Exploring consumer perceptions and familiarity on apple production and processing under different conditions: conventional, organic, home-made, artisanal and industrial

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"Exploring consumer perceptions and familiarity on apple production and processing under different conditions: conventional, organic, home-made, artisanal and industrial"

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ABSTRACT

Purpose- The purpose of this paper is to better understand consumer's familiarity with fruit processing as well as how fruit production conditions (organic and conventional farming), processing conditions (homemade, artisanal and industrial) and the type of processing (e.g. applesauce, apple cider and apple sorbet) influence consumer perceptions of processed fruits.

Design/methodology/approach- An online survey questionnaire was applied to 1,000 people living in France. They represented different genders, ages (18–60+) and sociodemographic categories. Participants were categorized based on their produce purchasing habits (conventional, local, organic, local-organic). The questionnaire contained multiple choice and five point Likert scale questions. Data were analyzed using non-parametric tests.

Findings- We found that participants saw year-round availability, fruit preservation and food waste reduction as processing advantages. Locally sourced products were preferred to organic products. The perceived disadvantages to processing were additive usage, nutrient loss and packaging. For consumers, these disadvantages drove highly differentiated perception**s** of industrial versus artisanal/homemade apple products. Processing conditions appeared to matter far more than production conditions (organic vs conventional). In general, consumers weren't familiar with processing operations, awareness was greater for consumers of local and/or organic produce than conventional consumers.

Originality/value- Research has shown that consumers view fresh organic fruit positively, but only few studies have looked at perceptions of processed fruit products and their familiarity with processing operations. Results of this study demonstrate that consumers could make better choices if they are given quality information about fruit production and processing.

Keywords: French-consumer perceptions, fruit processing, organic, conventional, local, homemade, industrial, artisanal

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INTRODUCTION

Healthy diets contain large quantities of fruits and vegetables, which are rich in nutrients and fibers but low in calories (FAO, 2020; Rekhy & McConchie, 2014). When consumed in appropriate amounts, they can help prevent micronutrient deficiencies and health conditions, including cardiovascular issues, certain types of cancer, type II diabetes, and obesity. The Food and Agriculture Organization (FAO) and World Health Organization (WHO) recommend the consumption of fruits and vegetables in all forms, whether fresh or processed (Hai Liu, 2013), as a means for improving public health and the economic stability of farmers (FAO, 2020).

Fruit are highly perishable, and thus their transformation may have many benefits, such as ensuring product microbial safety, preserving nutritional value, increasing shelf life, promoting year-around availability, and reducing waste (Deliza et al., 2003; Cheftel, 1995; Hai Liu, 2013; Augustin et al., 2016). Furthermore, processed products increase convenience for consumers and display a large range of sensory properties.

There is considerable evidence that food processing converts often non-edible raw materials into edible, safe, and nutritious food as well as the need for preservation and bioconversion. (Augustin et al., 2016; Fellows, 2022; Knorr & Augustin, 2021a; Van Boekel et al., 2010).
Food processing involves a combination of unit operations (a "process") that transform raw materials into foods with specific and identifiable properties. A process's unique combination and sequence of operations determines the nature of the final product (Fellows, 2022). Water and energy consumption might also vary among operations. Processing falls into four general categories: mechanical, biological, biotechnological and thermal (Kahl et al., 2014). In the case of processed fruit products, different unit operations include washing, cutting, mixing, thermal pasteurization, or packaging, which yield foods with diverse properties (X. Song et al., 2022; Ragaert et al., 2004). In recent years, consumers have become increasingly interested in adopting more sustainable diets that are based on fresh, natural, minimally processed, and additive-free foods (Lavilla & Gayán, 2018; Mesías et al., 2021). However, the concept of naturalness is not consensual between producers, transformers and consumers. Numerous studies have legal and technical perspectives (Sanchez-Siles et al., 2019). According to Roman et al., (2017) consumers define how natural a food is based on three categories: i) the way in which the food has been grown; ii) the way in which the food has been processed; and iii) the properties of the final product.
Consequently, many consumers have expressed concerns about processing methods (Deliza et al., 2005) and have increasingly negative perceptions of industrially processed foods, even if processing has immense advantages (Renard, 2022; Sadler et al., 2021), as detailed above.
The greater the transformation, the less natural foods are considered to be. That said, losses in naturalness depend also on the mode of production. Physical processing (e.g. chopping and blending) decreases naturalness less than chemical processing (e.g. chemical extraction from plant sources), according to Evans, de Challemaison and Cox (2010). The degree of mechanization also has an influence (Abouab & Gomez, 2015): handmade foods are perceived as more natural than machine-made foods.
Moreover, past research has shown that consumer perceptions are shaped by information about production and processing methods, where some are significantly distrusted or disliked

(Deliza et al., 2010; Grunert et al., 2003). For example, products arising from conventional and/or large-scale agriculture are seen as less natural, and foods containing artificial additives may be described as unhealthy or unfamiliar (Abouab & Gomez, 2015; Asioli et al., 2017; Etale & Siegrist, 2021). In addition, traits such as country of origin, organic certification, regional or local production, and environmental friendliness continue to predominate among consumer concerns.

Production methods are often tightly linked to production type and location. In the recent context of food transition, many consumers have begun to prioritize locally sourced food, which travels very short distances or is sold directly by farmers (Holloway et al., 2007). However, it has been demonstrated that a food's environmental impact (i.e., energy usage and carbon dioxide emissions) is determined less by transportation and more by production within the lifecycle of the food system (Poore & Nemecek, 2019).

Consumers also often express misgivings about conventional agriculture and intensive farming systems, with their high levels of pesticide usage (Aktar et al., 2009). In contrast, organic agriculture is seen as taking a holistic approach: it implements environmentally friendly farming practices, displays a keen interest in preserving biodiversity and natural resources, and maintains high standards for animal welfares and production approaches that appeal to consumers with a desire for more natural products and processes (Lasma et al., 2021). Therefore, consumption of organic fruit products could help boost human and planetary health.

While consumers are generally familiar with the benefits of raw organic foods (Denver & Jensen, 2014; Grzybowska-Brzezińska et al., 2017) Kahl et al., (2014), research is rare on consumer expectations and perceptions around organic fruit products that have undergone different degrees of processing (Prada et al., 2017). Notably, little is known about how consumers view foods that are homemade, artisanal, or industrial in nature (Etale & Siegrist, 2021).

Given this context, our study's main objective was to understand how the conditions under which fruits are produced and processed may influence consumer expectations. As examples, we used apple products that had experienced different degrees of transformation (apple sauce, apple cider, and apple sorbet). We sought to answer the following questions: Are consumers familiar with the unit operations involved in food processing? Do consumers have different perceptions of fruit products arising under different production conditions (organic, conventional, or local) and processing conditions (homemade, artisanal, or industrial)? What are the inter-individual differences according to consumption habits, gender, and age?

METHODOLOGY

We carried out an online quantitative survey that targeted residents of France. It was administered in November 2021 by a professional research agency (LightSpeed Company, Paris), which took care of participant recruitment and data collection. Participants were recruited via a consumer database owned by the agency. They should meet the specific consumer profile required for this study which was focused on omnivorous French adults who consumed fruits and vegetables at least twice a day. A first online screening ensured the selection of the participants based on their produce consumption, the place where they acquire their produce and sociodemographic characteristics.

Participants were informed that the information they provided would be kept entirely anonymous and that the data would be examined for statistical and research purposes. They were compensated with gift cards.

Online questionnaires are an interesting tool of growing applications for the evaluation of consumers' perception, allowing the achievement of a large number of responses from a given population (Honorio et al., 2019; Jaeger et al., 2018)

Participants

A total of 1,000 people living in France responded to the survey. They represented different genders (male/female), ages (18–60+), and sociodemographic categories (SDC) (**Table I**). All consumed fruits or vegetables at least twice a day. We classified the participants based on their produce (fruits and vegetables) purchasing habits. Their consumer type was one of the following: 1) conventional: they primarily purchased conventional produce (n = 282); 2) local: they primarily purchased locally sourced produce (n = 282); 3) organic: they primarily purchased organic produce (n = 270); 4) local and organic: they primarily purchased locally sourced organic produce (n = 167).

Questionnaire

The questionnaire had 4 sections with a total of 34 questions (mean duration = 17 min). Before data collection began, a preliminary survey was conducted with 20 participants to validate the questionnaire's reliability.

The first section aimed to understand what drove consumer choices of food in general and of fresh produce (fruits and vegetables) in particular. The second section sought to understand how consumers perceived different categories of processed fruit products (organic, conventional, homemade, artisanal, and industrial). The third section examined consumer perception and knowledge about processing operations, focusing on apple products reflecting three degrees of transformation (apple sauce, apple cider, and apple sorbet). This section also explored how production conditions (organic and conventional) and processing conditions (homemade, artisanal, and industrial) affected consumer perception of fruit products. Finally, the fourth section collected standard demographic data, such as age and gender.

The questionnaire contained multiple-choice questions as well as questions employing a five-point Likert scale. The latter revealed how respondents felt about the relative importance of different criteria (e.g., 1 = not at all important, 2 = not very important, 3 = somewhat important, 4 = important and 5 = very important).

Data Analysis to compare the independent samples

The data were analyzed using non-parametric tests (Kruskal Wallis). We generated descriptive summaries of the participants' sociodemographic status and perceptions of food production in general as well as fruit production and fruit processing in particular.

A Chi-squared test was used to assess differences in perceptions among groups, and the resulting proportions were compared using a two-proportion Z-test. For the multiple-choice questions, response frequencies were calculated.

Statistical analysis was performed using the XlStat software program (Addinsoft, Paris, France, 2021); the alpha level was 0.05.

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Table I. Description and classification of the survey participants.

		Total n=1000		Consumer Type							
				Conventional		Local		Organic		Organic and Local	
		n	%	n	%	n	%	n	%	n	%
Gender	Male	486	49	111	39	136	48	152	56	87	52
	Female	514	51	171	61	146	52	118	44	80	48
Age	18-29 years old	180	18	54	19	68	24	45	17	13	8
	30-39 years old	151	15	39	14	29	10	48	18	35	21
	40-49 years old	171	17	55	20	27	10	50	19	39	23
	50-59 years old	170	17	52	18	32	11	46	17	40	24
	60 + years old	329	33	82	29	126	45	81	30	40	24
Employment	Farmer	6	1	2	1	0	0	3	1	1	1
	Self-employed	13	1	1	0	3	1	5	2	4	2
	Craftsperson	20	2	8	3	3	1	8	3	1	1
	Student	36	4	15	5	12	4	9	3	0	0
	Manager and above	250	25	54	19	48	17	87	32	61	37
	Workman	79	8	34	12	12	4	21	8	12	7
	Unemployed	88	9	33	12	17	6	19	7	19	11
	Employed	235	23	70	25	72	26	52	19	41	25
	Retired	274	27	65	23	115	41	66	24	28	17
Mainly purchased produce	Organic	270	27	282	100	0	0	270	100	0	0
	Conventional	282	28	0	0	282	100	0	0	0	0
	Local	282	28	0	0	0	0	0	0	0	0
	Organic and local	167	17	0	0	0	0	0	0	167	100
Total		1000	100	282		282		270		167	

RESULTS & DISCUSSION

General consumer perceptions of food consumption and processed produce

To clarify how the participants perceived food production in general, we examined the percentage of "important" and "very important" (top two boxes) responses. The respondents' major concerns were 1) limiting food waste (94%); 2) eating a healthy diet (93%); 3) eating seasonal products (89%); 4) eating homemade products (88%); 5) eating locally sourced food (86%); and 6) preserving the environment (85%). A smaller proportion of participants (32%), rated eating ready-to-use products, most of these people were over 50 years old. Eating a healthy diet and eating seasonal products were significantly higher for those who generally purchased local, organic, or local organic produce ($p < 0.0001$).

More than 75% of all the participants agreed that organic food products are more expensive than conventional food products (81%); organic food products help preserve the environment (76%); and organic food products help preserve consumer health (75%). This is in agreement with the work of Ditlevsen et al., (2020), who observed that consumers (organic, local and indifferent) considered climate issues as important characteristics of food products.

In addition, half of consumers (51%) agreed that organic food products from France are of higher quality than organic food products from other countries, reflecting trust in national regulations governing organic farming. Actually, some consumers criticize the increasing quantity of imports in the national food market and regard local food as a more environmentally and climate friendly alternative, other consumers view local food from a

rather hedonistic viewpoint as fresher, safer and healthier than imported products (Feldmann & Hamm, 2015).

The participants strongly expressed the opinion that consuming locally sourced food helps to preserve the environment (80%). These findings are aligned with those of other studies on consumer perceptions of organic products. Literature point out that organic products are perceived by consumers as a more sustainable alternative (de Magistris & Gracia, 2016) because they are considered to be better for specific environmental impacts as the reduction of the quantity of greenhouse gasses emissions (Venkat, 2012)or the non-use of chemical fertilizers and pesticides (He et al., 2016).

For both fresh and processed produce, more minor concerns were the presence of packaging (46% and 51%, respectively); it was more relevant for products to have come from a local source (79% and 74%, respectively) than to be certified organic (61% and 66%, respectively). In fact, attention has been paid to local and organic food production (Adams & Salois, 2010) both product attributes are associated with better quality, taste, and freshness; they are considered healthy foods that also provide environmental benefits (Adams & Adams, 2011; Bingen et al., 2011; Campbell et al., 2013). However, as stated by Hempel & Hamm (2016), organically produced food became part of the globalization process when demand increased and could not be met by national supply alone (for example, in many European countries) whereas local food leads to more proximity in food production. As sometimes framed "local has become the new organic", consumers associate products from small-scale producers with some of the same features as local and organic. One might expect that the industrialization of the organic sector would drive consumers towards products from small-scale local production (Jensen et al., 2019).

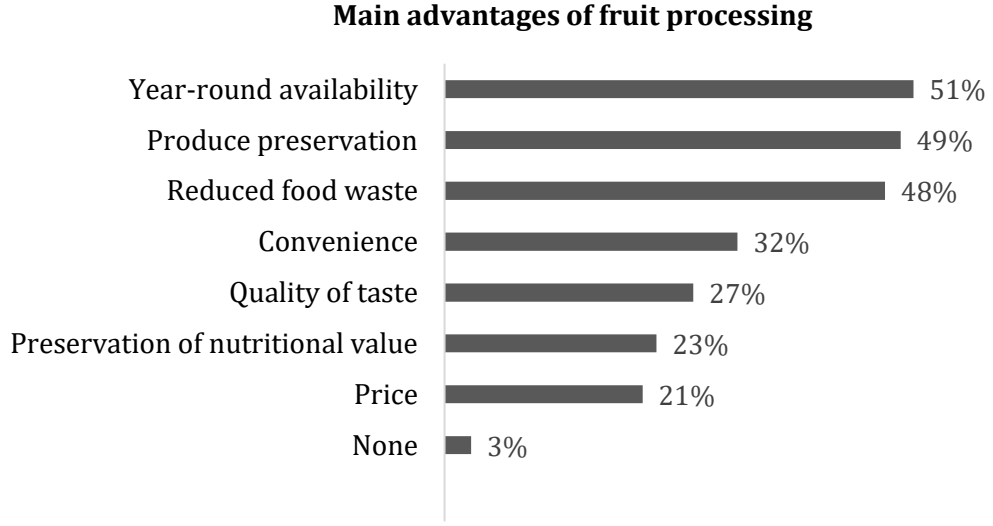
The major considerations when purchasing fresh produce were taste (92%), seasonality (86%), price (81%), local sourcing (79%), and fair compensation for farmers (76%). When purchasing processed produce, consumer concerns centered on taste (90%), price (82%), list of ingredients (81%), nutritional value (80%), and fair compensation for farmers (76%). These results are consistent with those from Ditlevsen et al., (2020), who observed that for food easy to prepare, freshness and taste were important items in food consumption.

Consumer acceptance of technologies is based on perceived risks and benefits of processing. Informing and making consumers aware of the benefits should increase the acceptance of processing (Meijer et al., 2021). The principal benefits of processing assessed by participants were year-round availability, produce preservation, and reduced food waste; the ~~main~~ perceived disadvantages were the use of additives, loss of nutritional value, and presence of packaging (Q Cochran test [Bonferroni $\alpha = 0.05$]; Fig. 1). Unexpectedly, taste was not seen as a major benefit of processing, whether taste is generally one of the most important food attributes (Ditlevsen et al 2020).

Over recent decades, consumers have been taking an increasing interest in their diets: they are seeking to reduce food waste; increase healthy eating habits; consume more seasonal,

local, and homemade products; and preserve the environment (Aschemann-Witzel, 2015; Goukens & Klesse, 2022; Honorio et al., 2019; Kokkoris & Stavrova, 2021).
When it came to both fresh and processed produce, respondents were largely concerned with taste, price, source, and fair compensation for farmers. While it was **relevant** that foods be locally sourced and organically produced, organic expectations were lower than locally sourcing in both: raw and processed fruits. Past research has shown that some consumers focus on the broader benefits of food from local sources (i.e., it is better for the environment and climate), while other consumers concentrate on the benefits it affords them personally (i.e., it is fresher, safer, and healthier) (Feldmann & Hamm, 2015). This favorable opinion of locally sourced food is rooted in the assumption that such food leads to fresher and better tasting products because of higher food safety, animal welfare, and environmental standards. Consumers thus appear to attribute the same positive qualities to locally sourced foods and organically produced foods (Denver & Jensen, 2014; Hempel & Hamm, 2016a, 2016b). Past research has highlighted that certain products, such as vegetables, fruit, meat, dairy products, and eggs, are automatically seen as having a local origin or are viewed significantly more favorably when they come from a local source (Chambers et al., 2007; Grebitus et al., 2013).

Respondents were aware of the advantages and disadvantages of processed produce. The main disadvantages that they cited were the use of additives, the loss of nutritional value, and the presence of packaging, which were tied to negative health and environmental impacts. Song & Schwarz (2009) found that the names of additives elicit feelings of unfamiliarity in consumers, which bumps up perceived health risks.



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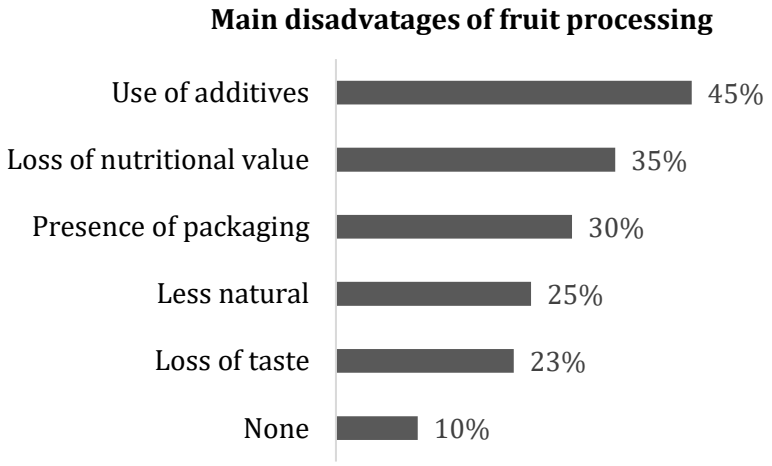

Figure 1. Perceived advantages and disadvantages of processed produce (n = 1,000). Differences in letters indicate statistical differences among groups. Q Cochran test (Bonferroni α=0.05)

Familiarity with processing operations and conditions (home-made, artisanal and industrial) for organic and conventional fruit products

In order to clarify how much participants knew about fruit processing (knowledge and familiarity on unit operations), we examined the frequencies of the top two responses ("Know it well" and "Know it fairly well") and the bottom two responses ("Never heard of it" and "Heard of it"). The respondents were most familiar with packaging (42%) and heat treatment (35%) (Fig. 2). The majority knew little to nothing about Ohmic heating (78%), aeration (76%), extrusion (75%), clarification (67%), homogenization (66%) or high-pressure processing (HPP; 61%) (Fig. 2). Song et al (2020) also reported a lack of knowledge of participants of a qualitative study regarding the processing of fruit and vegetable products in general. Familiarity with the processing technology has been recognized as one of the factors influencing consumer responses to new technologies (Frewer et al., 2011; Rollin et al., 2011). High pressure technology sounds less risky to consumers because people are familiar with the idea of pressure cooking at home, although from a technology point of view pressure cooking at home and high pressure technology are not closely related (Meijer et al., 2021).

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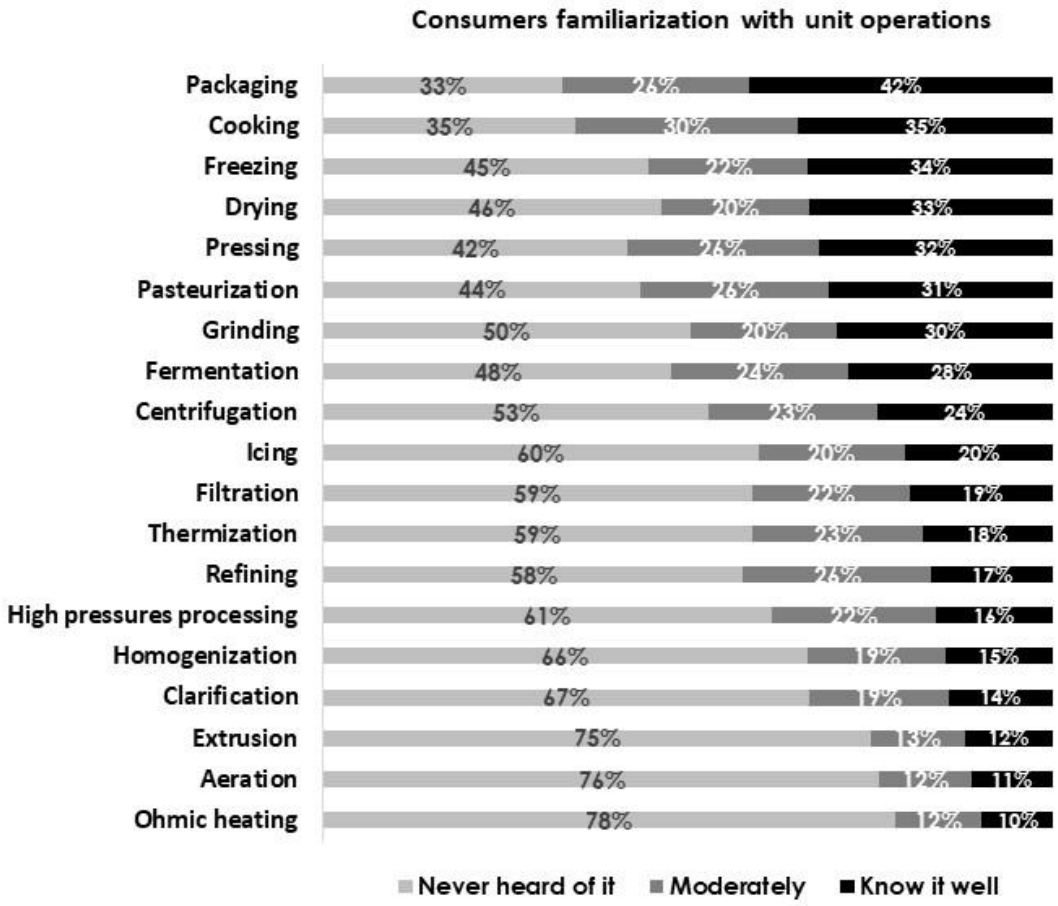

Figure 2. Consumers familiarity with processing operations (n=1000)

We also explored perceived differences between processing conditions. For all three example products (apple sauce, apple cider, and apple sorbet), respondents considered that major differences existed in processing between industrial and homemade products (> 70%) as well as between industrial and artisanal products (> 70%) (**Table II**).
Concerning home-made and artisanal comparison, 50% of respondents thought that the processing of homemade versus artisanal products was very different for apple sauce (50%), apple sorbet (50%), and apple cider (45%). A slightly lower percentage of participants thought processing of organic and conventional products was different or very different (apple cider = 48%, apple sauce = 47%, apple sorbet = 43%).

Organic processing technologies should include fewer processing steps, low environmental impact, while keeping the product as natural as possible (Hüppe & Zander, 2021). To further clarify perceptions regarding the processing of a conventional and an organic fruit, participants were asked whether processing was the same for conventional versus organic fruit products. A significant majority of respondents (56%) considered that a difference existed (two-proportion Z test: $p < 0.001$). It may be explained by consumers association of organic farming values, which involves best environmental practices, a high level of protection of biodiversity, conservation of natural resources to organic processing values such as fewer

processing steps, uses of additives and low environmental impact (Lasma et al., 2021; Hüppe & Zander, 2021).Thus, consumer's expectations towards organic food processing might be in line with the virtuous values of organic farming.

Respondents had different perceptions of fruit products resulting from various processing conditions (industrial, artisanal, and homemade) and production systems (organic and conventional). The greatest distinction was made between industrial products and artisanal/homemade products, whether the example food was apple sauce, apple cider, or apple sorbet. Even if many of the traditional unit operations used in industrial processing today (e.g. washing, chopping, pureeing, heating, chilling, freezing, fermenting, baking and cooking) have been used for the preparation and cooking of food at home (Knorr & Augustin, 2021a).

Even if consumers have become more and more interested in the composition and origin of the foods in their diets, they appear to remain less aware of how products are processed. Several technologies are difficult for consumers to understand, creating uncertainty and a feeling of lack of control in their minds. As a result, consumers need information about the production technology. Efforts can be made in order to let them know how their food is being processed in industry and highlight the benefits vis-a-vis preparing foods in a domestic environment (Meijer et al., 2021).

It is clear that participants made a major distinction between industrial processing (> 70%) and homemade or artisanal processing. This gap is likely rooted in consumer desire for more natural and minimally processed foods. Industrial processing was associated with the use of additives, the loss of nutrients, and the presence of packaging, which are equated with less natural products. Like with additive names, when consumers were unfamiliar with unit operations, they may view the resulting processed products as less natural. Past research has shown this is a general trend: consumers tend to amplify risks if a food or technology is strange to them, or, conversely, they will minimize risks if a food is familiar or homemade (Grunert, 2005). Work by Evans et al. (2010) suggested that the more a food was processed (i.e., incurring physical or chemical changes to itself or its ingredients), the less it was perceived as natural. Based on lessons from the juice industry, Honorio et al. (2019) has proposed that product acceptance will be improved if we facilitate consumer access to information about product ingredients and processing conditions.

Regardless of the degree of apple processing, almost 50% of respondents considered that organic apples were processed differently from conventional apples. Yet, this difference was less pronounced than the perceived difference between industrial and artisanal/homemade products.

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Table II. Perceived differences in processing for apple sauce, apple cider, and apple sorbet (n=1000).

Processing comparison	Apple sauce			Apple cider			Apple sorbet		
	Not different	Somewhat different	Different/Very different	Not different	Somewhat different	Different/Very different	Not different	Somewhat different	Different/Very different
Industrial VS Homemade	5%	18%	77%	7%	22%	71%	7%	20%	73%
Industrial VS Artisanal	5%	21%	74%	7%	21%	72%	6%	19%	74%
Homemade VS Artisanal	11%	39%	50%	13%	42%	45%	13%	37%	50%
Organic VS Conventional	14%	39%	47%	15%	37%	48%	15%	41%	43%

Apple sauce: impact of processing and production conditions on consumer perceptions

For the example product apple sauce, we compared three processing conditions (industrial, artisanal, and homemade) and two production conditions (organic and conventional). Participants were asked about the presence of differences between certain pairs of conditions (**Table III.a**).

The principal perceived differences between *homemade and industrial apple sauce processing* were the following: addition of sugar (65%), use of pesticides (62%), addition of citric acid (61%), addition of ascorbic acid (60%), addition of lemon (58%), cooking (56%), apple sorting (56%), and storage (56%). That said, over 30% of consumers saw no difference between industrial and homemade products for certain processing steps, namely apple harvesting (33%), fruit peeling (30%), washing (32%) and apple production (30%). Furthermore, around a third of the participants were unfamiliar with two operations: thermization (32%) and refining (30%).

The main perceived differences between *artisanal and industrial apple sauce processing* were the addition of sugar (60%), use of pesticides (59%), addition of citric acid (56%), and addition of ascorbic acid (55%). Over a third of participants thought there were no differences in operations such as packaging in glass containers (34%), fruit washing (34%), fruit peeling (33%), and fruit harvesting (33%). A large number of people were completely unfamiliar with certain steps, namely thermization (32%) and refining (30%).

A majority of respondents (55%) considered that *homemade and artisanal apple sauce processing* were essentially equivalent. Around 30% of participants were unfamiliar with thermization (32%) and refining (30%).

The main perceived differences in the *processing of organic versus conventional apple sauce* were use of pesticides (64%), apple production (57%), addition of sugar (47%), addition of ascorbic acid (45%), addition of citric acid (45%), and addition of lemon (45%). Around one-third of participants considered the following operations to be similar: fruit peeling (41%), cooking (39%), grinding (38%), apple harvesting (34%), washing (34%), packaging in glass containers (32%), cold storage (31%), packaging in plastic (30%), and packaging in bulk (30%). The same percentage were unfamiliar with thermization (32%), use of a food mill (32%), and refining (30%).

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Apple cider: impact of processing and production conditions on consumer perceptions

For the example product apple cider, we compared three processing conditions (industrial, artisanal, and homemade) and two production conditions (organic and conventional). Participants were asked about the presence of differences between certain pairs of conditions (**Table III.b**).

A majority of respondents considered that the main differences in *homemade and industrial apple cider processing* were apple storage and ripening (58%) and apple production (56%). Around one-third thought that the operations of packaging in glass containers (34%) and bottling (32%) did not differ. Around the same percentage of participants were unfamiliar with racking (34%) and yeasting (31%).
The main perceived differences between *artisanal (fermier) and industrial apple cider processing* were apple storage and ripening (60%) as well as apple production (60%). A minority of participants (32%) felt that packaging in glass containers was similar under both conditions. An equivalent percentage of participants were unfamiliar with racking (32%).

Most respondents (> 55%) considered that there were no major differences between *homemade and artisanal (fermier) apple cider processing*. Over one-third of participants viewed certain operations as similar in both cases: apple washing (39%), apple production (38%), packaging in glass containers (36%), bottling (34%), grating (34%), apple storage and ripening (34%), pressing (30%), and packaging in bulk (30%). Around a third were unfamiliar with racking (33%), yeasting (32%), and clarification (30%).

For the *processing of organic versus conventional apple cider***,** the main difference was considered to be apple production (58%). Respondents perceived the following operations as equivalent: bottling (42%), packaging (40%), pressing (39%), grating (39%), apple washing (35%), packaging in bulk (35%), and pasteurization (31%). Racking was again unfamiliar (33%).

This paper is a postprint of:
Espinosa-Brisset L , Pénicaud C, Souchon I, Saint-Eve A. 2023. *"Exploring consumer perceptions and familiarity on apple production and processing under different conditions: conventional, organic, home-made, artisanal and industrial".* British Food Journal. 125 (11), pp.3929-3952. **DOI 10.1108/BFJ-01-2023-0026**

Table III. Perceived differences in the processing of three example apple products: a) apple sauce, b) apple cider and c) apple sorbet. Specific pairs of conditions were compared (homemade, artisanal, and industrial; organic and conventional). The percentages indicate the relative number of participants (total n = 1,000) who perceived a difference.

a)

Apple sauce	Homemade VS Industrial			Artisanal VS Industrial			Homemade VS Artisanal			Organic VS Conventional		
	Difference	No difference	Unknown	Difference	No difference	Unknown	Difference	No difference	Unknown	Difference	No difference	Unknown
Apple production	53%	30%	11%	54%	29%	11%	36%	41%	12%	57%	19%	10%
Use of pesticides	62%	21%	12%	59%	22%	13%	42%	33%	14%	64%	13%	8%
Apple harvest	51%	33%	11%	50%	33%	11%	36%	41%	12%	41%	34%	10%
Apple sorting	56%	26%	13%	52%	29%	13%	39%	36%	14%	44%	29%	13%
Cold storage	56%	26%	14%	51%	29%	15%	42%	31%	16%	39%	31%	16%
Washing	52%	32%	12%	47%	34%	13%	36%	38%	14%	38%	34%	14%
Peeling	52%	30%	13%	48%	33%	14%	39%	37%	13%	29%	41%	16%
Cooking	56%	25%	13%	52%	28%	14%	42%	32%	15%	31%	39%	16%
Thermization	44%	19%	32%	41%	21%	33%	37%	20%	32%	28%	26%	32%
Grinding	47%	25%	24%	45%	25%	25%	37%	27%	25%	24%	38%	23%
Use of food mill	49%	21%	25%	44%	23%	28%	38%	25%	25%	28%	26%	32%
Refining	48%	17%	30%	45%	19%	30%	36%	24%	30%	31%	25%	30%
Addition: Sugar	65%	16%	14%	60%	18%	17%	50%	22%	17%	47%	22%	16%
Addition: Ascorbic acid	60%	14%	20%	55%	15%	24%	46%	20%	23%	45%	17%	23%
Addition: Citric acid	61%	13%	20%	56%	16%	23%	47%	18%	24%	45%	17%	23%
Addition : Lemon	58%	18%	19%	52%	20%	23%	43%	23%	23%	45%	18%	23%
Pasteurization	47%	21%	28%	43%	23%	28%	38%	23%	28%	39%	23%	23%
Packaging : bottles	50%	22%	23%	43%	26%	25%	39%	25%	25%	29%	29%	28%
Packaging : plastic containers	50%	24%	21%	43%	28%	24%	39%	26%	24%	32%	30%	23%
Packaging : glass containers	49%	28%	18%	40%	34%	20%	35%	33%	21%	32%	32%	22%
Packaging : bulk	46%	27%	23%	41%	29%	25%	36%	29%	24%	33%	30%	23%

b)

Apple Cider	Homemade VS Industrial			Artisanal (Fermier) VS Industrial			Home-made VS Artisanal (Fermier)			Organic VS Conventional		
	Difference	No difference	Unknown	Difference	No difference	Unknown	Difference	No difference	Unknown	Difference	No difference	Unknown
Apple production	56%	25%	11%	60%	23%	10%	36%	38%	14%	58%	18%	10%
Apple storage and ripening	58%	21%	13%	60%	21%	12%	39%	34%	14%	46%	25%	14%
Washing	52%	28%	13%	51%	28%	14%	33%	39%	15%	37%	35%	13%
Grating	47%	26%	19%	46%	26%	21%	33%	34%	20%	27%	39%	19%
Pressing	52%	23%	17%	52%	25%	17%	37%	30%	19%	30%	39%	16%
Clarification	45%	18%	29%	47%	17%	29%	32%	25%	30%	31%	28%	26%
Yeasting	46%	16%	31%	48%	16%	29%	34%	21%	32%	35%	22%	28%
Filtration	48%	21%	24%	49%	20%	25%	36%	25%	26%	33%	29%	24%
Alcoholic fermentation	49%	21%	23%	48%	21%	24%	36%	25%	26%	34%	29%	22%
Racking	39%	20%	34%	40%	20%	32%	30%	25%	33%	25%	27%	33%
Assembly	43%	22%	28%	47%	19%	27%	36%	25%	27%	30%	28%	28%
Bottling	43%	32%	17%	46%	29%	17%	35%	34%	18%	27%	42%	16%
Pasteurization	45%	22%	26%	44%	23%	26%	35%	26%	26%	30%	31%	24%
Packaging : glass bottles	42%	34%	16%	43%	32%	18%	31%	36%	20%	28%	40%	17%
Packaging : bulk	42%	28%	23%	42%	28%	24%	32%	30%	24%	29%	35%	22%

c)

Apple Sorbet	Homemade VS Industrial			Artisanal VS Industrial			Homemade VS Artisanal			Organic VS Conventional		
	Difference	No difference	Unknown	Difference	No difference	Unknown	Difference	No difference	Unknown	Difference	No difference	Unknown
Apple production	51%	31%	11%	56%	26%	12%	37%	38%	12%	52%	20%	12%
Washing	50%	31%	12%	52%	30%	12%	38%	37%	12%	37%	34%	14%
Apple peeling	51%	31%	12%	53%	28%	13%	38%	37%	12%	29%	42%	14%
Refining	47%	19%	27%	50%	18%	26%	39%	21%	26%	35%	25%	25%
Applesauce processing	58%	20%	15%	58%	21%	14%	44%	29%	14%	36%	33%	16%
Addition: Sugar	65%	15%	13%	62%	16%	15%	50%	22%	15%	47%	21%	16%
Addition: Additives	67%	12%	14%	65%	11%	17%	50%	20%	18%	56%	13%	15%
Homogeneization	45%	17%	31%	44%	18%	32%	38%	19%	30%	31%	22%	31%
Pasteurization	44%	22%	28%	45%	20%	29%	39%	22%	26%	29%	28%	27%
Maturation	46%	20%	28%	46%	19%	28%	37%	24%	26%	33%	25%	27%
Aeration	45%	16%	32%	44%	15%	35%	38%	17%	33%	31%	20%	34%
Frosting (intense stirring)	48%	18%	27%	47%	17%	29%	40%	21%	26%	32%	23%	29%
Packaging : Moulded plastic	47%	23%	23%	44%	24%	26%	40%	24%	24%	31%	31%	23%
Packaging : Plastic cups	47%	24%	22%	44%	25%	24%	38%	27%	22%	30%	31%	23%
Packaging: Extruded plastic	41%	19%	33%	41%	18%	34%	37%	19%	31%	26%	25%	34%
Final freezing	46%	23%	23%	42%	26%	25%	38%	25%	24%	29%	30%	26%
Storage	47%	26%	20%	46%	27%	20%	41%	26%	20%	30%	35%	20%

Apple sorbet: impact of processing and production conditions on consumer perceptions

For the example product apple sorbet, we compared three processing conditions (industrial, artisanal, and homemade) and two production conditions (organic and conventional). Participants were asked about the presence of differences between certain pairs of conditions (**Table III.c**).

Most respondents saw the following as the main differences between *homemade and industrial apple sorbet processing*: use of additives (67%), addition of sugar (65%), and production of apple sauce (58%). Around one-quarter to one-third saw no difference in apple washing (31%), apple production (21%), and apple peeling (31%). Respondents were unclear as to whether a difference existed in extrusion (33%), aeration (32%), or homogenization (31%).

The main differences between *artisanal and industrial apple sorbet processing* were considered to be the use of additives (65%), addition of sugar (62%), production of apple sauce (58%), and apple production (56%). Around one-third perceived no difference in apple washing (30%). Respondents did not know whether a difference existed in aeration (35%), extrusion (34%), or homogenization (32%).

A majority of participants (> 55%) viewed *homemade and artisanal apple sorbet processing* as equivalent. Smaller percentages perceived no difference in apple production (38%), apple peeling (37%), and apple washing (37%). Respondents were unclear as to whether a difference existed in aeration (33%), extrusion (31%), or homogenization (30%).

For the *processing of organic versus conventional apple sorbet*, the main perceived differences were the use of additives (56%) and apple production (52%). For a minority of participants, no difference was seen in apple peeling (42%), apple storage (35%), apple washing (34%), production of apple sauce (33%), packaging in cups (31%), packaging in plastic (31%) and freezing (30%). Respondents did not know whether a difference existed in extrusion (34%), aeration (34%), or homogenization (31%).

Consumers tend to know little about food production (Connor & Siegrist, 2010). Our results support this idea: participants were often unfamiliar with processing operations and product flow. Lesser known unit operations included thermization and refining in the case of apple sauce; raking, yeasting, and clarification in the case of apple cider; and aeration, extrusion, and homogenization in the case of apple sorbet.

The results from these three examples confirm that there is a limited knowledge of consumers about food processing (Bolhuis et al., 2022), however they have different perceptions and expectations from the processing conditions. For consumers industrially processed foods are highly different from artisanal and home-made food processing, which are perceived by them having less additives and processing steps. Consumers believe that homemade and natural foods are healthier than industrially processed foods (Devia et al., 2021).

The distinction was lower between organic and conventional apple products. In this comparison, perceived differences existed in apple production, the use of pesticides, and the addition of additives. Indeed, consumers expect organic fruit products to contain fewer additives (Lee & Yun, 2015).

There is a lack of knowledge and of trust within industrial food processing, with consumers being afraid of possible contaminants or chemical residues that might result from the way food is produced, formulated, and processed (Meijer et al., 2021). At the same time, there is a consumer's desire for taste, food safety, affordability, convenience but also for clear labelling and processing transparency (Song et al., 2020; Honorio et al., 2019; Siegrist, 2008). Consumers expect that information sources should be trustworthy, confirmed by experts and in compliance with regulations. Siegrist (2008) reported that when benefits are endorsed by independent organizations or scientists, the communication is more likely to positively influence consumers' interests in consuming food products processed by novel technologies.

Understanding inter-individual differences in consumer perceptions

Inter-individual differences in perceptions could largely be explained by consumer type and age. The effects of gender and sociodemographic category were less pronounced. Consumers of conventional produce mostly bought fruits and vegetables at regular supermarkets, whereas consumers of organic produce shopped at specialized stores. Consumers of local produce went to farmer's markets or otherwise bought directly from farmers. By buying local food, many consumers are seeking to establish or renew trust with their food system through development of personal relationships with farmers (Zepeda & Deal, 2009). Participants over 50 years of age were less interested in consuming ready-to-eat products, and participants over 30 years of age were more interested in consuming homemade products (Fig. 3).

Participants of different consumer types and ages prioritized different criteria in their overall food choices ($p < 0.0001$; **Table IV**). For example, eating a healthy diet and eating seasonal products was important for all respondents but was significantly more important for consumers of local organic produce, consumers of organic produce, and finally consumers of conventional produce ($p < 0.001$; Fig. 3), in that order.

Consumers of conventional produce were less interested in eating locally sourced food, supporting farmers, limiting the use of packaging, and promoting local/regional products. Whereas consumers of organic produce and local organic produce were significantly more likely to view organic food products as better for the environment, farmer health, and consumer health ($p < 0.001$). They perceived organic food products as having fewer pesticide residues and more health benefits than conventional food products. It is known that consumers of organic food have strong environmental and ecological values (Rana & Paul, 2017), which leads to the assumption that they tend to have different expectations of food processing than consumers of conventional food do have. Also, they considered that organic food products from France are of better quality than organic food products from other

countries, from their perspective they might see French organic products more fresh and safe than imported products as stated by (Feldmann & Hamm, 2015).

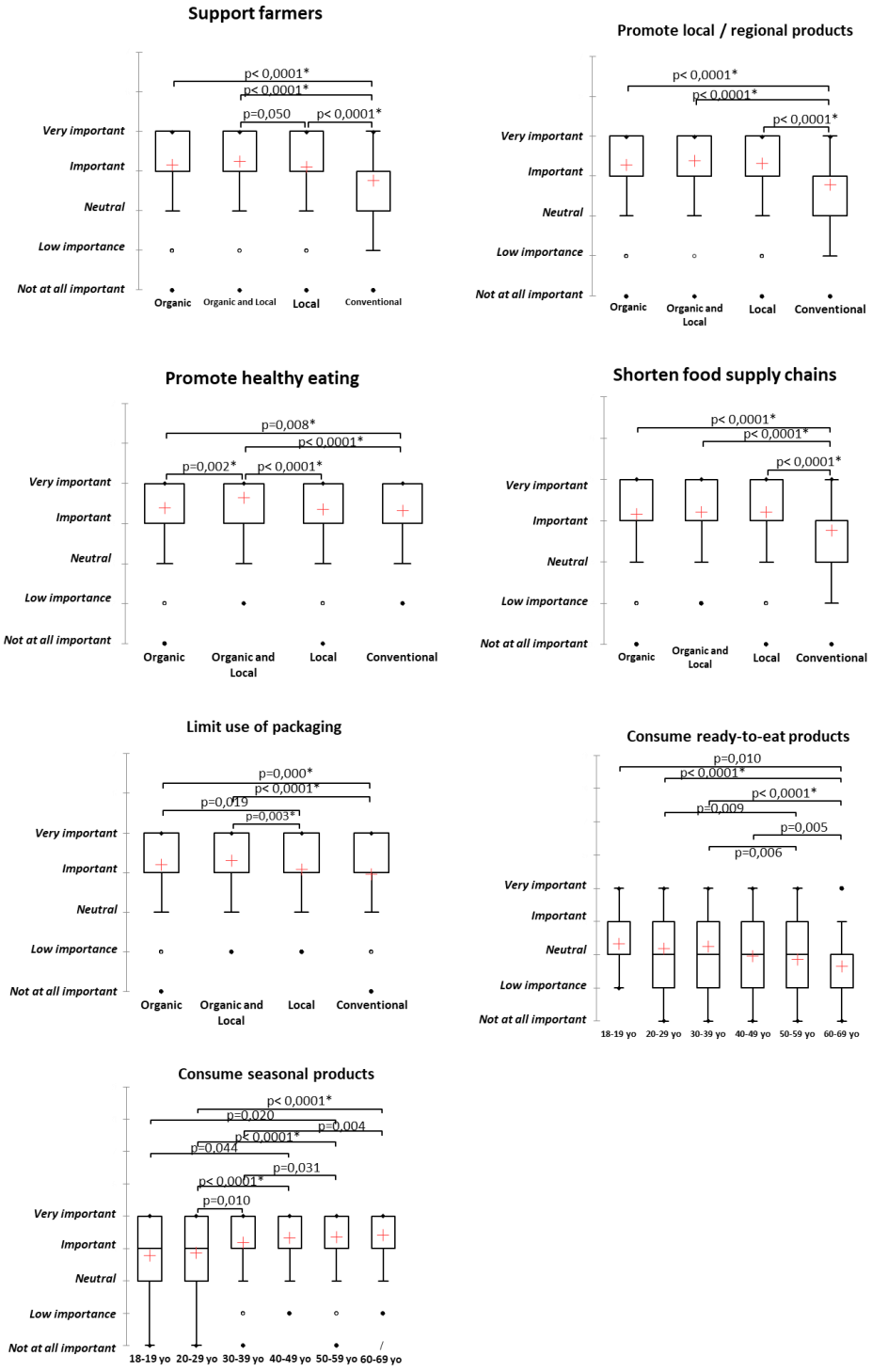

Figure 3. Relative importance of criteria guiding general food choices by consumer type and age (alpha level of 0.05).

Consumers of local, organic, and local organic produce felt that consuming locally sourced food products helps preserve the environment and provides health benefits. They considered that locally sourced food products contain fewer pesticide residues and are richer in vitamins. In particular, consumer knowledge about organic food is related to the environmental, health and social consciousness of consumers (Hansen et al., 2018). Consumers with a higher level of knowledge of food (such as organic and local consumers) may easily perceive the environmental, health and social benefits of consuming organic and local food. Indeed, Denver & Jensen (2014) differentiated two types of consumers: some consumers having a positive perception of organic apples and also having a strong preference for apples being locally produced and other type of consumers with a high perception of local products that did not have stronger preferences for the organic variety.

Table IV. Effect of consumer type, sociodemographic category (SDC), gender, and age on criteria related to food choices in general and purchases of fresh and processed produce in particular (Kruskal-Wallis tests, alpha of 0.05).

	p-value, alpha =0.05			
Food consumption in general	**Consumer type**	**SDC**	**Gender**	**Age**
Promote healthy eating	**<0,0001**	0,172	**0,006**	**<0,0001**
Avoid food waste	0,071	**0,001**	0,051	**0,000**
Consume seasonal products	**<0,0001**	**0,028**	0,718	**<0,0001**
Shorten food supply chains	**<0,0001**	0,389	0,077	**<0,0001**
Preserve the environment	**<0,0001**	0,918	0,651	**<0,0001**
Support farmers	**<0,0001**	0,588	0,711	**0,001**
Promote regional/local products	**<0,0001**	0,540	0,239	**<0,0001**
Consume homemade products	**0,047**	**0,011**	**0,006**	**<0,0001**
Consume ready-to-use products	0,350	**<0,0001**	**0,001**	**<0,0001**
Limit use of packaging	**<0,0001**	0,802	**0,027**	**0,003**
Purchases of fresh produce	**Consumer type**	**SDC**	**Gender**	**Age**
Seasonality	**<0,0001**	**0,017**	0,142	**<0,0001**
Taste	**0,019**	0,382	0,103	**<0,0001**
Locally sourced	**<0,0001**	0,455	0,706	**0,005**
Certified: organic	**<0,0001**	0,363	0,627	0,078
Certified: zero pesticides	**<0,0001**	0,604	0,111	**0,005**
Certified: environmentally friendly (HVE)	**<0,0001**	**0,018**	**0,018**	0,066
Fair compensation for farmers	**<0,0001**	0,133	**0,046**	**0,005**
Price	**<0,0001**	**0,002**	**0,020**	**0,022**
Presence of packaging	**0,009**	**0,001**	**0,549**	**0,002**
Purchases of processed produce	**Consumer type**	**SDC**	**Gender**	**Age**
Taste	**0,392**	0,838	**0,005**	**<0,0001**
Local source	**<0,0001**	0,718	0,088	**0,018**
List of ingredients	**<0,0001**	**0,022**	0,076	**0,000**
Nutritional value	**<0,0001**	0,557	0,132	**0,000**
Certified: Organic	**<0,0001**	0,143	0,957	0,059
Fair compensation for farmers	**<0,0001**	0,146	**0,002**	0,259
Price	**0,038**	0,201	**0,004**	**0,007**
Presence of packaging	**<0,0001**	**0,015**	0,712	**0,002**
Convenience (consumption and preparation)	**0,107**	0,483	0,766	**0,048**

Compared to the other three consumer types, for consumers of conventional produce, purchases of fresh fruit and vegetables were guided significantly less by seasonality, local sourcing, organic certification, zero pesticide certification, and certification of environmental friendliness (HVE in France) ($p < 0.001$). Consumers of conventional produce were also significantly more concerned with price ($p < 0.05$). As observed by Funk et al (2021), taste was considered as a benefit for all segments, all consumer types prioritized taste, a criterion that was significantly higher ($p < 0.05$) for consumers of local organic produce (Fig. 4a).

Similarly, when purchasing processed fruits, consumers of conventional produce were significantly less interested in local sourcing and fair compensation for farmers ($p < 0.001$) than was the case for consumers of local, organic, or local organic produce. All consumer types prioritized the list of ingredients, although its importance was greater for consumers of local, organic, or local organic produce. Furthermore, consumers of organic and local organic produce placed significantly greater weight on organic certification ($p < 0.001$). The presence of packaging was also a major criterion for consumers of organic produce and local produce ($p < 0.05$) (Fig. 4.b).

Our results are in line with Hüppe & Zander (2021), they showed that participants had little knowledge about processing technologies but were interested in their benefits. In our study, overall, participants lacked familiarity with most of the unit operations involved in fruit processing, although there was an effect of consumer type. For example, consumers of local, organic, or local organic produce were significantly more aware of some unit operations such as packaging and pasteurization ($p < 0.001$) than were consumers of conventional produce. HPP was largely unknown to the respondents, but it was particularly unfamiliar to consumers of conventional produce. Most of the participants knew nothing about aeration or Ohmic heating (Fig. 5). The fact that organic and local organic were more aware of some processing operations may be explained by the premise that organic and local consumers are generally more attentive and informed, they actively seek food information (Zepeda & Deal, 2009).

To better understand perceptions regarding fruit production and processing conditions, participants were asked if differences existed in processing operations for organic versus conventional fruit products. The answer was affirmative for a majority of all respondents (56%; $p < 0.001$) and consumers of conventional produce (61%; $p < 0.001$) (**Table V**). Such was not true for the other three consumer types, which means that, for them, the key difference was rooted not in product processing, but rather in food source and production system.
Organic processing technologies should involve fewer processing steps, low environmental impact, while keeping the product as natural as possible (Hüppe & Zander, 2021).

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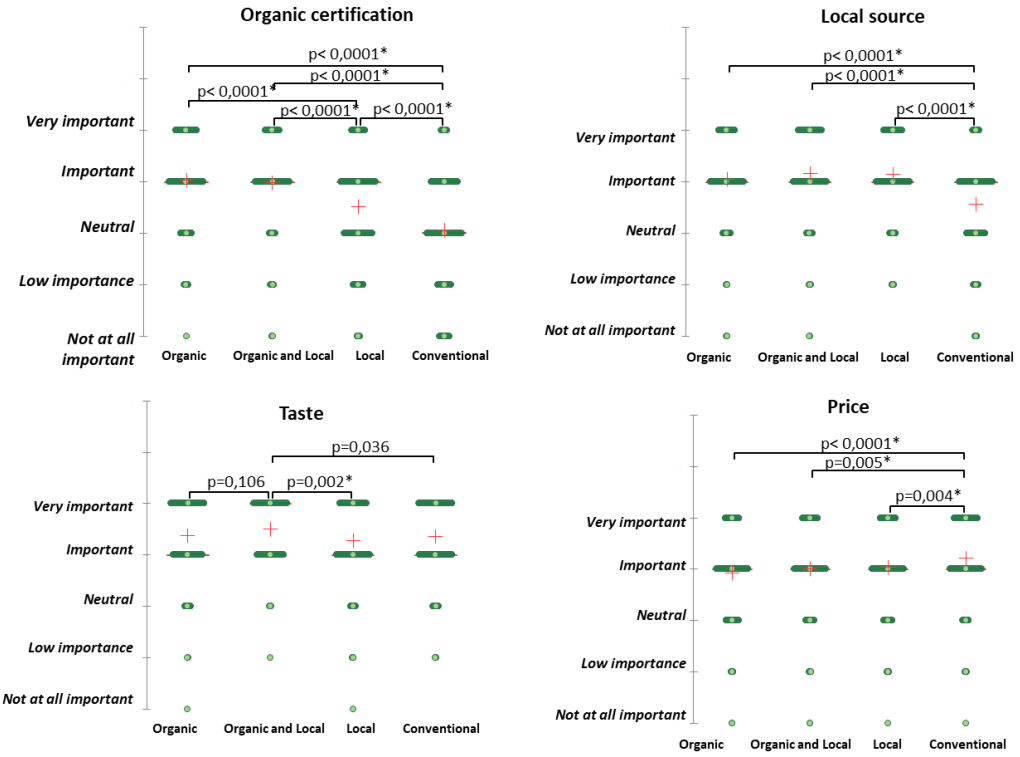
a)



b)

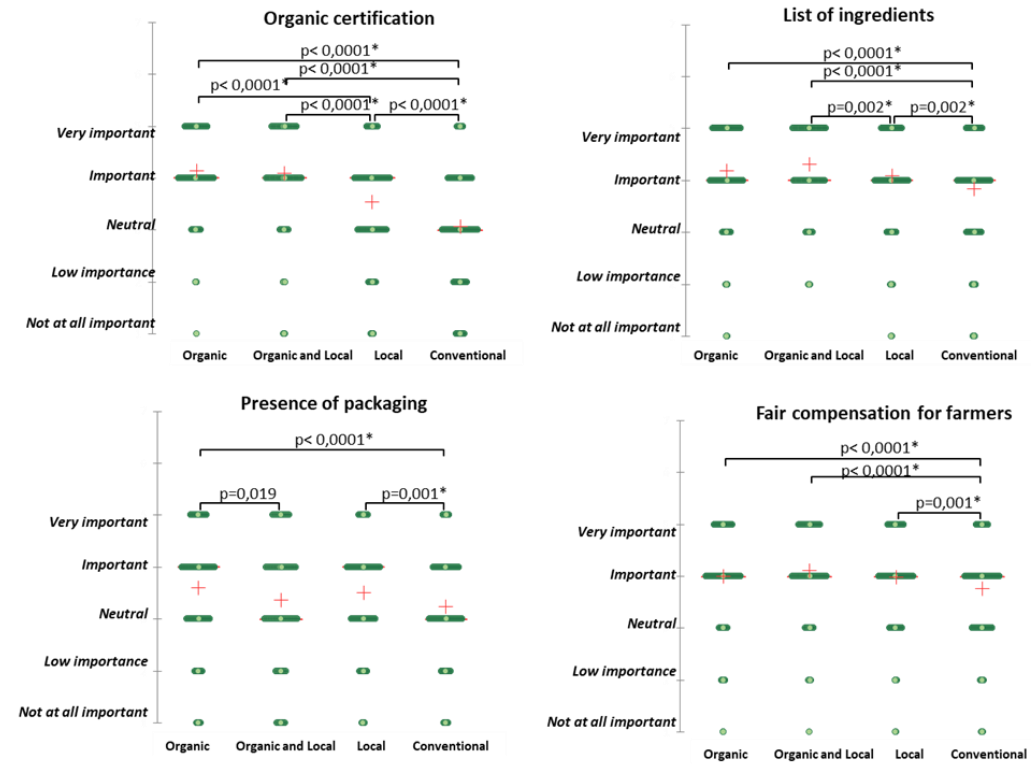


Figure 4. Relative importance of different criteria in purchases of (a) fresh produce and (b) processed produce by consumer type (alpha of 0.05).

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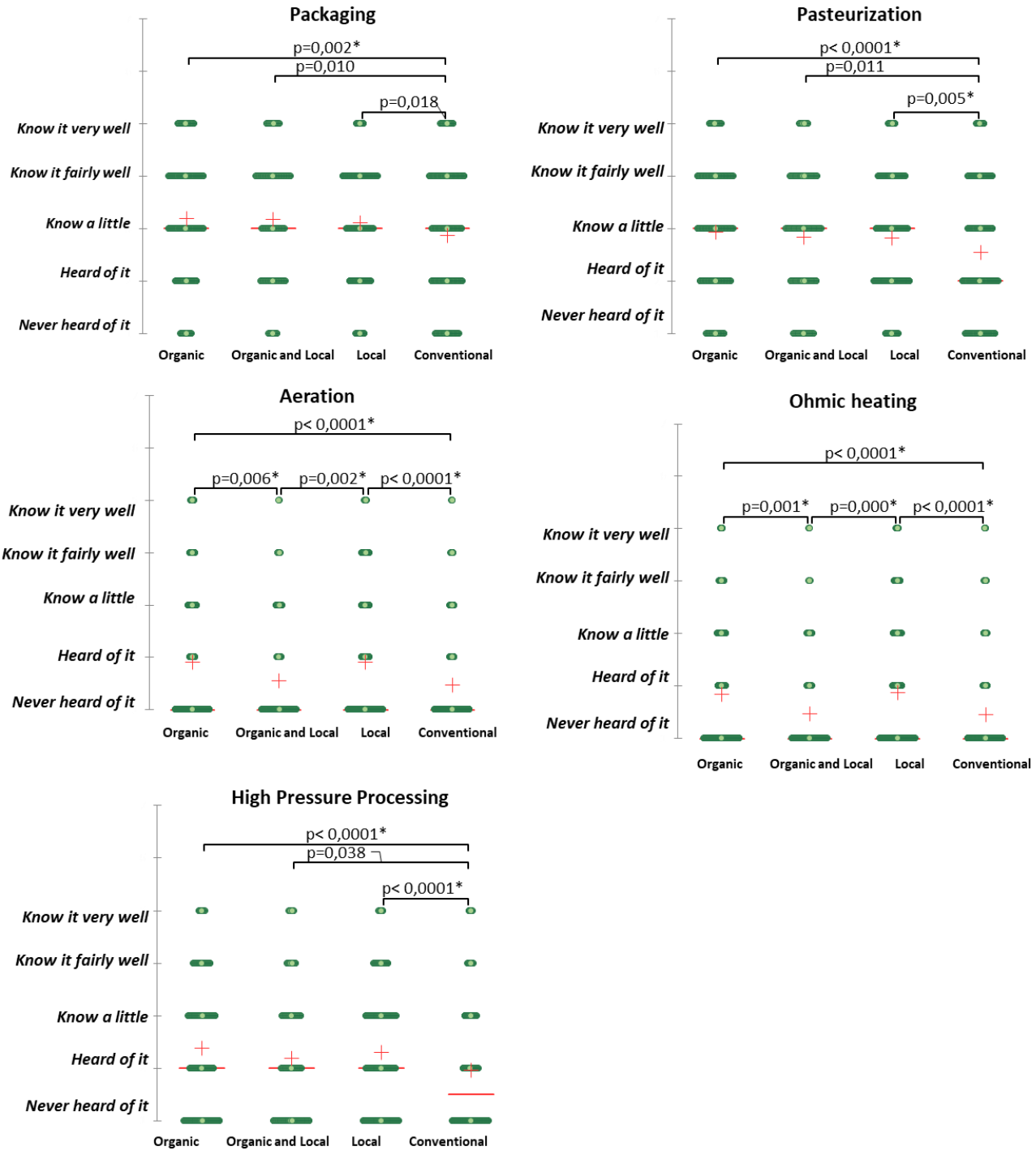

Figure 5. Familiarity of survey participants with certain unit operations (alpha of 0.05).

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Table V. Perceived differences in processing of organic versus conventional fruit products by consumer type. Two z proportion test results (alpha of 0.05).

Proportion	Total	Conventional	Organic	Local	Organic and Local
Different (n)	559	171	144	159	87
Not different (n)	443	111	127	124	81
Total	1002	282	271	283	168
Different (%)	56	61	53	56	52
p-value	**<0,0001**	**0,000**	0.193	0.083	0.358

CONCLUSIONS

Food processing provides numerous benefits ranging from food safety to shelf life extension of perishable foods and thus reducing reliance on seasonality. As mentioned by Knorr & Augustin (2021b), emerging food processing technologies has enabled the production of shelf-stable foods with improved retention of nutrients, flavors, colors, lowered energy and water requirements and reduced waste generation. That said, processing (in all different scales) increases variety in choices and provides convenience and a multitude of sensory properties to meet consumers' expectations**.**

As demand grows for foods that are healthy, natural, organic, and local, it is essential to understand how consumers perceive organic and conventional fruit that is processed under different conditions, such as homemade, artisanal, and industrial products. This was the aim of this study, which used three levels of fruit processing with an example of three apple products (apple sauce, apple cider, and apple sorbet) as the basis for its exploration of determining issues. We conducted an online survey with 1,000 French participants.

It was identified that consumers want to know benefits but not details of processing (Hüppe & Zander, 2021). We found that the respondents were aware of the advantages and disadvantages of fruit processing. The disadvantages that participants perceived of processed fruits were the use of additives, loss of nutrients, presence of packaging and sugar addition, which were key to the respondents' distinction between industrial versus artisanal and homemade products. This distinction was prominent, regardless of apple product type. The results from the three examples of apple processing (apple sauce, cider and sorbet) confirm that there is a limited knowledge of consumers about food processing, however they have different perceptions and expectations from the processing conditions. For consumers industrially processed foods are highly different from artisanal and home-made food processing (e.g additives additions, processing steps). Consumers believe that homemade and natural foods are healthier than industrially processed foods, even if some of the unit operations used in both transformations are the same but in different scales.

Furthermore, over 50% of respondents considered that organic fruit products are processed differently than conventional fruit products.), this difference may be explained by consumers association of organic processing to organic farming specific values (best environmental practices, high level of protection of biodiversity, conservation of natural resources).

Inter-individual differences among respondents were largely explained by consumer type and not by age or gender. Compared to consumers of conventional produce, consumers of local, organic, and local organic produce seemed to be more familiar with processing operations. As stated by Zepeda & Deal (2009) some organic consumers present an information-seeking behavior that leads to more in-depth knowledge, they cited the example of organic farming practices, they are knowledgeable about current trends in organic food, sustainable agriculture. They are more likely to gather information than organic light or conventional buyers. Thus they might be more concerned with the processing conditions and operations. The authors stated that conventional consumers have poor levels of awareness and information seeking behavior about organic products, and that they do not go to great lengths to seek out information on food and food issues.

There must be a societal transition toward healthier diets, and food technologies and production can play a positive role if they are no longer perceived in a negative light (Siegrist & Hartmann, 2020). Consumers, mainly conventional, will be better equipped to make healthy, informed choices if they are given quality information about food production and processing at different levels.

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