Consumers' Motivations towards Environment-Friendly Dietary Changes: An Assessment of Trends Related to the Consumption of Animal Products

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Abstract

In the context of global warming and environmental pressure, food chains must adapt to new production conditions while satisfying the evolving consumer demand. Livestock production is known for its negative ecological footprint, bringing forward the question of a possible transition towards more plant-based diets. Citizens' demand evolves at different speeds and integrates these new environmental concerns sometimes mixed with health or ethical issues. We carried out a survey with 1,715 respondents in France, about their food choice priorities and preferences, as well as the drivers of change. Our results indicate that 40% of respondents claim that their current diet is not what they would ideally have and 98% of them would like to reduce their animal product consumption. Classification algorithms reveals several salient variables separating classes of individuals wishing to shift their food diet towards less animal products: the willingness to change is stronger for the youngest, factors impacting the willingness to change are food pleasure, health and to a lesser extent social resistance and animal ethics. The less radical the animal products reduction is, the more environmental concerns become the main motivation.

1. Introduction

1.1. Background

Livestock production is known to have major negative effects on the environment (Godfray et al., 2018) and these are rising as global consumption of animals rises (Sans and Combris, 2015). Across studies, consistent evidence indicated that a dietary pattern higher in plant-based foods and lower in animal-based foods is associated with a lesser impact on the environment (Nelson et al., 2016; Seconda et al., 2018). In general, reductions in environmental footprints are proportional to the magnitude of animal-based food restriction (Aleksandrowicz et al., 2016) more precisely about climate change, the FAO estimated in 2013 that livestock production to be responsible for 14,5% of global greenhouse gases (GHG) emissions (Gerber et al., 2013). A worldwide study over 38,700 farms and 1,600 food processors shows that the carbon footprints of the lowest-impact animal products typically exceed those of vegetable substitutes (Poore and Nemecek, 2018). In the UK, the GHG emission of meat-eaters is twice as high as those in vegans (Scarborough et al., 2014). Across countries, vegan and low food chain diets (i.e. plant-based with forage fish, mollusks and insects) have the smallest GHG footprints (Kim et al., 2019). Reducing GHG emissions by reducing animal products consumption is only one side of the environmental benefits because livestock production is a major user of land worldwide, with an estimated use of 2.5 billion hectares (Mottet et al., 2017). Reducing animals production is not only reducing the carbon footprint of food but saving on land use is an opportunity that could additionally allow carbon sequestration at a massive scale. 1 billion hectares turned to forest and woodland would stock around two thirds of all GHG emissions since the beginning of the industrial revolution (Bastin et al., 2019). It is consequently no surprise that promoting plant-base diets is one among key measures to respect planetary environmental boundaries (Springmann et al., 2018). This recommendation for worldwide dietary change for the environment is reinforced by secondary effects as diets low in GHG have better overall diet quality and are more nutritious on several dimensions (Rose et al., 2019; Clark et al., 2019). These diets could bring substantial health benefits, reduce land clearing and species extinctions (Tilman and Clark,2014; Nelson et al., 2016), increase well-being, satisfaction, reduce food cost (Perignon et al.,2016) as well as bringing ethical benefits (Fehér et al., 2020).

However, despite compelling advantages, diet change towards plant-based diets remains limited. Modifications of dietary patterns evolve over the course of a person's life and are determined by a wide variety of factors (Povey et al., 1999; Vabo and Hansen, 2014). On the psychological aspect, while health and ethics have been key motivations towards plant-based diets in the past (Jabs et al., 1998), the environmental motivation seems on the rise (Ruby, 2012). As far as this environmental motivation goes, many factors influence consumers in their transition towards a climate-friendly plant-based diet such as personal, socio-cultural and external factors (Stoll-Kleemann and Schmidt, 2017). Identified hindrances for individuals to go towards plant-based diets relate to the lack of information and awareness, difficulty to get new cooking skills, diet balance concerns, pleasure of eating animal products, while enhancing the pleasure of plant-based food and enabling plant-based options in collective meals facilitates the transition (Graça et al., 2019; Fehér et al., 2020; Macdiarmid et al., 2016; Herzog, 2011).

1.2. Chapter Objectives

The focus of this chapter is to identify drivers –facilitating factors and hindrances– that may lead individuals to question their current dietary behaviors and consider changes towards reduced animal product consumption.

General Objectives

The general objective of the chapter is to discover these drivers through an empirical approach based on machine learning techniques applied to an extensive survey of more than 1,700 respondents in France.

Specific Objectives

The specific objectives of the chapter are:

1. To present the more salient answers to the survey.
2. To identify through machine learning, and more specifically classification techniques, the factors that best separate consumers who show motivation to move their current diets to less animal-based ones, from those who do not.
3. To analyze the status of environmental concerns within these factors. Are climate-related concerns prominent or secondary within the motivations expressed? Are other types of concerns involved, positively or negatively?

1.3. Chapter Outline

Section 2 presents the collection of data, the pre-processing of the raw data, and the classification models used. Section 3 highlights salient trends in the survey results, provides the classification results, and discusses the role of environmental concerns. Section 4 concludes with some perspectives.

2. Materials and Methods

The methodology used followed the following steps, detailed below: data acquisition, data pre-processing, problem reformulation in the form of a classification question, and classification method used.

2.1. Data Acquisition

In order to get insights on the drivers of individual behavioral changes towards reduced animal product consumption, we conducted an extensive survey, built an argument database from the scientific and grey literature and performed in-depth biographical interviews. All the collected

data are published in Salliou et al. (2019). This chapter focuses exclusively on the survey, which is presented hereafter. Interested readers may refer to Salliou and Thomopoulos (2018); Thomopoulos et al. (2019, 2020) for further information on the argument database and to Salliou and Thomopoulos (2020) for further information on the biographical interviews.

The survey was conducted among a panel of 1,715 French citizens. The questions belonged to the following categories:

- Key criteria in food choices
- Current food diet (Single question denoted by Q2)
- Past, ongoing or desired changes in food diet
- Attraction to various types of food
- Knowledge of alternatives to animal products
- Ideal food diet (Single question denoted by Q20)
- Reasons, hindrances and facilitating factors for reducing animal product consumption
- Ways of information practiced
- Socio-demographic information
- Agreement with 16 key arguments about animal product consumption.

These 16 arguments were extracted from the participatory online platform `Kialo` which allows users to co-construct argument hierarchies about any topic. We considered these arguments as central as they are the main and first degree arguments over a hierarchy of more than2,000 arguments expressed by over 1,400 participants about the topic of "humans should stop eating meat"[1].

2.2. Data Pre-processing

Splitting multiple-choice questions

Each multiple-choice question Q was splitted into n distinct boolean questions, where n is the number of possible answers to question Q.

For example, the multiple-choice question Q25 "I personally know a vegetarian and/or a vegan: (a) within my siblings, (b) in the rest of my family, (c) among my friends, (d) at work" was splitted into four distinct boolean questions Q25a "I personally know a vegetarian and/or a vegan within my siblings: yes/no", Q25b "I personally know a vegetarian and/or a vegan in the rest of my family: yes/no", and so on.

Hence, from 33 questions initially, the final number of columns is 112.

[1] https://www.kialo.com/the-ethics-of-eating-animals-is-eating-meat-wrong-1229?path=1229.0 1229.1

Encoding the categorical data

To facilitate the treatment by machine learning models, categorical data were converted into numerical values on an ordinal scale.

For example, in questionQ2"What is your current food diet?", the answer "Omnivorous" was encoded by 0, "Flexitarian" by 1, "Vegetarian" by 2 and "Vegan" by 3. The same encoding was used in question Q20 "Ideally, what would you like your food diet to be in the future?".

Feature scaling

The choice not to apply feature scaling was preferred, in order to avoid under-representing questions increasingly with the number of their possible answers.

2.3. Problem Formulation

From the description above, the questions addressed by this chapter can technically be summarized as:

- Do the global answers to Q2 and Q20 strongly differ?
- Considering the answer to each question Q as a variable (denoted by the same symbol Q for simplicity), what variables best separate the class of individuals for whom Q2=Q20, from the class of individuals for whom Q2≠Q20?

The latter is a classification problem. The classes to be separated are:

CLASS 0: Q2=Q20 (1045 samples)
CLASS 1: Q2≠Q20 (669 samples).

The explanatory variables are the 112 columns of the dataset, from which Q2 and Q20 were removed as irrelevant questions to compute the classification results, since they are used to define the output classes. The 110 remaining columns were thus used as explanatory variables.

2.4. Classification Method

After preliminary trials with all classification algorithms included in the `scikit-learn` Python package (Pedregosa et al., 2011), we ultimately selected Random Forest (RF) as the reference classifier for the following experiments, taking into account both average accuracy in a stratified 10-fold cross-validation and interpretability of its results. RF (Breiman, 2001) creates an ensemble of decision trees, training each one on a subset of the available data, thus reducing bias and delivering more robust predictions. RF determines relative variable (feature) importance, by evaluating the frequency of appearance of a variable in the splits of all the decision trees: The more a variable appears, the more important that variable is for the final

classification of the ensemble. For all experiments reported in this work, RF has default parameters[2], using a total of 100 decision trees.

Most classifiers, alongside their predictions, are also able to return a ranking of the relative importance of the variables in the problem, with the ones that best explain the variance in the results among the top. In order to obtain a more reliable ranking, RF is run in a 10-fold stratified cross-validation, and the rankings for each fold are aggregated in the final result.

3. Results and Discussion

3.1. Salient Trends in the Survey Results

As a first stage, the analysis of the global survey results allows setting out major observations concerning the central questions Q2 and Q20. Figure 1 displays the results obtained from the survey for questions Q2 and Q20.

"What is your current food diet?"

"Ideally, what would be your diet in the future?"

Fig. 1. Answers to questions about current and future diets

The results highlight that 40% of respondents claim their current diet is not what they would ideally like to have in terms of animal product consumption, which they would overwhelmingly like to reduce. In other terms, for 40% of the respondents, there is a gap between actual behavior –current food diet, asked inQ2– and personal convictions –ideal food diet, asked in Q20. This situation, denoted by "cognitive dissonance" from Festinger's seminal theory (Festinger, 1957), is known to be a first step towards an eventual change. This is explained by the fact that humans feel uncomfortable with internal contradiction. Citing Festinger (1957), "The existence of dissonance, being psychologically uncomfortable, will

[2] Random Forest Classifier:
https://scikit-learn.org/stable/modules/generated/sklearn.ensemble.RandomForestClassifier.html

motivate the person to try to reduce the dissonance and achieve consonance". In our case, dissonant individuals, i.e. belonging to CLASS 1, may try to solve the contradiction:

- By changing their dietary behavior to best fit their convictions. This case is primarily captured by the present survey and study. Indeed, dissonant individuals may tend to question and reconsider their food habits, and envision the reduction of animal products as a possibility.
- By modulating their convictions to best fit their actual dietary behavior, especially if the latter is perceived as difficult to change. This is observed in Festinger (1957): "Post-decision dissonance may be reduced by increasing the attractiveness of the chosen alternative, decreasing the attractiveness of the unchosen alternatives, or both". This means dissonant individuals may tend to focus on arguments that foster animal-based diets, or depreciate plant-based diets (Salliou and Thomopoulos, 2020), to justify their food habits.

Section 3.2 explores the variables that best separate the class of dissonant individuals (CLASS 1) from the class of consonant ones (CLASS 0).

3.2. Classification Results

The histogram of Figure 2 shows on the X-axis the list of variables selected in the 10 folds of RF stratified cross-validation, and on the Y-axis the number of folds each variable was selected in. This number may vary from 1 –if the variable was selected in one fold only– to10 –if the variable was selected in all of the ten folds. The mean accuracy obtained for the classifier was 0.65.

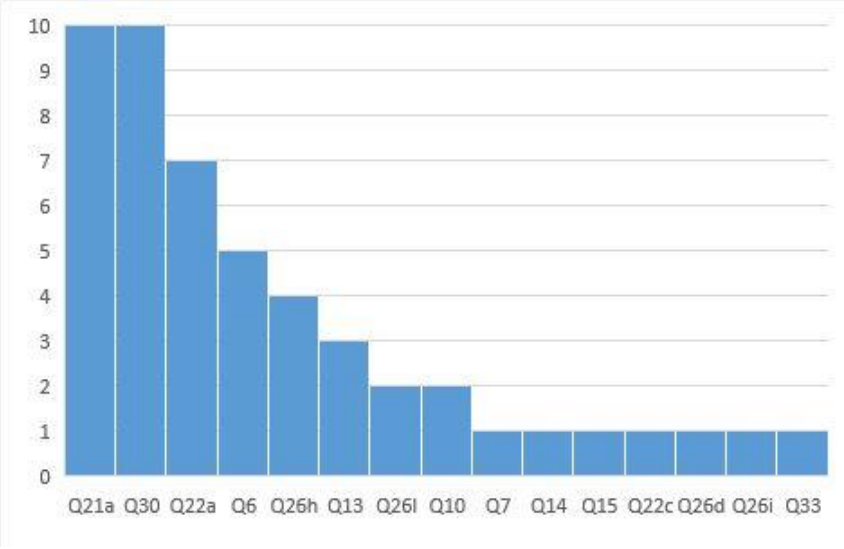

Fig. 2. Top-ranked variables

The survey questions corresponding to the top-ranked variables are detailed in Table 1.

Table 1. Questions corresponding to the top-ranked variables

Best explanatory variables (selected in at least half of the 10 folds)	
Q21a	Do you agree with the statement "I do not feel concerned by reducing the consumption of animal products"?
Q30	How old are you?
Q22a	Do you agree with the statement "I am not trying to reduce my consumption of animal products"?
Q6	On a scale of 0 to 10, to what level would you like to reduce your consumption of animal products?
Complementary explanatory variables (selected in 20 to 40 % of the 10 folds)	
Q26h	Do you agree with the statement "Eating animal products makes me happy"?
Q13	On a scale of 0 to 10, how much do you enjoy seafood?
Q26l	Do you agree with the statement "Vegetarian diets are better for health"?
Q10	On a scale of 0 to 10, how much do you enjoy eggs?
Explanatory variables involved to a lesser extent (selected only once in the 10 folds)	
Q7	On a scale of 0 to 10, how much do you enjoy red meat?
Q14	On a scale of 0 to 10, how much do you enjoy honey?
Q15	On a scale of 0 to 10, how much do you enjoy cereals?
Q22c	If you are trying to reduce your consumption of animal products, do you agree with the statement "My family's habits make this goal difficult for me"?
Q26d	Do you agree with the statement "Eating animals involves harming killed animals to obtain them"?
Q26i	Do you agree with the statement "Animals suffer"?
Q33	What is your occupational status?

We can notice that, within the best explanatory variables (top 4, selected in at least half of the 10 folds), 3 out of 4 play a role of "control" variables. Indeed, questions Q21a, Q22a and Q6 provide confirmation of the coherence of respondents' answers, in the sense that:

- Agreeing with the assertion of Question Q21a "I do not feel concerned by reducing the consumption of animal products" can be interpreted as a statement of cognitive consonance. The respondent does not perceive any issue in consuming animal products. This is clearly in line with membership in CLASS 0, the group of consonant individuals. Obtaining Q21a within the top-ranked variables is thus not surprising.
- The same observation can be made for Question Q22a. The assertion "I am not trying to reduce my consumption of animal products" is coherent with stating actual and ideal diets are identical, i.e. providing the same answer for Q2 and Q20, which is the definition of CLASS 0.
- Finally, Question Q6 "On a scale of 0 to 10, to what level would you like to reduce your consumption of animal products?" is a quantitative variant of Question Q22a. Respondents of CLASS 0 are logically expected to provide high-valued answers to Q6, since they perceive little dissonance in consuming animal products. On the contrary, low-valued answers to Q6 are coherent with CLASS 1, whose ideal diet is less animal-based.

More informative is the identification of Q30 “How old are you?” as a top-ranked explanatory variable. In order to gain a deeper insight into the relation between age and dissonance concerning the consumption of animal products, a visual representation of the classification helps analyze the results. Since the classification method used (RF) is based on an ensemble of decision trees, in Figure 3, we present one decision tree obtained. It was displayed using the `Orange` software (Demšar et al., 2013). Only the five first levels of the tree are depicted. The blue color is associated with CLASS 0, the red color with CLASS 1. The classification accuracy of this decision tree is 0.643, which is very similar to the mean accuracy obtained for the RF classifier.

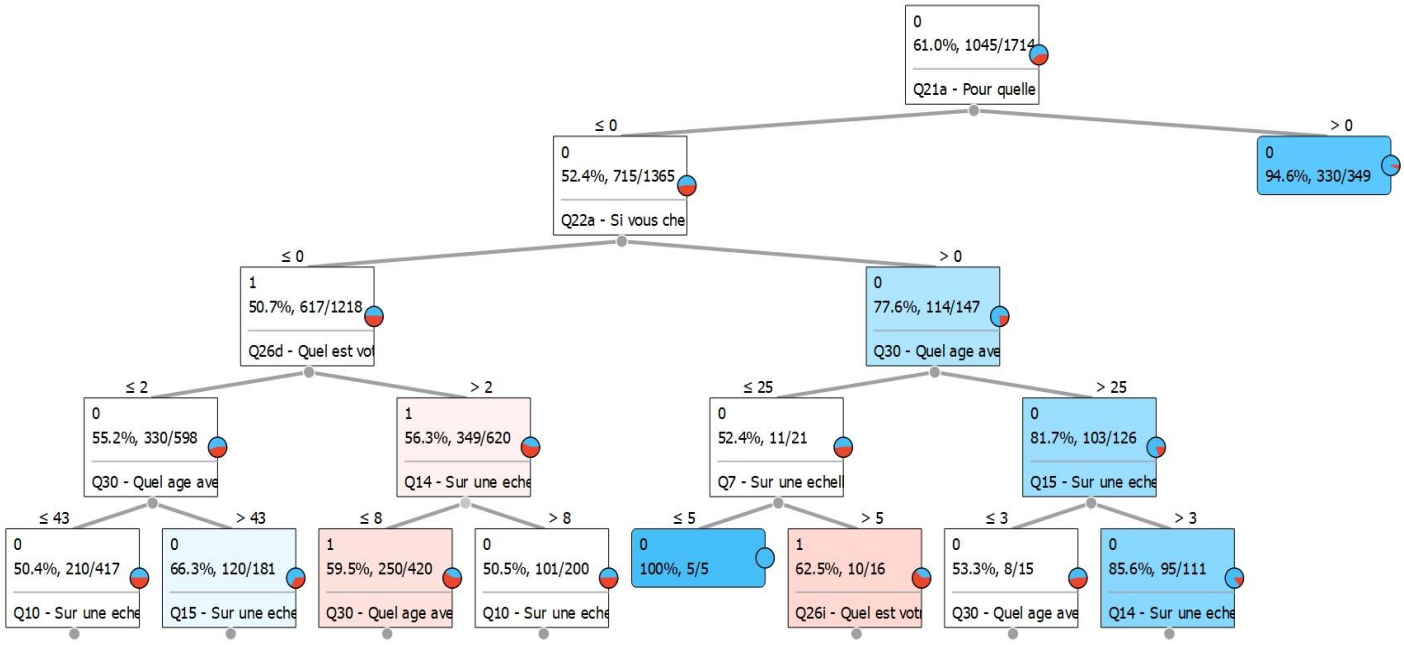

Fig. 3. Decision tree visualization

Once computed the first two splits accordingly to Q21a and Q22a, the use of Q30 as of the third split highlights cognitive dissonance is higher for young respondents, below 25 years old. In other words, within the individuals stating that (i) they feel concerned by reducing their consumption of animal products and (ii) they are trying to reducing their consumption of animal products, the wish of a different food diet than the actual one is stronger for the young. Q30 also appears in other parts of the decision tree, with the same trend observed i.e. a higher dissonance for the young. Conversely, this result also implies the wish of diet change, although present, is less radical for the older respondents, who would thus rather make smaller changes in their food habits within the same category of food diet.

The rest of the explanatory variables selected are discussed in the next section.

3.3. The Role of Environmental Concerns

The classification results above provide some clues about the main concerns that distinguish the respondents who consider, or not, a deep change in their food diets:

1. The overwhelming majority of the rest of selected variables (see Table 1) concerns the pleasure of food. This is true for variables Q26h, Q13, Q10, Q7, Q14 and Q15.
2. Quite well-ranked is the question of health, with Q26l.
3. A social hindrance explicitly appears in the results, namely the family's habits (Q22c).
4. Ethical concerns related to animal suffering are also present in the result list, through Q26d and Q26i.

In the shift towards less animal-based diets, environmental-related issues do not seem to play a prominent role in the motivations expressed, which first consider food pleasure, and to some extent health, social resistance, and animal ethics.

That being said, however, one must keep in mind that these variables are those which best separate dissonant from consonant individuals, i.e. the variables involved in the wish (or not) for deep diet changes led by a sense of inconsistency. Beside this case, motivations in daily food choices and reasons for more discrete changes in food habits warrant further examination. Therefore, direct respondents' answers also have to be consider, about their priorities in food choices (Question Q1), and their reasons to consider reducing animal product consumption (Question Q21). The results are shown in Figures 4 and 5, respectively.

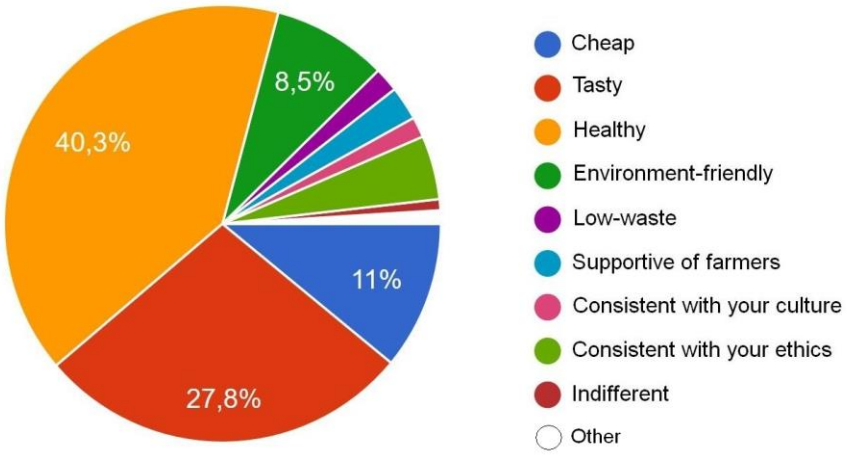

Fig. 4. Question Q1 "Above all, you expect the food you choose to be..."

Answers to Question Q1 (Figure 4) confirm the importance of health concerns for food choices in general, cited as the priority by 40.3% of respondents, and of food pleasure, cited as the priority by 27.8% of respondents. It is worth noting that, compared with the classification results, the ranking of these concerns is reversed. Respondents seem to somehow overestimate rational motivations (health), compared with the results computed by machine learning (food

pleasure first). The next criterion cited is food price, with 11% of answers. Then comes the environment, cited as the priority by 8.5% of respondents, followed by ethics. The latter was more significant in the classification results, thus ethics seems to have a stronger involvement in the feeling of inconsistency likely to induce deep diet changes.

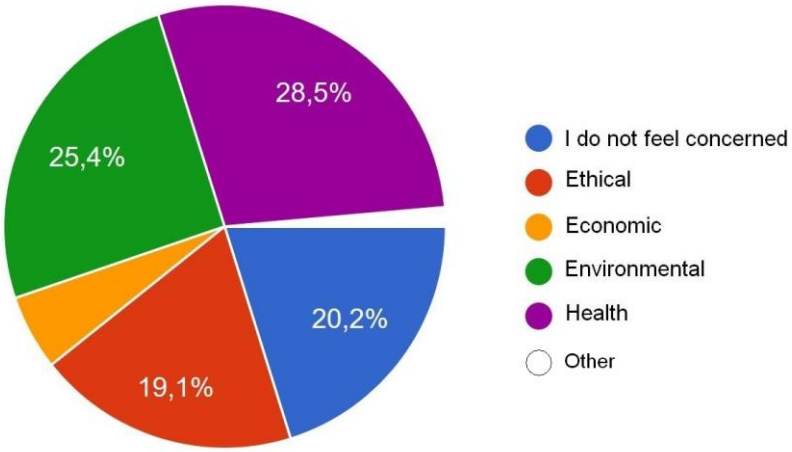

Fig. 5. Question Q21 "What is the main reason that makes you feel concerned by reducing the consumption of animal products?

Answers to Question Q21 (Figure 5) specifically concern the reasons for reducing animal product consumption. They still place health at the top of the list of reasons, with 28.5% of the answers. However, this time, health is closely followed by environmental concerns, with 25.4% of the answers. Then comes the "indifferent" answer ("I do not feel concerned") as well as ethical concerns, both around 20%, ahead of economic issues such as product price.

From these results, first, we can note that consumer awareness of the environmental impact of animal products is high. Indeed, compared with food choices in general (Question Q1), the results express a clear prominence of the status of environmental issues concerning animal products (Question Q21). The same observation can be made on ethical issues, which are more represented in the case of animal products. Overall, only 20% of respondents claim not to feel concerned by reducing animal product consumption, which is well below the 60% who do not envision a change in their food diet (CLASS 0). This observation supports the hypothesis of a possible less radical change than a shift in food diet, for the greatest number.

3.4. Achievements and limitations of the study

The previous sections 3.1 to 3.3 respectively addressed the three specific objectives stated in the introduction and pursued along the chapter, namely (1) salient trends deduced from the answers to the survey related to motivation for diet change, (2) best explanatory variables identified involved in motivation for reduced animal product consumption and (3) role of environmental concerns in motivation for reduced animal product consumption.

However, several questions remain. In particular, a deeper analysis of motivations per diet type (omnivorous, flexitarian, vegetarian, vegan) would allow policies to design targeted messages with regard to global warming. In this perspective, focusing on the category of omnivores who turn out to be dissonant regarding their actual food diet, seems the most promising. Indeed, omnivores constitute the large majority of individuals who could possibly make environment-friendly changes in their food diets and therefore reduce the food carbon footprint of the population.

Another insight would consist in better identifying the contours of the flexitarian category. "Flexitarian" is a fuzzy category of those who do not systematically consume meat, but deliberately somehow limit their consumption of meat, for highly variable reasons. Comparing their motivation profiles with those of omnivores or vegetarians would thus be instructive.

4. Conclusion

The drivers that lead individuals to consider diet changes towards reduced animal product consumption were explored through machine learning, applied to an extensive survey of 1,715 respondents in France. The main findings are:

1. Salient answers to the survey: The analysis revealed that there is a gap between current food diet and ideal food diet, for 40% of the respondents. This situation, known as "cognitive dissonance", is stronger for the young.
2. Main explanatory factors: Discriminant factors are food pleasure issues, health concerns and to a lesser extent social resistance and animal ethics.
3. Status of environmental concerns: Although environmental concerns do not appear significant in explaining such dissonance, they become prominent when it comes to motivating more discrete food changes towards a reduction of animal product consumption.

The latter finding consolidates the idea that the dynamics of emergence of daily changes in dietary habits, however slight, should be explored. A particularly suitable tool to carry such an exploration is agent-based simulation, which, by representing individual behaviors, allows one to understand and explore the impacts of these behaviors on the overall dynamics of a population. Several works such as (Thomopoulos et al., 2019; Taillandier et al., 2019) propose models of opinion change in terms of consumption of meat products. In particular, Taillandier et al. (2019) proposes to explicitly model the exchange of arguments between individuals and studies how these exchanges impact opinions regarding the consumption of meat products. However, both models only focus on the construction of opinions and do not simulate the gaps between food habits and attitudes towards food. It would therefore be particularly relevant to enrich them with new mechanisms to represent transitions between attitudes and practices.

Ongoing work is dealing with daily food choice in the short term, as opposed to the "ideal" choice in the long term towards a reduction in meat consumption. This is where

social norms seem to be an important source of inertia. The analysis of the biographical interviews carried out in Salliou et al. (2019); Salliou and Thomopoulos (2020) showed that social pressure was a major factor for abandoning the adoption of meatless diets. In ongoing simulations, we hypothesize that social acceptance of less meaty diets is underestimated, which is in line with the results of the present chapter. The objective is to observe the effect of a few individuals following their desired food diet, on the whole population over time.

Acknowledgements

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