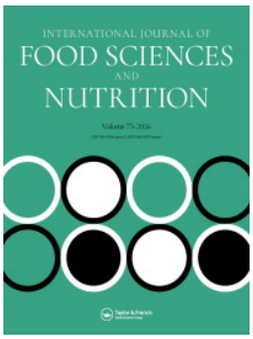

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RESEARCH ARTICLE

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Ultra-processed food consumption is not associated with household food waste in Italian adults: a cross-sectional study

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ABSTRACT

Ultra-processed foods (UPFs) are increasingly consumed worldwide, but their relationship with household food waste remains unclear. This cross-sectional study examined this association in 200 Italian adults using the NOVA Food Frequency Questionnaire and a 3-day weighted household food waste diary. UPFs accounted for 21.2% of total food consumption by weight, and 44.5% of participants reported food waste during the observation period. UPF intake did not differ according to food waste occurrence, and neither food waste prevalence nor quantity varied across UPF intake quartiles. Multivariable analyses showed no association between UPF consumption and either the odds of reporting food waste or the mean amount discarded among participants reporting waste. Higher household food expenditure was associated with higher odds of food waste, while older age and higher educational level were associated with greater waste quantities. Household food waste appears more strongly related to socio-demographic and household characteristics than to habitual UPF consumption.

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Ultra-processed foods; NOVA classification; household food waste; food sustainability; dietary patterns; Italy

Introduction

In recent decades, dietary patterns have undergone substantial changes, including a marked increase in the consumption of ultra-processed foods (UPFs) (Marino et al. 2021; Martini et al. 2021; Monteiro et al. 2025). According to the NOVA classification system, UPFs are industrial formulations made mostly or entirely from substances extracted from foods or derived from food constituents, often including additives designed to enhance flavour, texture, appearance, or shelf life (Monteiro et al. 2019). These products are often described as convenient, highly palatable, and ready-to-consume foods. Their widespread presence in contemporary diets reflects broader food system dynamics, including industrial food production, market structures, food availability, and changing lifestyles, rather than individual dietary choices alone (Baker et al. 2025). Evidence suggests associations with obesity, cardiometabolic diseases, mental health, and other adverse health outcomes, although the causal nature of these relationships and the broader interpretation of UPF consumption in relation to health remain actively debated (Lane et al. 2024; Visioli et al. 2025; Ludwig 2026).

Beyond their implications for human health, increasing attention has been paid to the broader environmental sustainability of dietary patterns. In this context, household food waste represents a key sustainability challenge (Teigiserova et al. 2020), raising the question of whether diets characterised by different levels of UPF consumption are also associated with different food waste behaviours. Across the food supply chain, households account for more than half of total food waste in Europe (EU 2026). A similar pattern has been

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reported in Italy, where household food waste accounts for 4.4% of the weight of food purchased (Aureli et al. 2021), while households contribute approximately 50% of national food waste (Waste Watcher 2024). Food waste generation at the household level is influenced by multiple factors, including socio-demographic characteristics, household composition, purchasing habits, meal planning, and food management practices (Yang et al. 2025; Etim et al. 2025). The characteristics of foods themselves may also influence their likelihood of being discarded. In this context, the relationship between UPF consumption and food waste is not straightforward. On the one hand, many UPFs have longer shelf lives and greater storage stability than fresh and perishable foods, which could reduce the likelihood of waste. On the other hand, dietary patterns characterised by greater reliance on convenience foods may be associated with food over-availability, less structured meal planning, and different household food management practices, potentially increasing the probability of discarding food (Kokthi and Guri 2025).

Despite growing interest in both UPFs and household food waste within sustainable food systems research, empirical evidence linking these domains remains limited. To our knowledge, only one previous study conducted in the United Kingdom has combined dietary assessment based on the NOVA classification with direct quantitative measurements of household food waste, reporting that most waste was attributable to unprocessed foods (Barker et al. 2023). Further evidence from different dietary, cultural, and household contexts is therefore needed. The present study aimed to investigate whether a higher habitual contribution of UPFs to the diet was associated with a different sustainability-related profile in Italian adults, with particular focus on measured household food waste. Specifically, we examined the association between UPF contribution and both the presence and quantity of household food waste, while also describing sustainability-related knowledge, attitudes, and behaviours.

Methods

Study design and participants

This cross-sectional observational study was conducted to investigate the association between UPF consumption and household food waste in a sample of Italian adults. Participants aged 18 years or older were recruited using a non-probability convenience sampling approach. Recruitment was carried out between November 2024 and March 2025 at the Department of Experimental and Clinical Medicine, University of Florence, Italy, through multiple channels, including university mailing lists, social media platforms, flyers, and personal contacts of researchers and university staff. Individuals interested in participating contacted the research team *via* email or through a dedicated online link and received detailed information about the study procedures and requirements. Following eligibility screening, participants who agreed to take part were provided with the study materials and instructions, either in person or *via* email, depending on their preference and location, and provided written informed consent. Once enrolled, participants were asked to complete a structured set of questionnaires and dietary records designed to collect information on socio-demographic characteristics, habitual dietary intake, attitudes towards food sustainability, and household food waste. Participants received standardised written instructions and examples of completed records to support accurate reporting. Additional assistance was provided *via* email or telephone when necessary. Participants were asked to complete all study components within a one-month timeframe. Overall, 243 individuals were approached, of whom 231 consented to participate. Among these, 200 completed all required study components and were included in the final analytical sample. The remaining 31 participants were excluded because they did not return the required materials within the study timeframe, despite reminder messages, or had incomplete data.

The study protocol was reviewed and approved by the Ethics Committee of the University of Florence (protocol number 0262840, approved on 25 October 2024). All participants provided written informed consent prior to participation. Data collection and processing were conducted in accordance with the principles of the Declaration of Helsinki and the European General Data Protection Regulation (EU 2016/679).

Assessment of socio-demographic, lifestyle, and sustainability-related attitudes

Participants completed a structured questionnaire designed to collect information on demographic and lifestyle characteristics. The questionnaire was self-administered and included both closed-ended and multiple-choice items. Variables collected included age, sex, educational level, occupational status, marital status, and number of household members. Information on dietary habits and household food management

was also assessed, including type of diet, weekly household food expenditure, and involvement in grocery shopping and meal preparation. Weekly household food expenditure was categorised as <50 €, 50–99 €, 100–150 €, or >150 €. For regression analyses, weekly household food expenditure was entered as an ordinal variable coded from 1 to 4 according to these categories, so the estimate represents a one-category increase. Body weight and height were self-reported and used to calculate body mass index (BMI), defined as weight in kilograms divided by height in metres squared (kg/m^2). Participants were categorised as having a BMI <25 kg/m^2 or ≥25 kg/m^2; the latter corresponds to overweight or obesity according to World Health Organization cut-offs (World Health Organization 2000).

Participants also completed a validated questionnaire assessing sustainability-related knowledge, attitudes, and behaviours (Aureli et al. 2022). The questionnaire includes 12 questions covering three thematic domains: (i) knowledge and awareness of food sustainability issues; (ii) perceptions regarding alternative protein sources; and (iii) eating behaviours related to sustainable food choices. The questionnaire assesses participants' understanding of the environmental impact of food production and consumption, their attitudes towards sustainable dietary practices, and their self-reported food-related behaviours. Response formats include Likert-scale items ranging from 1 to 10, dichotomous items (yes/no), and multiple-choice questions. As the questionnaire assesses distinct domains using items with different response formats and does not provide an overall score, results were analysed at the item level. For the 1–10 Likert-scale items, higher scores indicate stronger agreement with the statement as worded, whereas dichotomous and multiple-choice items were summarised as response percentages.

Assessment of UPF consumption

Habitual dietary intake was assessed using the NOVA Food Frequency Questionnaire (NFFQ), a validated dietary assessment tool specifically designed to estimate food consumption according to the NOVA classification system in adult populations (Dinu et al. 2021). The questionnaire includes food items grouped into nine main categories: fruits and nuts; vegetables and legumes; cereals and tubers; meat and fish; milk, dairy products, and eggs; oils and fats; sweets and sweeteners; beverages; and other foods. Participants were asked to report their usual frequency of consumption of each food item over the previous year. All foods included in the questionnaire had previously been categorised into the four NOVA groups according to the degree of industrial processing: minimally processed foods (MPF), processed culinary ingredients (PCI), processed foods (PF), and UPFs. For each participant, the contribution of each NOVA category to total food consumption was calculated. UPF consumption was expressed as the percentage contribution of UPFs to total dietary intake by weight. This approach was used because the NFFQ was validated to estimate UPF intake as a weight ratio rather than an energy ratio, allowing the inclusion of processed foods and beverages that provide little or no energy, such as artificially sweetened drinks.

Assessment of dietary intake and household food waste

All participants completed a 3-day (two weekdays and one weekend day) weighted dietary record. Dietary record data were entered into the Metadieta software application (Me.Te.Da., San Benedetto del Tronto, Italy) by trained personnel, carefully checked for errors, and used to estimate energy and nutrient intake, including carbohydrates, fat, protein, and dietary fibre. During the same observation period, participants also completed a 3-day household food waste diary, recording discarded edible foods and their weighted quantities. Food waste was defined as edible food intended for human consumption that was discarded, excluding non-edible fractions. Food waste outcomes were defined as: (i) the presence of any household food waste during the observation period (yes/no); (ii) the total quantity of household food waste over the three days, expressed in grams; and (iii) the quantity of food waste by food group, expressed as total grams over the three days. Descriptive analyses by food group were restricted to participants reporting any household food waste. For the Gamma regression analysis, the total three-day quantity was divided by three and expressed in g/day.

Statistical analysis

Given the exploratory nature of the study and the limited availability of previous evidence on the association between UPF consumption and quantitatively measured household food waste, no formal sample size calculation was performed. The final analytical sample of 200 participants was based on feasibility and participant availability, taking into account the

substantial commitment required to complete multiple dietary and household food waste records without financial compensation.

Data management and preliminary checks were performed using Microsoft Excel. Statistical analyses were conducted using IBM SPSS Statistics for Macintosh, version 30.0 (IBM Corp., Armonk, NY, USA). Missing data were handled using complete-case analysis, and no imputation was performed. Continuous variables were reported as means and standard deviations (SD) or as medians and interquartile ranges (IQR), as appropriate. Categorical variables were presented as counts and percentages. The distributions of UPF contribution to total food intake and household food waste were visually inspected before analysis. Given the large proportion of participants reporting no food waste and the right-skewed distribution of positive food waste values, household food waste was analysed both as a binary outcome and as a continuous outcome restricted to participants reporting any waste.

Mean UPF contribution was compared between the two groups using the Mann-Whitney U test. Participants were further categorised into quartiles according to the percentage contribution of UPFs to total food intake by weight. Quartile cut-offs were defined as follows: Q1, ≤16.8%; Q2, >16.8% to ≤20.6%; Q3, >20.6% to ≤25.5%; and Q4, >25.5%. Differences across quartiles were assessed using non-parametric statistical tests. Specifically, the Kruskal-Wallis test was used for continuous variables, while the chi-square test or Fisher's exact test, as appropriate, was used for categorical variables. The prevalence of household food waste and the quantity of food waste were also compared across quartiles of UPF contribution.

Crude and multivariable logistic regression models were used to evaluate the association between UPF consumption and the odds of reporting any household food waste during the 3-day observation period (binary outcome). UPF contribution was modelled as a continuous variable, and results were expressed per 10 percentage-point increase in UPF contribution. Estimates were reported as odds ratios (OR) with 95% confidence intervals (CI). The crude model included UPF contribution only. Among participants reporting at least one episode of household food waste, the association between UPF consumption and the quantity of food waste was analysed using generalised linear models with Gamma distribution and log link function, due to the right-skewed distribution of positive food waste values. Results were reported as ratios of mean food waste with 95% CI. Multivariable models were adjusted for age, sex, educational level, number of cohabitants, weekly household food expenditure, and total energy intake. These covariates were selected a priori as key socio-demographic, household-level, and dietary factors potentially associated with both UPF consumption and household food waste. Additional models further adjusted for BMI, involvement in grocery shopping, and involvement in meal preparation were conducted as sensitivity analyses. Statistical significance was defined as a two-sided p-value < 0.05.

Results

Characteristics of the study population

A total of 200 participants were included in the analysis. The main socio-demographic characteristics of the study population are reported in Table 1. The sample consisted predominantly of women (68%), with a mean age of 36.2 (SD 13.9) years. Overall, participants showed a relatively high educational level and were largely involved in household food management activities, with 74.5% habitually involved in meal preparation, and 72.5% habitually involved in grocery shopping. Dietary data indicated a pattern characterised by moderate energy intake and a macronutrient distribution broadly consistent with typical dietary patterns observed in adult Mediterranean populations. Indeed, protein, fat, and carbohydrate contributed 18.5% (SD 5.9), 34.9% (SD 7.2), and 47.1% (SD 6.9) of total energy intake, respectively.

Sustainability-related knowledge, attitudes, and behaviours

Selected item-level results from the sustainability questionnaire are shown in Figure 1, while the complete questionnaire results are reported in Figure S1. Overall, participants showed high awareness of food sustainability issues and high willingness to adopt selected sustainable dietary behaviours. The highest agreement scores were observed for willingness to reduce household food waste by implementing anti-waste strategies, with a mean score of 9.2 (SD 1.1), and willingness to buy mainly seasonal fruit and vegetables, with a mean score of 9.0 (SD 1.4). When asked what came to mind when thinking of a sustainable diet, the most frequently selected concepts were local supply chains (98%), low environmental impact (96%), high animal welfare standards (96%), healthy eating (93.5%), and minimally processed, traditional foods (91.5%). However, identifying a sustainable diet as minimally processed and traditional

Table 1. Characteristics of the study population.

Characteristic	
Sex	
Women	136 (68.0)
Men	64 (32.0)
Age, years	36.2 (13.9)
Body weight, kg	65.9 (11.8)
BMI, kg/m^2	23.2 (3.0)
BMI categories	
BMI <25 kg/m^2	135 (67.5)
BMI ≥25 kg/m^2	65 (32.5)
Education level	
High school or lower	86 (43.0)
University or postgraduate degree	114 (57.0)
Occupation	
Student	41 (20.5)
Employee	108 (54.0)
Self-employed	28 (14.0)
Homemaker/retired/unemployed	23 (11.5)
Marital status	
Single	101 (50.5)
Married/cohabiting	90 (45.0)
Other	9 (4.5)
Number of cohabitants	2 [1–3]
Type of diet	
Omnivorous	183 (91.5)
Other dietary patterns	17 (9.5)
Household food management	
Usually prepares meals	149 (74.5)
Usually grocery shops	145 (72.5)
Weekly food expenditure	
<50 €	47 (23.5)
50–99 €	95 (47.5)
100–150 €	47 (23.5)
>150 €	11 (5.5)
Daily energy intake and dietary composition	
Energy intake, kcal/day	1694 (409)
Protein, % energy	18.5 (5.9)
Fat, % energy	34.9 (7.2)
Carbohydrates, % energy	47.1 (6.9)
Dietary fibre, g/day	19.6 (7.2)
Saturated fatty acids, g/day	18.5 (6.6)

Data are presented as n (%), mean (SD), or median [Q1–Q3], as appropriate. Parentheses following continuous variables denote the SD, while square brackets denote the first and third quartiles.
BMI: body mass index; Q1: first quartile; Q3: third quartile.

was not associated with lower UPF consumption. Participants who selected this item had a mean UPF contribution of 21.1% (SD 6.4), compared with 22.2% (SD 6.8) among those who did not select it ($p = 0.579$). The main perceived barriers to eating more sustainably were cost, reported by 70%, unclear labelling (68%), and lack of time for shopping and cooking (56%).

UPF consumption in the study population

The distribution of dietary intake by weight according to the NOVA classification and the distribution of total UPF intake by weight across food groups are presented in Figure 2. MPFs accounted for the largest proportion of total intake by weight, with a mean contribution of 41.8% (SD 12.4), followed by PFs, 27.1% (SD 8.7), UPFs, 21.2% (SD 6.4), and PCI, 9.9% (SD 2.3). Across food groups, sweets and sweeteners, including biscuits, cakes, chocolate, confectionery, and sweet snacks, accounted for the largest share of total UPF intake by weight (24.0%), followed by cereals and tubers, including cereal-based UPFs such as bread alternatives, pizza, and focaccia (21.3%), and beverages, including sugar-sweetened beverages (15.7%).

Household food waste

During the three-day observation period, 44.5% of participants ($n = 89$) reported at least one episode of household food waste. Among participants reporting food waste, the mean total amount of discarded food was 211.7 g over three days (SD 179.3), corresponding to 70.6 g/day (SD 59.8). Household food waste quantities by food group among these 89 participants are reported in Table 2. The largest contributors to total household food waste were beverages, including soft drinks, energy drinks, wine and beer (17.4%), fruit and nuts (16.4%), cereals and tubers (15.3%), and vegetables and legumes (14.2%). Smaller contributions were observed for meat and fish (6.1%), and oils, fats and condiments (4.6%).

In descriptive analyses by food waste status, weekly household food expenditure differed between participants who reported food waste and those who did not ($p = 0.039$). In particular, the highest expenditure category (>150 €/week) was more frequent among participants reporting food waste than among those reporting no food waste (10.1% vs. 1.8%), suggesting that household purchasing volume or food availability may be relevant contextual factors in the occurrence of food waste.

Association between UPF consumption and household food waste

To evaluate whether UPF consumption differed between participants reporting food waste and those who did not, mean UPF contribution was compared between the two groups. The average contribution of UPFs to total dietary intake was 20.6% (SD 6.3) among participants who did not report food waste and 21.9% (SD 6.5) among those who reported at least one episode of waste, with no significant between-group difference ($p = 0.228$). Further analyses were conducted using quartiles of UPF contribution. Across quartiles, neither the prevalence of household food waste nor the quantity of food waste differed significantly ($p = 0.210$ and $p = 0.133$, respectively), with no evidence of a clear graded pattern.

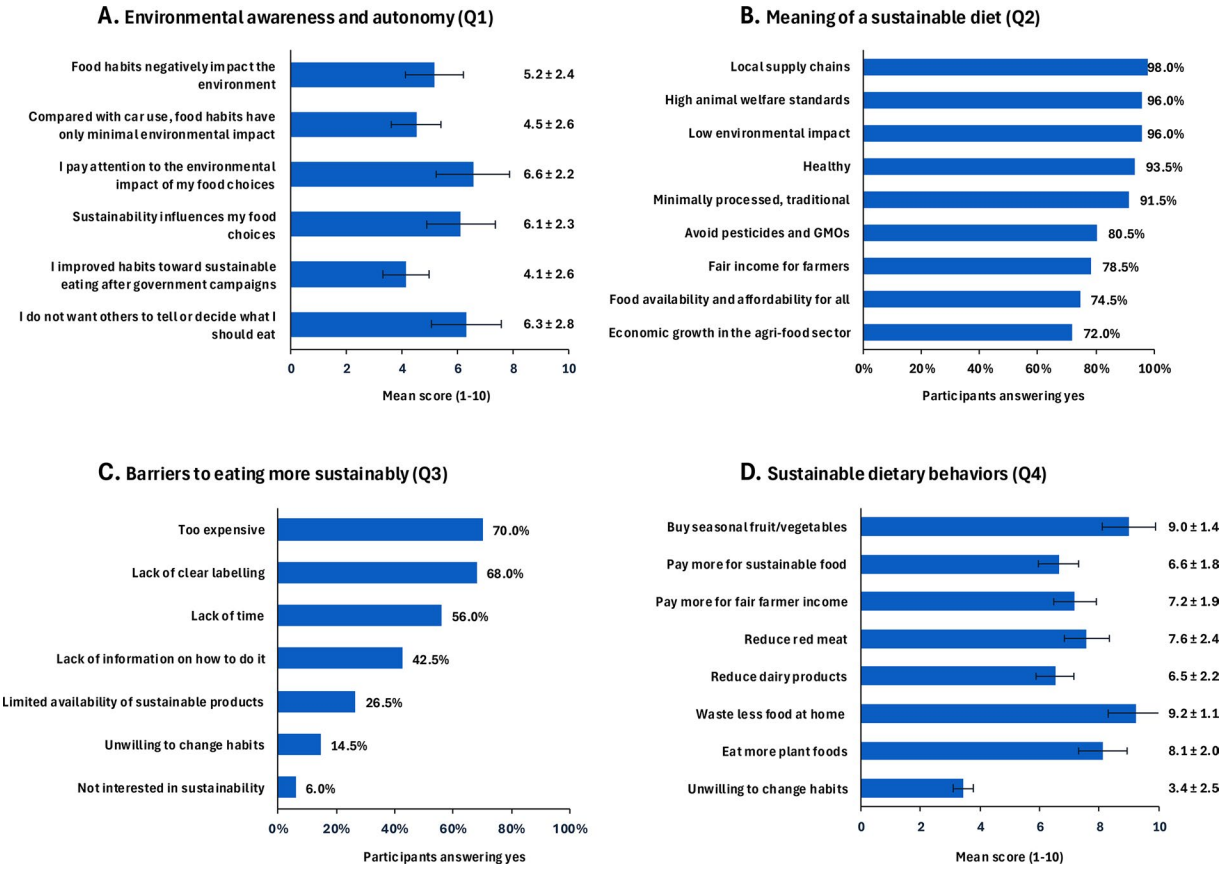

Figure 1. Selected results from the sustainability-related knowledge, attitudes, and behaviours questionnaire.
Likert-scale items are presented as mean ± SD on a 1–10 scale, where higher scores indicate stronger agreement with the statement as worded. All other values are percentages of participants answering yes.

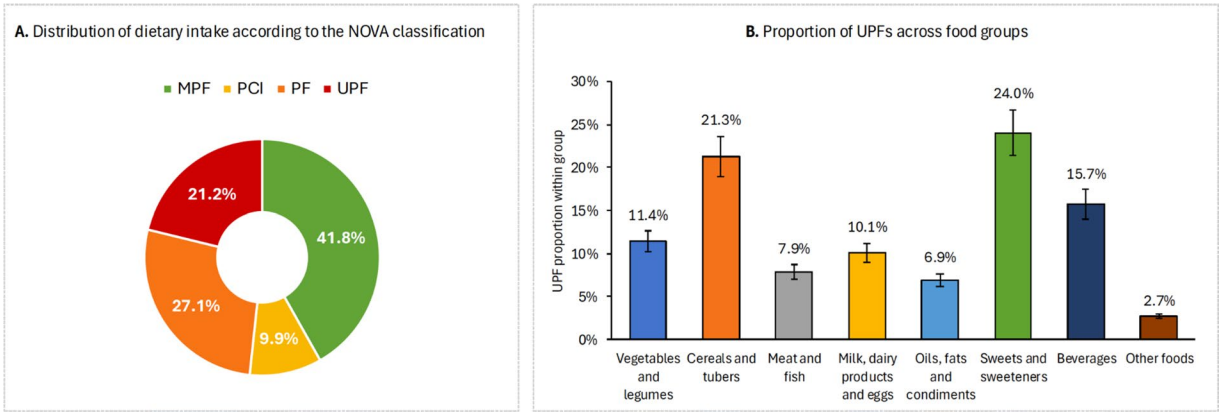

Figure 2. Distribution of dietary intake by weight according to the NOVA classification and distribution of total UPF intake by weight across food groups.
In the left panel, values represent each NOVA category's mean percentage contribution to total food intake by weight. In the right panel, values represent each food group's percentage share of total UPF intake by weight.

Multivariable analyses

Crude and multivariable logistic regression models were used to evaluate the association between UPF consumption and the odds of reporting any household food waste during the 3-day observation period (Table 3). In the crude model, a 10-percentage-point increase in the contribution of UPFs to total dietary intake was associated with 37% higher odds of reporting any household food waste (OR 1.37, 95% CI 0.88–2.12, $p = 0.165$), although the association was

Table 2. Mean household food waste by food group among participants reporting any food waste during the 3-day observation period ($n = 89$).

Food group	Mean (SD), g	Min – max range, g
Fruit and nuts	34.8 (72.6)	0–370
Vegetables and legumes	30.0 (64.1)	0–410
Cereals and tubers	32.4 (58.8)	0–250
Meat and fish	12.9 (25.9)	0–100
Milk, dairy products and eggs	21.0 (39.2)	0–150
Oils, fats and condiments	9.7 (19.6)	0–90
Sweets and sweeteners	26.9 (52.5)	0–210
Beverages	36.9 (67.5)	0–310
Other foods	7.2 (18.5)	0–90

Data are presented as mean (SD) and minimum–maximum. All quantities are total grams over the 3-day observation period.

Table 3. Association between UPF consumption and the odds of reporting any household food waste (crude and multivariable logistic regression).

Predictor	OR	95% CI	p-value
Crude model			
UPF contribution, per 10 percentage-point increase	1.37	0.88–2.12	0.165
Adjusted model			
UPF contribution, per 10 percentage-point increase	1.38	0.87–2.17	0.170
Age, per 10-year increase	1.08	0.87–1.33	0.502
Sex, male vs female	0.76	0.39–1.46	0.405
University degree or higher vs lower education	0.66	0.35–1.24	0.200
Number of cohabitants	0.91	0.68–1.23	0.550
Weekly household food expenditure, per category increase	1.77	1.13–2.76	0.013
Total energy intake, per 100 kcal/day	0.97	0.90–1.04	0.374

Outcome: any household food waste during the 3-day observation period (yes vs no).
The crude model included UPF contribution only. The adjusted model included age, sex, educational level, number of cohabitants, weekly household food expenditure, and total energy intake.
OR: odds ratio; CI: confidence interval; UPF: ultra-processed food.

not statistically significant. The estimate was virtually unchanged after adjustment for age, sex, educational level, number of cohabitants, weekly household food expenditure, and total energy intake (OR 1.38, 95% CI 0.87–2.17, $p = 0.170$). Among the covariates, each one-category increase in weekly household food expenditure was associated with 77% higher odds of reporting food waste

Among participants reporting food waste, the generalised linear model assessed the mean daily quantity of food waste (Table 4). A 10-percentage-point increase in UPF contribution corresponded to a 10% higher mean quantity, although this estimate was not statistically significant (ratio of means 1.10, 95% CI 0.85–1.43, $p = 0.459$). Older age and higher educational level were positively associated with the outcome.

Table 4. Association between UPF consumption and the mean daily quantity of household food waste among participants reporting at least one episode of food waste during the 3-day observation period (adjusted generalised linear model).

Predictor	Ratio of means	95% CI	p-value
UPF contribution, per 10 percentage-point increase	1.10	0.85–1.43	0.459
Age, per 10-year increase	1.22	1.08–1.37	<0.001
Sex, male vs female	1.28	0.88–1.85	0.198
University degree or higher vs lower education	1.60	1.12–2.29	0.010
Number of cohabitants	1.13	0.94–1.37	0.187
Weekly household food expenditure, per category increase	0.82	0.62–1.07	0.140
Total energy intake, per 100 kcal/day	1.01	0.96–1.05	0.822

Outcome: mean daily quantity of food waste, calculated as total food waste recorded over the 3-day observation period divided by three (g/day).
The model was adjusted for age, sex, educational level, number of cohabitants, weekly household food expenditure, and total energy intake.
CI: confidence interval; UPF: ultra-processed food.

Each 10-year increase in age was associated with a 22% higher mean quantity of food waste (ratio of means 1.22, 95% CI 1.08–1.37, $p < 0.001$), while participants with a university degree or higher reported a 60% higher mean quantity of food waste than those without a university degree (ratio of means 1.60, 95% CI 1.12–2.29, $p = 0.010$). Sensitivity analyses using an extended adjustment model, additionally including BMI, involvement in meal preparation, and involvement in grocery shopping, yielded materially unchanged results.

Discussion

In this cross-sectional study of Italian adults, we investigated whether the habitual contribution of UPFs to dietary intake was associated with household food waste, using an integrated assessment that combined a validated NOVA-based food frequency questionnaire with a 3-day weighted household food waste diary. The main finding was that UPF contribution was not significantly associated with either the odds of reporting any household food waste during the 3-day observation period or the mean amount of food waste among participants who discarded food. This result was consistent across descriptive comparisons, quartile-based analyses, and multivariable models adjusted for socio-demographic, household-level, and dietary factors, suggesting that the degree of food processing, when considered as the habitual dietary contribution of UPFs, is not clearly associated with household food waste in this sample.

The mean contribution of UPFs to total food intake by weight in the present sample was 21.2%. Although estimates cannot be compared directly across studies, as UPF intake is commonly expressed as a percentage of total energy intake, this finding appears broadly consistent with previous evidence suggesting that UPF consumption in Italy tends to be lower than that observed in several Northern European countries and in the United States (Martini et al. 2021; Monteiro et al. 2025; Ruggiero et al. 2025). This pattern may partly reflect the residual persistence of Mediterranean dietary habits characterised by a relatively high contribution of MPFs and home-prepared meals, although Italy and other Mediterranean countries are progressively shifting towards more Westernised dietary patterns, including greater consumption of UPFs (Dinu et al. 2022; Watanabe et al. 2024; Iacoponi et al. 2025; Praticò 2026).

Consistent with global estimates on household food waste (Scalvedi and Rossi 2021; Moonsamy et al. 2024; United Nations Environment Programme 2024), the foods discarded in our sample were mainly beverages, fruit and nuts, cereals and tubers, and vegetables and legumes, whereas meat and fish and oils, fats and condiments contributed smaller proportions. These categories include foods whose discard is commonly related to perishability, preparation practices, portion size, incomplete consumption, or difficulties in managing foods after purchase (Schanes et al. 2018). In the only previous study combining the NOVA classification with direct household food waste assessment, Barker et al. similarly reported that most household food waste in a UK sample was attributable to unprocessed foods (Barker et al. 2023), suggesting that the processing profile of the habitual diet is not necessarily aligned with the waste potential of foods discarded at home. This interpretation is consistent with behavioural studies suggesting that household food waste is mainly influenced by routine practices around shopping, storage, cooking, portioning, and leftover use (Hebrok and Boks 2017; Boulet et al. 2021; Tonini et al. 2023; Nucci et al. 2025; Natali et al. 2026), rather than by the overall dietary contribution of UPFs.

The sustainability-related knowledge, attitudes, and behaviours questionnaire adds an important interpretative dimension. Previous Italian studies using the same questionnaire showed that greater knowledge was associated with more favourable attitudes towards food sustainability and that reducing household food waste was among the behaviours participants were most willing to adopt, while practical barriers remained common even among sustainability-aware consumers (Gianfredi et al. 2024; Aureli et al. 2025). Although participants in the present study reported high awareness of food sustainability issues and strong willingness to adopt selected sustainable dietary behaviours, including reducing household food waste, almost half of them discarded edible food during the three-day observation period. This discrepancy suggests that motivation and knowledge alone may be insufficient when not accompanied by routines and practical conditions that make waste prevention easier to implement. This is consistent with the wider evidence on the attitude-behaviour gap in food sustainability, showing that intentions and environmental concern often have limited predictive value unless supported by resources, habits, and perceived behavioural control (Stancu et al. 2016; Le Borgne et al. 2021; Etim et al. 2025; Martin-Rios et al. 2025; Bourke et al. 2026). It also aligns with intervention-oriented reviews showing that food waste reduction requires not only motivation, but also practical strategies that facilitate waste-preventing behaviours in everyday life (Reynolds et al. 2019; van Geffen et al. 2020; Ananda et al. 2022; Liechti et al. 2024).

A further notable finding is that participants frequently associated sustainable diets with minimally processed or traditional foods. However, identifying a sustainable diet in these terms was not associated with lower UPF consumption. This suggests that sustainability-related knowledge may capture normative beliefs about what a sustainable diet should look like, without necessarily translating into the practical conditions that shape food choices. One possible explanation is the persisting uncertainty among the general population about what UPFs are and how they can be identified in everyday diets (Essman et al. 2026; Machado et al. 2026; McCausland et al. 2026). At the same time, this result is consistent with evidence showing that sustainable food choices are often constrained by time, price, convenience, availability, and habits, even among individuals with positive attitudes and environmental concern (Stancu et al. 2016; Le Borgne et al. 2021). UPFs may respond to several of these constraints because they are generally easy to purchase, store, prepare, and consume. Consistently, in a large sample of Italian women from the Moli-sani Study, more frequent home cooking was associated with greater consumption of unprocessed or MPF and lower UPF intake, but not with greater adherence to the Mediterranean diet, suggesting that cooking practices, food processing, and overall diet quality represent related but distinct dimensions (Di Costanzo et al. 2025). In line with this interpretation, cost,

unclear labelling, and lack of time for shopping and cooking were the most frequently reported obstacles to eating more sustainably in our sample.

Finally, the multivariable findings further indicate that household context is especially relevant. Indeed, weekly household food expenditure was positively associated with higher odds of reporting any food waste during the 3-day observation period, which may reflect greater food availability within the household, larger purchasing volumes, or a greater likelihood of buying perishable foods. Among participants who reported any food waste, older age and higher educational level were associated with greater quantities of discarded food. These findings differ from some previous reports, including Yang et al. who observed different socio-demographic patterns of household food waste (Yang et al. 2025). However, the literature as a whole show that socio-demographic predictors of food waste are often inconsistent across populations (Schanes et al. 2018; Grasso et al. 2019; Boulet et al. 2021; Tonini et al. 2023; Nguyen et al. 2025). Higher education may coexist with greater sustainability awareness, but also with higher purchasing power, busier routines, or greater consumption of fresh foods.

These findings have implications for sustainable nutrition research and public health messaging. More broadly, sustainable diets encompass multiple nutritional, environmental, cultural, and behavioural dimensions. The Mediterranean diet has been proposed as a culturally grounded model for translating planetary health principles into practice, while substantial heterogeneity in the construction of EAT-Lancet-derived indices illustrates that sustainable dietary adherence is not yet operationalised consistently across studies (Angelino et al. 2026; Aureli et al. 2026). Against this background, UPF reduction and household food waste reduction should not be treated as interchangeable targets, even though both fall under the broad umbrella of sustainable diets. Reducing UPF consumption remains relevant for diet quality and health-related concerns, while reducing household food waste requires attention to the management of foods after purchase. This distinction matters because promoting fresh and MPFs without also supporting households in managing perishability may fail to reduce domestic waste, and could even increase waste if purchasing, storage, portioning, and leftover practices are not addressed. Strategies to reduce household food waste should therefore include practical components such as meal planning, appropriate purchasing, food storage, portion management, use of leftovers, and interpretation of date labels (Reynolds et al. 2019; van Geffen et al. 2020; Liechti et al. 2024). The relevance of waste prevention also extends to food security and food-system resilience; a survey of Greek adults found that food waste, high food prices, and economic instability were widely perceived as threats to food security (Deligiannidou et al. 2025).

The results of this study should be interpreted in light of some limitations. First, the cross-sectional design does not allow causal relationships to be established between UPF consumption and household food waste. Second, convenience recruitment may have introduced selection bias because participants who were readily accessible and willing to complete the demanding study protocol may differ systematically from the broader Italian adult population in health, dietary, or sustainability-related characteristics. The sample also included a high proportion of women and participants with a relatively high educational level. Consequently, it should not be considered representative of the Italian adult population, and the generalisability of the findings is limited. Third, although the weighted food waste diary provides a more direct assessment than retrospective self-report questionnaires, the three-day recording period may not capture longer-term variability in household waste, including seasonal variation, irregular shopping cycles, or occasional waste episodes. A further limitation is the temporal mismatch between the exposure and outcome assessments. UPF contribution was estimated from habitual intake over the previous year, whereas household food waste was recorded over three days. Therefore, the exposure reflects usual dietary patterns, while the outcome may capture short-term household circumstances, shopping cycles, or isolated waste events. This mismatch may have attenuated associations. Nevertheless, this study also presents several strengths. To our knowledge, it is the first study conducted in an Italian adult sample within a Mediterranean context to examine habitual UPF contribution in relation to quantitatively measured household food waste. The use of a validated NOVA-based food frequency questionnaire allowed UPF contribution to habitual intake to be estimated using an instrument developed for the Italian context. In addition, the integration of dietary, household waste, and sustainability-related attitude data allowed the relationship between consumption patterns, waste behaviour, and sustainability perceptions to be examined in a more comprehensive way.

In conclusion, this study found no significant association between the habitual dietary contribution of UPFs and household food waste in a sample of Italian adults. Household food waste appeared to be more closely related to food expenditure, socio-demographic

characteristics, and the types of foods discarded than to UPF contribution itself. These findings suggest that food processing level and household food waste represent distinct dimensions of sustainable nutrition. Future studies should examine these dimensions over longer observation periods and in more diverse populations, while incorporating detailed measures of shopping, storage, meal planning, portion management, and leftover use. Such evidence would help clarify how dietary quality, food processing, and household practices interact in shaping the sustainability of everyday diets.

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Author contributions

CRediT: **Sofia Lotti**: Data curation, Formal analysis, Investigation, Software, Visualization, Writing – original draft; **Daniela Martini**: Conceptualization, Investigation, Methodology, Supervision, Writing – review & editing; **Donato Angelino**: Investigation, Methodology, Supervision, Writing – review & editing; **Ruben Fernandez-Rodriguez**: Methodology, Supervision, Writing – review & editing; **Barbara Colombini**: Investigation, Project administration, Resources, Supervision, Writing – review & editing; **Monica Dinu**: Conceptualization, Data curation, Funding acquisition, Investigation, Project administration, Supervision, Writing – original draft, Writing – review & editing.

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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