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The impact of environmental and health messaging, pulse prevalence, and filtering tools on pulse-based food choice and nutrient profiles: a randomized online experiment

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Introduction: Pulses deliver beneficial nutrient profiles together with low environmental impacts, yet pulse consumption in the US is below recommendations.
Methods: The aim of this study was to examine the impact of three interventions on pulse choices in a complex product environment: (1) the percentage of pulse products, (2) health/environment messaging, and (3) a pulse filter. We conducted a pre-registered experiment on participants' food choices in an online retail-style setting with a representative sample of over 6,400 US adults. The choice environment featured six food categories containing 50 products each. The intervention arms examined: (1) the proportion of pulse foods in the choice environment (10% vs. 20%), enhancing awareness of the benefits of pulses at the point of decision (health and/or environmental messaging), and reducing search costs for pulse products in complex retail environments via a pulse filter. We analyzed the data by calculating the proportion of pulse products chosen in each condition and by performing logistic regression on the choice of pulse products. Independent variables were the experiment conditions and food product categories, with covariates that adjusted for demographics and knowledge, beliefs, and consideration of health and environmental priorities.
Results: Results showed that messaging alone and increasing the prevalence of pulse products had modest but significant impacts [range of adjusted odds ratios (95% confidence intervals): 1.35 (1.00, 1.83) to 2.91 (2.26, 3.75)]. Providing a pulse filtering option markedly increased pulse product choices [9.13 (7.07, 11.80) to 20.48 (15.98, 26.24)].
Discussion: Combining messaging with filtering resulted in larger relative increases in pulse choices, suggesting that decreasing product search and identification costs may be an important component of interventions. We found that promoting the choice of pulse foods, which provides important nutritional and environmental benefits, can improve the nutrient content of foods selected.

KEYWORDS

food choice, search costs, nutrition, sustainability, filtering, messaging, pulses, plant-based foods

1 Introduction

The production of different types of food has varying impacts on the environment (Nijdam et al., 2012), which has important implications for contributions and adaptation to climate change (Campbell et al., 2017). While livestock production emits high levels of greenhouse gases (GHGs)—generating approximately 15% of anthropogenic GHGs (Gerber et al., 2013)—the production of pulses, which is an alternative to livestock-based foods as a plant-based protein source, contributes significantly less (Nijdam et al., 2012; Oliveira et al., 2019). A study estimating the reduction in GHGs when pulses were substituted for beef in people's diets found that this change alone would have achieved 50–75% of the US's then-current target reduction of GHGs (Harwatt et al., 2017). Pulses may also present a more acceptable substitute to animal-source proteins than other alternatives. An article on alternative proteins found that consumers preferred plant-based proteins—such as those found in pulses—to other alternative proteins, such as insects and lab-grown meat (Onwezen et al., 2021).

At the same time, human dietary choices have been increasingly linked to negative health impacts (Popkin et al., 2006). Low diet quality contributes to high rates of overweight and obesity (Hales et al., 2018; Hall and Guo, 2017), which, through related non-communicable diseases, is a leading cause of death in the US (Murphy et al., 2021). High intake of ultra-processed, calorie-dense foods leads to weight gain (Hall et al., 2019), which is linked to increased risk of type-2 diabetes, cancer, and heart disease (Preston et al., 2018). In contrast, higher intake of pulse foods has been linked to greater nutrient density and increases in diet quality (Mitchell et al., 2021).

Pulses are more environmentally sustainable (Nijdam et al., 2012), healthier (Foster-Powell et al., 2002; Mitchell et al., 2009), and more affordable than many other protein foods (Drewnowski and Conrad, 2024). These traits are important to many consumers (Akaichi et al., 2017; Cox et al., 2012; Glanz et al., 1998), although individuals may place different values on taste, health, sustainability, and affordability (Robinson et al., 2022). Despite offering numerous and diverse benefits, consumption of pulses in the US is significantly below recommended levels (Guenther et al., 2006; Perera et al., 2020).

Barriers to pulse consumption may include a host of factors, including lack of awareness of the benefits that pulses offer and perceived negative impacts, such as digestive issues (Henn et al., 2022; Winham et al., 2019, 2016), difficulty in identifying pulses in crowded retail environments (Melendrez-Ruiz et al., 2021), or lack of knowledge of what pulses are (Winham et al., 2020). Differences in awareness of pulses may mean that consumers are unfamiliar with the diversity of pulse types and the effects of consuming different pulses. For instance, beans are familiar to most Americans, while lentils and chickpeas may be less well known (Rehm et al., 2023; Sanjeevi and Monsivais, 2024; Winham et al., 2020). Further, research shows that a widely held barrier to consumption—that pulse foods lead to intestinal gas and bloating (Palmer et al., 2018; Winham et al., 2019)—is less likely to result from the consumption of lentils, chickpeas, and peas, potentially due to differences in alpha-galactosides in the raffinose family (Veenstra et al., 2010).

Additionally, consumers that are interested in environmentally responsible food choices have little information on which to rely during food choice. Robust literature has examined the impact of eco-labeling on consumer choice (Edenbrandt et al., 2025; Katare and Zhao, 2024; Muller et al., 2019; Rondoni and Grasso, 2021; Taufique et al., 2022; Vanclay et al., 2011); however, real-world implementation of these labels is limited in many countries. In the US, for instance, only the organic label is widely used in the marketplace (Big Room Inc., 2025). Further, it is believed to be unlikely that regulations will be enacted any time soon that mandate the use of eco-labels (Cole, 2025).

Efforts to identify ways to motivate changes in consumer behavior to improve human health and the sustainability of food production systems have engendered a significant body of literature (Cadario and Chandon, 2020; White et al., 2019). However, much of this research uses simple choice sets featuring two to four items at a time rather than the dozens to hundreds of products per category in many food retailers, which likely leads participants to pay more attention to products and information than they would in complex environments (Meißner et al., 2020). In fact, mobile eye-tracking studies documenting shoppers' attention to food and label information in real-world supermarkets found that only a small fraction of products and information are considered (Machín et al., 2023, 2020). Indeed, a study examining gaze behavior in a virtual reality supermarket found that pulses did not systematically capture attention (Melendrez-Ruiz et al., 2021). A frequent finding in studies on the impact of nutrition information is that many consumers report not observing product information, and only a small fraction of those who do notice it report using it (Cantor et al., 2015). The impacts of labeling interventions estimated from simple experimental studies are significantly larger than when implemented in real-world supermarkets (Dubois et al., 2021).

Most studies in complex retail or online environments examine interventions focused on labeling or product positioning (Katare and Zhao, 2024). However, there is a small, but growing, body of literature suggesting that reminder messages are effective at promoting healthy choices in crowded product environments (Arslain et al., 2020; Gustafson et al., 2018). These reminder messages are meant to activate consumers' innate goals and direct attention to accomplishing target outcomes. Reminders about health appear to refocus attention to health attributes (van Koningsbruggen et al., 2011), even among sample of participants not actively trying to change eating patterns (Hare et al., 2011), and can lead to increased frequency of healthy behaviors, such as physical activity (Calzolari and Nardotto, 2017; Habla and Muller, 2021). While subtle messages may go unnoticed (Papies et al., 2014), resulting in small impacts on choices (Panzone et al., 2021), reminders are stronger statements directing attention to the target outcome.

Stimulus-rich environments, such as retail markets with myriad unique products, may distract from other long-term goals of consumers, such as making environmentally friendly choices. Unless individuals actively consider the health and environmental impacts of choices or have established healthy consumption patterns (Gustafson, 2022; Tuyizere and Gustafson, 2023), consideration of health or environmental attributes may be forgotten or overlooked while shopping in the supermarket. While research shows that priming consideration of sustainability increases the likelihood that consumers will choose more environmentally friendly products (Thøgersen and Alfinito, 2020; Torma et al., 2018), most of this research has not been conducted in complex choice settings, which are more cognitively demanding to navigate and reduce the number of attributes that consumers consider when making choices (Meißner et al., 2020). Indeed, primes implemented in complex environments frequently have modest impacts on choices (Panzone et al., 2021; Papies et al., 2014).

The advent of online shopping has led to new areas of research examining changes in the choice environment. There are multiple novel interventions enabled by the technological interface used in online shopping. For instance, studies on the use of subsets or filters that permit shoppers to shape the choice environment according to their preferences have found that these tools can significantly increase the choice of foods with beneficial nutrient and/or environmental characteristics (Gustafson et al., 2025, 2024). Research on filters in visually crowded environments find less use of these tools, which, upon follow-up discussion with research participants, was due to the tools going unnoticed (Godden et al., 2025). A stronger intervention signal involves exposing consumers directly to products with key attributes of interest. A study that involved interventions examining (in part) forced versus voluntary commitments to a low-carbon product set found that both reduced emissions embodied in the products (Panzone et al., 2023). Recent research on personalizing food suggestions based on individual health priorities found that exposing participants to a priority-responsive subset of all available products (with the option to view all available products instead) significantly increased the choice of healthy products and improved the nutrient profile of chosen products relative to an optional personalized product set condition (Gustafson et al., 2025). Although exposing participants to the personalized product set intervention condition was the most effective, participants in that condition reported lower levels of product satisfaction with their product choices. This finding suggests that there may be trade-offs between efficacy, intervention forcefulness, and satisfaction with choices resulting from intervention conditions.

In this research, we conduct an experiment on the choice of pulse products, which were defined as foods with pulses among the first three ingredients. Since pulses have beneficial human health and environmental profiles (Drewnowski and Conrad, 2024; Oliveira et al., 2019), promoting the choice of pulse products presents an opportunity to improve human nutrition and decrease environmental impacts of food production. In the absence of eco-labeling, consumers attempting to make climate friendly choices will have to rely on other attributes, such as general information or beliefs about product types. The use of pulses as a source of protein and other important nutrients is an effective way to promote human and environmental health (Oliveira et al., 2019). Thus, strategies that promote consumption of pulse foods present an opportunity to decrease the impacts of food production on the environment while also combatting the health crises caused by poor diet.

We developed an intervention to target three drivers of pulse choice in a complex choice environment, featuring six food product categories with 50 unique products per category. The interventions we studied were (1) varying the prevalence of pulse products in the market (10% vs. 20% pulse products), which reflects growth trends in the global market for pulse products (Choudhury, 2025); (2) increasing awareness or attention to nutritional and/or environmental benefits of pulse products during the choice process (no message, nutrition only, environment only, nutrition and environment messaging); and (3) choice environment interventions addressing the (implicit) search costs associated with identifying pulse products (pulse products intermixed with other products vs. the option to filter out non-pulse products). We examined the impact of these interventions on the choice of pulses and the content of nutrients of public health concern in the foods chosen by participants in the choice task. While there are groups attempting to provide access to environmental impact information for food products—see, e.g., (CarbonCloud, 2025)—the available data do not cover many of the products used in this experiment, so our analysis was limited to nutritional outcomes. We additionally examined outcomes capturing beliefs and subject knowledge about pulse food relationships to health and environment outcomes, active consideration of health and environmental impacts during choice, and satisfaction with product choices to corroborate impacts of the interventions on different elements of behavior.

2 Experimental methods

We pre-registered the research design and analysis plan with the Open Science Framework (OSF)[1] for an experiment and survey implemented in Qualtrics, which is a widely used survey platform (Qualtrics, 2015). The survey is provided in full in the supplementary materials and is also available as a component of the OSF pre-registration. The research protocol was approved by the Institutional Review Board at the authors' institution (protocol #20221122409EX). The research was performed in accordance with guidelines for research with human subjects, including the Declaration of Helsinki. All participants were adult (≥19 years of age) residents of the United States (US) and provided informed consent prior to the research.

Participants were recruited from Dynata's consumer panels.[2] The researchers worked with Dynata to recruit a sample of participants representative of key demographic characteristics in the US, using US Census-based demographic quotas. The quotas set sample characteristics for sex, age, income, and education. We used the software program G*Power to calculate sample size (Faul et al., 2009). The aim was to be able to detect a small effect size (0.2) with 0.95 power at 0.05 alpha error probability. The targeted sample size was complete responses from 6,000 participants. We collected usable responses from 6,401 participants.

2.1 Product selection

The research design incorporated complexity into the choice environment by featuring six food categories that contained pulse foods among 50 unique food items per category. We identified pulse food product categories and products using the USDA-ARS FoodData Central Branded Foods Database (United States Department of Agriculture Agricultural Research Service, 2022).

To select the products to be included from the product database, we developed scripts in the R programming language that identified pulse foods within six food categories: Frozen Dinners and Entrees;

1 https://osf.io/uvec7
2 https://www.dynata.com/

Pantry Staples; Soups; Snacks; Sauces, Spreads, Dips and Condiments; and Frozen Patties and Burgers. A food was defined as a pulse product if a pulse was one of the first three ingredients in the food. Pulse products represented between 1.4 and 7.8% of products within each category, with a weighted average of 4.1% (Supplementary Table S1).

Although the product database identified thousands of products per food category, we included 50 products per category due to constraints on programming resources. Because maintaining the average prevalence of pulse products (4.1%) in the database would result in only two pulse products per category (out of 50 total products), we decided to increase the prevalence of pulse products in the experiment for a baseline condition to 10% (five out of 50). We randomly selected pulse and non-pulse foods from the database to populate each food category and retrieved nutrition information from the database. Next, we recorded each product's product image and retail price from the websites of national retailers. If information or a product image was unavailable for a product, we substituted the next randomly selected item meeting the necessary criteria (e.g., replacing a pulse snack item that had missing information with another pulse snack item, or a non-pulse soup with another non-pulse soup). We used FDA guidance to adjust nutrient values to a normalized serving size for that product category (Center for Food Safety and Applied Nutrition, 2018). The specific process for normalizing serving sizes is presented in Supplementary Table S2.

To provide data on differences in health attributes for pulse and non-pulse food products, we calculated the nutritional information for each product category for pulse and other foods. These variables include calories as well as nutrients listed as nutrients of public health concern due to overconsumption or underconsumption (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2020). Nutrients of public health concern include saturated fat, sodium, and added sugar as overconsumed nutrients, and dietary fiber, iron, potassium, and calcium as underconsumed nutrients. The nutrient contents of pulse and non-pulse foods showed significant differences for many nutrients (Table 1). Pulse foods featured significantly lower amounts of the overconsumed nutrients of public health concern: saturated fats, sodium, and added sugars. At the same time, the pulse foods had significantly higher amounts of underconsumed nutrients of public health concern (dietary fiber, potassium, and iron) than non-pulse foods. While not reported in Table 1, the survey of market prices of food products included in the study revealed a significant difference in prices of pulse and non-pulse products at the retailers we examined: while pulse foods averaged \$4.64 per product, the average price of non-pulse foods was \$5.21 (p-value = 0.03).

2.2 Consumer choice task

After agreeing to participate in the research, participants read a set of research instructions. Key details in the instructions included informing participants that they would be making one selection from each of six product categories that contained 50 products in each category. However, they could also indicate that they would not purchase any of the listed products if they did not identify a product they would want to purchase at the listed price. Further, while the choices in the research were hypothetical, we included a widely used tool to decrease the impact of the hypothetical nature of decisions on choices, which is known as a cheap talk script (Penn and Hu, 2018). A cheap talk script instructs participants to think of the choices as real—that they would be spending real money and taking the selected product home with them—and to consider the tradeoffs they would encounter from spending money on those items instead of other expenditures they face.

In the food product choice task, participants viewed the following information: an image of the product drawn from the manufacturer or a retail website, the product name, information from the Nutritional Facts Panel (calories, saturated fat, sodium, dietary fiber, added sugar, potassium, iron, and calcium), and the price of the product, which was collected from a national retailer's website. The nutrition information represents nutrients of public health concern identified in the *Dietary Guidelines for Americans, 2020–2025* due to over-consumption (saturated fat, added sugar, sodium) or under-consumption (dietary fiber, calcium, iron, potassium) (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2020). Food products were displayed in a randomized order for each participant, except the option allowing a participant to indicate that they would not purchase any of the available products was always located at the end of the list. After making choices in the six categories, participants completed a short survey with demographic questions and perceptions and knowledge of pulses.

2.3 Intervention conditions

Participants made food choices in an experiment with three arms designed to investigate influences on the food choice process. Each participant was randomized to one condition. The first arm was the percentage of pulse products in the food category and featured two levels: 10% of products were pulse products (i.e., 5 out of 50 products per food category) or 20% of products were pulse products (10 out of 50 products per category). The second arm investigated decreasing the costs associated with searching for and/or identifying pulse products, with two levels. In the first, pulse products were intermixed with

TABLE 1 Nutrient content per serving of pulse and non-pulse food products randomly selected for inclusion in the food product environment.

Mean	Energy (kcal)	Saturated Fat (g)	Sodium (mg)	Added Sugar (g)	Fiber (g)	Potassium (mg)	Iron (mg)	Calcium (mg)
Pulse	173.5	1.1	380.6	0.4	4.7	204.1	3.1	46.7
Non-pulse	193.3	3.3	469.9	1.3	1.7	108.5	1.5	43.3
T-test p-val.	0.21	0.00	0.03	0.00	0.00	0.00	0.03	0.63

330 total products randomly selected from USDA-ARS FoodData Central Branded Foods Database. Two-sided t-tests conducted on 60 pulse food products and 270 non-pulse food products. Product serving sizes were normalized within product categories.

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non-pulse products. In the second, pulse products were still intermixed with non-pulse products, but participants could also apply a filter to view only pulse products. The third arm was a messaging arm featuring four levels: (1) a control (no-message) condition; (2) a nutrition messaging condition; (3) an environmental messaging condition; and (4) a nutrition and environmental messaging condition (Supplementary Table S3). Together, the three arms yielded 16 distinction experiment conditions. Table 2 presents the 16 conditions resulting from the combination of intervention arms, along with the number of participants per condition.

2.4 Data and analysis

We cleaned and analyzed data using R Studio, version 2024.12.1 (2025) (Allaire, 2012). We examined the distribution of demographic variables among study participants in comparison with US census data using Fisher's Exact Tests. We also checked the representation of demographic variables among experiment conditions to check for evidence of successful randomization to condition.

The primary outcome in the analysis of the experiment was whether the food product chosen by a participant was a pulse product in each of the six food categories: Pantry Staples; Frozen Dinners and Entrees; Soups; Snacks; Sauces, Spreads, Dips, and Condiments; and Frozen Patties and Burgers. The dependent variable took the value of one if the product selected in a category was a pulse product; it took a value of zero if the product was not a pulse product or if the participant indicated that they would not purchase any of the available products. The data were structured as a panel dataset (one row for each food category), so that there were six rows per participant in the dataset. As an initial evaluation of the impact of experiment conditions on choices, we report the average percentage of pulse products chosen in each condition. To evaluate the robustness of these results to the inclusion of other explanatory variables, we conduct a logistic regression analysis with robust standard errors clustered by individual respondent. Independent variables in the analysis included the experiment conditions (reported relative to the omitted 10% condition, which had no filtering and no messaging), and food product categories (reported relative to the omitted Frozen Dinners and Entrees category). We estimated three additional regressions that added (1) variables capturing subjective knowledge, beliefs, and active consideration of health and environmental attributes, (2) demographic variables, and (3) knowledge, belief, consideration, and demographic variables to the analysis to account for the influence of these variables on choices. We report the estimates for the experiment conditions and product category variables in the body of the manuscript. Full results are presented in Supplementary material. We additionally report regressions of nutritional variables on experiment conditions, product category, and demographic characteristics in Supplementary material.

TABLE 2 Experiment conditions.

Condition name	Pulse %	Pulse filtering	Messaging	*N*
1. Ten	10%	No	None	428
2. Ten Filter	10%	Yes	None	406
3. Twenty	20%	No	None	403
4. Twenty Filter	20%	Yes	None	408
5. Ten Health	10%	No	Health	396
6. Ten Filter Health	10%	Yes	Health	382
7. Twenty Health	20%	No	Health	404
8. Twenty Filter Health	20%	Yes	Health	411
9. Ten Env.	10%	No	Environment	395
10. Ten Filter Env.	10%	Yes	Environment	384
11. Twenty Env.	20%	No	Environment	394
12. Twenty Filter Env.	20%	Yes	Environment	389
13. Ten Health & Env.	10%	No	Health & Environment	404
14. Ten Filter Health & Env.	10%	Yes	Health & Environment	397
15. Twenty Health & Env.	20%	No	Health & Environment	408
16. Twenty Filter Health & Env.	20%	Yes	Health & Environment	392

Secondary analyses examined the impact of the intervention conditions on participants' satisfaction with the choices they made (ordered logistic regression), beliefs about and subjective knowledge of the health and environmental impacts of pulses (ordered logistic regression), and active consideration of the health and environmental implications of food alternatives (logistic regression). For the analysis of data, the conditions were assigned numeric codes to blind the researcher to the condition. We presented adjusted odds ratios (adjusted proportional odds ratios for ordered logistic regressions) and 95% confidence intervals for all independent variables. Statistical significance was defined as p-values < 0.05.

Our analysis revealed surprisingly large impacts estimated for the pulse filter conditions. Therefore, we conducted an exploratory analysis that was not part of our original pre-analysis plan to understand the large impacts on pulse choice for the pulse filter conditions. We examined the use of the pulse filter in the conditions that contained only the pulse filter (i.e., no messaging) to examine relationships between participant characteristics and use of the pulse filter in the absence of messages directing participants' attention to pulse foods. We report differences in the use of the pulse filter by reported frequency of consumption of pulse foods in the text.

3 Results

Table 3 reports the summary statistics of the demographic characteristics for the full sample and compares it to estimates of the distribution of demographic characteristics in the US population (US Census Bureau, 2023). As Table 3 shows, the sample matches the US Census demographic characteristics closely. There were no significant differences between the sample and US Census data (p-values from the Fisher's Exact Tests are reported in the table). Fisher's Exact Tests also revealed no statistically significant differences in the distribution of any of the demographic variables across intervention conditions (Supplementary Table S4).

TABLE 3 Demographic characteristics of the full sample.

Category	Full sample	US census	Fisher's exact test p-value
Female (%)	51.1	50.4	0.875
Age (%)			0.585
19–24	19.6	10.4	
25–34	20.2	17.6	
35–44	18.8	17.2	
45–54	20.1	15.8	
55–64	14.8	16.4	
≥65	16.6	22.5	
Education (%)			0.901
Less than high school	6.2	10.4	
High School/GED	28.2	26.1	
Associate's degree	10.8	8.8	
Some College	16.4	19.1	
Bachelor's degree	23.8	21.6	
Graduate/Professional degree	14.2	14.0	
Prefer not to answer	0.5	NA	
Income (%)			0.823
0–25 K	20.9	16.0	
25–50 K	23.7	18.0	
50–75 K	18.0	16.2	
75–100 K	12.1	12.8	
100–150 K	12.9	16.9	
>150 K	11.0	20.2	
Prefer not to respond	1.3	NA	
Race/Ethnicity			0.539
White	68.7	62.4	
Hispanic/Latino	10.4	16.4	
Black/African American	18.6	12.4	
Native American/Alaska Native	2.5	2.2	
Asian	4.4	6.2	
Native Hawaiian/Pacific Islander	0.3	0.4	

Data from survey and the US Census American Community Survey Demographic and Housing Estimates (US Census Bureau, 2023). Survey N = 6,400.

3.1 Experiment on choice of pulse foods

Next, we examine the choice of pulse foods in the experiment. Figure 1 displays the proportion of pulse products chosen in each condition. A chi-square test of the distribution of pulse product choices across conditions found significant differences ($p < 0.001$). The condition with a low prevalence of pulse products (Ten Percent), no pulse filtering option, and no messaging is the most representative of current market conditions. In this condition, 4.4% of products selected were pulse products. In the Twenty Percent condition, the percentage of pulse products selected nearly doubled—to 8.4%. A chi-squared test found significant differences among conditions (test statistic = 2030.2, p-value < 0.001).

Messaging conditions (without filtering) yielded small increases in the choice of pulse products. The choice of pulse products in the environmental messaging conditions were 5.9% in the Ten Percent condition and 9.3% in the Twenty Percent condition. With exposure to health messaging, 6.9 and 11.8% of products were pulse in the Ten Percent and Twenty Percent conditions, respectively. In the combined environment and health messaging condition, pulse choices were 6.1 and 9.5% in the Ten Percent and Twenty Percent conditions.

The addition of a pulse filtering option, however, markedly increased the selection of pulse products. In the Ten Percent filter condition, the percentage of pulse products was 29.5% (compared to 4.4% in the Ten Percent condition). In the Twenty Percent filter condition, 33.2% of products selected were pulse products.

In the conditions that combined filtering with messaging, pulse product choices increased further. In the Ten Percent Filter Environment condition, 37.1% of products were pulses, while in the Twenty Percent Filter Environment condition, the value was 48.0%.

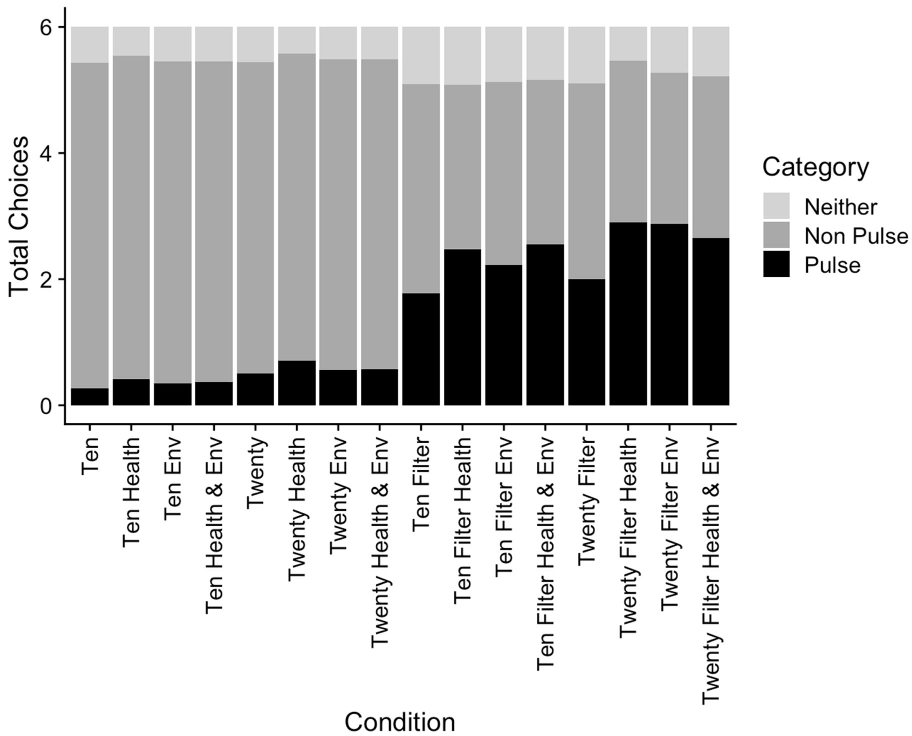

FIGURE 1
Number of pulse foods, non-pulse foods, and "none of these" choices in each condition across six food categories. For condition names, Ten and Twenty refer to the percentage of pulse products in the product set; conditions that contain health and/or environment presented messages to participants about pulse benefits in those areas; Filter conditions gave participants the ability to use a filter to see pulse products.

With health messaging and filtering, pulse product choices were 41.1 and 48.3% in the Ten Percent and Twenty Percent conditions. In the environment and health with filtering condition, pulse products represented 42.4 and 44.3% of choices.

Messaging increased pulse food choice compared to no messaging, but the effect size was much larger when the pulse-filtering option was included than when it was absent. For instance, with filtering, pulse product choices in environmental messaging conditions were 7.6 percentage points higher in the Ten Percent pulse-product condition and 14.7 percentage points higher in the Twenty Percent pulse-product condition (compared to a 1.5 percentage point increase and 1.0 percentage point increase in the comparable no-filter scenario). In health messaging conditions, pulse product choices were 11.6 percentage points higher in the Ten Percent condition and 15.1 percentage points higher in the Twenty Percent condition than in the comparable no-message filter conditions. Finally, the environment and health messages yielded increases of 12.9 percentage points (Ten Percent), and 11.0 percentage points (Twenty Percent) relative to the filter conditions without messaging.

Estimates of the impact of the experiment conditions (Table 4) corroborate the proportion of pulse-foods selected in each category (Figure 1). In general, increasing the percentage of pulse products in the choice sets increases the odds that participants choose a pulse product. Exposing participants to messages about the environmental, health, or environmental and health benefits of pulses results in modest increases in the selection of pulse products. However, introducing the ability to filter to pulse products dramatically increased the likelihood that participants chose pulse foods. Importantly, neither the addition of beliefs, subjective knowledge, and related variables, nor demographic control variables, meaningfully affected the estimated effect of the experiment conditions (full results including estimates of the control variables are presented in Supplementary Table S5).

The regression results show that there were differences in willingness to choose pulse foods across food categories. Specifically, participants were significantly less likely to choose pulse foods in the Frozen Patties and Burgers and the Snacks categories. There are additionally significant differences in the likelihood of selecting pulse foods among demographic characteristics and other control variables. The two oldest age categories (55–64 and ≥65) were significantly less likely to select pulse foods than the reference 19–24 years of age category. Participants with higher levels of household income were significantly more likely to choose pulse foods than individuals in the lowest income category (<$25,000 of household income). Higher levels of education were also associated with an increased likelihood of selecting pulse foods. Individuals with some college, associate's degrees, bachelor's degrees, or graduate/professional degrees were more likely to choose pulse foods than individuals with a high school education or less. Individuals who actively considered the impact of foods faced on health or environmental outcomes during food choice were significantly more likely to choose pulse foods. Individuals with higher levels of subjective knowledge of health and environmental impacts of pulses were also significantly more likely to choose pulse foods.

The intervention conditions also improved the nutritional characteristics of the foods selected (Table 5). While the impact of

TABLE 4 Logistic regression of the impact of experiment condition, product category, as well as attitudinal and demographic controls on choice of pulse products with individual-clustered standard errors.

Condition name	I aOR (95% CI)	II aOR (95% CI)	III aOR (95% CI)	IV aOR (95% CI)
Intercept	0.05 (0.04, 0.06)	0.02 (0.01, 0.03)	0.04 (0.03, 0.06)	0.02 (0.01, 0.03)
Twenty	2.00 (1.53, 2.62)	2.16 (1.65, 2.83)	1.99 (1.52, 2.60)	2.15 (1.64, 2.81)
Ten Environment	1.35 (1.00, 1.83)	1.30 (0.96, 1.76)	1.31 (0.97, 1.77)	1.25 (0.92, 1.69)
Twenty Environment	2.23 (1.71, 2.91)	2.27 (1.74, 2.98)	2.15 (1.65, 2.81)	2.20 (1.67, 2.88)
Ten Health	1.62 (1.22, 2.16)	1.59 (1.20, 2.11)	1.53 (1.15, 2.04)	1.52 (1.15, 2.03)
Twenty Health	2.91 (2.26, 3.75)	2.74 (2.13, 3.54)	2.77 (2.15, 3.57)	2.62 (2.03, 3.39)
Ten Health & Environment	1.41 (1.05, 1.91)	1.36 (1.01, 1.84)	1.37 (1.02, 1.85)	1.34 (0.99, 1.80)
Twenty Health & Environment	2.28 (1.74, 2.97)	2.13 (1.63, 2.78)	2.22 (1.70, 2.89)	2.07 (1.58, 2.70)
Ten Filter	9.13 (7.07, 11.80)	9.55 (7.34, 12.44)	8.80 (6.83, 11.33)	9.27 (7.13, 12.04)
Twenty Filter	10.87 (8.58, 13.95)	11.38 (8.84, 14.65)	10.79 (8.42, 13.83)	11.27 (8.75, 14.52)
Ten Filter Environment	12.87 (9.93, 16.66)	13.06 (10.06, 16.94)	13.13 (10.16, 16.96)	13.13 (10.13, 17.03)
Twenty Filter Environment	20.19 (15.70, 25.97)	20.46 (15.84, 26.43)	20.69 (16.10, 26.59)	20.82 (16.10, 26.91)
Ten Filter Health	15.28 (11.86, 19.68)	15.74 (12.17, 20.35)	15.71 (12.22, 20.20)	15.96 (12.37, 20.59)
Twenty Filter Health	20.48 (15.98, 26.24)	20.69 (16.09, 26.60)	20.94 (16.36, 26.80)	21.07 (16.39, 27.08)
Ten Filter Health & Environment	16.12 (12.52, 20.76)	16.16 (12.57, 20.78)	16.15 (12.56, 20.77)	16.25 (12.65, 20.88)
Twenty Filter Health & Environment	17.37 (13.52, 22.30)	17.85 (13.88, 22.97)	17.11 (13.36, 21.91)	17.54 (13.65, 22.54)
FPB	0.72 (0.67, 0.77)	0.70 (0.65, 0.76)	0.71 (0.66, 0.76)	0.70 (0.65, 0.76)
PS	0.97 (0.90, 1.05)	0.97 (0.90, 1.06)	0.97 (0.90, 1.05)	0.97 (0.90, 1.06)
SSDC	0.99 (0.93, 1.07)	1.00 (0.93, 1.08)	0.99 (0.92, 1.07)	1.00 (0.93, 1.08)
Snacks	0.78 (0.72, 0.83)	0.76 (0.71, 0.82)	0.77 (0.72, 0.83)	0.76 (0.70, 0.82)
Soups	0.97 (0.90, 1.04)	0.96 (0.89, 1.04)	0.97 (0.90, 1.04)	0.96 (0.89, 1.04)
Belief/knowledge controls	No	Yes	No	Yes
Demographic controls	No	No	Yes	Yes

aOR, adjusted odds ratio; 95% CI, 95% confidence interval; FPB, frozen patties and burgers; PS, pantry staples; SSDC, sauces, spreads, dips, and condiments. For condition names, Ten and Twenty refer to the percentage of pulse products in the product set; conditions that contain health and/or environment presented messages to participants about pulse benefits in those areas; Filter conditions gave participants the ability to use a filter to see pulse products.

intervention conditions on the nutritional quality of foods chosen varies somewhat from nutrient to nutrient, there is a consistently significant improvement in the nutrient content of foods chosen among conditions that include the pulse filter. The prevalence of pulse options within the choice environment appeared to have the second most important influence on the nutrient profiles of foods chosen, with 20% pulse prevalence increasing iron and potassium and decreasing saturated fat and sodium more so than the corresponding conditions containing 10% pulse prevalence.

3.2 The impact of experiment conditions on beliefs, knowledge, and active consideration of health and environment and satisfaction with products chosen

Next, we analyzed secondary outcomes of exposure to experimental conditions on beliefs about and perceived knowledge of the environmental and health implications of pulse production/consumption, active consideration of environmental and health outcomes, and participants' satisfaction with the products they selected. Exposure to the conditions with health and/or environment messages consistently and significantly increased the proportional odds of stronger beliefs that pulses offered nutritional benefits and/or environmental benefits (Table 6). The adjusted proportional odds ratios for a higher level of beliefs among individuals in messaging conditions ranged from 1.35 to 1.77. On the other hand, there was little impact of the experiment conditions on subjective (self-reported) knowledge of health and environmental benefits of pulses (Table 7). There were no significant impacts of conditions on the subjective knowledge of the outcome addressed in the message. That is, none of the health messaging conditions had a significant impact on subjective knowledge about health. However, two environmental messaging conditions had a significantly lower reported subjective knowledge about health.

Next, we examined active consideration of health and/or environmental outcomes during food choice (Table 8). Exposure to health and environmental messages increased consideration of health or environmental outcomes during food choice by 1.33–1.48 times. Focusing solely on active consideration of health, participants in the Ten Filter Health & Environment condition were 1.43 times more likely to actively consider health during food choice, while those in the

TABLE 5 Regression of nutrient content of foods chosen on experiment conditions, adjusted for product categories, demographic characteristics, and use of nutrient information during food choice.

Predictors	Energy (kcal)	Sat. fat. (g)	Sodium (mg)	Added sugar (g)	Dietary fiber (g)	Iron (mg)	Potassium (mg)	Calcium (mg)
(Intercept)	403.0 (396.3, 409.6)	5.69 (5.42, 5.95)	875.9 (857.8, 894.0)	1.42 (1.23, 1.6)	3.29 (3.11, 3.46)	3.21 (2.83, 3.58)	115.4 (104.6, 126.2)	110.8 (108.0, 113.7)
Ten Health	1.5 (−3.84, 6.84)	0.08 (−0.13, 0.3)	5.37 (−9.29, 20.03)	−0.24 (−0.39, −0.09)	0.06 (−0.08, 0.2)	0.09 (−0.22, 0.39)	0.63 (−8.13, 9.39)	1.59 (−0.74, 3.92)
Ten Env.	1.88 (−3.49, 7.24)	0.36 (0.14, 0.58)	4.1 (−10.63, 18.83)	−0.08 (−0.23, 0.07)	−0.01 (−0.15, 0.13)	0.11 (−0.19, 0.42)	5.47 (−3.33, 14.27)	2.43 (0.08, 4.77)
Ten Health & Env.	−1.81 (−7.14, 3.53)	0.06 (−0.15, 0.28)	5.2 (−9.44, 19.84)	−0.18 (−0.33, −0.03)	−0.04 (−0.18, 0.11)	0 (−0.3, 0.3)	5.52 (−3.23, 14.27)	1.98 (−0.35, 4.31)
Twenty	6.77 (1.42, 12.11)	0.06 (−0.15, 0.28)	−16.17 (−30.84, −1.51)	0 (−0.15, 0.15)	0.06 (−0.08, 0.2)	0.08 (−0.23, 0.38)	−0.05 (−8.81, 8.71)	−1.84 (−4.17, 0.49)
Twenty Health	−4.08 (−9.38, 1.23)	−0.16 (−0.37, 0.06)	−24.65 (−39.21, −10.1)	−0.08 (−0.23, 0.07)	0.17 (0.03, 0.31)	0.18 (−0.12, 0.48)	0.39 (−8.3, 9.09)	−2.2 (−4.51, 0.12)
Twenty Env.	−1.54 (−6.9, 3.81)	−0.18 (−0.39, 0.04)	−12.77 (−27.47, 1.93)	−0.02 (−0.17, 0.13)	0.1 (−0.04, 0.25)	0.11 (−0.19, 0.42)	1.79 (−6.99, 10.57)	−1.55 (−3.89, 0.79)
Twenty Health & Env.	2.61 (−2.7, 7.91)	−0.05 (−0.27, 0.16)	−14.62 (−29.19, −0.05)	−0.05 (−0.2, 0.1)	0.11 (−0.04, 0.25)	−0.06 (−0.36, 0.25)	0.47 (−8.24, 9.17)	−1.87 (−4.19, 0.44)
Ten Filter	−3.77 (−9.19, 1.66)	−0.41 (−0.63, −0.19)	−16.89 (−31.79, −2)	−0.21 (−0.36, −0.06)	1.01 (0.86, 1.15)	−0.07 (−0.38, 0.24)	17.94 (9.04, 26.84)	1.63 (−0.74, 4.01)
Ten Filter Health	−5.8 (−11.31, −0.29)	−0.69 (−0.91, −0.47)	−35.9 (−51.0, −20.7)	−0.32 (−0.47, −0.17)	1.57 (1.43, 1.72)	−0.06 (−0.37, 0.26)	25.81 (16.77, 34.84)	2.91 (0.5, 5.32)
Ten Filter Env.	−9.73 (−15.22, −4.23)	−0.77 (−0.99, −0.55)	−23.5 (−38.58, −8.43)	−0.36 (−0.51, −0.2)	1.39 (1.25, 1.54)	−0.04 (−0.35, 0.27)	27.4 (18.39, 36.4)	2.53 (0.13, 4.93)
Ten Filter Health & Env.	−8.14 (−13.58, −2.71)	−0.79 (−1.01, −0.57)	−27.92 (−42.84, −13)	−0.27 (−0.42, −0.12)	1.63 (1.48, 1.77)	0.08 (−0.23, 0.39)	30.7 (21.79, 39.62)	1.94 (−0.43, 4.32)
Twenty Filter	−4.24 (−9.65, 1.17)	−0.62 (−0.84, −0.4)	−34.1 (−48.9, −19.3)	−0.24 (−0.39, −0.09)	0.97 (0.82, 1.11)	0.45 (0.14, 0.75)	29.44 (20.57, 38.31)	−0.75 (−3.11, 1.62)
Twenty Filter Health	−8.32 (−13.63, −3.01)	−0.81 (−1.02, −0.6)	−49.9 (−64.5, −35.4)	−0.46 (−0.61, −0.31)	1.46 (1.32, 1.6)	0.6 (0.3, 0.9)	48.88 (40.17, 57.59)	1.7 (−0.62, 4.02)
Twenty Filter Env.	−6.22 (−11.65, −0.79)	−0.86 (−1.08, −0.64)	−50.3 (−65.3, −35.4)	−0.47 (−0.62, −0.32)	1.46 (1.32, 1.6)	0.45 (0.14, 0.76)	47.51 (38.6, 56.42)	1.4 (−0.97, 3.77)
Twenty Filter Health & Env.	−8.71 (−14.15, −3.27)	−0.76 (−0.98, −0.54)	−42.9 (−57.8, −28.0)	−0.44 (−0.59, −0.29)	1.32 (1.17, 1.46)	0.51 (0.2, 0.82)	45.42 (36.5, 54.35)	0.1 (−2.27, 2.48)

Estimate (95% confidence interval); significant ($p < 0.05$) positive slope estimates are marked in red; significant negative slope estimates are marked in blue; see Supplementary Tables S6–S13 for full regression results.
For condition names, Ten and Twenty refer to the percentage of pulse products in the product set; conditions that contain health and/or environment presented messages to participants about pulse benefits in those areas; Filter conditions gave participants the ability to use a filter to see pulse products.

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TABLE 6 Effect of experiment conditions on beliefs about the health and environment impacts of pulses.

Condition name	Health aOR (95% CI)	Environment aOR (95% CI)
Twenty	0.93 (0.71, 1.22)	0.97 (0.74, 1.26)
Ten Environment	1.19 (0.91, 1.55)	1.38 (1.06, 1.80)
Twenty Environment	1.02 (0.78, 1.33)	1.21 (0.93, 1.58)
Ten Health	1.16 (0.89, 1.52)	1.22 (0.94, 1.60)
Twenty Health	1.61 (1.24, 2.11)	1.39 (1.07, 1.82)
Ten Health & Environment	1.35 (1.03, 1.76)	1.46 (1.12, 1.91)
Twenty Health & Environment	1.38 (1.06, 1.81)	1.46 (1.12, 1.90)
Ten Filter	1.12 (0.85, 1.46)	0.97 (0.74, 1.26)
Twenty Filter	1.03 (0.79, 1.34)	1.07 (0.82, 1.39)
Ten Filter Environment	1.23 (0.94, 1.60)	1.77 (1.36, 2.31)
Twenty Filter Environment	1.13 (0.86, 1.47)	1.65 (1.26, 2.14)
Ten Filter Health	1.51 (1.15, 1.98)	1.39 (1.07, 1.82)
Twenty Filter Health	1.46 (1.12, 1.90)	1.47 (1.13, 1.91)
Ten Filter Health & Environment	1.38 (1.06, 1.81)	1.64 (1.26, 2.14)
Twenty Filter Health & Environment	1.44 (1.10, 1.88)	1.52 (1.71, 1.99)

For condition names, Ten and Twenty refer to the percentage of pulse products in the product set; conditions that contain health and/or environment presented messages to participants about pulse benefits in those areas; Filter conditions gave participants the ability to use a filter to see pulse products.

TABLE 7 Effect of experiment conditions on subjective knowledge about the health and environment impacts of pulses.

Condition Name	Health aOR (95% CI)	Environment aOR (95% CI)
Twenty	0.75 (0.58, 0.98)	0.85 (0.65, 1.11)
Ten Environment	0.69 (0.53, 0.89)	0.92 (0.71, 1.19)
Twenty Environment	0.73 (0.56, 0.94)	1.01 (0.78, 1.30)
Ten Health	0.78 (0.60, 1.01)	1.00 (0.77, 1.31)
Twenty Health	0.88 (0.68, 1.14)	1.10 (0.85, 1.41)
Ten Health & Environment	0.93 (0.72, 1.20)	0.98 (0.75, 1.27)
Twenty Health & Environment	0.77 (0.59, 1.00)	0.99 (0.76, 1.28)
Ten Filter	0.96 (0.74, 1.25)	0.96 (0.74, 1.25)
Twenty Filter	0.86 (0.66, 1.12)	0.89 (0.68, 1.15)
Ten Filter Environment	0.97 (0.74, 1.26)	1.19 (0.91, 1.55)
Twenty Filter Environment	0.81 (0.63, 1.05)	1.12 (0.87, 1.45)
Ten Filter Health	0.78 (0.60, 1.01)	0.99 (0.76, 1.29)
Twenty Filter Health	0.89 (0.69, 1.15)	1.13 (0.87, 1.46)
Ten Filter Health & Environment	0.88 (0.68, 1.14)	1.03 (0.80, 1.33)
Twenty Filter Health & Environment	0.83 (0.64, 1.08)	1.01 (0.78, 1.31)

For condition names, Ten and Twenty refer to the percentage of pulse products in the product set; conditions that contain health and/or environment presented messages to participants about pulse benefits in those areas; Filter conditions gave participants the ability to use a filter to see pulse products.

Twenty Environment group were less likely (OR = 0.74). For active consideration of environmental impacts, only one parameter estimate was significant. Participants in the Twenty condition were 0.66 times as likely to consider environment during food choice as those in the reference (Ten) condition. Examining active consideration of health and/or environmental outcomes showed that the Twenty Filter Health, and both Ten and Twenty Filter Health and Environment conditions, led to significant increases in active consideration of those outcomes during choice.

Next, we describe the relationship of conditions with participants' reported satisfaction with the products they chose (Table 9). In the first set of analyses, which did not control for the number of products chosen, multiple pulse filter conditions had significantly lower levels of satisfaction (with adjusted proportional odds ranging from 0.67 to 0.73). Once a variable incorporating the number of products chosen was incorporated, only one condition remained significant (Twenty Filter Environment, adjusted proportional odds = 0.71). Due to a design error in the experiment interface, participants could not remove the filter if they did not find a product they were interested in, which may have led many of them to indicate they would not purchase any of the available products.

Finally, we report the results of an exploratory analysis of the relationship between frequency of pulse consumption and the likelihood of using the pulse filter in Table 10. Individuals who consumed pulses more frequently were significantly more likely to use the pulse filter to help them identify pulse foods. Additional analyses (reported in Supplementary Tables S14–S16) show significant relationships between variables capturing consideration, habits, and priorities related to health and the environment and the use of the pulse filter. These results suggest that the availability of the pulse filter facilitated the identification of pulse products among people who regularly consumed them and who were motivated by health and environmental considerations.

4 Discussion

In this article, we extend and integrate recent reports examining the impact of messaging and choice environment interventions on product choice. We also estimated the impact of an experimental condition that increased the number of options with the target attribute (a pulse within the first three ingredients in a product) to simulate a recent trend in the development of more pulse products. While the presence of products and attributes in the market is the result of market interactions between producers' product offerings and consumers' purchase decisions, the development of pulse products has been growing steadily and that growth is expected to increase over the next decade (Choudhury, 2025).

We found significant impacts of all intervention arms on the choice of pulse food products. While messaging increased the choice

TABLE 8 Effect of experiment Conditions on active consideration of health and/or environment impacts of foods in the choice environment.

Condition name	Health aOR (95% CI)	Environment aOR (95% CI)	Health/Environment aOR (95% CI)
Intercept	0.54 (0.44, 0.66)	0.17 (0.13, 0.22)	0.67 (0.55, 0.81)
Twenty	0.97 (0.72, 1.28)	0.66 (0.43, 0.99)	0.88 (0.67, 1.17)
Ten Environment	0.87 (0.65, 1.16)	0.78 (0.52, 1.17)	0.90 (0.68, 1.19)
Twenty Environment	0.74 (0.55, 0.99)	0.90 (0.61, 1.33)	0.78 (0.59, 1.04)
Ten Health	1.09 (0.82, 1.45)	0.82 (0.55, 1.22)	1.14 (0.87, 1.51)
Twenty Health	1.12 (0.84, 1.48)	0.89 (0.60, 1.32)	1.13 (0.85, 1.48)
Ten Health & Environment	0.92 (0.69, 1.23)	0.84 (0.56, 1.24)	0.92 (0.69, 1.21)
Twenty Health & Environment	1.10 (0.83, 1.46)	0.94 (0.64, 1.39)	1.12 (0.85, 1.47)
Ten Filter	1.07 (0.80, 1.42)	0.85 (0.57, 1.27)	1.04 (0.79, 1.38)
Twenty Filter	1.07 (0.80, 1.42)	0.90 (0.61, 1.33)	1.13 (0.86, 1.49)
Ten Filter Environment	1.09 (0.82, 1.45)	1.14 (0.78, 1.66)	1.25 (0.94, 1.65)
Twenty Filter Environment	1.09 (0.82, 1.45)	1.32 (0.91, 1.91)	1.17 (0.88, 1.54)
Ten Filter Health	1.13 (0.85, 1.51)	0.79 (0.53, 1.19)	1.08 (0.82, 1.44)
Twenty Filter Health	1.29 (0.98, 1.71)	1.26 (0.87, 1.83)	1.38 (1.05, 1.82)
Ten Filter Health & Environment	1.43 (1.08, 1.90)	1.18 (0.81, 1.71)	1.48 (1.12, 1.95)
Twenty Filter Health & Environment	1.26 (0.95, 1.68)	1.26 (0.87, 1.83)	1.33 (1.01, 1.76)

For condition names, Ten and Twenty refer to the percentage of pulse products in the product set; conditions that contain health and/or environment presented messages to participants about pulse benefits in those areas; Filter conditions gave participants the ability to use a filter to see pulse products.

of pulse products, the provision of a pulse filtering option led to markedly greater increases in choice of pulse foods. The combination of messaging and filtering had the greatest impact, which aligns with previous findings showing that combined messaging and filtering has a higher impact on choices than messaging alone, which also had a significant impact relative to a control condition (Gustafson et al., 2024). Importantly, the conditions featuring pulse filters also had significant impacts on the amount of nutrients of public health concern in the US, increasing the content of underconsumed nutrients (such as dietary fiber and potassium) and decreasing the content of overconsumed nutrients (such as saturated fat and sodium). This finding aligns with the fact that pulses are a rich source of many important nutrients (Drewnowski and Conrad, 2024), but provides valuable evidence highlighting that promoting food products that contain pulses as an ingredient also improves the nutritional profile of selected foods.

The fact that the pulse filter option alone had a larger impact than the messages alone may seem counterintuitive. However, the filter itself—containing the words "pulse"—may have primed consideration of health and/or environmental concepts (Urminsky and Goswami, 2019), while also markedly reducing search costs to identify pulse products. In our exploratory analysis, we found significant positive relationships between individual characteristics related to habits, knowledge, and priorities about health and environment during food choice and use of the pulse filter. This suggests that the presence of the filter may have enabled individuals who regularly consumed pulses and had greater health and environmental preferences to focus in on pulse products.

The combination of messaging and filter conditions resulted in the highest likelihood of pulse products being selected. This reflects findings from other settings. A number of articles examining messages

TABLE 9 Effect of experiment conditions on satisfaction with products selected.

Condition name	I aOR (95% CI)	II aOR (95% CI)
Twenty	1.01 (0.78, 1.30)	0.98 (0.76, 1.27)
Ten Environment	1.06 (0.82, 1.38)	1.05 (0.81, 1.36)
Twenty Environment	1.03 (0.79, 1.33)	0.98 (0.76, 1.28)
Ten Health	0.97 (0.75, 1.25)	0.89 (0.69, 1.15)
Twenty Health	1.01 (0.78, 1.30)	0.92 (0.71, 1.19)
Ten Health & Environment	1.02 (0.79, 1.32)	0.99 (0.77, 1.29)
Twenty Health & Environment	0.96 (0.74, 1.23)	0.91 (0.70, 1.17)
Ten Filter	0.89 (0.68, 1.14)	1.02 (0.78, 1.31)
Twenty Filter	0.73 (0.56, 0.94)	0.83 (0.64, 1.08)
Ten Filter Environment	0.82 (0.64, 1.07)	0.94 (0.73, 1.23)
Twenty Filter Environment	0.67 (0.52, 0.87)	0.71 (0.55, 0.93)
Ten Filter Health	0.97 (0.75, 1.25)	0.83 (0.64, 1.08)
Twenty Filter Health	0.73 (0.56, 0.95)	0.93 (0.72, 1.21)
Ten Filter Health & Environment	0.73 (0.56, 0.94)	0.82 (0.63, 1.06)
Twenty Filter Health & Environment	0.82 (0.63, 1.07)	0.90 (0.69, 1.17)
Products Chosen (number)	–	1.76 (1.69, 1.84)

For condition names, Ten and Twenty refer to the percentage of pulse products in the product set; conditions that contain health and/or environment presented messages to participants about pulse benefits in those areas; Filter conditions gave participants the ability to use a filter to see pulse products.

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TABLE 10 Use of pulse filter by frequency of pulse consumption in conditions with filtering but no messaging.

Predictors	Odds Ratios	CI	*p*
(Intercept)	0.42	0.35–0.50	**<0.001**
Frequency of Pulse Consumption (ref: never)			
Less than once per month	1.03	0.83–1.29	0.767
2–4 times per month	1.32	1.08–1.62	**0.007**
2–6 days per week	1.70	1.39–2.08	**<0.001**
At least once per day	1.67	1.27–2.19	**<0.001**

Bold text indicates significant *p*-values.

that prime or prompt consideration of health and the environment has found impacts on blood oxygenation level dependent measures of brain function (Hare et al., 2011), purchases in supermarkets (Gustafson et al., 2018; Papies et al., 2014), the set of products considered and information used during the choice process (Arslain et al., 2021; Gustafson et al., 2021; Gustafson, 2023; Gustafson and Rose, 2023) as well as choice of healthier/sustainable products in experimental settings documenting choice process variables (Arslain et al., 2020; Gustafson et al., 2024), and valuation of products (Hosni et al., 2025).

The results related to message type—health only, environment only, health and environment combined—are mixed. While we expected that the combined message would be most impactful in promoting the choice of pulse foods, it is not true in all conditions. For example, while the combined message does lead to the highest likelihood of pulse choice among the Ten Filter messaging conditions, it has the lowest likelihood among the Twenty Filter messaging conditions. While some research suggests that combined health and environment messages are most effective at promoting pulse-related consumption (Lemken et al., 2017), our results may highlight tradeoffs associated with attempts to present multiple pieces of information. For instance, a recent study on the impact of obesity and food waste information on portion size preferences found that simultaneously presenting information yields smaller effects than sequentially presenting information (Hosni et al., 2025). Of the health and environmental messages, results suggest that the health messages had a greater impact on the selection of pulse products, which reflects findings in other studies that health concerns appear to be more relevant and impactful during food choice than environmental concerns (Henn et al., 2022).

Further, our results point toward the role of complexity in limiting the effectiveness of informational, labeling, or incentive-based interventions to promote healthier choices. In complex, real-world retail environment, the attention paid to products and relevant attributes for healthy decisions, such as warning labels or nutrition information appears is limited (Cantor et al., 2015; Dubois et al., 2021; Elbel et al., 2009; Machín et al., 2023, 2020). In fact, more complex choice environments have been found to decrease individuals' attention to products and product attributes (Meißner et al., 2020). While reminders to consider important outcomes, such as health, have been found to shift attention to healthier products and to relevant attribute information (Arslain et al., 2021), the potential impact of reminder messages in isolation may be limited. Evidence suggests that these messages are markedly more impactful when the choice environment aligns with the message: at a rural supermarket serving a predominantly minority community, a reminder message about fruit and vegetable consumption goals led to significantly higher purchases of produce as well as healthy foods in general (Gustafson et al., 2018). However, a reminder message about general healthy food purchasing goals, with products identified by a locally designed, culturally appropriate labeling system (Gustafson and Prate, 2019), did not significantly increase purchases (Gustafson et al., 2018). Note that fruits and vegetables were contained within the set of all healthy products and thus it should have been easier for shoppers in the general message condition to find healthy products they would want to purchase than shoppers in the fruit and vegetable message condition. In online settings, pulse-focused messages combined with a pulse attribute filter significantly outperformed pulse messages alone in an environment in which pulse products were randomly intermixed with non-pulse products (Gustafson et al., 2024). Further, while messages may recruit attention to attributes that tend to be overlooked during choice in complex environments, they may also crowd out attention to other health or environmental attributes (Gitungwa et al., 2024; Lemken et al., 2024).

Our results about the relationship between demographic characteristics and pulse choice also provide important information. While previous studies on pulses in a US context have tended to focus on specific populations, such as low-income women or ethnic minority women in Midwestern communities (Palmer et al., 2018; Winham et al., 2019, 2016), we have data from a large sample that reflects the national distribution of key demographic characteristics. We find significant results for all demographic characteristics except race/ethnicity. Women were significantly less likely to select pulse products. Recent analysis of National Health and Nutrition Examination Survey (NHANES) data on legume consumption (which includes pulses) shows insignificant differences in consumption by gender (Perera et al., 2020), but these NHANES data reflect shared consumption environments among household members rather than individual food choices. We find lower levels of pulse choice in older adults than young adults, which may partially reflect differences in attention to sustainability issues (Yamane and Kaneko, 2021), and also reflects findings in previous studies (Perera et al., 2020). Pulse choice also differs by income. While pulses are affordable (Didinger and Thompson, 2020; Drewnowski and Conrad, 2024)—and, in fact, were less costly on average in this experiment, we find increased odds of pulse consumption with higher levels of income. The educational variable differentiates estimated pulse choice more than any other demographic characteristic. Respondents with education beyond high school were significantly more likely to choose pulse products than those with high school or less.

There are significant differences in the likelihood of pulse choice by product category. When choosing foods from the Frozen Patties and Burgers and the Snacks categories participants were significantly less likely to choose a pulse product than when choosing from the Frozen Dinners and Entrees category. This result is interesting because of the frequency with which pulses are suggested as a way to substitute away from animal-source foods in the burger category (Oliveira et al., 2019; Onwezen et al., 2021; Tarrega et al., 2020), and growth in pulse offerings in the snack category (Choudhury, 2025). Our findings may suggest that efforts to increase pulse consumption should focus on other food categories.

Finally, there are some important limitations to this research that should be noted. First, the decisions made in the experiment are hypothetical, which was necessitated by a desire to recruit a large sample of respondents with diverse demographic characteristics from throughout the US. While we employed techniques that have been found to mitigate the impact of hypothetical bias, we cannot rule out the possibility that choices would differ if participants were exchanging real money for real products. Second, the filter condition featured a programming error that prevented participants from removing the filter once it was in place. This resulted in increases in participants in those conditions saying that they would not choose any product. Whereas 9.4 percent of choices made by participants were the "none of these" response in the 10 and 20% pulse conditions, this increased by approximately 5.5 percentage points to 15 percent in the 10 and 20% subset conditions. The increase in the percent of "none of these" choices between conditions with and without the filter in place was consistent across messaging conditions as well. Further, as noted earlier, the pulse filter may have primed thoughts about health and/or the environment (Urminsky and Goswami, 2019), which would have exaggerated the effect of the filter intervention relative to a real-world scenario in which multiple filter options would be present. In future work on the feasibility of filters to promote desirable food choices, we will ensure that the filter is removable and that other filter options are available to avoid focally priming pulse benefits.

However, we also find evidence that the pulse filter eased the difficulty of finding a pulse food among the other products, making the filter particularly useful for a product category that some people have a hard time identifying (Melendrez-Ruiz et al., 2021; Winham et al., 2020). Finally, much of the recent research on consumer choice of sustainable food products has focused on labels or measures, such as carbon emissions or food miles, that attempt to represent a direct environmental impact. However, these labels have not been widely implemented, and even finding estimates for these values is currently difficult. We chose to focus on information that is universally available in the study area—the presence (and—in real-world product environments—the ranking in the list of ingredients) of pulses in food products. While this does not provide the summary measure of environmental impact that labels do, it does represent the information upon which many people have to make decisions in the real-world.

5 Conclusion

This research shows that interventions targeting a key ingredient—having pulses as one of the top three ingredients in a food product—can significantly improve the nutritional profiles of foods selected, which is true even though participants in all conditions had access to nutrient information. While we were unable to find comprehensive information about environmental impacts of enough food products to analyze the impact of promoting pulse foods on emissions or other important environmental outcomes, the findings about the impact on the nutritional profiles of chosen foods may very well translate to sustainability attributes as well. Given that it is unlikely that many countries, such as the US, will implement mandatory eco-labeling laws, interventions promoting information already available, such as pulse content in food products, may be the next best option.

We find that interventions that combine messaging with filtering, which allows easy identification of pulse products, resulted in the greatest increase in choice of pulse products and improved the nutritional profiles of products chosen by participants. Our results also suggest that the trend toward more pulse product offerings may lead to higher purchases of pulse products. However, the development of pulse food products may need additional evidence about consumer receptiveness to pulse foods by food category, because consumers were less likely to choose pulse food products in food categories—snacks and frozen patties and burgers—that have been a focus of increasing pulse products. Messaging that highlights affordability and convenience may help promote pulse consumption within demographic categories that have lower consumption levels, helping expand the reach of nutritional benefits of pulse consumption.

Data availability statement

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

Ethics statement

The studies involving humans were approved by the research protocol was approved by the Institutional Review Board of the University of Nebraska-Lincoln (protocol #20221122409EX). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

CG: Methodology, Conceptualization, Validation, Visualization, Supervision, Writing – original draft, Project administration, Data curation, Funding acquisition, Formal analysis. HG: Writing – review & editing, Investigation. DR: Funding acquisition, Visualization, Writing – review & editing, Methodology, Data curation, Supervision, Conceptualization, Project administration.

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Conflict of interest

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

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2025.1667600/full#supplementary-material

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