	—	—	—	365
		Guangzhou city	—	—	—	—	361
	Central region	Hefei city	—	—	—	—	350
		Changchun city	—	—	—	—	341
	Western region	Xining city	—	—	—	—	344
		Chengdu city	—	—	—	—	352
Urban area			95.60%				
Core variables	Descriptions	Definitions	Intervention group (<i>N</i> = 1 127)		Control group (<i>N</i> = 986)		
			mean	SD	mean	SD	
Before intervention							
Label cognition	whether the quality guaranteed date label is answered correctly	correct = 1; incorrect = 0	0.20	0.40		0.15	0.36
Purchase willingness	I will buy NEM	seven-Likert scale	3.95	1.71		3.44	1.72
After intervention							
Label cognition	whether the quality guaranteed date label is answered correctly	correct = 1; incorrect = 0	0.62	0.49		0.14	0.34
Purchase willingness	I will buy NEM	seven-Likert scale	4.10	1.62		3.39	1.63

Seven-Likert scale: Strongly disagree = 1, disagree = 2, somewhat disagree = 3, general = 4, somewhat agree = 5, agree = 6, strongly agree = 7; we divide six cities into three regions based on the regional division method of Li et al. (2020); SD – standard deviation; Obs. – number of observations; NEM – near-expired milk

Source: Authors' work

but also further identify the net effect of the impact. The basic idea of this method is to regard the implementation of a new policy or intervention as a 'natural experiment' or 'quasi-experiment' that is exogenous to the economic system (Chen and Wu 2015). On the one hand, the implementation of our information in-

tervention may make the participants' label cognition and purchase willingness different before and after the intervention. On the other hand, the above two indicators may differ between the intervention and control groups at the same time. The DID model regression estimation can effectively control the impact of other

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synchronous interventions and the prior difference between the intervention and control groups to identify the net effect of the intervention (Wang and Ge 2022). Therefore, our information intervention is a 'quasi-natural experiment,' and the intervention's impact can be evaluated using the DID method. See the following Equation (2) for model construction:

$$Y_{it} = \beta_0 + \beta_1 treat_i + \beta_2 post_t + \beta_3 treat_i \times post_t + \beta_4 X_{it} + \varepsilon_{it} \quad (2)$$

where: Y_{it} – the participant's willingness to consume NEM before and after the information intervention; the index $t = 0$ and 1 – a time series of data; $treat_i$ – a dummy variable representing the group effect of the intervention group, and this dummy variable is extracted from the survey; $post_t$ – a time dummy variable, which captures the time effect of the intervention period; $treat_i \times post_t$ – the real effect of the intervention group during the intervention period; X_{it} – participants' age, gender, education, risk attitude, *per capita* disposable income, family health status, and family size; β_3 – our key interest, coefficient which represents the net effect of the intervention.

RESULTS

The correlation between label cognition and NEM purchase willingness

OLS benchmark regression. Label cognition positively affects NEM's purchase willingness. We mainly focus on the impact of initial label cognition on consumers' initial willingness to purchase NEM, and the results of OLS benchmark regression are shown in the first column of Table 3. For one unit increase in label cognition, the corresponding NEM purchase willingness increases by 0.258, which confirms our concerns. The higher the label cognition, the more explicitly consumers know that the NEM is simply food that lasts in taste or flavour while still edible, bringing higher purchase willingness.

Although we mainly concern about label cognition, we still have some interesting findings regarding control variables. Among the control variables, the age of participants significantly negatively affects their willingness to purchase NEM, which means that young consumers may have a higher acceptance of NEM. The relationship between consumers' purchase willingness and *per capita* household disposable income is reversed, possibly related to wealthier consumers' higher demand for fresher foods (Neff et al. 2015).

Another possible reason is that NEM is often accompanied by sales discounts, which may be more attractive for consumers with lower disposable income to save on daily expenses and bring a higher willingness to purchase.

Robustness test. To ensure the robustness of the results, we test the robustness by changing dependent variables and expanding the sample. *i)* Changing dependent variable. We use the answer obtained by 'I will buy NEM to reduce food waste' as a substitute variable Y_2 for the dependent variable for further regression analysis, and the regression results are shown in the second column of Table 3. The effect of label cognition on NEM purchase willingness still passes the signifi-

Table 3. The regression result of the correlation between label cognition and NEM purchase willingness

Variables	(1) Y_1	(2) Y_2	(3) Y_1
Label cognition	0.258*** (0.097)	0.167* (0.096)	0.252*** (0.096)
Age	-0.021*** (0.006)	-0.011** (0.005)	-0.019*** (0.005)
Gender	-0.038 (0.077)	0.204*** (0.075)	-0.012 (0.075)
Education	0.111 (0.097)	0.007 (0.094)	0.064 (0.094)
Risk attitude	0.002 (0.044)	0.094** (0.043)	-0.016 (0.043)
Disposable income	-0.175*** (0.049)	-0.057 (0.047)	-0.172*** (0.048)
Family size	-0.054* (0.030)	0.006 (0.029)	-0.051* (0.029)
Health state	-0.433*** (0.089)	-0.246*** (0.087)	-0.420*** (0.088)
City controls	YES	YES	YES
Constant	6.099*** (0.353)	4.682*** (0.349)	5.987*** (0.348)
R-squared	0.037	0.016	0.033
Observations	2 113	2 113	2 209

*, **, *** $P < 0.1$, $P < 0.05$, and $P < 0.01$, respectively; robust *t*-statistics in parentheses; to avoid the influence of multicollinearity on the results, we conducted the test, and the result of mean VIF = 1.31 proves that there is no obvious multicollinearity in our model; disposable income is treated with logarithm (lnx) in regressions; Y – the participant's willingness to purchase NEM; NEM – near-expired milk

Source: Authors' work

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cance test, which verifies the robustness. *ii*) Expanding the sample. Since we pre-delete the samples that do not consume milk in the benchmark regression to exclude the influence of the food type we select and the dietary differences on the results, we expand to the whole sample 2 209 and conduct the robustness test again. The regression results in the third column of Table 3 verify the robustness again.

Heterogeneity analysis. Considering that there are already some specialised near-expired food stores in eastern China, we wonder if there are significant area differences in consumer cognition and their willingness to purchase. The results in the first three columns in Table 4 show that the correlation between label cognition and purchase willingness passes the significance test in the eastern area, which may be related to the fact that consumers in the east have more opportunities to get in touch with new things and relatively high purchase willingness for NEM. In addition, it is also

curious how the educational level of consumers affects this relationship. We compare the effect of this factor by grouping regressions for different educational levels (see columns 4 and 5 in Table 4 in detail), and the correlation between label cognition and purchase willingness passes the significance test at the higher education level.

The effect of information intervention

Descriptive analysis: Differences between before and after the information intervention. Since label cognition significantly impacts consumers' willingness to purchase NEM, we further demonstrate the effect of information on consumers' label cognition and their purchase willingness through random information intervention experiments. The results show that 61.67% of participants in the intervention group correctly answers the meaning of the quality guaranteed date label after information intervention (with an increase

Table 4. Heterogeneity analysis results (OLS model)

Variables	(1) Eastern China	(2) Central China	(3) Western China	(4) Lower education	(5) Higher education
Label cognition	0.355** (0.157)	0.129 (0.168)	0.265 (0.185)	0.196 (0.216)	0.276** (0.110)
Age	-0.022** (0.010)	-0.005 (0.009)	-0.032*** (0.009)	-0.017* (0.009)	-0.022*** (0.007)
Gender	0.085 (0.130)	-0.050 (0.131)	-0.161 (0.140)	-0.013 (0.175)	-0.043 (0.085)
Education	-0.075 (0.169)	0.248 (0.162)	0.178 (0.173)	–	–
Risk attitude	-0.142* (0.074)	0.018 (0.075)	0.118 (0.081)	0.156 (0.100)	-0.033 (0.049)
Disposable income	-0.153* (0.081)	-0.191** (0.088)	-0.166* (0.085)	-0.218** (0.111)	-0.162*** (0.055)
Family size	-0.026 (0.047)	-0.076 (0.054)	-0.057 (0.056)	-0.104* (0.061)	-0.040 (0.035)
Health state	-0.582*** (0.149)	-0.347** (0.158)	-0.329** (0.160)	-0.803*** (0.213)	-0.341*** (0.097)
City controls	–	–	–	YES	YES
Constant	5.862*** (0.547)	5.347*** (0.630)	5.922*** (0.573)	6.935*** (0.726)	5.981*** (0.418)
R-squared	0.046	0.019	0.049	0.075	0.030
Observations	726	691	696	466	1 647

*, **, *** $P < 0.1$, $P < 0.05$, and $P < 0.01$, respectively; robust t -statistics in parentheses; disposable income is treated with logarithm (lnx) in regressions; OLS – ordinary least square

Source: Authors' work

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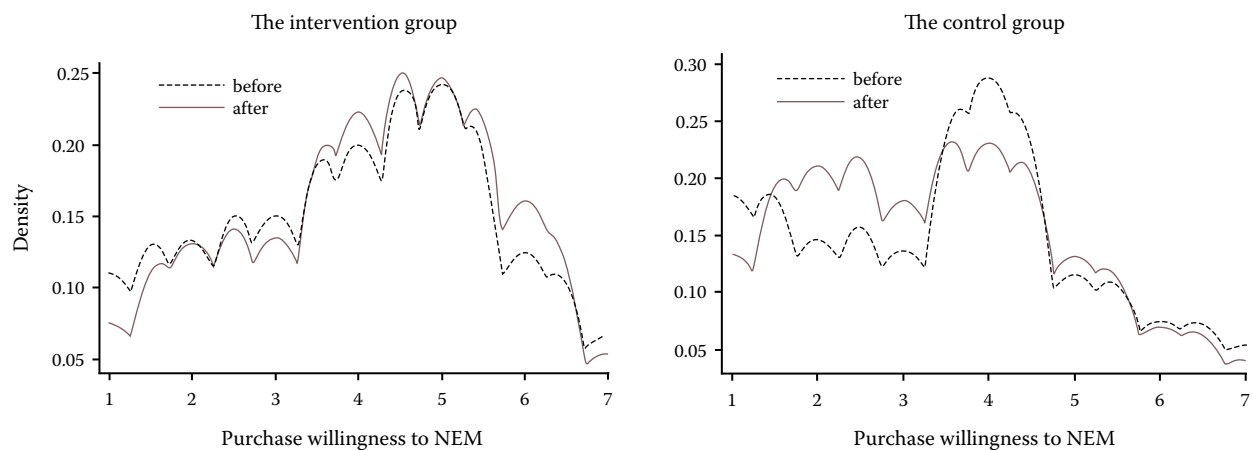


Figure 1. The kernel density graphs of participants' purchase willingness to NEM before and after the information intervention

NEM – near-expired milk

Source: Authors' work

of 42.15%), while the cognitive changes in the control group show a decrease, which means information intervention can effectively improve consumers' label cognition (Turvey et al. 2021).

However, it is not enough for us to explore changes in cognition, and we would like to know the further effects on purchase willingness. Further, we use the kernel density graphs to show the changes in participants'

NEM purchase willingness before and after information intervention in both the intervention and control groups (see Figure 1). Before the information intervention, 38.24% of participants in the intervention group has a negative attitude toward NEM. In contrast, after the intervention, the proportion drops to 33.27%, and the average willingness to purchase NEM increases from 3.95 to 4.10, while in the control group, this initial negative attitude is exacerbated.

The net effect of information intervention. Although we can see the changes in label cognition and NEM purchase willingness before and after the information intervention from descriptive statistics, we further use the econometric analysis DID model

Table 5. The net effect of the information intervention and robust regression results

Variables	(1)	(2)	(3)
	Y_1	PSM-DID	Y_2
DID	0.209** (0.102)	0.220* (0.121)	0.191* (0.103)
Constant	5.320*** (0.248)	5.368*** (0.283)	4.594*** (0.247)
Control variables	YES	YES	YES
Individual fixed effect	YES	YES	YES
Time fixed effect	YES	YES	YES
ATT	–	8.30	–
R-squared	0.062	0.062	0.031
Observations	4 226	3 378	4 226

*, **, *** $P < 0.1$, $P < 0.05$, and $P < 0.01$, respectively; robust t -statistics in parentheses; disposable income is treated with logarithm ($\ln x$) in regressions; Y – the participant's willingness to purchase NEM; NEM – near-expired milk; PSM – propensity score matching; DID – difference-in-differences; ATT – average treatment effect on the treated

Source: Authors' work

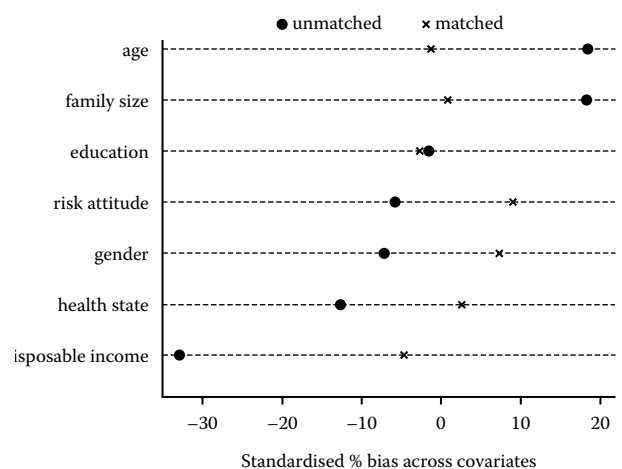


Figure 2. Variations in standardised bias

Source: Authors' work

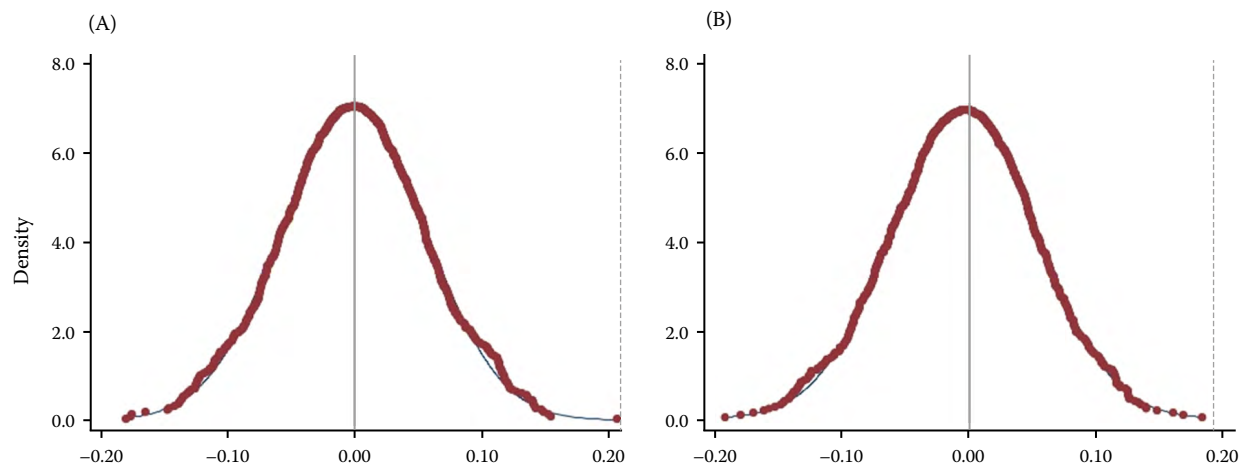


Figure 3. Density curve of simulated coefficients: (A) is for Y_1 ; (B) is for Y_2

Y – the participant's willingness to purchase NEM; NEM – near-expired milk

Source: Authors' work

to further obtain the net effect of information intervention between the intervention group and the control group, and the (1) column of Table 5 reports the estimated results. The results show that information intervention significantly affects participants' willingness to purchase NEM, and the net effect is 0.209, which means the intervention increases participants' purchase willingness by 0.209.

Robustness test. i) PSM-DID. Propensity score matching (PSM) is suitable method for reducing bias and controlling the effect of observable variables, thereby producing a quasi-random trial effect (Zhang et al. 2022). Combining PSM with DID to achieve

a quasi-random trial effect has been widely used in the impact assessments of policies (Fu et al. 2021; Deng et al. 2024). Therefore, although our study is a typical randomised trial, to avoid the influence of potential bias on the results in the actual operation, we use nearest-neighbor matching to match the sample for additional regressions.

The observable variables include the participant's age (age), gender (gender), education level (education), risk attitude (risk_attitude) and their families' *per capita* disposable income (disposable_income), the number of people (family_size), and the members' health state (health_state).

Table 6. Heterogeneity analysis results (DID model)

Variables	(1) Younger	(2) Older	(3) Female	(4) Male	(5) Lower education	(6) Higher education
DID	0.134 (0.142)	0.271* (0.146)	0.128 (0.133)	0.315** (0.159)	0.238 (0.224)	0.201* (0.114)
Constant	4.584*** (0.332)	4.751*** (0.393)	5.181*** (0.310)	5.492*** (0.412)	5.795*** (0.517)	5.314*** (0.293)
Control variables	YES	YES	YES	YES	YES	YES
Individual fixed effect	YES	YES	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES	YES	YES
R-squared	0.071	0.044	0.068	0.061	0.099	0.053
Observations	2 154	2 072	2 436	1 790	932	3 294

*, **, *** $P < 0.1$, $P < 0.05$, and $P < 0.01$, respectively; robust t -statistics in parentheses; disposable income is treated with logarithm (lnx) in regressions; DID – difference-in-differences

Source: Authors' work

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As shown in Figure 2, the bias of each variable is closer to zero, indicating that our match is effective and that we can conduct further tests for robustness (Deng et al. 2024). Based on the matched samples, we conduct a further regression, and the regression results are shown in the (2) column of Table 5. The coefficient estimate passes the significance test at the level of 10%, which is consistent with those of the benchmark DID regression and further indicates that the result is robust.

ii) Changing dependent variable. As with the changing dependent variable in the second column of Table 3, we make the same variable substitution here, and the regression results are shown in the (3) column of Table 5. The coefficient estimate passes the significance test, which verifies the robustness.

iii) Placebo test. We further conduct placebo tests to avoid the influence of possible interference of random factors and perform the random sampling 1 000 times. Figure 3 displays the kernel density distributions of the estimated coefficients for random samples, and both equations are concentrated on both sides of 0 and follow a normal distribution, indicating that random factors do not affect the purchase willingness of the NEM and further validating the robustness of the results (Deng et al. 2024).

Heterogeneity analysis. We then discuss the heterogeneity of the net effect of the intervention across different populations to refine our results further. First of all, age. We divide the sample by median age, and the results of grouping regression are shown in the (1–2) columns of Table 6. The net effect of information interventions on older people passes a significance test compared to younger people, which may be related to that older people pay more attention to such information about their health and food safety. In addition, males and the group with higher education have more significant improvement in the purchase willingness of NEM.

DISCUSSION

Before the intervention, the majority of consumers have negative attitudes toward NEM. Consumers' average initial purchase willingness is 3.99, below the neutral value of 4. Our finding is similar to that of the research conclusion of Aschemann-Witzel et al. (2015). Further, we verify the relationship between consumers' label cognition and willingness to purchase the NEM. We find that reducing consumers' misunderstanding of FDL is a crucial way to increase their willingness to purchase the NEM.

Although we only take NEM as the research object in this study, considering the prevalence of misunderstanding and milk is the representative of perishable food consumers are most concerned about, our research results may have universal practicability. In addition, considering consumers tend to combine food safety with perishables compared to non-perishables, our results may have better results in non-perishables, which is of great significance to the development of the near-expired food industry.

Our label information intervention significantly improves consumers' willingness to purchase NEM. Although this kind of effect has also been confirmed in previous studies by Aschemann-Witzel et al. (2019) and Giesen and Hooze (2019), our unique contribution is that while prior studies mainly focus on the effect of declarative encouragement words on the purchase willingness of NEM, we verify the effectiveness of information intervention with FDL meaning. This means that date label knowledge popularization can be used as an effective type of information intervention to help consumers understand the correct meaning of the FDL and realize the label is not a safety indicator but an indicator of food quality or flavour, and subsequently, further improve consumers' willingness to purchase NEM.

We need to clarify in particular that our study is not intended to lead consumers to purchase near-expired foods but aims to explore the impact of eliminating prejudice on consumer behaviours. Consumers should look at near-expired food rationally and scientifically and should not wear biased glasses, not only to reduce food waste but also to maximize the value of these edible foods.

Finally, we come up with some implications: First, considering the NEM is a crucial opportunity to reduce food waste, we need to pay more attention to the positive publicity of near-expired food to help consumers understand correctly, improve their purchase willingness, and reduce unnecessary food waste. Second, our study is the expansion and effective confirmation of K-A-P theory in the field of NEF research, which means that subsequent scholars can continue to apply this theory to further expand in this field. In addition, for policy makers, the validity of this theory provides theoretical support for adopting more effective information popularization. Considering there is an urgent need to remove consumers' misunderstanding of FDL, the most priority and effective way to reduce misunderstanding, increase the willingness of consuming NEF and reduce food waste is to carry out popular science

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to consumers in a similar way to information intervention to change their cognition of FDL and NEF. Only by changing consumers' cognition can they change their subsequent behavior. Third, when implementing information intervention, we need to carry out differentiated intervention measures for consumers in different regions and with different characteristics.

CONCLUSION

Our study explores the consumers' purchase willingness of NEM, empirically analyses its relationship with label cognition and the role of information intervention in improving consumers' purchase willingness of NEM, and finally discusses the heterogeneity. The research results provide the empirical basis and feasible methods for eliminating the public's misunderstanding of NEM, developing the NEF industry, and generating new ideas for reducing food waste worldwide.

Our research has the following four main conclusions. First, consumers' misunderstanding of FDL is a crucial reason for their generally low purchase willingness for NEM. Second, the relationship described above is more significant among participants in the eastern region and those with higher education. Third, information intervention effectively improves consumers' label cognition and enhances their purchase willingness for NEM. Fourth, information intervention has a more prominent effect on the older, male, and higher-education groups.

There are still several limitations. First, considering that the definition and management of NEF are not well regulated in most transitional economies, we weaken the accuracy of consumers' understanding of the definition of NEM. And the definition of NEM based on consumers' cognition has better reflected their consumption willingness for this kind of suboptimal food. Our research provides a forward-looking idea for developing NEF globally, and we believe that as the definition and regulation of NEF become more and more complete, the accuracy of the research can be further improved. Second, due to the constraints of the online survey, most of our research objects come from urban residents, and the proportion of rural residents is just 4.40%. However, due to the different living habits between rural and urban residents, their attitudes towards NEF may also be different. Therefore, it is a direction of effort to targeted research based on rural areas in the future. Third, due to the difficulty of data acquisition, our research focuses on consumers' willingness to purchase NEF rather than their actual

behaviours. Although purchase willingness is a favourable predictor of behaviour and can reflect consumers' expected purchase behaviour to a certain extent, we can obtain the specific purchasing behaviour through field investigation for further research.

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