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The influence of information about nutritional quality, environmental impact and eco-efficiency of menu items on consumer perceptions and behaviors

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A R T I C L E I N F O

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A B S T R A C T

While food and dietary patterns are major determinants of a population's health, our daily food choices also put pressure on the environment. In that context, providing graphical and comprehensive information is a widely used and potentially promising communication tool to promote healthier and more environmentally sustainable choices when eating out-of-home. Hence, the purpose of this study was to assess the influence of information about environmental impact and nutritional quality of meal options on consumers' food choices, consumption and perceptions. A total of 80 men and 80 women were recruited, consisting of students and employees of *Université Laval (Quebec City, Canada)*. Participants were randomly assigned to one of four experimental conditions, with menu information displaying: 1) greenhouse gas emissions scores, 2) nutritional quality scores, 3) eco-efficiency scores or 4) no information (control). Participants had to choose between two meals (i.e., beef burritos or chicken meal) both showing one of the above-mentioned conditions and then consume the chosen meal. Results indicated that nutritional and environmental information had an impact on meal choice. More specifically, participants exposed to such information tended to choose more frequently the meal with the most favorable score for the related condition (p-values < 0.05). However, no impact was observed on the amount of food consumed (p-values > 0.05). These findings suggest that communicating information about environmental impact and nutritional quality of menu items to consumers within institutional settings could be relevant to tackle more sustainable food choices.

1. Introduction

As known for many years, food and dietary patterns are major determinants of a population's health (Hu, 2002). The importance of a healthy diet in preventing chronic diseases is now well demonstrated by scientific studies and improving the diet of various populations could prevent one fifth of deaths worldwide (Afshin et al., 2019). In addition to the issues associated with public health, our daily food choices also have environmental impacts. The food system is itself responsible for one-third of global anthropogenic greenhouse gas (GHG) emissions (Crippa et al., 2021). The amount of GHG emissions that a product generates during its life cycle can be expressed as an impact score in a unit common to all contributions within the impact category, e.g., in kilogram of carbon dioxide equivalent *(kg CO_2 eq.)*, which can also be designated as the carbon footprint (Finnveden et al., 2009; Röös, Sundberg, & Hansson, 2014). GHG emissions of food are indeed produced at every stage of the food supply chain including food production, storage, distribution, processing, packaging, retailing, marketing, preparation, consumption

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and waste management (Fanzo et al., 2017; Röös et al., 2014).

Although not all the responsibility can be placed on their shoulders, consumers could play a significant role on the environment by making informed food choices that benefit both the environment and their own health (Macdiarmid, 2013; Poore & Nemecek, 2018). There is growing evidence that health and environment "wins-wins" are possible (World Health Organization, 2018). In 2019, the EAT-Lancet Commission released a report, which defined global scientific objectives for healthy diets and environmentally sustainable food production allowing a "win-win" universal combination (Willett et al., 2019), showing that these two aspects can easily be paired. Moreover, in the last few decades, the importance given to sustainable development in food production appears to have increased since consumers in industrialized countries are more and more interested in ethical and environmental information about food (Sautron et al., 2015). However, this growing awareness does not automatically translate into actual sustainable choices and behaviors (Bray, Johns, & Kilburn, 2011; Vermeir & Verbeke, 2006).

In that context, the use of communication tools and the presence of information could have an impact in enhancing consumers' knowledge, influencing their attitudes and redirecting their food choices and behaviors (Verbeke, 2008). To do so, various informational policies and tools have been developed by public health organizations. For example, there are specific nutrition labelling requirements for all prepackaged foods and beverages in Canada to provide consistent information and help consumers make informed choices (Government of Canada, 2015). However, there is no national menu labelling regulations, and other than in chains restaurants in Ontario (where menu labelling is mandatory) (Government of Ontario, 2015), consumers are unlikely to receive an information at the point of sale regarding the nutritional quality of the foods they are purchasing and consuming. However, the budget allocated by households to their out-of-home meals seems to have increased in the last years, notably in restaurants (Statistics Canada, 2020). Such changes in eating habits might encourage poor dietary choices, since consumers are less likely to receive information on the nutritional content of their ready-to-eat meals. To address this gap, the use of graphical and comprehensive information represents a promising communication approach to improve consumer understanding of the nutritional information of food or meals sold in different sectors (Ikonen et al., 2019). Although this strategy appears to be generally effective in improving food choices, there is still some variability in the effectiveness reported between studies, where several reviews suggest that qualitative information and interpretive logos seem to have a greater beneficial impact (Fernandes et al., 2016; Hoefkens et al., 2011; Sinclair, Cooper, & Mansfield, 2014). Also, posting logos to inform consumers is also increasingly applied in the context of environmentally sustainable consumption. Carbon footprint labels are considered as one of the youngest food eco-labels (Spaargaren et al., 2013). Consumers' perceptions seem to be quite positive about such labels, but the impact over meal choices and carbon emissions reduction seems to be moderate (Brunner et al., 2018) or even quite small (Slapø, 2016; Spaargaren et al., 2013) in canteen practices and restaurants. Several reasons have been evoked to explain this slight gap, such as the confusion in interpreting these carbon labels or the lack of understanding and awareness of consumers (Gadema & Oglethorpe, 2011; Hornibrook, May, & Fearne, 2015). The use of traffic-light color labels seems however to be the most useful way of presenting this information (Spaargaren et al., 2013).

Furthermore, a recent systematic review regarding protein consumption concluded that all possible factors should be simultaneously addressed to increase the opportunities of promoting changes in food behaviors, including health and environment (Hartmann & Siegrist, 2017). Pulkkinen et al. also suggested that combining communication about health and climate change should be further studied (Pulkkinen et al., 2015). Using both nutritional and carbon footprint information might have the potential to promote healthier and more environmentally sustainable choices when eating out-of-home. A few studies have examined the impact of nutritional information combined with the carbon footprint of food products on consumer's choices but to date, merely hypothetical choices have been evaluated (Hoek et al., 2017; Huang, et al., 2021; Michiel et al., 2021; Osman & Thornton, 2019). Studies nevertheless report a favorable response from consumers. Osman and Thornton observed a trend from consumers toward making meal choices with lower GHG emissions and lower calorie content when environmental and nutritional information was introduced through a dual traffic-light labeling in a hypothetical simulated canteen environment (Osman & Thornton, 2019).

However, to our knowledge, no study has yet examined the influence of the information about the nutritional quality and environmental impact of meals on the perception and actual behavior of consumers in the context of a university cafeteria. Thus, the overall objective of this study was to assess consumer's perceptions of information regarding environmental impact and nutritional quality of meals in a cafeteria setting. To do so, we more specifically aimed to determine whether the presence of this information influences food choice and food consumption among students and workers at *Université Laval (Quebec City, Canada)*. We then further examined which particular characteristics of study participants (e.g. gender, age, BMI, occupational status, environmental attitudes, nutritional knowledge and other socio-demographic characteristics) may explain the potentially observed differences in their food choice and dietary intake based on the type of information presented on the menu. We hypothesized that individuals' food choices, consumption, and perceptions are influenced by the information available on menus regarding the nutritional quality and carbon footprint of meals. We also hypothesized that a certain variability in food perceptions and behaviors exists across different groups according to socio-demographic and other characteristics, such as gender, age, level of education, family income and environmental attitudes.

2. Methods

2.1. Participants

The research team recruited 80 men and 80 women between March and November 2020 through *Université Laval* community's mailing list. Recruitment was originally planned to take place from March to July 2020. It started in the beginning of March but had to be rapidly stopped due to COVID-19, and then resumed from July to November 2020. Eligibility to participate in the study was determined by an individual short phone interview. Participants had to be aged between 18 and 65 years and had to be a university student, worker or both. Exclusion criteria were having food allergies or intolerances and using medication that could affect appetite sensation and food intake (e.g., corticosteroids, antidepressants, antipsychotics). Pregnant or lactating women were also excluded. A brief questionnaire was used to confirm a moderate or higher favourable attitude towards 80 % of the food items offered on the cafeteria menu used as the basis for the study (>2 on a five-point Likert scale). As there were no vegetarian meals in the two choices, vegetarian individuals were indirectly excluded from the study as well.

All procedures of this study, which includes human participation, were approved by the *Université Laval* Ethics Committee (2019–349/16–12-2019). Each participant gave its informed consent and received CAD $20 for his/her participation.

2.2. Study design and procedures

All participants were asked to come to a single and individual session (between 11:00 AM and 2:00 PM) at the Clinical Investigation Unit (CIU) of the Institute of Nutrition and Functional Foods (INAF) in a pre-meal state (i.e., not having consumed any meal/snack/beverage 2 h prior to the session, except for water). The meeting lasted approximately one hour. Participants had to choose and consume a meal, as offered by the campus cafeteria. The meal choices (n = 2) presented to them had been previously determined based on the results of life cycle assessment (LCA) and nutritional profiling of different meals truly offered at *Université Laval*. The experimenter read the menu to the participant, left a few minutes to the participant to read it again if needed and make his/her decision. Since participants could change their eating behaviors if they knew the real purpose of the study, they were told the aim was to conduct a taste-rating task of new meals for the food operator. In this context, they had to fill a taste rating scale during the meal. See Fig. 1 for experimental design and testing session.

2.2.1. Menu development

Two main meal choices were presented to each participant. These two meals were chosen so that scores would differ enough to allow consumers to acknowledge a significant difference between both options. It is worth mentioning that for the two meal choices, the most "advantageous" scores for each condition (nutritional, GHG and "eco-efficiency") were always in favor of the same choice since nutrition and environment are generally paired (Willett et al., 2019). The graphical information illustrating the scores had been developed specifically for this study by the University's design and communication department and were presented as traffic-light colored labels (see Fig. 1). Two "extreme" meals, with their respective scores associated with the condition, were also presented on each menu as reference values to promote understanding among participants (i.e., ground beef poutine as the extreme unfavorable choice for all conditions and vegetable tofu stir-fry on rice as the extreme favorable choice for all conditions).

Once accepted in the study, participants were randomly assigned to one of the four experimental conditions: 1) menu displaying the GHG score only; 2) menu displaying the nutritional score only; 3) menu displaying an "eco-efficiency" score, which represents a combination of the GHG score and the nutritional score or; 4) menu with no information (control) (see Fig. 1 for experimental design of the study and Table 1 for contingency table of the four conditions). Randomization was performed according to gender (n = 20 men and n = 20 women per condition). The only differences between the four menus were the respective scores and the information explaining the scores. Menus were pre-tested with volunteers other than the study participants. See Fig. S1 in Supplementary Materials for an example of menu (i.e., French version of GHG score menu).

2.2.2. Score calculation

2.2.2.1. Nutritional quality score. Nutritional composition of the meals was determined using the *Nutrific* online tool (https://nutrific.fsaa.ulaval.ca), which is developed by *Université Laval* and based on the Canadian Nutrient File (CNF) version 2015 (Government of Canada, 2018). Nutritional composition data were then used to determine the nutritional quality score of each meal with the Nutrient-Rich Food Index 9.3 (NRF9.3) nutrient profiling tool (see Tables S1 and S2 in Supplementary Materials for more details). This tool represents the sum of the percent daily values (DVs) provided by a food or meal for nine nutrients whose consumption is "to be encouraged" (protein; fiber; vitamins A, C, and E; calcium; iron; potassium; and magnesium), from which is subtracted the sum of the percent DVs for three nutrients "to be limited" (saturated fat, added sugars and sodium). Because data on added sugars are not readily available in Canadian food databases, total sugars were used instead, with 100 % DV set to 100 g, as per Health Canada's Table of DVs for nutrition labelling (Government of Canada, 2016). Calculations of the NRF9.3 were based on a unit of measurement of 100 kcal and each nutrient could not exceed 100 % of its DV to avoid overvaluing foods that provide very large amounts of some specific nutrients (Drewnowski, 2009). The 9.3 version of the NRF was selected notably because it represents the index that obtained the best validation results (Drewnowski, 2009; Fulgoni, Keast, & Drewnowski, 2009) and because different variations of this tool have already been associated with the carbon footprint in the scientific literature (Drewnowski et al., 2015).

Table 1
Contingency table of the four experimental conditions.

		Presence of nutritional quality information	
		YES	NO
Presence of environmental information	YES	Eco-efficiency; n = 40	GHG; n = 40
	NO	Nutrition; n = 40	Control; n = 40

2.2.2.2. Environmental impact score. A standardized method for quantifying the environmental impact of a product at one or more of its supply chain stages is the life cycle assessment (LCA) (Finnveden et al., 2009; Röös et al., 2014). The environmental impact analysis of both menu items was performed using LCA approach according to the *ISO 14044:2006* standard (International Organization for Standardization, 2006). Despite some limitations, this approach remains a primary means to estimate the food's environmental impact (Clune, Crossin, & Verghese, 2017). Indeed, the use of GHG emissions estimated by LCA represents the most widely used measure of the environmental impact of diets in the literature (Jones et al., 2016). The functional unit was defined as being the production of food ingredients composing a one menu item. The system boundaries were fixed from cradle to farm (and when possible, to processing) gate. The CNF was used to make the conversion from cooked to raw food to perform the LCA (Government of Canada, 2018). The transportation and cooking were excluded from the analysis because this information was not available for the most part of analyzed food ingredients. The Open LCA software version 1.10.2 (GreenDelta, 2021) and the international database *Ecoinvent version 3.6* ((Ecoinvent, 2021) Zurich, Switzerland) were used to assess the LCA of studied meals, completed when needed with *Agribalyse* (ADEME and INRAE, 2020) and scientific literature. The life cycle impact assessment was conducted by

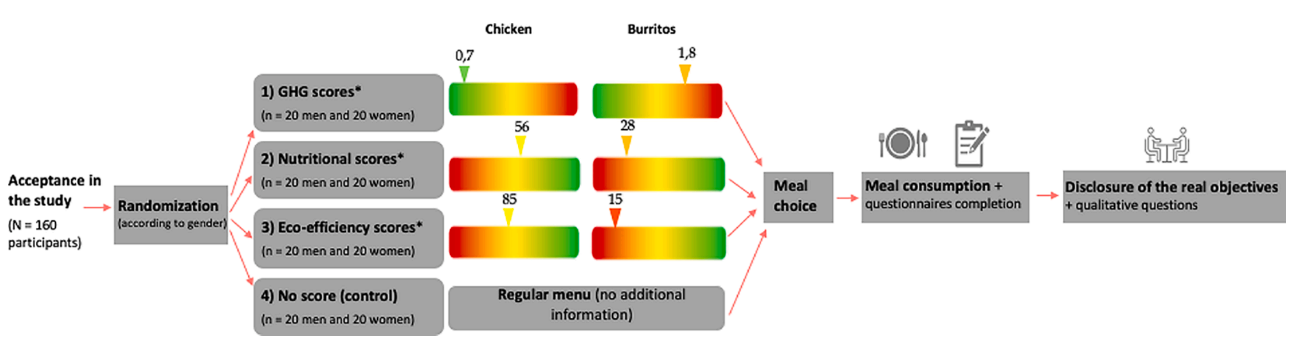

Fig. 1. Experimental design of the study and testing session. *All experimental score groups had, in addition to the respective scores on their menu, complete explanations of these scores (See Figure S1 for the complete French version of GHG score menu).

using Impact World + method (Bulle et al., 2019) and the midpoint category Climate change (short term) was chosen to illustrate the environmental impact score (or GHG score).

2.2.2.3. Eco-efficiency score. Thereafter, the eco-efficiency score was calculated for each menu item. The concept of eco-efficiency can be defined by the ratio of product or service value to its environmental impact (Lehni & World Business Council for Sustainable, 2000) according to the *ISO 14045:2012* standard (International Organization for Standardization, 2012). For the present study, the eco-efficiency score was calculated by dividing the nutritional quality score of the menu item by its GHG score. Calculation of the scores occurred prior to the experimental phase, i.e., during Fall 2019 and Winter 2020.

2.3. Questionnaires

After the taste rating survey, questionnaires were completed by each participant. The New Ecological Paradigm Scale (NEP) was used to measure attitudes and concerns towards nature and the environment (Dunlap et al., 2000; Schleyer-Lindenmann et al., 2016). The Food Choice Motives questionnaire was used to assess what guides participants' choices at the grocery store into nine dimensions scores (ethics and environment, traditional and local production, taste, price, environmental limitation, health, convenience, innovation and absence of contaminants) (Sautron et al., 2015). Participants also had to fill the Intuitive Eating Scale (Carbonneau et al., 2016), the Nutrition Knowledge questionnaire (Bradette-Laplante et al., 2017), the Food Liking Questionnaire (Carbonneau et al., 2017) and a sociodemographic questionnaire which covered aspects such as ethnicity, salary, education level and matrimonial status.

2.4. Food choices, consumption and perceptions

Levels of hunger and satiety were assessed before and after the meal on a 150 mm visual analogue scale, which consisted of four questions. The amount of food consumed was measured by weighting the plate before and after the meal. From the quantities consumed in grams, it was possible to estimate the quantities of calories consumed relatively to the chosen meal. At the end of the testing session, as a manipulation check, each participant was asked to provide its opinion regarding the real objective of the study. They were then informed of the actual purpose of the study. The choice of meal and the reasons expressed by the participant were entirely documented with opened questions as 'Which influence do you think the information provided on the menu may have had on your choice and on your appreciation of the meal?', 'How else could the information have been distributed?' and 'What other information could have been provided in order to make better choices for both your health and the environment?'. Finally, a second written consent was provided to allow the use of collected data and participants were asked to not talk about any of the details of the study with other people who might participate afterwards.

2.5. Anthropometric measurements

Participant's height and weight were measured just before they were told the real objectives of the study, and BMI was then calculated (kg/m^2).

2.6. Statistical analyses

Prior to the study, sample size estimations determined that 160 participants ($n = 80$ males and $n = 80$ females) were minimally needed to be able to detect a significant difference in the meal chosen between the four groups with an α level of 0.05 and a power (1- β) error probability of 0.80. To assess the primary objective of the study, logistic regression analyses were used to determine how the presence of environmental and nutritional information, separately (conditions 1, and 2) or combined (condition 3), was associated with the meal chosen by participants compared to the control group (condition 4), and to identify which covariates were also associated with the participants' food choices. Odds ratios (OR) and 95 % confidence intervals (CIs) were calculated. An OR above 1 reflected a higher likelihood of choosing the chicken meal (i.e., the likelihood of being influenced by the type of information shown, and of choosing the meal having the most favorable score on the menu compared to the control group). A mixed model (ANCOVA) was used to determine the impact of each condition on food consumption, either in grams or kilocalories. Mixed models were then used to assess our secondary objective, namely the impact of nutritional and environmental information on the level of satiety after the meal as well as general appreciation of the meal. For these analyses, unstandardized coefficients (B) were presented to demonstrate the effect size of each variable and covariate over the outcomes in both raw and adjusted models. Residuals of categorical variables considered in the mixed model analyses were all normally distributed. GHG and nutrition scores interaction, which represent the difference between the total effect (eco-efficiency score) and the combination of the nutrition and GHG scores effect, has also been tested in the analyses. Moreover, considering that many variables can influence the outcomes of the study, several variables were used as covariates in all analyses: age, BMI, sex, occupational status, fasting time before the meal, levels of desire to eat before the meal, level of environmental consciousness, level of knowledge in nutrition, family income, highest level of education completed and whether or not they had children. Baseline characteristics between the four groups were compared using analysis of variance (ANOVA), the Kruskal-Wallis test and Chi-Square test depending on the type of variable. Differences at p-values < 0.05 were considered significant. All statistical analyses were performed using Statistical Analysis Software (SAS) Studio version 3.8 (SAS University).

3. Results

Baseline characteristics of the four experimental groups ($n = 20$ men and $n = 20$ women per group), i.e., GHG emissions score, nutritional quality score, eco-efficiency score and control group, are shown in Table 2. No dropout was observed, so all participants initially recruited were included in the analyses. No differences were observed in baseline characteristics between the four groups. However, further analyses were still adjusted for some of these characteristics because either the literature shows an influence of those variables over food choices and habits (Campos, Doxey, & Hammond, 2011; Drichoutis, 2005; Thøgersen & Nielsen, 2016), or the research team *a priori* considered them as influential. For all primary analyses, we present both raw and adjusted models.

3.1. Influence of environmental and nutritional information on food choice

Fig. 2 illustrates the proportions of meal chosen by participants according to each of the four experimental conditions, where the chicken meal was chosen more frequently in the three conditions that provided information on the menu. More specifically, Table 3 presents logistic regression analyses that aimed to identify the type of information associated with the meal choices. As shown, the likelihood of choosing the chicken meal was higher with the GHG, nutrition and eco-efficiency scores for both the unadjusted and adjusted models when the control group was used as the reference, while the three score conditions did not differ between each other ($p > 0.05$). Moreover, the total effect of the eco-efficiency score was lower than the combination of nutrition and GHG scores effect in the unadjusted model ($p = 0.03$), but no difference was observed in the adjusted model ($p > 0.05$).

Table 2
Baseline characteristics of the sample (n = 160).

	GHG score (n = 40)		Nutritional score (n = 40)		Eco-efficiency score (n = 40)		No score (control) (n = 40)		
Baseline characteristics	Mean	SD	Mean	SD	Mean	SD	Mean	SD	P-value
Age (years)	33.4	12.5	33.4	10.9	32.6	12.0	32.1	10.7	0.94
BMI (kg/m^2)	24.2	4.2	24.3	3.7	23.5	3.6	24.3	3.8	0.76
Pre-meal fasting time (mins)*	235.8	159.0	282.9	245.1	295.4	276.1	206.7	54.8	0.06
Pre-meal desire to eat (over a 150 mm scale)	113.7	23.8	112.4	22.6	115.1	27.3	109.1	24.1	0.72
New Ecological Paradigm Scale score (over 5)	4.1	0.5	4.0	0.6	4.1	0.5	4.0	0.4	0.64
Nutrition knowledge score (%)	71.1	12.4	71.1	8.4	69.5	10.6	71.9	9.0	0.76
	n	%	n	%	n	%	n	%	P-value
Occupational status									
University employee	14	35	14	35	14	35	12	30	0.49
Student	22	55	21	52.5	25	62.5	27	67.5	
Both	4	10	5	12.5	1	2.5	1	2.5	
Highest level of education									
High school	1	2.5	0	0	2	5	1	2.5	0.26
College	9	22.5	9	22.5	12	30	15	37.5	
University	30	75	31	77.5	26	65	24	60	
Family Income (CA$)									
0–19 999	11	27.5	5	12.5	12	30	14	35	0.48
20 000–39 999	4	10	6	15	5	12.5	3	7.5	
40 000–59 999	5	12.5	4	10	2	5	2	5	
60 000–79 999	8	20	5	12.5	5	12.5	7	17.5	
80 000–99 999	5	12.5	4	10	3	7.5	2	5	
≥ 100 000	5	12.5	10	25	13	32.5	10	25	
No response	2	5	6	15	0	0	2	5	
Have children	9	22.5	13	32.5	14	35	9	22.5	0.46

Continuous variables are described as means and standard deviations while categorical variables are described as numbers and percentages.
There is no significant difference in the baseline characteristics between the 4 groups (p > 0.05).
*Missing values: pre-meal fasting time (GHG: *n* 2; Nutrition: *n* 1; Control: *n* 1).

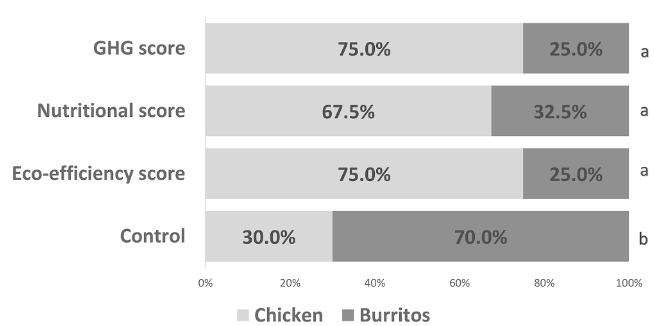

Fig. 2. Proportion of meal choices according to each condition. [a,b] Groups with unlike letters were significantly different (p<0.05).

3.2. Influence of environmental and nutritional information on food consumption

In terms of food consumption in grams, Table 4 shows that an information effect was observed in the unadjusted model when comparing each score condition with the control group. More specifically, participants in the eco-efficiency score group ate the least, followed by the GHG score group and nutritional quality score group. There was however no significant difference between the total effect of the eco-efficiency score and the combination of GHG and nutrition scores effect (p > 0.05). A similar pattern was observed for the unadjusted food consumption in terms of calories, except that calorie consumption did not differ between the GHG, nutrition and eco-efficiency conditions (p > 0.05). Also, the eco-efficiency score had a lower effect than the combination of the nutrition and GHG scores effect (p = 0.03) (see Table S3 in Supplementary Materials).

Once covariates were included in analyses of food consumption in grams, no more differences remained between each score condition and

Table 3
Odds ratios of the influence of the information over the selection of the chicken meal (i.e. the likelihood of being influenced by the type of information shown) and interaction between GHG and nutrition scores effect.

	Model 1 (No adjustment)			Model 2 (adjusted)		
Conditions	OR	95% CI	P-value	OR	95% CI	P-value
Control	(Ref)	(Ref)	(Ref)	(Ref)	(Ref)	(Ref)
GHG score	7.000[a]	2.615–18.738	**0.0001**	6.042[a]	2.028–18.001	**0.001**
Nutrition score	4.846[a]	1.882–12.482	**0.001**	6.071[a]	1.933–19.065	**0.002**
Eco-efficiency score	7.000[a]	2.615–18.738	**0.0001**	7.702[a]	2.549–23.272	**0.0003**
GHG and nutrition scores interaction[†]	0.206	0.052–0.825	**0.03**	0.210	0.043–1.033	0.05

Model 2: Odds ratios are adjusted for age, BMI, sex, occupational status, fasting time before the meal, levels of desire to eat before the meal, level of environmental consciousness, level of knowledge in nutrition, family income, highest level of education completed and whether or not having children.
Logistic regressions were used to create Models 1 and 2.
The % of correct classification for Model 1 is 71.9% and for Model 2 is 62.6%.
[a] GHG, Nutrition and Eco-efficiency conditions are not significantly different between each other (p > 0.05) using both models.
[†] GHG and nutrition scores interaction represent the difference between the total effect (eco-efficiency score) and the combination of the nutrition and GHG scores effect.

Table 4
Analysis of the influence of information over food consumption (in grams) and interaction between GHG and nutrition scores effect.

	Model 1 (No adjustment)			Model 2 (adjusted)		
Conditions	B	Std. Error	P-value	B	Std. Error	P-value
Intercept (control)	432.2[c]	13.5	(Ref)	396.0[ab]	14.7	(Ref)
GHG score	−79.4[ab]	19.1	**<0.0001**	−15.5[a]	13.1	0.24
Nutrition score	−47.3[a]	19.1	**0.01**	17.8[b]	13.7	0.20
Eco-efficiency score	−92.2[b]	19.1	**<0.0001**	−24.5[a]	13.0	0.06
GHG and nutrition scores interaction[†]	34.5	27.0	0.20	−26.9	18.4	0.15

Model 2: means and standard errors are adjusted for meal choice, age, BMI, sex, occupational status, fasting time before the meal, levels of desire to eat before the meal, level of environmental consciousness, level of knowledge in nutrition, family income, highest level of education completed and whether or not having children.
ANCOVA statistical tests were used to create Models 1 and 2.
[a,b,c] Mean values within a column with unlike superscript letters were significantly different ($p < 0.05$).
[†] GHG and nutrition scores interaction represent the difference between the total effect (eco-efficiency score) and the combination of the nutrition and GHG scores effect.

the control group. However, participants in the nutrition score group ate more than the GHG score group and eco-efficiency score group (Table 4).

In fact, the meal chosen represents the covariate that was mostly associated with food consumption, since participants choosing burritos ate more (ß = 143.6; $p < 0.001$) than those choosing the chicken. Also, men ate more than women (ß = 21.4; p = 0.03) and participants having children ate less than those not having any children (ß = −33.9; p = 0.01). Moreover, half the participants with a lower desire to eat before the meal (i.e., participants with ≤ 116 mm over the 150 mm scale) ate significantly less (ß = −20.4; p = 0.04) than those with a higher score of desire to eat before the meal (>116 mm). Food consumption in calories followed the same pattern than food consumption in grams when including covariates (i.e., Model 2), with the only exception that calorie consumption was lower in the eco-efficiency score group compared to the control group (ß = −36.8 kcal; p = 0.03) (see Table S3 in Supplementary Materials).

3.3. Influence of environmental and nutritional information on level of satiety after the meal consumption and on the general meal appreciation (over 150 mm scales)

For all secondary outcomes, only adjusted models were used, with the same covariates as in the adjusted model for food consumption in grams. There was no difference in the mean satiety after the meal between the four experimental groups. The chosen meal and gender were associated with this outcome: participants choosing burritos felt significantly more full (ß = 30.9; $p < 0.0001$) than those choosing the chicken meal and men felt less full (ß = −17.7; p = 0.004) than women after the meal.

The eco-efficiency score group differed from the other experimental groups in terms of the general appreciation of the meal chosen and eaten by each participant, regardless of the meal choice, since choice was included as a covariate. Indeed, participants from the control group and GHG score groups had a greater appreciation of their meal compared to those from the eco-efficiency score group (ß = 16.8; p = 0.002 and ß = 10.0; p = 0.05 respectively). The effect of the eco-efficiency score was however not significantly different than the combination of the nutrition and GHG scores effect for the general appreciation (ß = −3.32; p = 0.66). There was a small positive effect of the desire to eat before the meal on the general appreciation (ß = 0.21; p = 0.006).

4. Discussion

To our knowledge, this is the first study to assess the influence of information combining both nutritional quality and GHG emissions of meals on actual food choices, consumption, and perceptions among consumers, which provides more robust evidence than consumers intentions and hypothetical choices. The influence of these two types of information was also evaluated separately, by comparing a total of four experimental groups of participants, as well as considering the interaction between them. The main results of the current study indicate that being exposed to environmental, nutritional and eco-efficiency information through traffic-light labelled scores influence consumers choices, which is in line with the proposed hypotheses, while no significant effect of each type of information was observed over food consumption. The meal chosen by participants had the greatest influence on the amount consumed. As expected, socio-demographic and other participant characteristics had an influence on these outcomes, but only in terms of food consumption and other secondary outcomes, and not regarding meal choice. Furthermore, our results suggest that the total effect of the eco-efficiency score is generally not different than the combined effect of nutrition and GHG scores.

4.1. Influence on food choices and consumption

Previous intervention studies regarding point-of-purchase menu labelling have experienced mixed results regarding nutritional information. Several studies have evaluated the impact of nutrition information for out-of-home meals using a traffic-light label, as conducted in our study. A US longitudinal study noticed increases in green items sales and decreases in red items sales over 24 months in a large hospital cafeteria, albeit this intervention was combined to a choice architecture intervention (Sonnenberg et al., 2013; Thorndike et al., 2014; Thorndike et al., 2012). Regarding food consumption, Lowe et al. showed that providing more options for making healthier food choices and adding food labels containing a color-coding system and other nutritional information improves macronutrient and energy intakes among university and hospital employees who are regular users of the cafeteria (Lowe et al., 2010). However, this study was conducted in a real cafeteria setting with several meals offered. The context differed from our study in which participants' choices were limited. Such a real-life setting could explain the disparity with our own results, where the influence of nutritional information on the calorie intake was not significant.

Regarding carbon footprint information, studies assessing consumer perceptions report positive results (Hartikainen et al., 2014; Upham, Dendler, & Bleda, 2011), while studies evaluating the impact of carbon labels on meal choices observed mixed results. In a university canteen practice in the Netherlands, Spaargaren et al. experimented a labelling system with black and white CO_2 label and a comprehensive labelling system with traffic-light colors. An overall modest but significant shift in CO_2 scores was observed for the average lunch meal, with the colored traffic-light label lowering carbon scores by 3% (Spaargaren et al., 2013). However, it should be noted that they tested several other interventions, such as posters and videos, in addition to promote the awareness about the association between food and climate within the cafeteria. Although participants themselves indicated to have a positive attitude towards issues of environment and climate change, authors explain this modest change on behavior with the fact that participants thought that their established routine of the lunch time period was disrupted by these interventions. Participants also had difficulties understanding carbon labels in the absence of meaningful frame of reference (Spaargaren et al., 2013). In our study, a complete explanation of the respective scores was provided on each menu in addition to extreme meals as a reference, so participants did not necessarily encounter difficulties in understanding the information provided. Considering the experimental design of our study, participants were also not in an actual hurried lunchtime context, which could explain the greatest extent of influence observed. Two other studies in university cafeterias in Oslo and Sweden also observed a small shift in meal choices through sale shares with the introduction of traffic-light labels (Brunner et al., 2018; Slapø, 2016). Slapø observed a decrease of 9 % of meat dishes and an increase of vegetarian dishes by 4 % for the first 20 days (Slapø, 2016). Brunner et al. evaluated the impact over the vegetarian, fish or meat meals separately and an impact was observed mostly over meat meals. Indeed, reduced sales shares of red and yellow labeled meat were observed, which were marginally and non-statistically significant, respectively. An increased sale share of meat dishes carrying green label, which was highly significant, was observed as well. The authors noticed gender differences, albeit not significant, in response to labels, and mixed results when comparing between age groups (Brunner et al., 2018), an observation which was not found in our study. Very few studies seem to have evaluated the impact of the carbon footprint on food consumption. However, the relatively low impact of the carbon label on consumers' purchasing decisions among the studies (Spaargaren et al., 2013; Brunner et al., 2018; Slapø, 2016) contrasts with our own results. This might be explained by our quasi-experimental study where participants were not in a real cafeteria setting and therefore not influenced by other factors (e.g., price, convenience, social pressure), albeit they nonetheless had to choose and consume a real meal.

Few studies have evaluated the impact of combined nutritional and environmental information on meal choices. Filimonau and Krivcova evaluated the impact of traffic-light colored nutritional information combined to carbon emissions and food provenance in a UK restaurant, where the nutritional information was well perceived. However, only half of the participants noticed the carbon footprint information and took it into consideration when placing food orders (Filimonau & Krivcova, 2017). When an additional explanation was provided as to what the carbon footprint represented, a bigger proportion of participants reported they would like to see this information on display when dining out in the future (Filimonau & Krivcova, 2017). Comparison with our own results is thus limited because in our case, we made sure that participants were aware of the information by reading the menu with them. On the other hand, Osman and Thornton showed that canteen consumers exposed to nutritional and environmental information separately through traffic-light colors, responded with positive, substantial changes in hypothetical meal choices that were lower in both carbon emissions and caloric content were observed. Also, combining information through a dual traffic-light label led to an even more perceptible shift on both levels, which is in line with our results, while they also noticed a slightly greater effect size over sustainable consumption. This is however difficult to compare with our results since participants in the current study had only two meal choices from which each information was combined and we cannot distinguish which aspect they prioritized between nutrition and environment. Although this was an experimental study on hypothetical choices, Osman and Thornton also tested a traffic-light label in a context of meals and used benchmarks and additional information which could have helped consumers understand the information presented (Osman & Thornton, 2019). Such results are globally in accordance with our results. No study combining nutritional and environmental information on menus seems to have evaluated the impact over food consumption so far.

4.2. Influence on secondary outcomes

Findings from this study did not provide any evidence that nutritional and environmental information influence level of satiety after the meal. Once again, the type of meal chosen had the greatest impact on this outcome, burritos having more satisfied the appetite of participants. Gender had an impact too, with women generally feeling more full after the meal compared to men. Since other studies did not necessarily evaluate other outcomes after the choice of meal (in part because impact was assessed through sale shares or hypothetical choices), this outcome is difficult to compare with previous studies.

Moreover, participants who had eco-efficiency information on their menu appear to have appreciated their meal less than those with no information, regardless of the chosen meal. These results could possibly be explained by negative inferences caused by environmental food information. Indeed, Schuldt and Hannahan showed that a negative impression could occur towards information about organic food attributes, which was translated into a lower taste rating among some consumers (Schuldt & Hannahan, 2013). Such findings could possibly be extrapolated to the eco-efficiency information provided in the current study. Huang et al. also showed that people facing nutrition and carbon labels simultaneously have a lower evaluation on taste of the food than when these two labels are presented separately (Huang et al., 2021), which is quite similar to what was observed in the current study. Although it was an anticipated evaluation, authors explain this lower evaluation by the fact that participants infer that resources were allocated to healthy and environmental aspects (Huang et al., 2021). On the other hand, information about nutritional quality alone had no significant impact on meal appreciation compared to the control group, which is consistent with the results of Lassen et al., who noticed no adverse effect in their healthy certified canteen with regard to food satisfaction, number of daily customers or amount of edible plate waste (Lassen et al., 2014).

5. Strengths and limitations

A major strength of this study is that consumers had to make a real food choice and consume the chosen meal in controlled settings, while most experimental studies evaluate hypothetical choices, intentions or even changes in sale shares. Moreover, we recruited actual consumers of cafeteria settings as the study was opened exclusively to the campus students and workers. Since they did not know the real objectives of the study beforehand, we were able to observe what we believe to be the closest to their real behavior even though we did not conduct a field experiment. Moreover, the understanding of the scores was made easier using traffic-light color grading scales to make it more accessible, meaningful and intuitive for non-experts as proposed by Schaubroeck et al. (Schaubroeck et al., 2018), in addition with the presentation of reference values as proposed by Cowburn and Stockley (Cowburn & Stockley, 2007), using "extreme" meals as examples. Additionally, we have presented a new methodology of combining the nutritional and the environmental dimensions of meals in an eco-efficiency score tool as a step to implement these components in a practical use, as only a few studies to date have explored this type of integrated sustainability score (Hallström et al., 2018). This new tool could be very useful for future implementation in cafeteria settings considering the increased consumer awareness for both health and environmental issues.

However, our results need to be interpreted in the context of a relatively educated population and are therefore not generalizable to the entire population because we used a university sample, comprising mostly students as well as employees. Also, the two meal choices presented to participants had noticeable different scores to make the difference obvious, given that for budgetary and logistical reasons, we could not present more than two choices (i.e., we conducted the study in a living laboratory and not in the cafeteria). This limited number of meal options could have increased the possibility of taste being a key determinant of their choice in comparison to when several options are presented, since literature reports that food choices are particularly oriented by taste and price (Bailey & Harper, 2015; Garnett et al., 2015). While no price information was indicated on the menu, it should be noted that these "meals of the day" are equally priced in the university cafeteria. Moreover, as one of the main aims of the study was to evaluate the effect of the information over the outcomes, the menu included a complete explanatory text of the various scores to ensure their comprehension, which would not be possible to implement under real cafeteria conditions. In the real cafeteria setting, very few people would indeed take the time to understand the information and therefore the scores would need to be outstanding and comprehensive with only a brief observation. However, the use of this explanatory text also represents a strength because we were able to counteract the lack of noticing and understanding reported by many authors regarding logos presenting the carbon footprint.

6. Conclusion and recommendations

The results of the present study suggest that communicating information about eco-friendly and nutritious menu choices to consumers within institutional settings could be relevant to enable them to make more eco-efficient food choices. However, as highlighted by Truelove and Parks, it is important to keep in mind that the provision of information and knowledge, albeit necessary, is not sufficient to motivate and promote behavioral change (Truelove & Parks, 2012). Indeed, other individual factors come into play, and looking to the demand side of the food supply is only part of the challenge as the retailers/suppliers perspective is crucial (Gadema & Oglethorpe, 2011). However, the display of these types of information could have beneficial collateral impacts as it could motivate cafeteria meal providers, and on a larger scale the food industry, to reformulate and improve their food offer with healthier and more eco-friendly alternatives, as this has taken place to some extend in the US regarding the health aspect (Rincón-Gallardo Patiño et al., 2020; Petimar et al., 2021). Providing that information could also have an impact that goes beyond the point-of-purchase, as it could possibly raise consumers' interest and awareness about the impact that their food choices can have on the environment.

Our findings present promising opportunities to promote behavioral food changes at a larger scale. However, further studies should investigate the influence of these types of information under real purchasing conditions, such as a university cafeteria or restaurant setting at mealtime. Also, the impact of the presence of information must be evaluated over a longer period since the long-term effect of a climate-friendly label is still unclear. Some studies indeed reported that a certain "fatigue" to the presence of labels appears over time and that their effectiveness is possibly short lived (Slapø, 2016). Furthermore, since logos are mostly used to facilitate consumer understanding and ultimately help them making informed choices, these should be developed in accordance with what is proposed in the literature and in consultation with the users and managers of university cafeterias. Logos should also be pre-tested prior to their possible recommendation and implementation in a given setting.

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CRediT authorship contribution statement

Gabrielle Plamondon: Investigation, Data curation, Formal analysis, Resources, Visualization, Writing – original draft. **Marie-Ève Labonté:** Conceptualization, Funding acquisition, Methodology, Writing – review & editing. **Sonia Pomerleau:** Supervision, Investigation, Resources. **Stéphanie Vézina:** Funding acquisition, Writing – review & editing. **Sergey Mikhaylin:** Conceptualization, Funding acquisition, Methodology, Writing – review & editing. **Laurence Laberee:** Investigation, Writing – review & editing. **Véronique Provencher:** Conceptualization, Funding acquisition, Methodology, Project administration, Writing – review & editing.

Declaration of Competing Interest

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Appendix A. Supplementary data

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