Does the provision of information increase the substitution of animal proteins with plant-based proteins? An experimental investigation into consumer choices☆

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ABSTRACT

A widespread transition towards diets based on plant proteins as substitutes for animal proteins would contribute to food system sustainability. Such changes in consumer food choices can be fostered by public policy. We conducted a field experiment to test whether providing consumers with information regarding the negative consequences of meat consumption on the environment or health increases the substitution of animal-based proteins with plant-based proteins. The consumers had to make three meal selections online and consume the products at home, the first without exposure to information and the latter two after exposure to environmental or health information. One group of consumers served as the control and received no information. The results show that half of the consumers consumed meals with animal proteins in all three cases. Observational learning does not enhance the impact of the information intervention. However, for a sub-sample of consumers, environmental information increases the likelihood of consuming plant-based protein products. Overall, a short-term information policy does not appear to be sufficient for altering consumer behaviour regarding the consumption of animal proteins.

1. Introduction

During the past century, consumption of animal-based proteins in typical Western diets has increased dramatically in terms of both frequency and amount. Western diets are currently largely based on the consumption of meat, which contributes more than 15% of daily energy intake, 40% of daily protein intake and 20% of daily fat intake (Daniel et al., 2011). Although this tendency has stabilized in France and the European Union since the beginning of the 2000s to approximately 85 kg of meat per capita per year (FranceAgriMer, 2020), meat consumption is still growing at the world level: the United Nations Food

and Agriculture Organization (FAO) expects that, after an increase about 42 million tons in 10 years, meat demand would increase from 328 in 2019 to 470 million tons by 2050. The increase in meat consumption imposes negative consequences on both the environment and public health (Hallström et al., 2014; Tilman and Clark, 2014): the effects of livestock production on the environment, i.e. climate change, land use, biodiversity, water resources, are currently well established (Poore and Nemecek, 2018; Steinfeld et al., 2006)[1] and the excessive consumption of processed meat has been classified as "carcinogenic to humans" and red meat as "probably carcinogenic to humans" (WHO, 2015; Bouvard et al., 2015) as well as associated with

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higher all-cause mortality (Larsson and Orsini, 2014).[2] Shifting diets towards reduced meat consumption in industrialized countries should benefit health, mainly by reducing the risk of obesity, cardiovascular diseases and stroke, type 2 diabetes and some cancers (Micha et al., 2010; WHO, 2015), and improve the sustainability of the food sector (Foley et al., 2011; West et al., 2014). Reducing meat consumption in high meat eating countries is thus recommended and would align the objectives of improving the health of the population and enhancing environmental protection (Godfray et al., 2018; Nelson et al., 2016; Springmann et al., 2016; Willett et al., 2019).

Substituting animal proteins with plant-based proteins in household diet and consumption habits would be a part of the solution (Bajzelj et al., 2014; de Boer and Aiking, 2019; Willett et al., 2019). Indeed, plant-based proteins are a good substitute for animal-based proteins, allowing consumers to hold calorie and protein intake constant while limiting negative consequences on the environment and health (Aiking et al., 2006; Aiking and de Boer, 2020; Petersen et al., 2021; Poore and Nemecek, 2018). Such substitutions are possible only if consumers are ready to do these changes, and the necessary first step condition for this is the consumers' awareness of health and environmental consequences of animal proteins consumption and production (Aiking, 2014; Wellesley et al., 2015).[3] In the 2010's, according to the results of various studies conducted in Western countries, only less than 30% of consumers identified the production and consumption of meat as having negative consequences on the environment (Garnett et al., 2015; Hartmann and Siegrist, 2017) and a strong heterogeneity is observed among individuals' awareness about health concerns of excessive meat consumption (Wezemael et al., 2010).[4] Recent studies observe that consumers' awareness of the consequences of animal proteins on the environment is still low (Hartmann et al., 2021; Siegrist and Hartmann, 2019) whereas consumers over-estimate the environmental impact of alternative plant-based proteins (Siegrist and Hartmann, 2019). In a survey conducted among Swiss consumers in 2020, Hartmann et al. (2022) find that consumers overestimate the environmental friendliness and healthiness of animal-based products while they underestimate it for plant-based alternative products. Consumers are still unaware of the consequences of meat over-consumption on health and the environment while this is a prerequisite for behavioural changes.

The current paper addresses whether an information policy providing guidance about the environmental or health damage caused by meat consumption may shift consumers' behaviour towards consumption of more plant-based proteins instead of animal-based proteins. Information campaigns are instruments that can improve consumers' awareness and promote substitution of meat (Apostolidis and McLeay, 2016; Spiller and Nitzko, 2015). This instrument is also viewed as an important and necessary stage towards consumers' acceptability of more invasive policies and their effectiveness in encouraging such substitutions (Dagevos and Voordouw, 2013). Other instruments can be implemented to encourage changes in food consumption such as fiscal policy, availability policy or food environment policy (Bonnet et al., 2020; Godfray et al., 2018; Just and Byrne, 2020), but are not always desirable or possible to set up. Indeed, fiscal policy and accessibility

policy would certainly face consumers' and producers' resistance who observe a reduction in their economic interests (Bonnet et al., 2020; Just and Byrne, 2020) whereas nudges that change food environment are not applicable to home contexts (Just and Byrne, 2020). Information provision instead should not interfere with individual economic interests and concern consumers' decisions in any food choice context. We thus directly test the impact of an information policy on real consumers' choices by conducting a field experiment where a sample of consumers chose from three different processed products, each one with a meat version and a vegetarian version with very similar characteristics and protein levels. The consumers made their selections from among these six products and were instructed to take them home and eat them during the week. This task was repeated three times: in the first week consumers made their choice without any information while in the second and third week consumers of the treated groups received either an information about the negative consequences of meat consumption on the environment in terms of water use or health in terms of the possibility of developing a cardiovascular disease.

Other barriers hinder substitutions in favour of plant-based proteins due to a lack of consumers' knowledge and self-confidence about such products, especially regarding hedonics and convenience (Varela et al., 2021). Observational learning can help foster these substitutions because it guides consumers in their food choices when they have limited experience or information, as it has been shown in restaurant settings (Cai et al., 2009; Fishman et al., 2019) and in choice experiments (Edenbrandt et al., 2020). The observation of peers' behaviour affects consumers' food intake and choices through social norms or social learning (Herman et al., 2019; Higgs, 2015; Robinson et al., 2014). Indeed, observing food choices of peers allows the consumers to infer the quality of the product. In the experiment, consumers' are given the full set of consumers' evaluations before they make their third choice of food product to test whether observational learning may reinforce environmental or health information about consequences of meat consumption.

Individual characteristics also affect consumers' food choices. Several studies based on questionnaires have identified segments of consumers who differ in their preferences for meat and meat substitutes. Gender, age and income vary between segments with female, young and higher incomes that are over-represented in segments characterized by a low consumption, an ongoing reduction or an interest in reducing the consumption of meat (Apostolidis and McLeay, 2016; Latvala et al., 2012). Overall, a high consumption of meat, a low interest in meat substitutes, and a lack of willingness to adopt more plant-focused diets are still the dominant cultural pattern in most Western societies, even though some segments of consumers are more willing to change their dietary habits based on environmental or health motivations (de Boer et al., 2007; Graça et al., 2015b; Latvala et al., 2012; Schösler et al., 2012). Strong meat consumption habits or routines also prevent substitutions with plant-based proteins (Apostolidis and McLeay, 2016; de Boer et al., 2014; Latvala et al., 2012). Consumers' personality is identified as another driver of meat consumption (Kemper, 2020; Rosenfeld, 2018; Ruby, 2012). Specifically, personality traits such as openness and agreeableness are negatively associated with consumers' self-reported meat consumption (Keller and Siegrist, 2015; Pfeiler and Egloff, 2018; Tiainen et al., 2013). Some inconsistent results are nevertheless observed among previous studies, in particular regarding the role of conscientiousness, extraversion and neuroticism (Pfeiler and Egloff, 2020). We therefore elicit these characteristics of the consumers who participated in the experiment to assess how they moderate the impact of information on substitutions between animal and plant-based proteins.

In the literature, the impact of information interventions on meat consumption is mainly addressed by the analysis of intentions to reduce meat consumption (see Harguess et al. (2020) for a systematic literature review) or self-reported consumptions (Carfora et al., 2017, 2019). There is an obvious gap in the literature on the effect of public

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[2] Based on epidemiologic data, a positive association between consumption of red meat and colorectal cancer has been shown with strong mechanic evidence. Pancreatic and prostate cancer is also associated with the consumption of red meat. The consumption of processed meat is classified as carcinogenic to humans on the basis of sufficient evidence for colorectal cancer. A positive association between the consumption of processed meat and stomach cancer has also been shown (WHO, 2015).

[3] For instance, in the case of tobacco consumption, awareness of implications for health has been central to support the policy interventions (Britton, 2012).

[4] Environmental concerns were ranked lower than health concerns as reasons for considering reducing meat consumption (Dibb and Fitzpatrick, 2014).

policy on reduction in real meat consumption (Taufik et al., 2019). Our paper contributes to filling this gap. Closely related to our paper and in this streamline of research, some recent studies have analysed the impact of information about animal or plant-based proteins on consumers' real food choices. In grocery stores in Oslo, Austgulen et al. (2018) placed recipe booklets promoting vegetable dishes on stands focusing on either the health benefits or the climate benefits of meals with plant-based proteins. The results show a small increase of vegetable purchases. Castellari et al. (2019) report the results of a laboratory experiment eliciting consumers' willingness to pay for beef burger meat and soy burger meat with and without information about the impact of beef and soy on health and the environment. They find only weak effects of the provision of information. The question of the substitution between plant-based and animal proteins was not addressed in these studies. By contrast, Van Loo et al. (2020) conducted a choice experiment where participants selected among farm-raised beef and burger patties with plant-based proteins. They also find minor effects of environmental information on willingness-to-pay for the products. Based on data from both a choice experiment and actual purchases, Edenbrandt and Lagerkvist (2021) measure how a traffic light carbon label affects purchases of red meat substitutes. The effect is positive but many consumers are not willing to make such substitutions. A part of consumers may make information avoidance (Edenbrandt et al., 2021).

Our paper contributes to this literature, as it provides complementary tests evaluating the impact of information on real consumers' meat consumption behaviour. Our results confirm the limited effects of information on the substitution of animal proteins with plant-based proteins. Our study has five main contributions to this literature. First, we study real choices and consumption of consumers between meals with animal-protein or vegetarian-protein instead of declared intentions. Second, we directly address the substitution between such meals instead of addressing only the increase of vegetable consumption or the decrease of meat consumption. Third, we compare the impact of two types of information, i.e. in terms of environment and health, on such substitutions. Fourth, consumers choose their products online and consume them at home that makes our study setting more natural and real, limiting some of the biases induced in lab experiments. Fifth, the methodology we use provides a highly controlled environment that makes our measure of the impact of information on meat consumption more accurate: we compare consumer behaviours when they receive the information to their initial choice without any information and to other participants' choices who never receive any information throughout the experiment. Our study thus provides new insights on the direct effect of environmental and health information on consumers' real consumption and substitution between plant-based proteins and animal proteins while limiting biases due to experimental evaluation.

The paper is organized as follows. The experimental design, procedures and econometric models are detailed in Section 2. Section 3 presents the results. Section 4 discusses policy implications of the results and concludes.

2. Experimental design and procedures

The experiment involved participants making choices over a pre-defined set of ready-made food products on a dedicated online website specifically developed for the study.[5] 309 consumers participated in our study. The participants were citizens of Dijon (a medium-sized city in eastern France) and were selected by an external recruitment company.

Table 1
List of products.

	With animal-based proteins	Without animal-based proteins
	Couscous with meat	Couscous with vegetables
Protein intake	11.1 g/100 g	7.15 g/100 g
In-store price	€10.67	€10.62
	Chili con carne with rice	Vegetarian chili with rice
Protein intake	7.75 g/100 g	7.75 g/100 g
In-store price	€10.63	€8.82
	Pasta with bolognese sauce	Pasta with tomato basil sauce
Protein intake	7.45 g/100 g	6.65 g/100 g
In-store price	€5.28	€4.11

The food product that was chosen by each participant was then ordered, and participants picked it up at the recruitment company's premises in the city centre of Dijon. They were instructed to consume it at home in the week following their order. We implemented real incentives by ensuring that the participants truly received and consumed the product that they chose. Their choice thus revealed their own preferences and was not affected by hypothetical bias.[6]

2.1. Products

The pre-defined set of ready-made food products offered to the participants included three products existing on the market that constitute the main meal for lunch or dinner with one version made of animal-based proteins, mostly beef, and one vegetarian alternative made of plant-based proteins: couscous, chili and pasta. The two alternatives of each product were chosen to have as similar a protein intake as possible to make choices comparable.[7] The participants were informed of the weight of each product, which was the standard weight for a four-person main meal. They were also informed of the brands, ingredients, and nutritional facts of the products (all of them organic to guarantee minimum quality). The products are listed in Table 1; the prices given here are in-store prices at the time the experiment was conducted and are only indicative as they were not given to the participants. Indeed, the objective of the experiment is to evaluate substitutions between plant-based protein and animal protein products and not to derive participants' willingness-to-pay. Not giving prices thus limits their influence on product choices of the participants that let substitutions being primarily based on the type of proteins. A picture of the products, as they were offered to the participants on the website, and the products characteristics that were available to consumers, are presented in Appendix A.

2.2. Treatments

The experiment consisted of three treatments with a between-subjects design, i.e. a participant made decisions in only one treatment group. In the *control treatment* (CT), no information was provided, whereas in the *environment treatment* (ET) and the *health treatment* (HT), participants received information on the negative consequences of intake of animal-based proteins on the environment and health, respectively. Each treatment consisted of four stages with a one-week interval between them (a figure summarizing the stages of the treatments is presented in Appendix B).

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[5] The study design was submitted for approval to the Personal Protection Committee (registration number $2016 - A00353 - 48$), which noted that specific authorization was not required for this investigation. Then, the data were declared to the French Data Protection Authority (registration number: $oE19701952$).

[6] Studies show that consumers' intentions to make specific decisions are different from their real behaviour (Adamowicz and Swait, 2012; Webb and Sheeran, 2006).

[7] Substitutions of animal proteins with plant-based proteins are mainly done by replacing meat by chickpeas and vegetables and white couscous by kamout khorasan wheat couscous for couscous and meat by soy protein, kidney beans and vegetables for chili. Meat has been replaced by tomatoes for pasta that makes a lower amount of proteins but that is small as proteins are mainly brought by white spaghettis.

Control treatment. Participants did not receive any external information about the consequences of animal-based protein intake. The four stages were as follows:

- Stage 1: During her first session on the website, each participant filled in questionnaires on her socio-demographic characteristics and food consumption habits and then chose and ordered a product among the six offered products.
- Stage 2: In her second session, each participant described the dish she chose in Stage 1, uploaded a picture of the meal on her plate,[8] gave the product a rating (between 0 and 5) and wrote her review. Then, she chose and ordered another product from among the same six offered products.
- Stage 3: In her third session, each participant described the dish she chose in Stage 2, uploaded a picture of the meal on her plate, gave the product a rating (between 0 and 5) and wrote her review. Then, she was presented with the total number of participants (across all treatment groups) who wrote a review of the chosen product in Stage 1, the average of the star ratings for each product and an option to access the reviews. The participant then chose and ordered another product from among the same six offered products;
- Stage 4: In her fourth session, each participant described the dish she chose in Stage 3, uploaded a picture of the meal on her plate, gave the product a rating (between 0 and 5) and wrote her review. She then answered an end-of-experiment questionnaire on her personality traits.

Environment and health treatments. Participants received an external intervention in Stages 2 and 3 about the negative consequences of animal-based protein intake on the environment or health. Before choosing and ordering the product, participants could read a summary and illustrated card with the question tag "Did you know?" and the following explanation (see Appendix C for the text of cards):

- Information provided in the environment treatment: For 25% to 30% of proteins, the production of 1 kg, i.e. 2.2 lbs, of beef requires the consumption of 15000 l, i.e., 507210 US fl oz, of water, which is equivalent to 188 showers, whereas the production of 1 kg of pulses requires the consumption of only 4000 l, i.e., 135256 US fl oz of water, which is equivalent to 50 showers (Water Footprint Network).
- Information provided in the health treatment: Over-consumption of beef (consumption of more than 500 g, i.e., 1.1 lbs, per week) may lead to a decline in health and an increase in the risk of developing a cardiovascular disease. Consumption of 260 g, i.e., 0.57 lbs, of pulses is equivalent to consuming 210 g, i.e., 0.46 lbs, of beef and helps satisfy the recommendation to consume at least 58 g, i.e., 0.13 lb, of proteins per day (European Food Safety Authority).

The experiment aims to test the following two hypotheses:

Hypothesis 1. Environment and health information make choices of vegetarian products more likely.

Hypothesis 2. Observational learning, i.e. observation of the average of the star ratings for each product, makes:

  a. choices of products with high ratings more likely;
  b. choices of vegetarian products with high ratings more likely when the participants receive environment or health information.

2.3. Questionnaires

Participants had to answer questionnaires in both Stage 1 and Stage 4. The Stage 1 questionnaire asked about respondents' socio-demographic information (gender, age, number of children and number of adults in the family, education, net monthly family income) and food consumption habits (frequency of consumption of dairy products, vegetables, starches, fruits, red meat, white meat and fish as well as time spent cooking on weekdays and usual consumption of the offered products). We controlled for whether participants were frequent consumers of the products offered in the experiment: couscous, chili con carne and pasta bolognese. The Stage 4 questionnaire asked about the Big-5 personality traits: openness, conscientiousness, extraversion, agreeableness and neuroticism. The Big-5 questions consisted of 16 items based on the SOEP Scales Manual (Richter et al., 2013). Each item was evaluated on a 7-point Likert scale.

2.4. Sample

Experiment participants were inhabitants of the city of Dijon (France) aged between 21 and 67 years old, with an average age of approximately 44. The conditions that they had to fulfil to participate in the experiment were that they (i) are used to eat animal-based proteins, (ii) agreed to take part in food choices, (iii) had a computer or a smart phone (as the meal choices were made online), (iv) agreed to log on to the dedicated website and order (for free) one product from a restricted set of six products once a week for three weeks, and (v) agreed to consume the products that they ordered, take a picture of their plate when they consumed the product, and upload the picture to the website. A total of 309 consumers participated in the experiment: 102 in the control group, 104 in the environment group and 103 in the health group.[9] The answers to the questionnaires for each treatment group are presented in Appendix D. Table 6 presents participants' socio-demographic characteristics, Table 7 their eating habits, Table 8 their usual consumption of couscous, chili con carne and pasta bolognese and Table 9 their personality traits.

Half of the participants were women (157 women and 152 men). Their families were composed, on average, of 0.7 children and 1.9 adults. Forty-two percent held a diploma equivalent to the baccalaureate or below, 30% held a bachelor's degree and 28% held a master's degree or Ph.D. Net monthly family income was lower than €2300 for 38% of the participants, between €2300 and €3800 for 43% and higher than €3800 for 20%. Regarding food consumption habits, 80% of participants reported consuming dairy products, vegetables and starches more than five times a week. Approximately 70% reported eating red meat, white meat or fish between one and four times a week. If we aggregate the data, we note that 28% of participants reported eating animal proteins between one and four times a week, 51% between five and seven times a week, and 20% more than seven times a week. There was some heterogeneity in the distribution of the Big-5 personality traits among participants with the highest score in descending

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[8] To maximize the chances of participants eating the product within the allocated time, we asked them to take a picture of their meal on their plate and upload it to the website.

[9] We conducted sample size calculations based on the χ_2 test with power of 0.8 and significance level of 0.05. Assuming an increase of the proportion of choices for plant-based protein products between stage1 and stages 2 and 3 about 2% maximum in the control treatment and expecting to identify an average treatment effect of 10 points, i.e. an increase of the proportion of choices for plant-based protein products between stage 1 and stages 2 and 3 in the environment and health treatments by 10%, the test suggests 102 participants in each treatment. If the increase in the control treatment is lower than 2% or the treatment effect higher than 10 points, the required number of participants would be lower than 102.

order for conscientiousness, extraversion, openness, agreeableness and neuroticism.[10]

According to Pearson χ_2 tests for discrete variables and Kruskal–Wallis tests for continuous variables, the answers for socio-demographics, food consumption habits or personality traits were not significantly different among the treatment groups at the 5% level (see last column of Tables in Appendix D). Wilcoxon rank-sum tests lead to the same results.

2.5. Econometric models

The analysis aims to estimate the impact of environmental and health information on the participant's choice to consume a vegetarian meal. We apply a difference-in-difference econometric analysis based on the following equation.

$$y_{it} = \alpha + \beta T_i + \gamma S_t + \delta(T_i \times S_t) + \mu X_i + \epsilon_{it} \qquad (1)$$

where y_{it} indicates whether participant i's choice in stage t is a vegetarian meal or not, $y_{it} \in \{0, 1\}$ with $y_{it} = 1$ if she chooses a vegetarian meal; T_i is a dummy denoting the treatment in which the participant is affected, S_t is a dummy indicating the stage of the experiment, that is identical between participants. The treatment effect is identified by the interaction between the treatment and the stage, $T_i \times S_t$, with δ. We control for a vector of individual characteristics, X_i, including eating habits, socio-demographics and personality traits. ϵ_{ijt} is an unobserved random term. Results are reported in Table 4. We estimate a logit model because the explained variable is binary.

Alternatively, the heterogeneity of consumers' preferences may moderate the impact of information on choices. To account for this potential heterogeneity, we use the Ward hierarchical clustering method to create two groups based on individual characteristics (eating habits, socio-demographics and personality traits) in Model (1) and also on the participant's choice of a vegetarian meal in stage 1 in Model (2). We then conduct a logit model for each group following Eq. (1) without control of individual characteristics. Results are reported in Table 5.

3. Results

In this section, we first describe participants' choices in the different treatments and stages of the experiment and thus assess the impact of the provision of environmental and health information on food choices. Second, we study individual product choices depending on individual characteristics with the econometric analysis.

3.1. Descriptive statistics

We first describe consumers' product choices in each treatment and each stage of the experiment to give a general picture of the aggregated decisions. We present both the initial choices of participants, which correspond to the products that they chose on the website and took home from our distribution point, and the corrected choices, which are their product choices "corrected" for the sides that they reported consuming with the product. An initial choice of a vegetarian product that was consumed with animal proteins (meat, fish or charcuterie) is classified as a choice for the animal-protein version of the product. For the rest of the data analysis, we focus on the corrected choices, as they are more representative of the real consumption of animal proteins by the participants. We then present the dynamics of the individual choices over the three stages of the experiment.

Table 2 reports the frequency of food product choices by treatment and stage. We observe that in Stage 1, the shares of consumers who chose a meal without animal proteins are as follows: 29% in the control treatment, 26% in the environment treatment and 21% in the health treatment. When we correct for consumption of sides with meat, the shares of participants who did not consume animal proteins in Stage 1 become 21% in the control treatment, 18% in the environment treatment and 15% in the health treatment. The large majority of participants consumed animal proteins in the three treatments when there was no information intervention. The shares of both initial and corrected choices are not significantly different among the treatment groups in Stage 1 (Mann–Whitney rank-sum tests: $p > 0.1$). For Stage 2, the share of vegetarian initial choices (corrected choices) is approximately 29% (25%) for the control treatment, 28% (24%) for the environment treatment, and 27% (19%) for the health treatment. For Stage 3, the share of vegetarian initial choices (corrected choices) is approximately 38% (26%) for the control treatment, 38% (36%) for the environment treatment, and 33% (24%) for the health treatment. Despite additional information about the negative consequences of animal-proteins consumption on the environment or health, the large majority of participants consume animal proteins in Stages 2 and 3 as well. The difference between initial choices and corrected choices is about 8 points in Stage 1 but tends to decrease in the environment treatment as the experiment progresses (4 points in Stage 2 and 2 points in Stage 3). This decrease is not observed in the control and health treatments. The information may keep consumers from adding animal proteins when they are made aware of environmental consequences of meat consumption.

The dynamics of individual corrected choices confirm that a large proportion of the participants consumed products with animal proteins in all three stages of the experiment: 47% of the participants in the control treatment group, 45% in the environment treatment group and 54% in the health treatment group. Figs. 1–3 give the overall image of the dynamics of the individual corrected choices in the control, environment and health treatment groups, respectively (see Table 10 in Appendix for the full distribution). These figures present at each stage of the experiment the share of participants who have chosen a meal with animal proteins ("meat") or a meal with vegetarian proteins ("veg") (the sum of the two equals 100%). The colour red represents participants who consumed a meal with animal proteins in Stage 3 while the colour green represents participants who consumed a meal with only vegetarian proteins in Stage 3. The colours help to identify the trajectory of choices of the participants.

We compare the distribution of the dynamics of the corrected choices over the three stages of the experiment between the treatments and we find no significant difference (Mann–Whitney rank-sum tests: $p = 0.959$ for comparison between the control and the environment treatment, $p = 0.215$ for comparison between the control and the health treatment and $p = 0.215$ for comparison between the environment and the health treatment). Thus, a large proportion of the participants were not affected by the information intervention set up in the experiment. This leads to the first result:

Result 1. In the three treatment groups, an important share of participants consumed animal proteins in each stage of the experiment (47% in the control, 45% in the environment and 54% in the health treatment group) that underlines the limited impact of the information intervention.

This result is in line with the results of recent studies emphasizing that consumers are reluctant to modify their meat consumption behaviour, as in Lanz et al. (2018) and Edenbrandt and Lagerkvist (2021). This category of consumers may not be receptive to the information provided to them (Edenbrandt et al., 2021).

In Stage 3, in addition to receiving environmental or health information, participants observed the full set of consumers' average rating of

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[10] The Cronbach alpha is greater than 0.5 for each of the five personality traits, which indicates acceptable internal consistency among each trait's inventory items. We obtain weaker internal consistency for conscientiousness and agreeableness, as in Bazzani et al. (2017) and Ufer et al. (2019). The Cronbach alpha is approximately 0.82 for openness, 0.52 for conscientiousness, 0.78 for extraversion, 0.52 for agreeableness and 0.70 for neuroticism.

Table 2
Frequency of food choices by treatment and stage.

| Product	Control tr.		Environment tr.		Health tr.	
	Initial	**Corrected**	**Initial**	**Corrected**	**Initial**	**Corrected**
Stage 1						
Chili con carne	26.47	27.45	26.92	26.92	34.95	34.95
Couscous with meat	29.41	36.27	31.73	35.58	32.04	36.89
Pasta bolognese	14.71	15.69	15.38	19.23	11.65	13.59
Animal meal	**70.59**	**79.41**	**74.04**	**81.73**	**78.64**	**85.44**
Vegetarian chili	2.94	1.96	9.62	9.62	5.83	5.83
Couscous with vegetables	21.57	14.71	9.62	5.77	10.68	5.83
Tomato pasta	4.90	3.92	6.73	2.88	4.85	2.94
Vegetarian meal	**29.41**	**20.59**	**25.96**	**18.27**	**21.46**	**14.56**
Stage 2						
Chili con carne	31.37	31.37	26.92	26.92	23.30	24.27
Couscous with meat	14.71	17.65	24.04	25.00	23.30	27.18
Pasta bolognese	24.51	25.49	21.15	24.04	26.21	29.13
Animal meal	**70.59**	**74.51**	**72.12**	**75.96**	**72.82**	**80.58**
Vegetarian chili	3.92	3.92	8.65	8.65	4.85	3.88
Couscous with vegetables	13.73	10.78	11.54	10.58	12.62	8.74
Tomato pasta	11.76	10.78	7.69	4.81	9.71	6.80
Vegetarian meal	**29.41**	**25.49**	**27.88**	**24.04**	**27.18**	**19.42**
Stage 3						
Chili con carne	17.65	19.61	16.35	16.35	19.42	20.39
Couscous with meat	19.61	23.53	19.23	20.19	17.48	21.36
Pasta bolognese	24.51	30.39	26.92	27.88	30.10	33.98
Animal meal	**61.76**	**73.53**	**62.50**	**64.42**	**66.99**	**75.73**
Vegetarian chili	11.76	9.80	12.50	12.50	10.68	9.71
Couscous with vegetables	15.69	11.76	11.54	10.58	8.74	4.85
Tomato pasta	10.78	4.90	13.46	12.50	13.59	9.71
Vegetarian meal	**38.24**	**26.47**	**37.50**	**35.58**	**33.01**	**24.27**
N	102	102	104	104	103	103
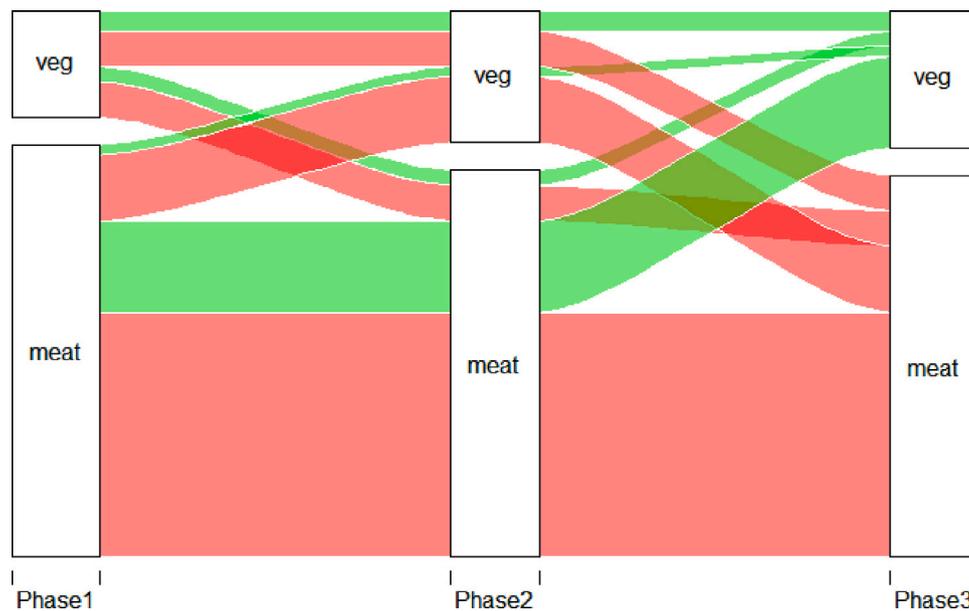
Fig. 1. Dynamics of vegetarian corrected choices in the control treatment group.

the products chosen in Stage 1 and the number of reviews available for each product. Participants could also consult the reviews left by other participants. In total, 244 of the 309 participants left a review of the product chosen in Stage 1. The two main characteristics mentioned by participants were the taste and the quantity of the product: 126 reviews included a positive evaluation of the taste of the product, while 64 included a negative evaluation; 88 reviews described the quantity as insufficient, while 9 described it as reasonable. The environment was never mentioned, and only one review mentioned health. Nine reviews recognized the advantages of the organic attributes of the product. The content of the reviews appears to have had a limited impact on consumers' choices, as 243 participants (79%) never clicked on the button to read the reviews, while 29 participants clicked on one product review, and 37 clicked on more than one. Each product review was consulted between 17 and 27 times only.

Table 3 presents the average rating and the number of reviews for each product.

The ratings attributed by consumers to the products that they chose in Stage 1 are quite high for all products. The lowest average rating was for the spaghetti bolognese (with an average rating of 3.791), and the highest was for the vegetarian chili (with an average rating of 4.684).
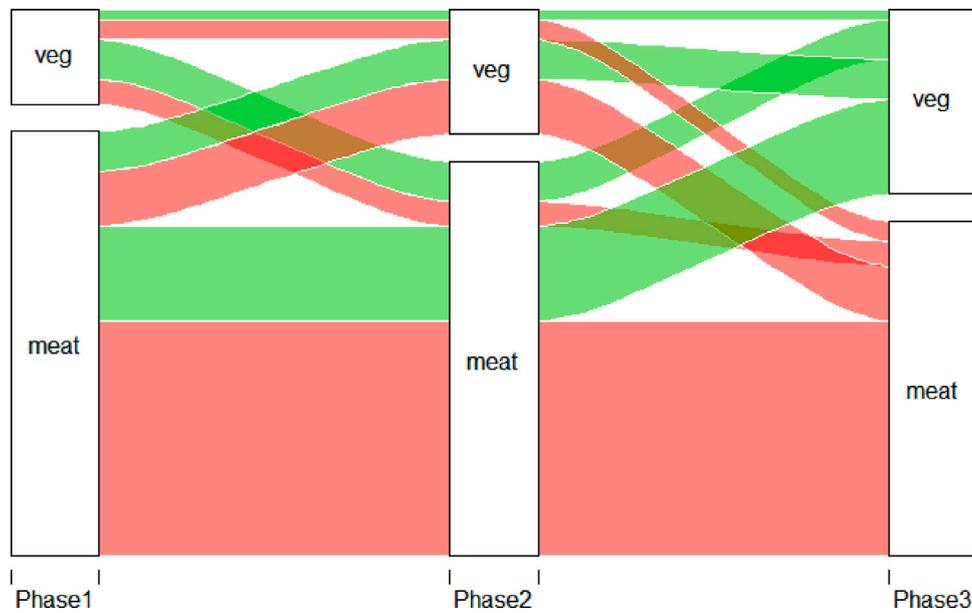
Fig. 2. Dynamics of vegetarian corrected choices in the environmental treatment group.
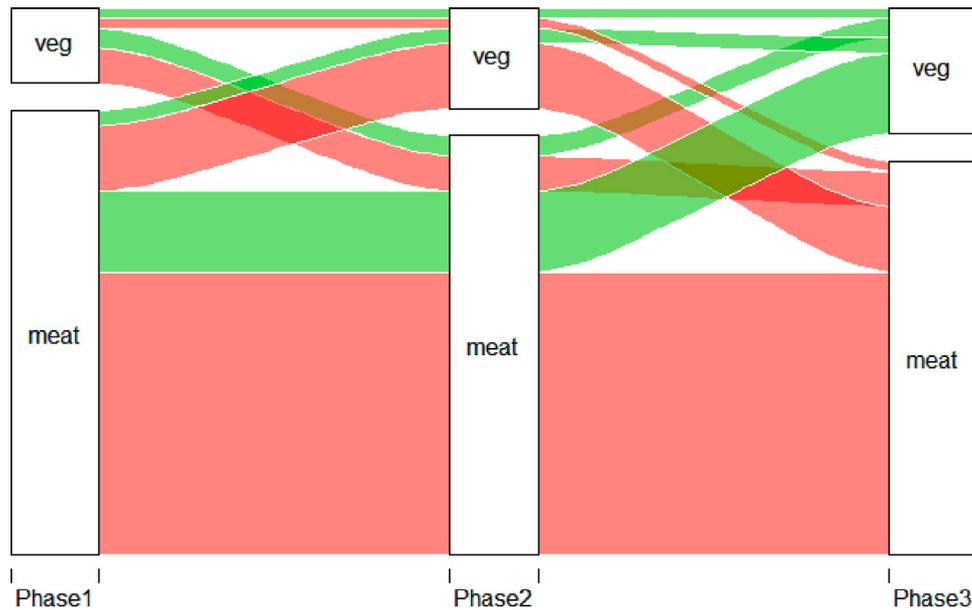

Fig. 3. Dynamics of vegetarian corrected choices in the health treatment group.

Table 3
Average rating and number of reviews for each product.

Product	Average rating	Number of reviews
Chili con carne with rice	4.088	69
Couscous with meat	4.135	80
Pasta with bolognese sauce	3.791	28
Vegetarian chili with rice	4.684	17
Couscous with vegetables	4.116	39
Pasta with tomato basil sauce	4.294	11

The number of comments is heterogeneous across the products and reflects participants' choices in Stage 1 of the experiment.[11]

We calculate the change of individual ratings between Stage 2 and Stage 3 in order to test the impact of observational learning on product choices. The evolution rate of individual ratings is the difference between the average rating of the participant's product choice in Stage 3 and the average rating of her product choice in Stage 2 divided by the latter. On average, this rate equals 1.05% and is significantly different from zero (Wilcoxon signed-rank tests: $p = 0.0304$). Participants choose, on average, products with higher ratings when they observe the average of the star ratings for the products. Among participants who choose a vegetarian product in Stage 3, the evolution rate of individual ratings equals 7.2%, that is significantly different from zero (Wilcoxon signed-rank tests: $p < 0.001$). These rates are about 8.05%, 6.38% and 7.18%

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[11] On average, over the three treatments, the percentage of participants who chose chili con carne with rice is 29%, couscous with meat 31%, pasta

bolognese 14%, vegetarian chili with rice 6%, couscous with vegetables 14% and pasta with tomato basil sauce 6%, with corresponding percentages of reviews of 28%, 33%, 11%, 7%, 16% and 5%.

Table 4

Choice of a vegetarian meal (Logit models - average marginal effects).

	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
Environment tr.	0.017 (0.036)	−0.026 (0.061)	0.021 (0.036)	0.030 (0.036)	0.033 (0.036)
Health tr.	−0.049 (0.037)	−0.072 (0.064)	−0.038 (0.037)	−0.032 (0.038)	−0.028 (0.038)
Stage 2	0.056* (0.033)	0.048 (0.055)	0.056* (0.033)	0.056* (0.033)	0.056* (0.033)
Stage 3	0.110*** (0.032)	0.057 (0.055)	0.110*** (0.032)	0.110*** (0.032)	0.110*** (0.032)
Stage 2 × Environment		0.012 (0.079)			
Stage 3 × Environment		0.101 (0.077)			
Stage 2 × Health		0.011 (0.083)			
Stage 3 × Health		0.052 (0.081)			
Eating habits					
Vegetables 5 to 7 times per week			−0.027 (0.040)	−0.019 (0.041)	−0.016 (0.041)
Vegetables more than 7 times per week			0.052 (0.041)	0.065 (0.042)	0.057 (0.044)
Animal proteins 5 to 7 times per week			−0.011 (0.034)	−0.008 (0.034)	−0.007 (0.034)
Animal proteins more than 7 times per week			−0.079* (0.045)	−0.084* (0.046)	−0.076 (0.047)
Socio-demographic variables					
Male				0.011 (0.030)	0.005 (0.032)
Age				−0.001 (0.001)	−0.001 (0.001)
Family net monthly income in]1500–2300]				−0.082* (0.047)	−0.077 (0.048)
Family net monthly income in]2300–3800]				−0.074* (0.040)	−0.072* (0.041)
Family net monthly higher than 3800				−0.082* (0.048)	−0.074 (0.048)
Personality traits					
Openness					0.005 (0.015)
Conscientiousness					0.005 (0.017)
Extraversion					−0.014 (0.014)
Agreeableness					0.010 (0.016)
Neuroticism					−0.014 (0.013)
Log-likelihood	−490.98	−489.88	−486.69	−484.35	−482.94
Wald Chi-2	14.43	16.66	22.29	26.42	28.73
Panel groups	309	309	309	309	309
Observations	927	927	927	927	927

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses.

in the control, environment and health treatments, respectively, and are not significantly different between the treatments (Mann–Whitney rank-sum tests: $p = 0.567$ for comparison between the control and the environment treatment, $p = 0.967$ for comparison between the control and the health treatment and $p = 0.681$ for comparison between the environment and the health treatment). The environmental or health information does not reinforce the effect of the observation of the star ratings of the products on the participant's product choice. This leads to the second result:

Result 2. Observational learning increases, on average, individual ratings, and its effect on choices of vegetarian products with high ratings is not related to the information intervention.

These two first results outline the limited effect of the information intervention on choices of vegetarian products. We now assess the impact of the information intervention considering heterogeneity of consumers' preferences.

3.2. Econometric analysis

Table 4 reports the estimates of Models (1) to (5) based on Eq. (1) in Section 2.5. Each model explains individual choices of vegetarian products in the control, environment and health treatment groups. The explained variable takes value 1 if the participant consumes a vegetarian meal. In Model (1), the explaining variables are dummies for the treatment and the stages of the experiment. In Model (2), we add the crossed variables between the treatment dummies and the stage dummies, that estimate the difference-in-difference model and then identifies the effect of the environmental or health information. Models (3) to (5) are Model (1) with controls for eating habits in Model (3), eating habits and socio-demographics in Model (4), and eating habits, socio-demographics and personality traits in Model (5).

Models (1) to (5) perform similarly in terms of goodness of fit of the data according to the log-likelihood. The difference-in-difference

method applied in Model (2) does not show a significant impact of the treatment on the participants' likelihood of choosing the vegetarian product: the individual likelihood of consuming a meal with plant-based proteins only is not larger for consumers who received an information about the negative consequences of animal-proteins consumption on the environment or health than for consumers who did not access any additional information. Result 3 is as follows:

Result 3. Provision of information about the negative consequences of meat consumption on the environment or health does not impact individual likelihood to choose plant-based proteins products.

Models (3) to (5) do not highlight any significant role of individual characteristics. Although the sign of estimates are generally consistent with the literature, the significance levels hardly reach the 10% threshold and the effects cannot be considered as different from zero. An interesting result is that all models (excluding Model (2) consisting in interactions between treatments and stages) show a significant and positive impact of Stage 3 on consumers' choice of plant-based proteins. This result suggests a positive impact of observational learning on consumers' choice of vegetarian meals, independently of the effect of information. This finding is in line with previous studies highlighting the role of the social context and the importance of others in supporting substitutions of animal-based proteins with plant-based proteins (Graça et al., 2019). This result is nevertheless to be nuanced as the food product choices in Stage 3 of the experiment may also reflect consumers' seeking for diversity as they are inversely correlated to consumers' choices in Stage 2 (Spearman correlation test: z=-0.173, p=0.002). Product choices in Stage 3 and Stage 1 are not significantly correlated (Spearman correlation test: z=-0.092, p=0.105).

The logit models for two subsamples of the consumers based on the Ward hierarchical clustering assess the role of information for a specific class of consumers who have homogeneous preferences. Table 5 reports the estimates of Model (1) that includes eating habits, socio-demographics and psychological traits for the definition of the clusters

Table 5
Choice of a vegetarian meal, by cluster (Logit models - average marginal effects).

	Model (1)		Model (2)	
	Cluster 1	Cluster 2	Cluster 1	Cluster 2
Environment tr.	0.056 (0.078)	−0.171 (0.105)	0.089 (0.082)	−0.196* (0.103)
Health tr.	−0.053 (0.085)	−0.083 (0.097)	−0.015 (0.089)	−0.119 (0.093)
Stage 2	0.020 (0.080)	0.78 (0.075)	0.024 (0.087)	0.068 (0.072)
Stage 3	0.119 (0.075)	−0.22 (0.080)	0.138* (0.080)	−0.019 (0.075)
Stage 2 × Environment	−0.020 (0.106)	0.112 (0.126)	−0.024 (0.111)	0.119 (0.125)
Stage 3 × Environment	0.007 (0.099)	0.257** (0.126)	−0.032 (0.104)	0.290** (0.124)
Stage 2 × Health	0.055 (0.112)	−0.045 (0.123)	0.035 (0.118)	−0.008 (0.120)
Stage 3 × Health	0.041 (0.106)	0.022 (0.128)	−0.001 (0.111)	0.078 (0.122)
Log-likelihood	−304.32	−180.19	−280.82	−203.94
Wald Chi-2	15.14	9.55	12.99	11.67
Panel groups	193	116	179	130
Observations	579	348	537	390
Characteristics of the clusters				
Vegetarian choice in Stage 1	–	–	0.179 (0.384)	0.177 (0.383)
Vegetables less than 5 times per week	0.254 (0.436)	0.121 (0.327)	0.246 (0.432)	0.146 (0.355)
Vegetables 5 to 7 times per week	0.435 (0.497)	0.440 (0.498)	0.436 (0.497)	0.438 (0.498)
Vegetables more than 7 times per week	0.311 (0.464)	0.440 (0.498)	0.318 (0.467)	0.415 (0.495)
Animal proteins less than 5 times per week	0.311 (0.464)	0.276 (0.449)	0.313 (0.465)	0.277 (0.449)
Animal proteins 5 to 7 times per week	0.482 (0.501)	0.552 (0.499)	0.486 (0.501)	0.538 (0.500)
Animal proteins more than 7 times per week	0.207 (0.406)	0.172 (0.379)	0.201 (0.402)	0.185 (0.389)
Male	0.503 (0.501)	0.474 (0.501)	0.475 (0.501)	0.515 (0.502)
Age	35.902 (7.230)	57.069 (4.811)	34.988 (6.691)	56.046 (5.426)
Family net monthly income in [0–1500]	0.181 (0.386)	0.164 (0.372)	0.196 (0.398)	0.146 (0.355)
Family net monthly income in]1500–2300]	0.202 (0.403)	0.198 (0.400)	0.184 (0.389)	0.223 (0.418)
Family net monthly income in]2300–3800]	0.461 (0.500)	0.371 (0.485)	0.453 (0.499)	0.392 (0.490)
Family net monthly higher than 3800	0.155 (0.362)	0.267 (0.444)	0.168 (0.375)	0.238 (0.428)
Openness	4.900 (1.099)	4.944 (1.197)	4.844 (1.089)	5.017 (1.192)
Conscientiousness	5.250 (0.875)	5.425 (1.006)	5.203 (0.873)	5.472 (0.982)
Extraversion	5.081 (1.261)	5.267 (1.157)	5.020 (1.266)	5.331 (1.145)
Agreeableness	4.838 (0.985)	4.963 (1.027)	4.788 (0.975)	5.018 (1.026)
Neuroticism	4.067 (1.310)	3.917 (1.183)	4.132 (1.275)	3.844 (1.233)

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses for Models (1) and (2) estimations.
Standard deviations in parentheses for the characteristics of the clusters.
Model (1): Among cluster 1, 58, 67 and 68 participants in treatments control, env. and health. Among cluster 2, 44, 37 and 35 participants in treatments control, env. and health.
Model (2): Among cluster 1, 52, 64 and 63 participants in treatments control, env. and health. Among cluster 2, 50, 40 and 40 participants in treatments control, env. and health.
Model (2) includes the same participants in Cluster 2 and adds 14 participants.

whereas Model (2) includes the same variables plus the participant's choice in Stage 1. The distribution of characteristics defining the two clusters are indicated below the estimates.

The effect of the environment treatment crossed with the third stage is significant for participants in cluster 2: in the presence of observational learning, environmental information significantly increases cluster 2 participants' likelihood to consume a vegetarian meal. Models (1) and (2) give similar results. This cluster 2 accounts for 37.5% of the consumers in Model (1) and 14 additional consumers in Model (2), i.e. 42.1% of the consumers. The models show that the environmental information significantly increases the likelihood of choosing a vegetarian meal for a subset of the sample. This leads to our fourth result.

Result 4. Provision of information about the negative consequences of meat consumption on the environment increases individual likelihood to choose plant-based proteins products among a subsample of the consumers.

Participants' food product choices show that they were not all equally affected by the provision of information on the negative consequences of meat consumption on the environment. The finding of a positive impact of the environmental information on the choices of plant-based protein food products among only a portion of consumers is consistent with the review by Graça et al. (2019), who emphasize that consumers differ in their meat consumption and willingness to substitute animal proteins with plant-based proteins. They show that the majority of studies are consistent in the finding that females consume less meat than males and are more open to following plant-based diets. This is also the case for consumers of higher socio-economic

status. Findings related to age are not consistent across studies, with some studies finding that younger consumers are more willing to follow plant-based diets, while in some other studies this is the case for older consumers. Graça et al. (2019) also focus on capability and opportunity variables, among them access to information, difficulty in cooking, or sensitivity to bitter taste (capability variables) and perceived norms or the importance of others in supporting the transition to a plant-based diet (opportunity variables). Consumers' motivation to reduce their animal protein consumption depends on many variables, such as beliefs or awareness of the consequences of following plant-based diets, taste experiences, perceived convenience, familiarity, meat attachment, etc. Consumption of plant-based proteins then clearly depends on consumers' individual characteristics, and our study additionally shows that the effectiveness of information interventions is also related to consumers' individual characteristics.

4. Discussion and conclusion

In this experiment, we investigated whether consumers substitute ready-made food products with animal proteins with ready-made food products with exclusively plant-based proteins when they receive information about the damage to the environment or health caused by meat consumption. We found that approximately half of the participants in our experiment always chose meals with animal-based proteins regardless of whether they were exposed to the information intervention. The information that the participants received did not significantly change their choices on average. This result suggests that consumers have strong habits or strong preferences regarding meat consumption and are not easily convinced to modify their behaviour in the short term. This result reinforces the recent literature on the

effect of information on meat consumption (Austgulen et al., 2018; Castellari et al., 2019; Edenbrandt and Lagerkvist, 2021; Edenbrandt et al., 2021). However, our results also show that when consumers were sorted according to their individual characteristics, a sub-sample responded to the information they received emphasizing the negative consequences of meat consumption on the environment by increasing the likelihood of participants to choose plant-based protein products. Our results also show that consumers who are reluctant to choose vegetarian meals at first increased their preferences for plant-based protein products when observing the full set of consumers' evaluations of the products, independently of the information they receive.

The lack of impact of information policy on the average consumer may come from the specificity of meat and its substitutes. Meat has a special characteristic, strongly anchored in consumers' habits. Indeed, meat has held a certain status in many societies for a long time (Fiddes, 1991); in the 1970s, for example, it was seen by consumers as the food product with the highest value, with meals structured around three components: meat or fish, a staple and vegetables (Douglas, 1972). Such preferences may be difficult to change, and meat is still currently one of the most popular food products in many countries (Verbeke et al., 2010). In addition, meat is generally perceived to be healthy (Verbeke et al., 2010). This belief is true if meat consumption is not too high, and therefore, consumers may not be aware of the negative effect of over-consumption of meat on health. In contrast, meat substitutes with plant-based proteins such as pulses are not spontaneously selected by consumers, perhaps due to a dislike of the taste, difficulty of preparation or perceptions of pulses as a food for vegetarians (Melendrez-Ruiz et al., 2019). It is certainly more difficult to induce substitution of animal proteins with plant-based proteins among consumers who have strong habits regarding meat consumption than among consumers with more flexible consumption habits.

Other explanations may be related to consumers' psychology. According to cognitive dissonance theory (Festinger, 1957), it is possible that consumers with strong preferences for meals with animal-based proteins form self-serving beliefs that minimize the negative consequences of meat consumption on the environment or their health. In this case, the information intervention may not be strong enough to modify their beliefs and then their consumption decisions. The same argument is used by Hestermann et al. (2017) to explain the meat paradox, which describes how consumers form self-serving beliefs and ignore the consequences of meat consumption for animal welfare.

4.1. Limitations and future research directions

The over-consumption of meat has important and various impacts on the environment and health. In this study, we focused on the use of water and the risk of developing a cardiovascular disease but many other consequences on the environment (e.g., greenhouse gas emissions, biodiversity, land use...) and health (e.g., risk of developing cancer, obesity, etc.) could have been emphasized. Also, the information was given with a summary and illustrated card but it could have taken many different other forms (e.g., scientific article, newspaper article, government communication, product labelling, etc.). Our study contributes to the literature on the impact of information on the substitution of animal proteins with plant-based proteins by studying real choices in a specific context. In order to obtain a comprehensive picture of the information intervention effects on real consumption, more work is needed and future research should continue to address this question.

The substitution of animal proteins with plant-based proteins is a difficult change to make that depends on consumers' individual characteristics, their experience and motivation or even their capability and opportunity (Graça et al., 2019). Participants in the experiment made three choices in total that may not be enough to observe significant changes in consumption. It would be interesting to conduct the same experiment on a longer period of time. The number of products offered

should also be increased to allow more potential substitutions. Replicating this type of experiment where consumers make real food choices with a larger sample of consumers representative of the population in France, and also in other countries in Europe or even wider would improve external validity and the scope of the results.

Meat attachment of some people can hinder consumption changes (Graça et al., 2015a). Because participants in the experiment were about 44 years old on average and 86% were older than 29 years old, they may be consumers with strong preferences for meat and information may not be sufficient to alter their product choices. It seems natural, then, to focus information interventions on younger people, such as children or teenagers (Wynes and Nicholas, 2017). We think that an important target for future research is the study of young people's reaction to information campaigns to shift food consumption behaviour towards more sustainable diets, including ones with less animal-based protein.

4.2. Policy implications

Our results suggest that providing information on the environmental or health damages associated with the consumption of animal proteins is not sufficient to significantly alter meat consumption in the short run: about half of the participants in the experiment consumed animal-based proteins at each of their three choices. In addition, we show that consumers were more likely to substitute animal proteins with plant-based proteins when they observed product evaluations by other consumers. Individual characteristics of the participants in the experiment had hardly any effect on food product choices. We conclude that consumers' preferences regarding meat are difficult to change with information provision, which confirms results of related studies (Austgulen et al., 2018; Castellari et al., 2019; Edenbrandt and Lagerkvist, 2021; Edenbrandt et al., 2021; Van Loo et al., 2020).

An information intervention on the longer run may induce higher effects. Thus, the first recommendation that our study suggests for public policy would be to repeat information interventions on the long term. Then, information campaigns can be coupled with other recommended policy interventions, such as consumer education, financial incentives or regulatory mechanisms. For instance, taxes on greenhouse gas emissions can affect meat consumption (Bonnet et al., 2018; Briggs et al., 2013; Edjabou and Smed, 2013) and may be less negatively perceived if they are accompanied by information campaigns. Some see change in norms as a key driver of global diet change (Eker et al., 2015; Higgs, 2015; Higgs and Ruddock, 2020; Nyborg et al., 2016; Sparkman and Walton, 2017). Possible changes in norms could be helped along by information policy interventions (Dasgupta et al., 2016), which may change preferences (Bowles, 1998). Information that presents the damages of meat consumption could also be complemented by some information presenting consumers with a transition framework and messages focused on good behaviours to adopt instead of the reasons why consumers should change their behaviour (de Boer and Aiking, 2019). Finally, we think that public policy-makers should take into account the diversity of consumer characteristics and motivations and adapt the related policies accordingly.

CRediT authorship contribution statement

Pascale Bazoche: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Nicolas Guinet:** Software. **Sylvaine Poret:** Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing. **Sabrina Teyssier:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.foodpol.2023.102426.

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