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Effect of composition information on the perception of innovative beverages mixing animal and plant ingredients by consumers

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MASTER'S THESIS

**Effect of composition information on the perception of innovative
beverages mixing animal and plant ingredients by consumers**

Internship from **15/03/2021** to **10/09/2021**

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ABBREVIATIONS

C: Consumers ; NC: Non-Consumers

CSGA: Centre des Sciences du Goût et de l'Alimentation

STLO: Sciences et Technologies du Lait et de l'Œuf

KEYWORDS

Mixed products, consumers, hedonism, nutrition, environment.

MOTS-CLES

Produits mixtes, consommateurs, hédonisme, nutrition, environnement.

ABSTRACT

We studied the reaction of consumers and non-consumers of plant-based alternatives towards beverages mixing cow milk with soy juice or oat juice. We focused on the liking of these products and on the perceived nutritional and environmental quality. We compared the results obtained by presenting the products with or without composition information, with two types of composition information (plant-based or mixed) and between consumers and non-consumers of plant-based alternatives. We found that the plant-based composition information increased the appreciation of products containing oat. Both composition information had a similar impact on the perceived nutritional quality. The mixed composition information decreased the environmental scores of products containing soy, the plant-based composition information increased the environmental scores of products containing oat. Consumers of plant-based alternatives had a higher appreciation of the products, gave higher nutritional scores (especially with the plant-based composition information) and environmental scores than non-consumers.

RÉSUMÉ

Nous avons étudié la réaction de consommateurs et non consommateurs de produits végétaux face à des boissons mélangeant du lait de vache avec du jus de soja ou d'avoine. Nous nous sommes intéressés à l'appréciation de ces produits et à la qualité nutritionnelle et environnementale perçue. Nous avons comparé les résultats obtenus en présentant les produits avec ou sans information de composition, avec deux types d'information de composition (végétale ou mixte) et entre des consommateurs et des non consommateurs d'alternatives végétales. Nous avons constaté que l'information de composition végétale augmentait l'appréciation des produits contenant de l'avoine. Les deux informations de composition avaient un impact similaire sur la qualité nutritionnelle perçue. L'information de composition mixte diminuait la note environnementale des produits contenant du soja, l'information de composition végétale augmentait celle des produits contenant de l'avoine. Les consommateurs de produits végétaux appréciaient plus les produits, donnaient de meilleures notes nutritionnelles (notamment avec l'information de composition végétale) et environnementales que les non consommateurs.

SYNTHÈSE

1. Objectifs et hypothèses

Au cours de mon stage de fin d'études, je me suis demandé comment les informations de composition modifiaient la perception par les consommateurs de boissons mixtes animales/végétales. Les boissons mixtes sont définies comme des boissons mélangeant des ingrédients d'origine animal avec des ingrédients végétaux. Les deux objectifs principaux étaient : (i) étudier l'effet de l'information donnée aux participants sur l'acceptation sensorielle et la perception de la qualité nutritionnelle et environnementale de produits mixtes ; (ii) comparer cet effet entre les consommateurs et les non consommateurs d'alternatives végétales. Nous avons émis trois hypothèses :

- Présenter les mêmes produits mixtes avec ou sans information de composition change leur appréciation (H1a), la perception de leur qualité nutritionnelle (H1b) et de leur qualité environnementale (H1c).
- Présenter les mêmes produits mixtes avec une information de composition mixte ou végétale n'a pas le même impact sur leur appréciation (H2a), la perception de leur qualité nutritionnelle (H2b) et de leur qualité environnementale (H2c).
- L'effet de l'information de composition n'est pas le même entre des consommateurs réguliers et des non-consommateurs d'alternatives végétales aux produits laitiers. L'information de composition n'influence pas de manière similaire l'appréciation (H3a), la perception de la qualité nutritionnelle (H3b) et la qualité environnementale (H3c) de mêmes produits mixtes entre les deux groupes.

2. Matériels et méthodes

L'étude comptait 120 participants recrutés dans la base de données de PanelSens du CSGA. Ils étaient répartis en deux groupes de 60 participants choisis selon leur fréquence de consommation d'alternatives végétales aux produits laitiers. Au-delà d'une consommation supérieure à plusieurs fois par mois, les participants ont été recrutés pour représenter les consommateurs et en-deçà de trois fois par an, les participants ont été considérés comme non consommateurs.

Les produits utilisés au cours de l'étude étaient des mélanges de lait demi-écrémé UHT, de jus de soja et de jus d'avoine. Chacun de ces produits étaient commercialisés. Les deux types de mélange soja-lait et avoine-lait étaient présentés avec deux ratios différents : 50–50 ou 75% de lait–25% de jus végétal.

L'étude se déroulait en deux sessions. Durant la première session, les participants étaient exposés aux quatre produits à l'aveugle, sans aucune information et avec un code à 3 chiffres. Après une pause de 5 minutes, les mêmes produits étaient présentés à nouveau, mais accompagnés d'une information de composition, un code différent et un ordre de présentation différent. La moitié des participants avait une information de composition mixte (produit à base de lait et de jus de soja ou de lait et de jus d'avoine) et l'autre moitié avait une information de composition végétale (jus de soja ou jus d'avoine). A chaque étape, les participants devaient évaluer leur appréciation hédonique et leur perception de la qualité nutritionnelle et environnementale. La deuxième session avait lieu minimum 7 jours après la première. Le même processus expérimental était appliqué mais les participants qui avaient été exposés à une information mixte au cours de la première session étaient désormais exposés à une information végétale et inversement. Les produits utilisés étaient les mêmes qu'en première session mais codés différemment et présentés dans un ordre différent. Les participants évaluaient de nouveau la qualité hédonique, nutritionnelle et environnementale. Les ordres de présentation ont été équilibrés selon un carré latin de Williams à toutes les étapes. Puis, après cette évaluation, ils répondaient à un questionnaire pour évaluer leurs critères de choix alimentaire.

Au cours des deux sessions, les participants évaluaient leur appréciation hédonique sur une échelle à 7 points de « Je n'aime pas du tout » à « J'aime beaucoup », les qualités nutritionnelle et environnementale attendues sur une échelle à 7 points de « Mauvaise qualité » à « Très bonne qualité ». Au cours de la deuxième session, le questionnaire de caractérisation évaluait d'une part l'importance de la qualité sensorielle, nutritionnelle et environnementale dans l'achat d'un produit alimentaire ; d'autre part les facteurs (santé, naturel, local, etc.) caractérisant un lait végétal. Chaque item était évalué sur une échelle de 6 points de « Pas du tout d'accord » à « Tout à fait d'accord ».

3. Analyse statistique

Pour déterminer si la présence ou l'absence d'une information de composition changeaient l'appréciation et la perception des qualités nutritionnelle et environnementale de

produits mixtes, nous avons comparé les notes obtenues avec chaque type d'information avec les notes obtenues à l'aveugle au cours de la même session. Nous avons réalisé une ANOVA à 3 facteurs sur le tableau contenant les résultats pour l'information « Mixte » (TD1) et celui contenant les résultats pour l'information « Végétale » (TD2), avec comme variables expliquées « Hédonique », « Nutrition » et « Environnement » et variables explicatives « Participant » (facteur aléatoire), « Produit » et « Information » (facteurs fixes) et les interactions « Participant*Produit » et « Produit*Information ».

Ensuite, pour déterminer si les informations de composition « mixte » ou « végétale » changeaient de manière identique l'appréciation et la perception des qualités nutritionnelle et environnementale de produits mixtes, nous avons soustrait les notes obtenues avec chaque type d'information avec les notes obtenues à l'aveugle au cours de la même session. Nous avons réalisé une ANOVA à 3 facteurs sur le tableau contenant les résultats avec comme variables expliquées « Hédonique », « Nutrition » et « Environnement » et variables explicatives « Participant » (facteur aléatoire), « Produit » et « Information » (facteurs fixes) et les interactions « Participant*Produit » et « Produit*Information ». Cette analyse n'a été faite que lorsque la première analyse avait mis en évidence que les informations de composition « mixte » ou « végétale » influençaient toutes deux les notes d'appréciation et la perception de la qualités nutritionnelle ou environnementale des produits.

Finalement, pour déterminer l'influence de la consommation d'alternatives végétales sur le comportement vis-à-vis d'une information de composition, nous avons effectué une ANOVA à mesures répétées sur les tableaux TD1 et TD2 dans lesquels une colonne avec le groupe de participants était ajoutée. L'ANOVA avait comme variables expliquées « Hédonique », « Nutrition » et « Environnement » et variables explicatives « Participant » (facteur aléatoire), « Information » (facteur répété), « Groupe », « Produit » et les interactions « Groupe*Produit », « Groupe*Information » et « Produit*Information » (facteurs fixes).

Pour chacune des ANOVA, si un résultat significatif était obtenu pour les variables dépendantes « Information » et « Produit*Information », un test de Newman-Keuls était effectué pour déterminer les différences entre chaque produit dans chaque condition d'information.

Pour évaluer si un facteur était considéré significativement différemment entre les deux groupes de participants, nous avons effectué des t-tests.

4. Résultats

Nos résultats ont montré qu'en considérant l'ensemble des produits, fournir une information de composition aux participants n'a pas modifié leur appréciation des produits. Mais une différence existait pour certains produits uniquement. Les produits à l'avoine appréciés sans information l'étaient encore plus avec une information de composition végétale. En revanche, une information de composition mixte n'a jamais changé l'appréciation. De plus, les consommateurs de notre étude ont plus apprécié les produits que les non consommateurs, ce qui est cohérent avec les résultats du questionnaire dans lequel les consommateurs ont déclaré qu'un lait végétal était plaisant. Malgré cela, fournir une information de composition a eu le même effet pour les deux groupes.

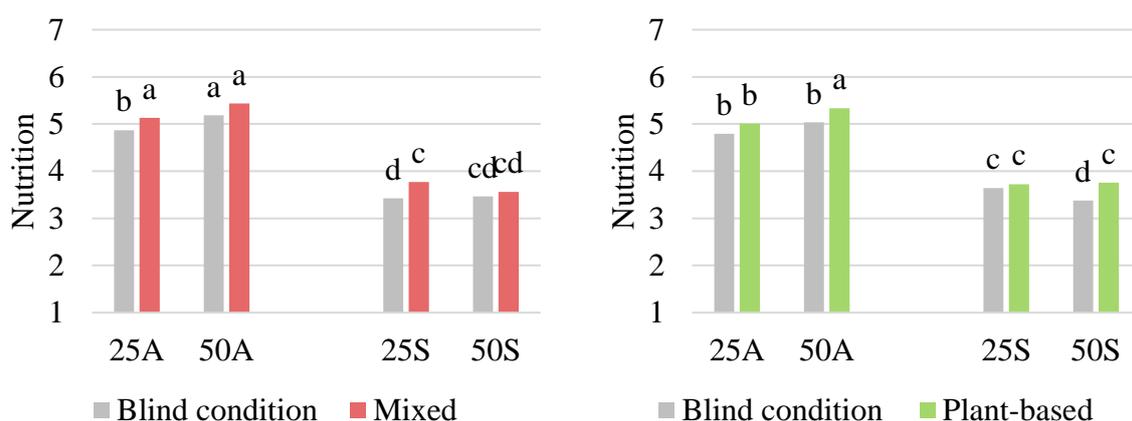


Figure 1 : Notes nutritionnelles moyennes pour chaque condition sans et avec information de composition pour les quatre produits.

Les lettres sont le résultat d'un test de Newman-Keuls sur le facteur « Produit » : les produits avec une lettre similaire ne sont pas significativement différents. Chaque figure compare les scores avec et sans information au cours d'une même session. 25A : 25% Avoine, 50A : 50% Avoine ; 25S : 25% Soja, 50S : 50% Soja

La perception de la qualité nutritionnelle a été influencée par les informations de composition mixte et végétale mais il n'y a pas de différence entre l'effet de chacune des informations. De plus, les consommateurs ont eu une meilleure perception de la qualité nutritionnelle des produits que les non consommateurs, ce qui est cohérent avec les résultats du questionnaire, les consommateurs considérant les produits végétaux comme bons pour la santé. Les consommateurs ont eu tendance à donner de meilleures notes aux produits présentés avec une information de composition végétale tandis que les non consommateurs ont eu

tendance à donner de meilleures notes aux produits présentés avec une information de composition mixte.

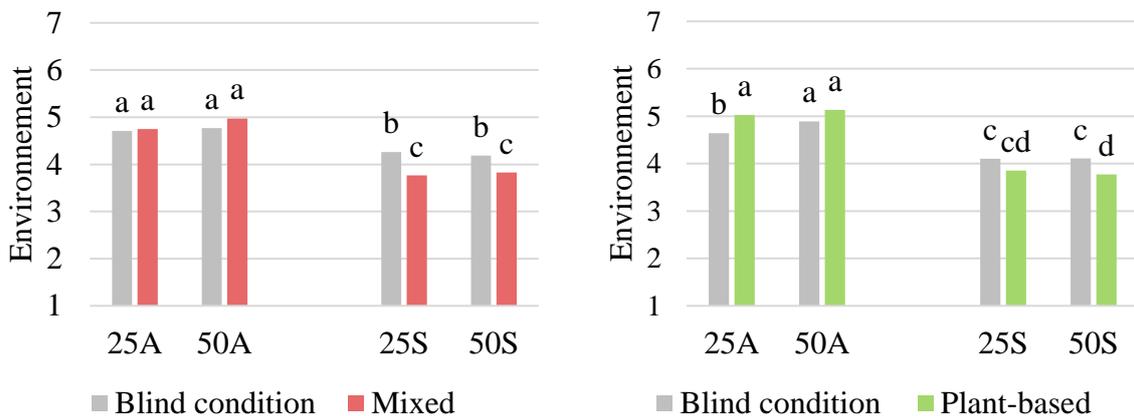


Figure 2 : Notes environnementales moyennes pour chaque condition sans et avec information de composition pour les quatre produits.

Les lettres sont le résultat d'un test de Newman-Keuls sur le facteur « Produit » : les produits avec une lettre similaire ne sont pas significativement différents. Chaque figure compare les scores avec et sans information au cours d'une même session. 25A : 25% Avoine, 50A : 50% Avoine ; 25S : 25% Soja, 50S : 50% Soja

Une information de composition mixte a diminué les scores environnementaux donnés aux produits à base de soja tandis qu'une information de composition végétale a augmenté les scores environnementaux donnés aux produits à base d'avoine. De plus, les notes environnementales étaient meilleures avec une information de composition végétale qu'à l'aveugle mais il n'y avait pas de différence pour l'information de composition mixte. Les notes attribuées par les consommateurs et les non consommateurs n'étaient différentes qu'avec une information de composition végétale, ce qui est cohérent avec les résultats du questionnaire, dans lequel les consommateurs ont déclaré considérer les produits végétaux comme bons pour l'environnement. Une information de composition mixte a fait diminuer les notes dans les deux groupes de participants.

Finalement, nous avons constaté que les notes nutritionnelles et environnementales semblent suivre les notes hédoniques : il y aurait un lien entre l'appréciation et la perception de la qualité environnementale et notamment de la qualité nutritionnelle. Le plus un produit était apprécié, le mieux il était perçu d'un point de vue nutritionnel et environnemental.

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INTRODUCTION

1. General context of the study

Many studies are now focusing on solutions to counter the nutritional and environmental issues. Among the results of these studies, it has been proposed to curb the consumption of animal ingredients, despite a rising demand for animal protein containing food such as milk or meat by consumers (Profeta et al., 2021; Steinfeld et al., 2006). In order to carry out this change in the diet, consumption of plant ingredients should increase. However, they are still little consumed, because plant ingredients are not widely known and are still poorly accepted. Thus, researchers have focused on innovative products mixing plant ingredients and animal ingredients. These products are called either “mixed”, “hybrid” or “blended” products. We will refer to them as “mixed products” in this report. In the literature, many studies have focused on mixed products based on meat (Grasso et Jaworska, 2020; Guinard et al., 2016; Lang, 2020; Neville et al., 2017; Profeta et al., 2021; Sogari et al., 2021), but only a few, quite recent, studies have concentrated on mixed products based on milk (Guyomarc’h et al., 2021; Saint-Eve et al., 2021; Youssef, 2016).

Mixed products would bring the advantages of plant ingredients. Plant ingredients are considered as more sustainable than animal ingredients. Indeed, meat production, for example, is responsible for greenhouse missions, water consumption, fertilizer use, resulting in a loss of biodiversity and climate change (Profeta et al., 2021). Life Cycle Assessments have shown a higher carbon footprint for animal proteins than soy protein (Thrane et al., 2017). On a nutritional aspect, legumes and seeds, for example, are rich in proteins, minerals (i.e. magnesium, potassium), fibers, vitamins and unsaturated fatty acids. However, these plant-ingredients are not sufficient to answer the nutritional needs, as they contain limiting amino acids and not enough essential minerals such as calcium. Combining plant ingredients with animal ingredients would be a way to reach a sufficient nutritional value (Tangyu et al., 2019). However, these benefits are not well-known by consumers.

The acceptability of plant-based products depends on the consumers attitude towards their health (Grasso et Jaworska, 2020), but also on their favourability towards the reduction of meat consumption (Tarrega et al., 2020). Their consumption patterns also have an influence, as people consume more or less plant alternatives (Michel et al., 2021). Then, consumers are more or less familiar with some products or ingredients of animal or plant origin, depending on how often they consume them. Plant-based products consumption also depends on the

sensory acceptability of such products (Hoek et al., 2011; Michel et al., 2021). Sensory perception of a product by consumers is influenced by several factors. On the one hand, the intrinsic attributes of the product, such as its taste, aroma, colour, etc., directly influence the liking of the product (Oliveira et al., 2017). On the other hand, the extrinsic attributes such as labels, any information given to consumers about the nutritional composition, the environmental or sensory quality, or the product brand, etc., can have an influence on both the perception of the organoleptic properties of a product and their appreciation (Biondi et Camanzi, 2020). Indeed, information may result in expectations from consumers regarding the sensory properties of a product. If the product does not meet the expectations of the consumers, the perception will be impacted (Choi et Lee, 2019). In addition, consumers have some knowledge about a product and its ingredients, but also beliefs, which can both have an influence on the perception of this product. Finally, the more the product matches the values and beliefs of the consumer, the better is the appreciation (Bernard et Liu, 2017).

Therefore, as mixed products are new, it is difficult to determine the consumers' behaviour towards them. The unfamiliar mix of ingredients might create negative expectations and, as we said before, have an impact on the acceptability of products. It is essential to focus on the impact of information given to consumers and then determine whether giving information can decrease eventual negative expectations. A recent research focusing on mixed cheeses showed no influence of composition information on the consumers' liking (Saint-Eve et al., 2021). The present study was undertaken to determine if the composition information had an effect on the liking and perception of the properties of another type of mixed products: a beverage containing milk and plants, by consumers with different levels of familiarity with milk substitutes.

2. Study instigators

This collaborative study was carried out by the Joint Research Unit “Sciences et Technologie du Lait et de l’Œuf” (STLO) and the Joint Research Unit “Centre des Sciences du Goût et de l’Alimentation” (CSGA). Researchers of the STLO laboratory have been working for a few years on the formulation of mixed fermented yogurts containing milk and lupine. However, as the products are not yet ready to be tasted, the present study will be carried out on another alternative to dairy products: a beverage containing milk and a plant juice. Researchers of the CSGA work on the perception of healthy and sustainable products by consumers. In this project, their aim is to check the how information about the formulated products impact the

perception and liking of the products by consumers. My internship took place in the team Culture, Expertise, Perception of the CSGA in Dijon. I was recruited by the French research institute “Institut National de Recherche pour l’Agriculture, l'alimentation et l'Environnement” (INRAE).

3. Objectives and hypothesis of the study

The two main objectives were: (i) to study the effect of the information given to consumers on sensory acceptance, and the perception of the nutritional and environmental quality of mixed products; (ii) to compare this effect between consumers and non-consumers of plant alternatives. We made three hypotheses:

- Presenting the same mixed products with or without composition information changes their appreciation (H1a), the perception of their nutritional quality (H1b) and the perception of their environmental quality (H1c).
- Presenting the same mixed products with a “mixed” or a “plant-based” composition information changes their appreciation (H2a), the perception of their nutritional quality (H2b) and the perception of their environmental quality (H2c).
- Effect of composition information is not the same on regular consumers and non-consumers of plant-based alternatives to dairy products. Composition information does not influence similarly the appreciation (H3a), the perception of their nutritional quality (H3b) and the perception of their environmental quality (H3c) of the same mixed products for both groups.

MATERIAL AND METHODS

1. Material

1.1. Study organisation

The study lasted 6 months from March to August, 2021. First, it has been submitted to the ethics committee of the university Université Bourgogne Franche-Comté and registered by the department of data protection of CNRS (treatment number 2-21104). At the same time, we organized a pre-test with 14 participants. Once the questionnaire was ready and the study validated by the ethics committee, we started the recruitment of the participants.

1.2. Participants

One hundred and twenty (120) participants took part to this study. They came from Dijon and its surroundings. They were 19 to 51 years old, without any medical condition, food allergy or intolerance. Pregnant were also excluded. Participants were recruited with the PanelSens database of the CSGA. This database is composed of more than 14 000 participants. More than 7 000 were available during our study. We pre-selected 3 638 men and women, who corresponded to our selection criteria. We identified them thanks to a recruitment email explaining the study and the inclusion criteria. About 245 participants answered. We recruited 120 participants among those that suited the inclusion criteria of our study (consumption frequency of milk substitutes, as explained below). Before starting the study, written informed consent was obtained from participants. To ensure confidentiality of the information given by the participants and their anonymity, each participant was assigned a drawn code. At the end of the second session, participants received a voucher worth €10. Figure 1 shows each step of the recruitment until the end of the study.

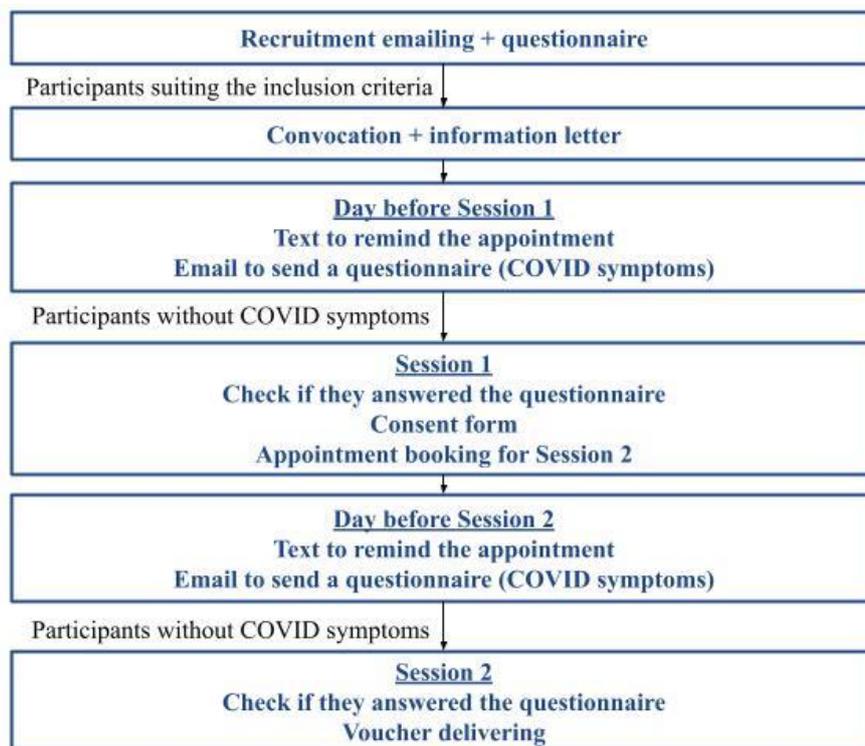


Figure 1: Description of the recruitment until the end of the experiment.

During the recruitment, participants were informed that the experiment would involve the consumption of beverages containing milk and/or plant milk. We asked them their

frequency of plant alternatives consumption and separated them into two groups, according to their consumption. If they declared consuming plant alternatives several times a month or more, they were considered as consumers (C), and if their declared consumption was below three times a year, they were considered as low or non-consumers (NC). There were 60 participants in each group, in order to have a comparable headcount in both groups and a sufficient statistical power. Table 1 shows the repartition of participants among the groups, according to their gender and age.

Table 1: Description of participants.

Category	Characteristic	Consumers		Non-consumers	
		<i>N</i>	%	<i>N</i>	%
Gender	Female	49	40.8	47	39.2
	Male	11	9.2	13	10.8
Age	19-31	15	12.5	14	11.7
	32-41	25	20.8	24	20.0
	42-51	20	16.7	21	17.5

1.3. Preparation of the products

The products we used for the study are mixed beverages containing marketed UHT semi-skimmed cow milk (Lait demi-écrémé, Bio Village), to which were added oat juice (Organic oat drink, gluten free, vegan, The Bridge La Famiglia Organic) or soy juice (Boisson au soja, Nature, Vegan, Soy). The two types of mixed products, milk-soy juice and milk-oat juice, were presented with two different ratios of milk and plant juice: 50 - 50, or 75% of milk - 25% of plant juice. But first, as the percentages of proteins of milk, soy juice and oat juices were different, we chose to homogenize the content of proteins of these three beverages to have the same ratio of protein in the final products, for technological issues for the STLO. Indeed, we used cow milk, soy juice and oat juice containing respectively 3.3%, 3.8% and 0.9% of proteins. We watered down the cow milk and soy juice to obtain beverages containing 0.9% of proteins. Then, we determined the respective ratios of cow milk and oat or soy beverages to test in the study. The 50 - 50 and 75 - 25 ratios were chosen after pre-tests, because they resulted in products that could be easily discriminated on an organoleptic point of view. Table 2 presents the composition of the four mixed products (visible in Appendix 1) used for the study (the percentages indicated are the percentages of the diluted beverages, in the final products).

Table 2: Composition of the four products used in the study.

Sample coding	Plant beverage proportion		Milk* proportion
	Soy*	Oat	
50S	50%	-	50%
25S	25%	-	75%
50A	-	50%	50%
25A	-	25%	75%

* soy and milk were diluted to contain 0.9% of proteins

2. Methods

1.1. Sessions organisation

Session 1 (Appendix 2): During this session, participants were first exposed to the four products in a blind condition. Products were coded with 3-digit numbers, and were presented without any information. After a 5 minutes break, the same products were presented again, but this time with composition information. The 3-digit codes of the products were different, as well as their order of presentation. Products were presented to half participants as having a mixed composition (mix of soy beverage and milk, or oat beverage and milk, according to their real composition) and to the other half, as plant-based products (soy or oat beverages, according to the plant ingredient they contained), without mentioning the presence of milk. In each of these two steps, participants had to assess their liking of the products, and the nutritional and environmental quality they expected, as further explained in part 2.1.2.

Session 2 (Appendix 2): This session took place at least 7 days after the first one. During this session, the same experimental design was used but participants previously exposed to the mixed composition information during the second step of the first session were exposed to the plant-based information, and vice-versa. Products were the same as in Session 1. Participants assessed the same characteristics as in session 1 (liking, nutritional quality, environmental quality). Once they had finished this evaluation, they completed a questionnaire, to evaluate their criteria of food choices.

In each session and step of a session, the order of presentation of the four products was balanced between participants, following a Williams Latin square. There were 4 different 3-digit codes for each of the 4 conditions (blind 1, blind 2, plant-based, mixed). To create the sessions and to collect the data, we used FIZZ software (version 2.51, Biosystemes).

1.2. Evaluation form and questionnaire

During the Session 1 and the Session 2, and with blind or informed conditions, participants had to assess their appreciation of the four products on 7 points scales anchored from “I do not like at all” to “I like it very much”. They assessed the expected nutritional and environmental quality of the four products on 7 points scales anchored from “Very low quality” to “Very high quality” (the complete form in French can be seen on Appendix 3). Figure 2 shows the two scales used during the evaluation.

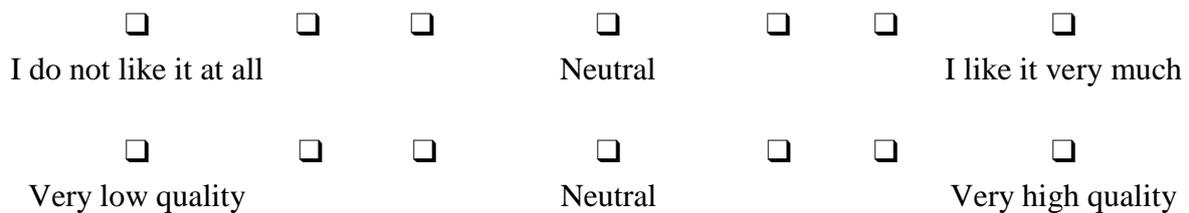


Figure 2: 7 points scales used in the evaluation form.

The form about the criteria of food choices filled by participants during the second session contained two main questions divided in several items to which corresponded a scale. The first question contained three items: “When buying a food product, I consider: its impact on health / its impact on the environment / its taste” and the second question contained 11 items: “Generally, for me, a plant-based milk is rather a product: healthy / useful / pleasant / natural / affordable / familiar / respectful of the environment / respectful of the animal welfare / respectful of the fair-trade / local / buyable in organic shop”. This questionnaire was based on the Single-Item Food Choice Questionnaire (Onwezen et al., 2019) and completed with some items of the Sustainable Food Choice Questionnaire (Verain et al., 2021). Each item was evaluated on a 6-points scale anchored from “Strongly disagree” to “Strongly agree” (the complete questionnaire in French is available in Appendix 4). Figure 3 shows the scale used in the questionnaire.



Figure 3: 6 points scale used in the questionnaire.

3. Statistical analysis

First, in order to determine if the presence or the absence of a composition information changed the liking, and the perception of the nutritional and environmental quality of mixed products, we compared the scores obtained with each type of information to the scores obtained with the blind condition during the same session. For this, we used two tables of data: TD1 contained all the results for the 120 participants, when submitted to a “mixed” composition information and TD2 contained all the results for the 120 participants, when submitted to a “plant-based” composition information (whether in Session 1 or in Session 2). In each table, in the rows, there are the 120 participants, the four products, the two modalities “presence” and “absence” of information (960 rows), and the columns are the variables “Participant”, “Product”, “Information”, “Hedonic score”, “Nutritional score” and “Environmental score”. Each table contains the scores given by participants during a same session (Session 1 for 60 participants and Session 2 for 60 other participants). We made a 3 factors ANOVA on each table, with the dependent variables “Hedonic”, “Nutrition”, “Environment” and the independent variables “Participant” (random factor), “Product” and “Information” (fixed factors) and the interactions “Participant*Product” and “Product*Information”.

Second, in order to know if a “mixed” or a “plant-based” composition information change identically the liking, and the perception of the nutritional and environmental quality of mixed products, we used a table of data containing all the results for the 120 participants (TD3). The data was obtained by subtracting the scores given to the same product with a composition information and with the blind condition, during the same session. In the rows, there are the 120 participants, the four products and the 2 information Mixed or Plant-based (960 rows), and the columns are the variables “Participant”, “Product”, “Information”, “Hedonic score”, “Nutritional score” and “Environmental score”. We made a 3 factors ANOVA with the dependent variables “Hedonic”, “Nutrition”, “Environment” scores and the independent variables “Participant” (random factor), “Product” and “Information” (fixed factors) and the interactions “Participant*Product” and “Product*Information”. This analysis was made only when the first one evidenced that both “mixed” and “plant-based” composition information had an influence on the appreciation and the perceived nutritional and environmental quality.

Finally, in order to determine the influence of the consumption of plant-based alternatives by participants on the behaviour towards a composition information, we made a Repeated Measures ANOVA on the tables TD1 and TD2, to which the group of participants

was added. The dependent variables were “Hedonic”, “Nutrition”, “Environment” and the independent variables “Participant” (random factor), “Information” (repeated factor), “Group”, “Product” and the interactions “Group*Product”, “Group*Information” and “Product*Information” (fixed factors). We looked more particularly at the effects of “Group”, “Group*Information” and “Group*Product”.

For all these ANOVAs, when a significant result was obtained for the dependent variables “Information” or “Product*Information”, a Newman-Keuls tests was carried out to access the differences between each product in each specific condition on information. All data analyses were performed with 5% risk using XLSTAT software (version 2021.3.1, Addinsoft).

To analyse the answers to the questionnaire, we performed t-tests on the results obtained for each item to determine if they were significantly different between the two groups of participants.

RESULTS

1. Characterisation of participants

We characterised the participants according to their answers to the questionnaire. Figure 4 shows the importance of taste and nutritional and environmental properties when buying any food product and Figure 5 shows how the participants consider plant-based milks, comparing consumers and non-consumers of plant-based alternatives to dairy products. In Figure 5, only the properties that both groups consider differently in plant-based milk alternatives are shown. Box-plots of the factors that are not different between both groups (Natural, Respectful of fair-trade, Local, Buyable in organic shop) are given in Appendix 5.

Figure 4 shows that both consumers and non-consumers of plant-based alternatives are mostly driven by the taste of the product they buy. However, consumers are more concerned by the impact on the health and the environment than non-consumers. Figure 5 shows that consumers considered plant-based milks as more pleasant (p-value < 0,0001), healthy (p-value = 0,000), respectful of the environment (p-value = 0,001), useful (p-value = 0,022), affordable (p-value = 0,001), familiar (p-value < 0,0001) and respectful of the animal welfare (p-value = 0,024) than non-consumers. Both consumers mainly considered a plant-based milk as healthy and respectful of the animal welfare but consumers also considered the pleasantness and the non-consumers the usefulness.

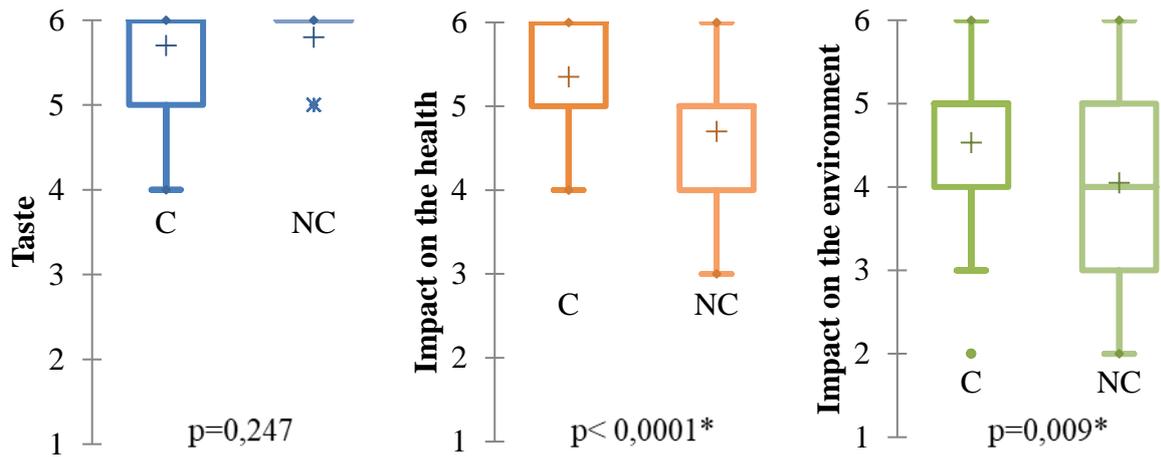


Figure 4: Comparison of consumers and non-consumers' answers to the question "When buying a food product, I consider".

* significant result (alpha = 0,05)

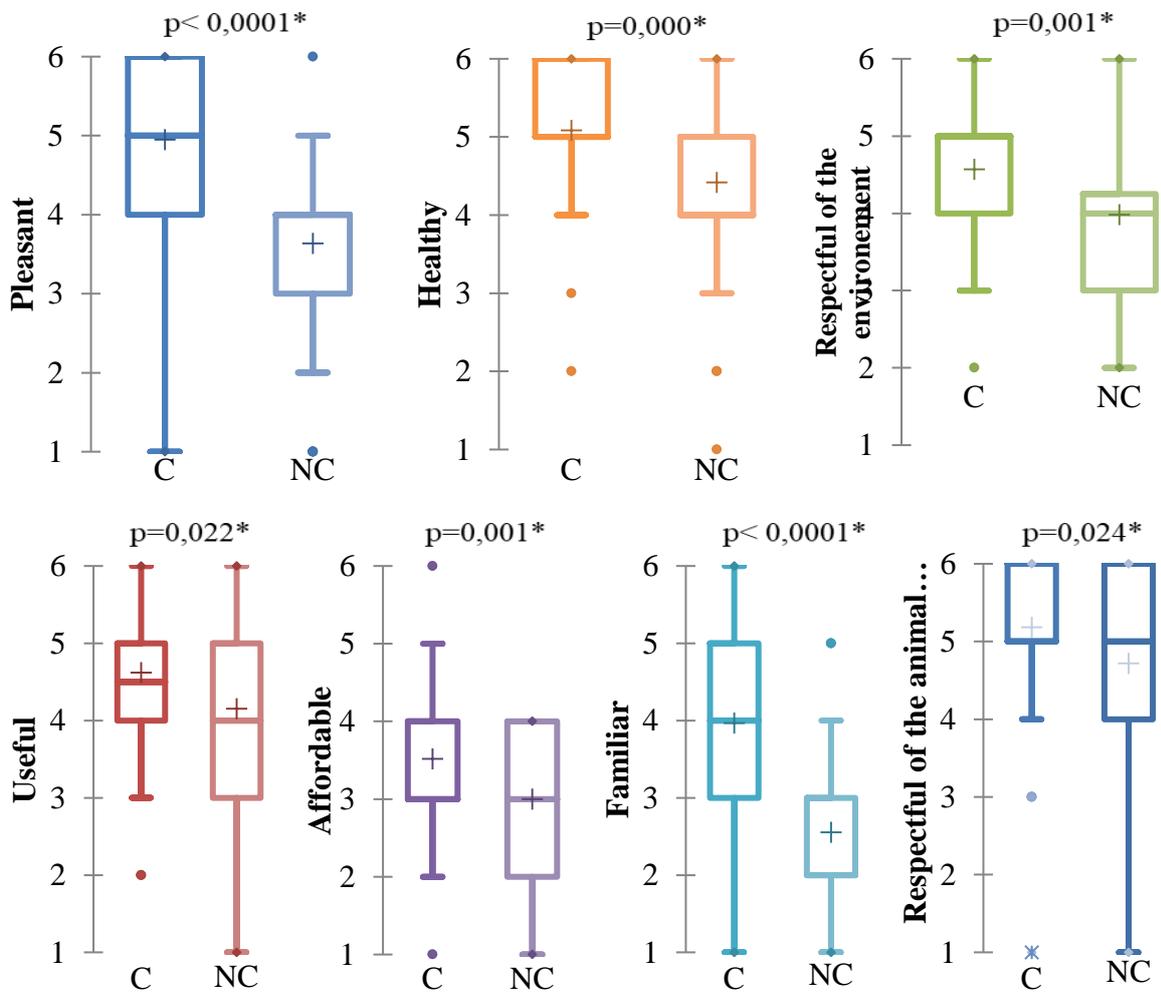


Figure 5: Comparison of consumers and non-consumers' answers to the question "Generally, for me, a plant-based milk is rather a product".

* significant result (alpha = 0,05)

2. How does a composition information change the liking of mixed products?

We are going to determine if the liking of mixed products is influenced by the presence or the absence of composition information. Figure 6 shows the average hedonic scores obtained for the four products with and without information “mixed” and “plant-based” and Table 3 shows the result of ANOVAs comparing the scores obtained for the four products, in presence or absence of information, for the two types of information, mixed and plant-based.

Table 3: p-values of the ANOVAs on the dependant variable “hedonic”, as a function of the factors “Participant”, “Product”, “Information” and the interactions “Participant*Product” and “Product*Information”.

	<i>Participant</i>	<i>Product</i>	<i>Info</i>	<i>Participant*Product</i>	<i>Product*Info</i>
<i>ddl</i>	119	3	1	357	3
<i>Mixed information</i>	<10 ^{e-4}	<10 ^{e-4}	0,452	0,006	0,059
<i>Plant-based information</i>	<10 ^{e-4}	<10 ^{e-4}	0,249	0,002	0,031

The scores with and without information are compared within the same session. The results in bold are significant at 5% risk.

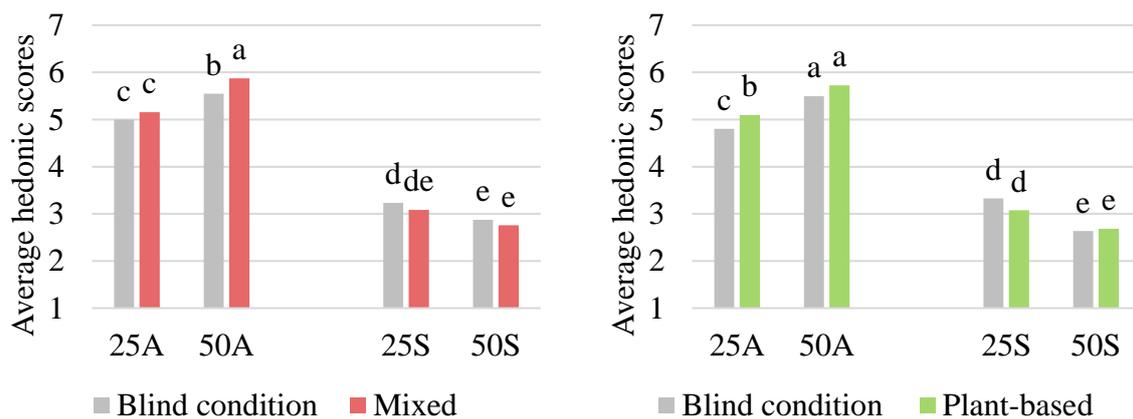


Figure 6: Average hedonic scores given to the four products in blind condition and with “mixed” information and “plant-based” information.

The letters are the result of a Newman-Keuls test on the factor “Product”: products with a similar letter are not significantly different. Each figure compares scores given with and without information within the same session.

The significant effect of the factor “Participant” observed in both conditions means that the scores given to the products by the different participants are different. This is not surprising,

as the subjects were not trained and the liking is a subjective measurement. Then, we will not comment further this factor “Participants” for the other hedonic results presented in this report (expected environmental and nutritional quality is also subjective so any “Participant” effect observed on these scores later in this document will not be mentioned either). The significant effect of the factor “Product” indicates that the products were not appreciated the same, and this result was expected, as the products were designed to taste differently. Figure 6 shows that oat-based products were more appreciated than soy-based products, either without or with information of the two types, “mixed” or “plant-based”. The significant effect observed for the interaction “Participant*Product” means that all participants did not like the same products. The effect of the factor “Information” and the interaction “Product*Information” are the most interesting results to answer our question. The effect of the factor “Information” is not significant, which means that the liking scores for the four products considered all together were not different with or without information. The interaction “Product*Information” was not significant when the information provided to participants was “mixed”, but it was significant when the information was “plant-based”. This significant effect means that the effect of the “plant-based” information was different depending on the products: the average scores showed in Figure 6 show that some oat-based products were more appreciated with a composition information than with the blind condition.

3. How does a composition information change the perception of the nutritional quality of mixed products?

3.1. Comparison of the change of perception of the nutritional quality of mixed products induced by the presence or absence of composition information

We are going to examine if the perception of the nutritional quality of mixed products is influenced by the presence or the absence of composition information. Figure 7 shows the average nutritional scores obtained for the four products with and without information “mixed” and “plant-based” and Table 4 shows the result of ANOVAs comparing the scores obtained for the four products, in presence or absence of information, for the two types of information, mixed and plant-based.

Table 4: p-values of the ANOVAs on the dependant variable “nutrition”, as a function of the factors “Participant”, “Product”, “Information” and the interactions “Participant*Product” and “Product*Information”.

	<i>Participant</i>	<i>Product</i>	<i>Info</i>	<i>Participant*Product</i>	<i>Product*Info</i>
<i>ddl</i>	119	3	1	357	3
<i>Mixed information</i>	<10 ^{e-4}	<10 ^{e-4}	0,000	<10 ^{e-4}	0,571
<i>Plant-based information</i>	<10 ^{e-4}	<10 ^{e-4}	0,000	0,028	0,424

The scores with and without information are compared within the same session.

The results in bold are significant at 5% risk.

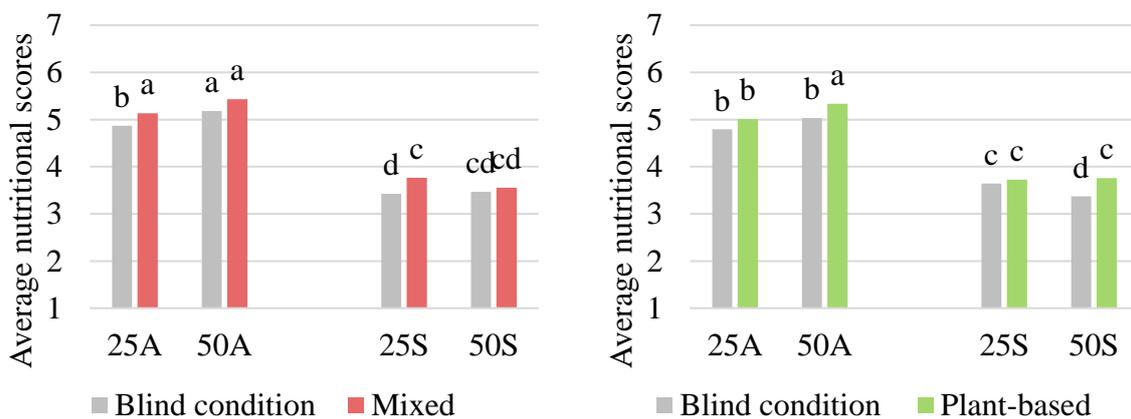


Figure 7: Average nutritional scores given to the four products in blind condition and with “mixed” information and “plant-based” information.

The letters are the result of a Newman-Keuls test on the factor “Product”: products with a similar letter are not significantly different. Each figure compares scores given with and without information within the same session.

The significant effect of the factor “Product” shows there is a difference of scores between the products. Figure 7 shows that oat-based products were considered as more nutritional than soy-based products, either without or with information of the two types, “mixed” or “plant-based”. It is surprising and interesting that there were differences between the products with the blind condition, as the participants did not know the composition of the product. The significant effect of the interaction “Participant*Product” indicates that all participants did not have the same opinion on which products had the higher or lower nutritional quality. The significant effect of the factor “Information” for both conditions means that the presence of a “mixed” or “plant-based” information influenced the average nutritional

scores for the four products, which were globally increased in presence of information on both conditions (Figure 7). Finally, the effect of information was the same for all products, with both “mixed” and “plant-based” information, as showed by the non-significant interaction “Product*Information” with both contents of composition information.

3.2. Comparison of the change of perception of the nutritional quality of mixed products induced by information, with two types of composition information

As we showed a significant effect of both “mixed” and “plant-based” information on the perception of the nutritional quality, we are now going to examine if these two effects are comparable. Table 5 shows the result of the ANOVA on the differences between scores obtained in the blind condition and the informed condition, for the four products and for the two types of information “mixed” and “plant-based”.

Table 5: p-values of the ANOVA made on the difference between the score with a composition information and the score with the blind condition, on the dependant variable “nutritional score”, comparing two types of information, mixed and plant-based.

	<i>Participant</i>	<i>Product</i>	<i>Info</i>	<i>Participant*Product</i>	<i>Product*Info</i>
<i>ddl</i>	119	3	1	357	3
<i>Score differences</i>	0,004	0,970	0,926	0,476	0,182

The scores with and without information are compared within the same session.

The results in bold are significant at 5% risk.

The factor “Information” and the interaction “Product*Information” are not significant, showing that the effect of composition information (in comparison with the scores obtained in the blind condition) was not different between the two types of information.

4. How does a composition information change the perception of the environmental quality of mixed products?

We are going to see if the perception of the environmental quality of mixed products is influenced by the presence or the absence of composition. Figure 8 shows the average environmental scores obtained for the four products with and without information “mixed” and “plant-based” and Table 6 shows the result of ANOVAs comparing the scores obtained for the

four products, in presence or absence of information, for the two types of information, mixed and plant-based.

Table 6: p-values of the ANOVAs on the dependant variable “environment”, as a function of the factors “Participant”, “Product”, “Information” and the interactions “Participant*Product” and “Product*Information”.

	<i>Participant</i>	<i>Product</i>	<i>Info</i>	<i>Participant*Product</i>	<i>Product*Info</i>
<i>ddl</i>	119	3	1	357	3
<i>Mixed information</i>	<10 ^{e-4}	<10 ^{e-4}	0,013	0,026	<10 ^{e-4}
<i>Plant-based information</i>	<10 ^{e-4}	<10 ^{e-4}	0,864	0,708	<10 ^{e-4}

The scores with and without information are compared within the same session.

The results in bold are significant at 5% risk.

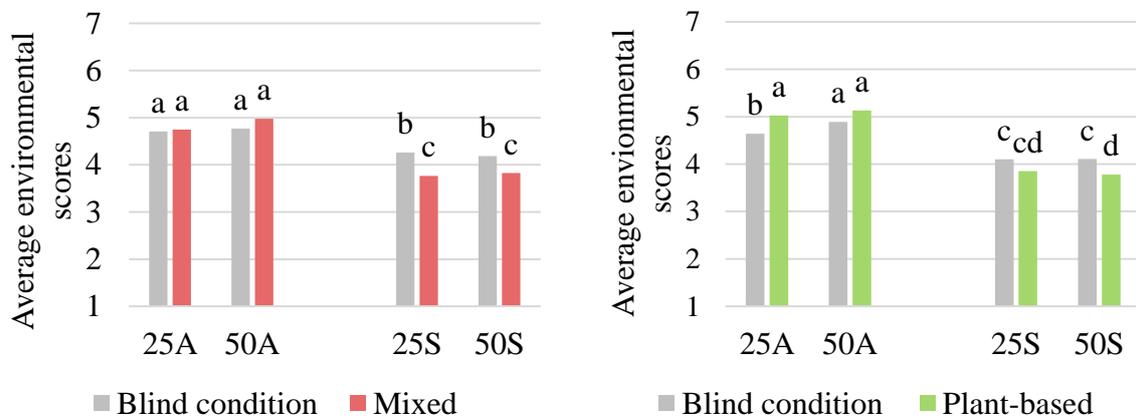


Figure 8: Average environmental scores given to the four products in blind condition and with “mixed” information and “plant-based” information.

The letters are the result of a Newman-Keuls test on the factor “Product”: products with a similar letter are not significantly different. Each figure compares scores given with and without information within the same session.

The significant effect of the factor “Product” shows that products are considered to have a different effect on the environment: oat-based products are considered to be better for the environment than soy-based products, either without or with information of the two types, “mixed” or “plant-based” (Figure 8). It is surprising and interesting that there were differences between the products assessed in the blind condition, as the participants did not know the composition of the product. The effect of “Participant*Product” obtained during the session when the products were presented as “mixed” means that every participant did not have the

same opinion on which products described as “mixed” had the higher or lower environmental quality. The significant effect of the factor “Information” in the “mixed” condition means that the presence of this information globally influenced the environmental scores for the four products. The significant effect of “Product*Information” means that the effect of the “mixed” composition information depended on the products. Figure 8 shows that soy-based products were considered as better for the environment in the blind condition than with the “mixed” information. The “plant-based” information had no global effect on the environment scores, as the effect of “Information” is not significant but as there is a significant effect of “Product*Information”, the effect of the “plant-based” information depended on the products. Figure 8 shows that some oat-based products were considered as better for the environment with the “plant-based” information than in the blind condition.

5. Do the consumption frequency of plant-based alternatives to dairy products by participants change their appreciation and their perception of the nutritional quality and environmental quality of mixed products?

5.1. Hedonic appreciation of mixed products according to the frequency of plant-based products consumption

Figure 9 shows the average hedonic scores obtained for the four products for each group for each condition of information and Table 7 shows the result of ANOVAs comparing the two groups for the raw hedonic scores obtained for the four products, for the two types of information, mixed and plant-based.

Table 7: p-values of the ANOVAs on the dependant variable “hedonic”, as a function of the factors “Group”, “Product”, “Information” and the interactions “Group*Product”, “Group*Information” and “Product*Information”.

	<i>Group</i>	<i>Product</i>	<i>Info</i>	<i>Group*Product</i>	<i>Group*Info</i>	<i>Product*Info</i>
<i>ddl</i>	1	3	1	3	1	3
<i>Mixed information</i>	<10 ^{e-4}	<10 ^{e-4}	0,453	0,898	1,000	<u>0,060</u>
<i>Plant-based information</i>	<10 ^{e-4}	<10 ^{e-4}	0,249	0,373	0,745	0,031

The scores with and without information are compared within the same session. The results in bold are significant at 5% risk.

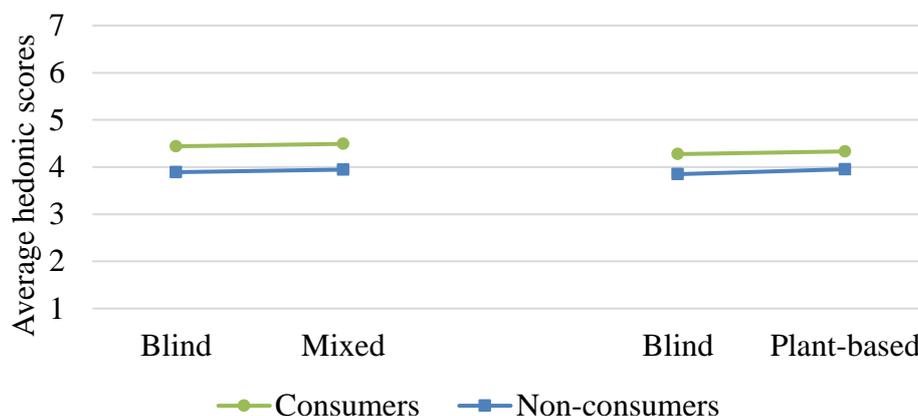


Figure 9: Average hedonic scores of the blind and informed conditions for the mixed information and the plant-based information and for consumers and non-consumers.

For these results and the following ones, we will focus on the factors dealing with the effect of the group, that is to say “Group”, “Group*Product” and “Group*Information”. The significant effect of the factor “Group” shows that the liking scores of both groups were different. Figure 9 shows that consumers of plant-based alternatives to dairy products appreciated more the products presented as either “plant-based” or “mixed” than the participants who do not consume or consume few plant-based products. In both groups, products liking scores ranked in the same order, as the effect of the interaction “Product*Group” is not significant. As the effect of the interaction “Group*Information” is not significant, the effect of information was the same for both groups: the reaction to composition information, compared with the absence of information, was not different between consumers and non-consumers.

5.2. Perception of the nutritional quality of mixed products according to the frequency of plant-based products consumption

We will now study the influence of the consumption frequency of plant-based products on the perception of the nutritional quality of mixed products. Figure 10 shows the average nutritional scores obtained for the four products for each group for each condition of information and Table 8 shows the result of ANOVAs comparing the two groups for the raw nutritional scores obtained for the four products, for the two types of information, mixed and plant-based.

Table 8: p-values of the ANOVAs on the dependant variable “nutritional”, as a function of the factors “Group”, “Product”, “Information” and the interactions “Group*Product”, “Group*Information” and “Product*Information”.

	<i>Group</i>	<i>Product</i>	<i>Info</i>	<i>Group*Product</i>	<i>Group*Info</i>	<i>Product*Info</i>
<i>ddl</i>	1	3	1	3	1	3
<i>Mixed information</i>	0,002	<10^{e-4}	0,000	0,865	0,331	0,571
<i>Plant-based information</i>	0,000	<10^{e-4}	0,000	0,716	0,051	0,421

The scores with and without information are compared within the same session. The results in bold are significant at 5% risk.

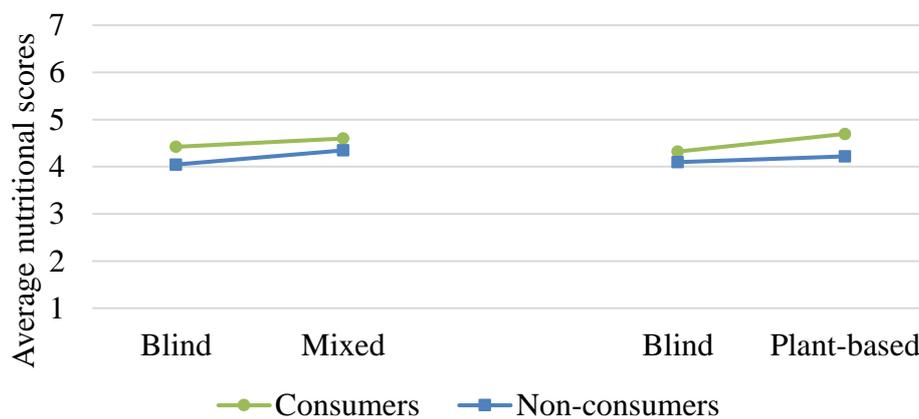


Figure 10: Average nutritional scores of the blind and informed conditions for the mixed information and the plant-based information and for consumers and non-consumers.

The significant effect of the factor “Group” evidences a difference between the scores given by the two groups: Figure 10 shows that the consumers of plant-based alternatives to dairy products gave higher nutritional scores to the products indicated as either “plant-based” or “mixed” than the participants who do not consume or rarely consume plant-based products. Each group ranked the products in the same order, as the effect of the interaction “Group*Product” is not significant. The information had the same effect on the two groups, as shown by the non-significant effect of the interaction “Group*Information”.

5.3. Perception of the environmental quality of mixed products according to the frequency of plant-based products consumption

We are going to examine if the perception of the environmental quality of mixed products is influenced by the consumption frequency of plant-based products. Figure 11 shows the average hedonic scores obtained for the four products for each group for each condition of information and Table 9 shows the result of ANOVAs comparing the two groups for the raw environmental scores obtained for the four products, for the two types of information, mixed and plant-based.

Table 9: p-values of the ANOVAs on the dependant variable “environmental”, as a function of the factors “Group”, “Product”, “Information” and the interactions “Group*Product”, “Group*Information” and “Product*Information”.

	<i>Group</i>	<i>Product</i>	<i>Info</i>	<i>Group*Product</i>	<i>Group*Info</i>	<i>Product*Info</i>
<i>ddl</i>	1	3	1	3	1	3
<i>Mixed information</i>	0,610	<10 ^{e-4}	0,013	0,704	0,630	<10 ^{e-4}
<i>Plant-based information</i>	0,001	<10 ^{e-4}	0,864	0,434	0,759	<10 ^{e-4}

The scores with and without information are compared within the same session. The results in bold are significant at 5% risk and the results in italics and underlined are significant at 10% risk.

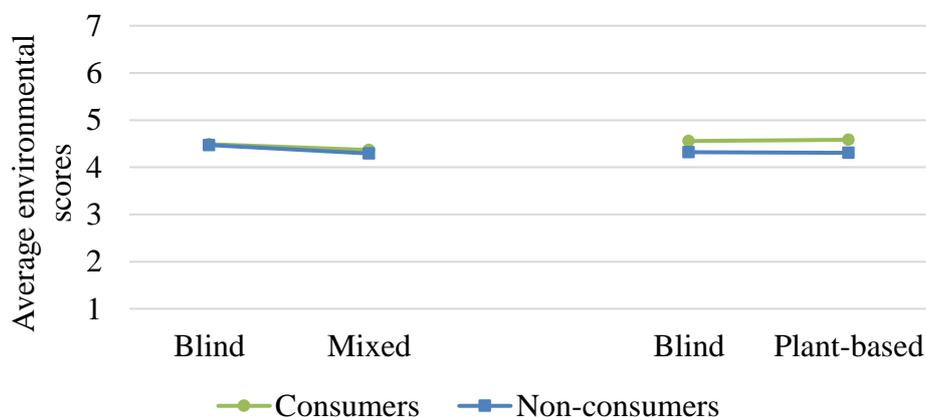


Figure 11: Average environmental scores of the blind and informed conditions for the mixed information and the plant-based information and for consumers and non-consumers.

The significant effect of the factor “Group” for the “Plant-based” information shows that there is a difference of scores given by the two groups: Figure 11 shows that the consumers

of plant-based alternatives to dairy products considered the products presented as “plant-based” as better for the environment than the participants who do not consume or rarely consume plant-based products. But for the “mixed” information, the difference between the groups is not significant. Each group ranked the products similarly, as the effect of the interaction “Product*Group” is not significant. As the effect of the interaction “Group*Information” is not significant, the effect of information was the same for both groups: the reaction to composition information, compared with the absence of information, was not different between consumers and non-consumers.

DISCUSSION

1. Effect of the information on the liking of mixed products

Our results showed that, all products considered together, providing a composition information to participants did not modify their appreciation of the products; but for some specific products, providing a plant-based composition information had an influence. Then, our hypothesis H1a is only partially verified. Products appreciated without information (oat products) are even more liked with a plant-based composition information, whereas there is no difference for soy products when presented as “plant-based”. An explanation could be that participants might have expectations regarding sensory properties of some plant-based products, that were activated by the composition information. Soy is indeed generally not appreciated in France. A previous study showed through focus groups and soy-yogurts blind tasting that soy products are considered insipid and unpleasant by French people (Tu et al., 2012). On the contrary, oat-based products such as drinks, yogurts, porridges, biscuits, etc., appeared to be appreciated by Finnish consumers, through an online questionnaire followed by sensory tests using the Check-All-That-Apply method and hedonic scales (Laaksonen et al., 2020). In France, our results show that oat-based products could be more easily accepted than soy-based products, these latter may even be rejected.

In our study, the mixed composition information never changed the liking of the products. As our products are not commercialised and as mixed products are new, the mixed composition information was probably unfamiliar for the participants. Thus, they might not have specific expectations regarding the sensory quality of mixed products. So, there is a difference between the effect of plant-based composition information, which could modify the

liking of products, and mixed composition information, which did not, thus our hypothesis H2a was verified.

It has been shown in another study on mixed cheeses that providing mixed composition information has no effect on the liking. Cheeses were tasted with a blind condition and with an informed condition and evaluated with hedonic scales (Saint-Eve et al., 2021). The fact that providing information can impact the liking is a well-known concept. A study showed that providing the information “contains caffeine” with energy drinks has a negative impact on the liking, in comparison with tasting without information (Morris et Elgar, 2020). Another study showed that providing the information regarding the species and the method or production of fish had an impact on the hedonic evaluation compared with a blind condition (Claret et al., 2016). A study on powdered drinks demonstrated that brand and package information had an impact on the liking of these products (Varela et al., 2010). Then, providing particular information might change the appreciation of the products in some cases, but the results of our study, in line with the study of Saint-Eve et al. (2020), suggests that indicating that products are “mixed” do not change their liking, especially in a negative way. This result is encouraging concerning the acceptability of mixed products and their placing on the market. More results are needed to confirm this.

There was a difference of liking of the products between consumers and non-consumers: consumers liked the products more than non-consumers. This is consistent with the results obtained through the questionnaire: consumers of our study declared to consider plant-based alternatives to milk as pleasant, whereas non-consumers did not. Then, the results of the sensory analysis and their declaration in the questionnaire are coherent. An explanation for the liking differences could be that consumers are more exposed to plant-based ingredient, increasing their liking, or that they eat plant-based products because they like these products. However, products were not rejected by non-consumers, as the liking scores were average. In other studies, it also has been shown that there are differences of liking according to the frequency of plant-based products and then, according to the familiarity with these products. A cross-cultural study about beliefs, barriers and promoters of plant-based products consumption compared Vietnamese participants, who are regular consumers, and French participants, who are not. The results evidenced that Vietnamese liked soy-based products more than French participants (Tu et al., 2012).

Despite the different liking of the products, providing information had the same effect on both groups, meaning that our hypothesis H3a is not verified. Both consumers and non-consumers gave similar hedonic scores with and without information, for each composition information. Then, the intrinsic appreciation of the products might be the major effect influencing the liking of the products in informed situations of tasting.

2. Effect of the information on the perception of the nutritional quality of mixed products

Both mixed and plant-based information influenced the perception of the nutritional quality of the products, compared with the blind condition. Then, our hypothesis H1b is verified. Nutritional scores in informed conditions were probably influenced by participants' knowledge about the ingredients. They might have a positive opinion on the nutritional quality of oat, soy and milk. Indeed, the literature indicate that both soy (Aschemann-Witzel et Peschel, 2019; Tu et al., 2012) and oat (Laaksonen et al., 2020) are considered as healthy. As there is no difference between the effect of the mixed and the plant-based composition information on the perception of the nutritional quality, our hypothesis H2b is not verified.

There was a difference of the perception of the nutritional quality between the two groups. This is coherent with the results of the questionnaire, as consumers of plant-based alternatives to milk considered these products as healthier than non-consumers did. Consumers of plant-based products might eat them because they consider them good for their health. Either their beliefs might be reported on products indicated with a mixed composition information or they might have a good opinion on the nutritional quality of milk, soy and oat. Milk being considered as healthy by consumers of plant-based alternatives can seem surprising, because a study showed that health factors drove the replacement of milk by plant-based alternatives, milk being often considered as high in fat and carbohydrates (McCarthy et al., 2017). Non-consumers seem to react more to the mixed composition information. Then, non-consumers might be reassured by the presence of milk. Indeed, milk is considered as healthy and notably important for bones (Mobley et al., 2014). However, as the results are not significant, this should be verified by further studies.

Providing information had the same effect on both groups, meaning that our hypothesis H3b is not verified.

3. Effect of the information on the perception of the environmental quality of mixed products

Our hypothesis H1c is only partially verified, as the effect of composition information on the perception of the environmental quality depended on the type of information and on the products. Indeed, a mixed composition information decreased the scores given to soy-based products whereas a plant-based composition information increased those given to oat-based products. Participants gave higher environmental notes to oat products indicated as plant-based than without information but gave similar environmental notes to all products between the blind condition and a mixed composition information. Participants might have a lower opinion of the environmental quality of milk in comparison with plant-based products. A study has shown that milk is considered as sustainable, but less than some plant-based dairy alternatives (Schiano et al., 2020). Then, indicating the presence of milk seems to decrease the opinion of participants about the environmental quality of the products, despite the presence of plant ingredients. However, there is a difference for the environmental quality between a mixed and a plant-based composition information, as it seems that participants have a good opinion of products presented as containing oat alone but a bad opinion of products presented as containing both soy and milk. Then, our hypothesis H2c is verified.

The difference of perception of the environmental quality between consumers and non-consumers is only verified for the plant-based composition information. This is coherent with the results of the questionnaire: consumers declared to find plant-based products as more respectful of the environment than non-consumers. Then, as expected, consumers had a more positive opinion of the products' environmental quality than non-consumers but this difference was not expressed anymore when the products were presented as containing milk. With a mixed composition information, both groups gave lower environmental scores. Once again, milk seems to have a negative effect on the perception of the environmental quality. Indeed, milk is considered as less sustainable than plant-based products (Schiano et al., 2020). For consumers of plant-based alternatives, this might be an issue. For example, a study showed that Swiss consumers considered that soy-based meat substitutes have a low environmental impact (Siegrist et Hartmann, 2019). This could be why the group of consumers perceived a higher environmental quality for the products indicated as "plant-based" than the ones indicated as "mixed". Then, indicating the presence of milk might be an issue for the population who already consume alternatives to animal ingredients such as milk.

Providing information had the same effect on both groups, meaning that our hypothesis H3c is not verified.

4. A link between the nutritional and the environmental quality of mixed products assessed in absence of information and the hedonic score

Our results evidenced that the environmental and nutritional scores varied between products when no information was provided to participants. This result was unexpected, since in absence of information, participants do not have any indication about the composition of the products and only rely on what the organoleptic properties: taste, texture, colour, etc. Then, they deduced a nutritional and an environmental quality from them. Besides, it seems that the environmental and nutritional scores followed the hedonic scores: The more a product was liked, the better it was considered nutritionally and environmentally. Another study has shown that the liking and the healthiness perception of caffeinated energy drinks follow the same pattern (Morris et Elgar, 2020). More literature is needed to confirm this.

Another explanation could be that participants recognised the product as plant-based when they tasted them without information. This could also explain the absence of difference between the blind and the plant-based condition on the evaluation of environmental quality. If so, they might have considered this belief only and not the plant-based composition information provided in their evaluation of the environmental quality. The influence of this information could have been decreased, because there is not any new information to consider. Then, plant-based ingredients might be easily recognised through their organoleptic properties. Soy, for example, has indeed a particular taste. Soy yogurts are described as “bitter” and even with the descriptors “wood”, “earthy” and “chalk” by French participants while Vietnamese describe it as “umami” (Tu et al., 2010). If they thought the product was a plant-based product but it was later indicated as a mixed product, then as it was not what they expected, it might have decreased their environmental scores.

5. Highlights and limitations of the study

Finally, our study has a sufficient statistical power, as there were 60 participants in each group. Furthermore, the evaluation of the nutritional and the environmental quality without any information was innovative. Comparing the data with and without information is often found

in literature, but comparing two types of composition information for the same products was a new approach.

As a limitation, it can be mentioned that we indicated the plant ingredient with the composition information: “soy” or “oat”. However, it might have impacted the evaluation of the product, as soy is not well perceived in France. Then, it would have been interesting not to mention the name of the plant ingredient, but instead give a more general composition information such as “This product is composed of plant-based ingredients” (plant-based composition information) or “This product is composed of plant-based ingredients and milk” (mixed composition information).

CONCLUSION

Our study has enlightened the consumers behaviour towards new products mixing cow milk with plant-based ingredients. The results will help researchers formulating products matching as best as possible the consumers’ liking and expectations.

First, we can note that both mixed and plant-based composition information increased the perceived nutritional quality of all products. But the effect of mixed and plant-based composition information on the liking and perceived environmental quality depended on the composition of the products. There was no difference between providing a plant-based or a mixed composition information on the liking and the perception of the nutritional quality. However, for the perception of the environmental quality, providing mixed composition information did not seem to be beneficial, contrary to providing plant-based composition information. Furthermore, there are differences between the regular consumers of plant-based alternatives to dairy products and the non-consumers regarding the products evaluation, as consumers considered them more positively. Finally, the influence of providing composition information is not different between the two groups of participants.

All these results show that the composition information of mixed products should not be an issue for their commercialisation, except maybe for people who are very concerned by the environmental issues. Mixed dairy products seem to be an encouraging lever to introduce plant ingredients in the diet of people who do not regularly consume plant-based food.

BIBLIOGRAPHICAL REFERENCES

Aschemann-Witzel, J., Peschel, A.O., 2019. Consumer perception of plant-based proteins: The value of source transparency for alternative protein ingredients. *Food Hydrocolloids* 96, 20-28. DOI 10.1016/j.foodhyd.2019.05.006

Bernard, J.C., Liu, Y., 2017. Are beliefs stronger than taste? A field experiment on organic and local apples. *Food Quality and Preference* 61, 55-62. DOI 10.1016/j.foodqual.2017.05.005

Biondi, B., Camanzi, L., 2020. Nutrition, hedonic or environmental? The effect of front-of-pack messages on consumers' perception and purchase intention of a novel food product with multiple attributes. *Food Research International* 130, 108962. DOI 10.1016/j.foodres.2019.108962

Choi, Y., Lee, J., 2019. The effect of extrinsic cues on consumer perception: A study using milk tea products. *Food Quality and Preference* 71, 343-353. DOI 10.1016/j.foodqual.2018.08.004

Claret, A., Guerrero, L., Gartzia, I., Garcia-Quiroga, M., Ginés, R., 2016. Does information affect consumer liking of farmed and wild fish?. *Aquaculture* 454, 157-162. DOI 10.1016/j.aquaculture.2015.12.024

Grasso, S., Jaworska, S., 2020. Part Meat and Part Plant: Are Hybrid Meat Products Fad or Future?. *Foods* 9 (12), 1888. DOI 10.3390/foods9121888

Guinard, J.-X., Myrdal Miller, A., Mills, K., Wong, T., Lee, S.M., Sirimuangmoon, C., Schaefer, S.E., Drescher, G., 2016. Consumer acceptance of dishes in which beef has been partially substituted with mushrooms and sodium has been reduced. *Appetite* 105, 449-459. DOI 10.1016/j.appet.2016.06.018

Guyomarc'h, F., Arvisenet, G., Bouhallab, S., Canon, F., Deutsch, S.-M., Drigon, V., Dupont, D., Famelart, M.-H., Garric, G., Guédon, E., Guyot, T., Hiolle, M., Jan, G., Le Loir, Y., Lechevalier, V., Nau, F., Pezennec, S., Thierry, A., Valence, F., Gagnaire, V., 2021. Mixing milk, egg and plant resources to obtain safe and tasty foods with environmental and health benefits. *Trends in Food Science & Technology* 108, 119-132. DOI 10.1016/j.tifs.2020.12.010

Hoek, A.C., Luning, P.A., Weijzen, P., Engels, W., Kok, F.J., de Graaf, C., 2011. Replacement of meat by meat substitutes. A survey on person- and product-related factors in consumer acceptance. *Appetite* 56 (3), 662-673. DOI 10.1016/j.appet.2011.02.001

Laaksonen, O., Ma, X., Pasanen, E., Zhou, P., Yang, B., Linderborg, K.M., 2020. Sensory Characteristics Contributing to Pleasantness of Oat Product Concepts by Finnish and Chinese Consumers. *Foods* 9 (9), 1234. DOI 10.3390/foods9091234

Lang, M., 2020. Consumer acceptance of blending plant-based ingredients into traditional meat-based foods: Evidence from the meat-mushroom blend. *Food Quality and Preference* 79, 103758. DOI 10.1016/j.foodqual.2019.103758

McCarthy, K.S., Parker, M., Ameerally, A., Drake, S.L., Drake, M.A., 2017. Drivers of choice for fluid milk versus plant-based alternatives: What are consumer perceptions of fluid milk?. *Journal of Dairy Science* 100 (8), 6125-6138. DOI 10.3168/jds.2016-12519

Michel, F., Hartmann, C., Siegrist, M., 2021. Consumers' associations, perceptions and acceptance of meat and plant-based meat alternatives. *Food Quality and Preference* 87, 104063. DOI 10.1016/j.foodqual.2020.104063

Mobley, A.R., Jensen, J.D., Maulding, M.K., 2014. Attitudes, Beliefs, and Barriers Related to Milk Consumption in Older, Low-Income Women. *Journal of Nutrition Education and Behavior* 46 (6), 554-559. DOI 10.1016/j.jneb.2013.11.018

Morris, C., Elgar, J., 2020. Impact of caffeine and information relating to caffeine on young adults' liking, healthiness perception and intended use of model energy drinks. *LWT* 132, 109879. DOI 10.1016/j.lwt.2020.109879

Neville, M., Tarrega, A., Hewson, L., Foster, T., 2017. Consumer-orientated development of hybrid beef burger and sausage analogues. *Food Science & Nutrition* 5 (4), 852-864. DOI <https://doi.org/10.1002/fsn3.466>

Oliveira, D., Ares, G., Deliza, R., 2017. Influence of intrinsic and extrinsic factors on consumer liking and wellbeing perception of two regular and probiotic milk products. *Journal of Sensory Studies* 32, e12261. DOI 10.1111/joss.12261

Onwezen, M.C., Reinders, M.J., Verain, M.C.D., Snoek, H.M., 2019. The development of a single-item Food Choice Questionnaire. *Food Quality and Preference* 71, 34-45. DOI 10.1016/j.foodqual.2018.05.005

Profeta, A., Baune, M.-C., Smetana, S., Bornkessel, S., Broucke, K., Royen, G., Enneking, U., Weiss, J., Heinz, V., Hieke, S., Terjung, N., 2021. Preferences of German Consumers for Meat Products Blended with Plant-Based Proteins. *Sustainability* 13, 650. DOI 10.3390/su13020650

Saint-Eve, A., Irlinger, F., Pénicaud, C., Souchon, I., Marette, S., 2021. Consumer preferences for new fermented food products that mix animal and plant protein sources. *Food Quality and Preference* 90, 104117. DOI 10.1016/j.foodqual.2020.104117

Schiano, A.N., Harwood, W.S., Gerard, P.D., Drake, M.A., 2020. Consumer perception of the sustainability of dairy products and plant-based dairy alternatives. *Journal of Dairy Science* 103 (12), 11228-11243. DOI 10.3168/jds.2020-18406

Siegrist, M., Hartmann, C., 2019. Impact of sustainability perception on consumption of organic meat and meat substitutes. *Appetite* 132, 196-202. DOI 10.1016/j.appet.2018.09.016

Sogari, G., Li, J., Wang, Q., Lefebvre, M., Gómez, M.I., Mora, C., 2021. Factors influencing the intention to purchase meat-mushroom blended burgers among college students. *Food Quality and Preference* 90, 104169. DOI 10.1016/j.foodqual.2020.104169

Steinfeld, H., Gerber, P.J., Wassenaar, T., Castel, V., Rosales, M., De haan, C., 2006. *Livestock's Long Shadow: Environmental Issues and Options*, Food and Agriculture Organization of the United Nations.

Tangyu, M., Muller, J., Bolten, C.J., Wittmann, C., 2019. Fermentation of plant-based milk alternatives for improved flavour and nutritional value. *Applied Microbiology and Biotechnology* 103 (23), 9263-9275. DOI 10.1007/s00253-019-10175-9

Tarrega, A., Rizo, A., Murciano, A., Laguna, L., Fiszman, S., 2020. Are mixed meat and vegetable protein products good alternatives for reducing meat consumption? A case study with burgers. *Current Research in Food Science* 3, 30-40. DOI 10.1016/j.crfs.2020.02.003

Thrane, M., Paulsen, P. V., Orcutt, M. W., Krieger, T. M.,2017. Soy protein. In S. R. Nadathur, J. P. D. Wanasundara, & L. Scanlin (Eds.), *Sustainable protein sources* (pp. 23–45). London: Academic Press. DOI 10.1016/B978-0-12-802778-3.00002-0.

Tu, V.P., Husson, F., Sutan, A., Ha, D.T., Valentin, D., 2012. For me the taste of soy is not a barrier to its consumption. And how about you?. *Appetite* 58 (3), 914-921. DOI 10.1016/j.appet.2012.01.023

Tu, V.P., Valentin, D., Husson, F., Dacremont, C., 2010. Cultural differences in food description and preference: Contrasting Vietnamese and French panellists on soy yogurts. *Food Quality and Preference* 21 (6), 602-610. DOI 10.1016/j.foodqual.2010.03.009

Varela, P., Ares, G., Giménez, A., Gámbaro, A., 2010. Influence of brand information on consumers' expectations and liking of powdered drinks in central location tests. *Food Quality and Preference* 21 (7), 873-880. DOI 10.1016/j.foodqual.2010.05.012

Verain, M.C.D., Snoek, H.M., Onwezen, M.C., Reinders, M.J., Bouwman, E.P., 2021. Sustainable food choice motives: The development and cross-country validation of the Sustainable Food Choice Questionnaire (SUS-FCQ). *Food Quality and Preference* 93, 104267. DOI 10.1016/j.foodqual.2021.104267

Youssef, M., 2016. Substitution of animal proteins by plant proteins: Effect of health and environmental information on the acceptability of mixed yogurts. *Eurosense, 7th European Conference on Sensory and Consumer Research*. Dijon Congress Centre, Dijon, France, 11 - 14 September 2016. 2016.

APPENDICES

Appendix 1: Pictures of the four products used in the study



50S: 50% soy – 50% milk



50A: 50% oat – 50% milk



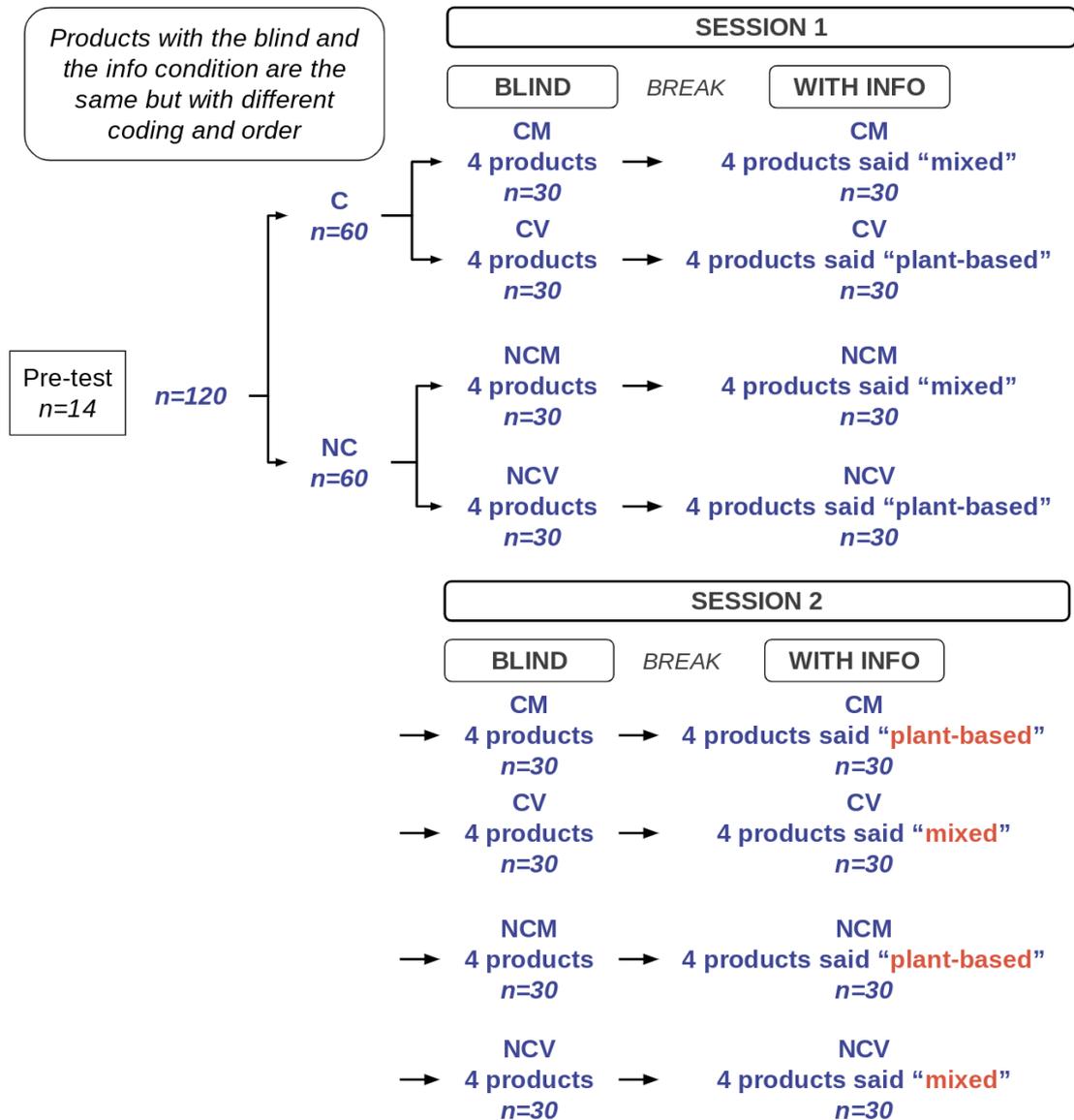
25S: 25% soy – 75% milk



25A: 25% oat – 75% milk

Appendix 2: Organisation of the sessions

C: Consumers, NC: Non-consumers, CM: Consumers submitted to the mixed information in Session 1, CV: Consumers submitted to the plant-based information in Session 1, NCM: Non-consumers submitted to the mixed information in Session 1, NCV: Non-consumers submitted to the plant-based information in Session 1



Appendix 4: Characterisation questionnaire

Lors de l'achat d'un produit alimentaire, je prends en compte :

1. Son impact sur la santé :

<input type="checkbox"/>					
Pas du tout d'accord	Pas d'accord	Plutôt pas d'accord	Plutôt d'accord	D'accord	Tout à fait d'accord

2. Son impact sur l'environnement :

<input type="checkbox"/>					
Pas du tout d'accord	Pas d'accord	Plutôt pas d'accord	Plutôt d'accord	D'accord	Tout à fait d'accord

3. Son goût :

<input type="checkbox"/>					
Pas du tout d'accord	Pas d'accord	Plutôt pas d'accord	Plutôt d'accord	D'accord	Tout à fait d'accord

De manière générale, pour moi, un lait végétal est plutôt un produit :

1. bon pour la santé :

<input type="checkbox"/>					
Pas du tout d'accord	Pas d'accord	Plutôt pas d'accord	Plutôt d'accord	D'accord	Tout à fait d'accord

2. utile :

<input type="checkbox"/>					
Pas du tout d'accord	Pas d'accord	Plutôt pas d'accord	Plutôt d'accord	D'accord	Tout à fait d'accord

3. agréable :

<input type="checkbox"/>					
Pas du tout d'accord	Pas d'accord	Plutôt pas d'accord	Plutôt d'accord	D'accord	Tout à fait d'accord

4. naturel :

<input type="checkbox"/>					
Pas du tout d'accord	Pas d'accord	Plutôt pas d'accord	Plutôt d'accord	D'accord	Tout à fait d'accord

5. abordable :

<input type="checkbox"/>					
Pas du tout d'accord	Pas d'accord	Plutôt pas d'accord	Plutôt d'accord	D'accord	Tout à fait d'accord

6. familier :

<input type="checkbox"/>					
Pas du tout d'accord	Pas d'accord	Plutôt pas d'accord	Plutôt d'accord	D'accord	Tout à fait d'accord

7. qui respecte l'environnement :

<input type="checkbox"/>					
Pas du tout d'accord	Pas d'accord	Plutôt pas d'accord	Plutôt d'accord	D'accord	Tout à fait d'accord

8. qui respecte la cause animale :

<input type="checkbox"/>					
Pas du tout d'accord	Pas d'accord	Plutôt pas d'accord	Plutôt d'accord	D'accord	Tout à fait d'accord

9. issu du commerce équitable :

<input type="checkbox"/>					
Pas du tout d'accord	Pas d'accord	Plutôt pas d'accord	Plutôt d'accord	D'accord	Tout à fait d'accord

10. local ou régional :

<input type="checkbox"/>					
Pas du tout d'accord	Pas d'accord	Plutôt pas d'accord	Plutôt d'accord	D'accord	Tout à fait d'accord

11. vendu en magasin bio :

<input type="checkbox"/>					
Pas du tout d'accord	Pas d'accord	Plutôt pas d'accord	Plutôt d'accord	D'accord	Tout à fait d'accord

Appendix 5: Factors describing a plant-based product according to the consumers and non-consumers (non-significative results)

