Article

Are they careful enough? Testing consumers' perception of alternative processing methods on the quality of organic food

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Abstract: Given the increasing public interest in how ingredients are processed and the growing demand for organic food products, it is critical to understand consumers' expectations about the process-related quality of organic products. Consumers perceive organic food to be nutritious, healthy and either natural or less processed, as they are afraid of the loss of nutrients and other natural properties of the food products. However, emerging food processing technologies might generate healthy and safe food options with nutritional quality properties. Simplified communication schemes might help to overcome this barrier. The main objective of this paper is to propose a working definition of "careful processing" for organic products and test its consistency while being used in scoring different processing methods by consumers. Results show that the proposed definition allows to consistently rate alternative processing methods. Consumers tend to score novel processing methods such as pulsed electric fields and microwave as less careful, supporting the idea that organic consumers want the least man-made interference with their food products. Results show that a simple but effective definition of careful processing may help consumers to distinguish further organic food products from conventional ones, no matter which communication scheme is used.

Keywords: food processing; packaging; UHT; high-pressure; pulsed-electric fields; pasteurization; micro-wave; consumer research; farm-to-fork.

1. Introduction

Organic food systems involve different actors, so to provide high-quality diets with higher nutritional content, policymakers need to ensure that all stages of systems work in harmony. Therefore, beyond agriculture, all processes and activities involved in food production, such as processing and storage, should be considered carefully [1]. However, considering the process-related characteristics has been overlooked up-to-date in the organic food process [2]. There is still a lack of mandatory standards and indications specifically related to the organic food processing part [3]. This is a critical issue, especially since almost every food product is now processed somehow [4].

Food processing and packaging technologies have ensured food safety. They have provided many benefits to both consumers and producers, such as extending the shelf life of unprocessed foods, enabling their storage for more prolonged use, making them edible and more convenient [4,5]. Although both thermal and non-thermal processing technologies can be used to process foods, the food industry has been applying heat treatments to pasteurize or sterilize food for many years. This has been done mainly because of the perceived benefits of pasteurization in terms of efficacy and safe end-products. However, previous studies showed that different processing methods could have diverse effects on different dimensions of food quality, including changes in the products' sensory, biochemical, and nutritional characteristics [6–8].

Obtaining fresh-like quality and safe products with a high nutritional value has led the food industry to pursue intensive research on alternative food processing and packing technologies to achieve higher-quality and safer foods in more efficient ways. As a result, the food industry has recently faced novel processing technologies [6,9] such as high-pressure processing (HPP), pulsed electric fields (PEF) and microwave processing. Among the packaging methods, the industry has developed: modified atmosphere packaging (MAP), edible coating and active packaging [6,7,10,11]. In general, all these methods have been identified to reduce processing time and temperature while minimizing quality losses and input energy during production [6,7,10,11]. Therefore, their effective implementation may meet the needs of potential organic consumers who want safe, tasty and easy-to-use organic processed products with "fresh-like" characteristics and long shelf-life [12].

Most consumers perceive organic food as a product that has been processed naturally and with health-related benefits [13]. Although much work has been done on consumer perception and the use of alternative food processing methods [14,15], very little is known about organic consumers' perception of food processing methods in organic food production. Naspetti and Zanoli [16] demonstrated that current organic consumers seem unaware of organic food production and processing methods. Organic consumers demand more information. They also desire to distinguish organic products from conventional ones in terms of the processing methods applied. However, as these process-related attributes cannot be judged through experience, they become a question of credible information [17]. Better communication seems fundamental to organic consumers' awareness.

Informing organic consumers about processing methods in a simplified way might be a good alternative that would also decrease their cognitive effort. Organic consumers expect that organic food is processed with "care" [18] , given that "care" is a principle and an essential value in organic food production [19]. New technologies should be evaluated on how they fulfil "careful processing" in the organic industry, offering consumers an understandable tool when evaluating organic products. However, there is still no consent on what "care" means in organic food processing.

Previous research on the topic has been limited. There is still confusion in the organic industry regarding a clear definition for careful processing. Various authors [3,20,21] proposed definitions of careful processing focused on the product, considering the maximization in the presence of essential elements while avoiding undesirable compounds or nutritional losses. However, Kahl et al. [3] also highlighted the need for a broader definition that links carefulness to three key dimensions: the product, the environment and the people.

The aim of this study was to test if the concept of "careful processing" could be used to consistently rate different processing methods for organic food while controlling for different "carefulness" communication schemes.

With the help of a panel of experts, a working definition for "careful processing" was developed, based on previous research [3,21], and the principles of organic production [19], including the three dimensions of "care" related to food quality, environment, and human health [20]:

"Careful processing refers to methods that aim to:

a) preserve the nutritional and sensory quality of raw materials from organic farming by limiting the use of additives,

b) minimize the risks for consumer and worker health while promoting fair supply-chains, and,

c) limit the impact on the environment by:

- reducing the use of water and energy,
- optimizing waste management, and

- promoting recyclable/reusable packaging."

In this study, the validity of this definition was tested in scoring different alternative processing methods. We expected that:

H1: The careful processing definition allows to consistently rate different processing methods,

Previous studies have established that front-of-pack labelling, like traffic light nutrition labels (green, red, and amber), are a helpful tool to communicate with consumers on making healthier choices [22–24]. Zhang et al. [25] confirmed that the salient traffic-light inspired labels (green, red, and amber) may be a more effective mean to communicate to consumers than purely numeric guideline-daily-amounts labels. Some studies pointed that colour-coded scheme is easier to interpret by the consumer [26]. However, others have found that a monochromatic scheme is more effective than a color-coded scheme in capturing consumer attention faster [27,28].

Given this ambiguity, and the fact that a scoring task is not as passive as viewing a label, we expected that:

H2: The type of communication scheme (mono-chrome vs color-coded) does not significantly influence how the technologies are rated.

A mixed factorial randomized experiment was designed to test these hypotheses.

2. Materials and Methods

2.1. Participants

A total of 130 organic consumers, older than 18 years old, were recruited from Amazon's Mechanical Turk. Of the respondents, 115 participants (88%) were occasional organic consumers, reporting a certified organic food products consumption between 5% to 50%. The remaining 15 participants (12%) were regular organic consumers, which implied that more than 50% of the food products they buy are certified organic.

Participants with a red-green colour deficiency were excluded from the experiment, using the simplified 6 plates (plate numbers; 1, 2, 4, 8, 10, 14) version of the highly reliable Ishihara colour test [29]. This was a crucial step to avoid any bias, as the study included colour scales. Participants were also informed that the information they will provide will considerably contribute to new scientific knowledge on organic food processing methods and may benefit them as organic consumers.

2.2. Experimental Design

The study consisted of a classification task of 8 processing methods (thermal: pasteurization (control), UHT, microwave; non-thermal: modified atmosphere, pulsed electric fields, high-pressure preservation, edible coating, active packaging; measured) x 2 communication schemes for “careful processing” (monochromatic bar scale vs colour bar scale) mixed factorial design to check that the type of communication scheme does not influence the classification of the technology.

The eight processing methods were chosen according to their current and potential application in the food industry [6,7,10,11]. Both familiar processing methods (pasteurization processing) and, respectively less-familiar (novel) processes to consumers were included in the study [30,31].

2.3. Procedure

Conveying unbiased scientific and technological information to ordinary consumers might be difficult [32,33].

After having been shown the definition of "careful processing", participants were shown a short (3 minutes) cartoon video[1] with textual information (240 characters max each, neutral description) on the 8 different processing methods, where pasteurization was presented as the current standard thermal technology and the other as thermal/non-thermal alternatives. The video was designed with short and plain-language definitions to enhance the understandability of complex technologies. Specific benefits or risks of each technology were not discussed to avoid generating bias on the subjects.

The dependent variable (DV) consisted in a continuous scale measuring "carefulness" (as from the definition) ranging from 0 to 100 (0 = Not at all careful, 100 = Very careful), using two different communication schemes. The first communication scheme consisted of a monochromatic colour bar scale (dark blue = not at all careful, blue = not so careful, whitish pale blue = very careful) presented in Figure 1. The second one included a multi-colour bar scale (red = not at all careful, yellow = not so careful, green = very careful.) showed in *Figure 2*.

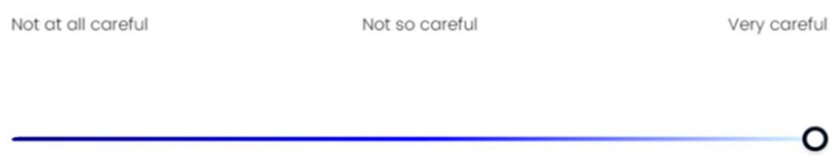

Figure 1. The monochromatic communication scheme

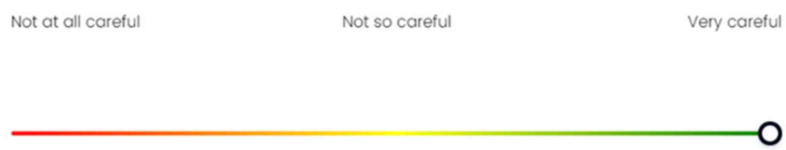

Figure 2. The multi-colour communication scheme

Participants were randomly assigned at each of the two communication schemes (i.e., experimental conditions).

The participants' attention to the video was tested through a multiple-choice question regarding the information presented in the video. Participants who responded wrongly to the question were not allowed to continue the experiment.

3. Results

A one between-factor repeated measures ANOVA was run on the sample to determine if there were differences in carefulness ratings of the different processing methods due to the communication scheme used. The results showed that the communication scheme did not elicit statistically significant differences in mean carefulness score, $F(1, 128) = 1.91$, $p = 0.17$. Consistently with Hypothesis H2, also the method-by-scheme interaction was not statistically significant ($F(7, 896) = 1.13$, $p = 0.34$).

However, there was a statistically significant effect of the method on carefulness ratings, $F(7, 896) = 13.50$, $p < .001$.

1 Link for the informative video which is created for the present research: https://youtu.be/Veks_qH_OcM

Pooling the error allows to test the carefulness score for each technology in each scheme and estimate simple effects, using pasteurization as the reference method. In both schemes, all methods were rated not significantly different in carefulness than pasteurization, except for novel methods (microwave and pulsed electric fields), that were considered less careful in all schemes (**Table 1**).

Table 1. Simple effects of processing methods at each communication scheme

Method/Scheme	Contrast	Std. err.	t	P>t
(active vs past) Mono	-1.692308	4.247585	-0.40	0.690
(active vs past) Colour	-3.661538	4.247585	-0.86	0.389
(edible vs past) Mono	-1.630769	4.247585	-0.38	0.701
(edible vs past) Colour	2.169231	4.247585	0.51	0.610
(hpp vs past) Mono	-4.769231	4.247585	-1.12	0.262
(hpp vs past) Colour	.6153846	4.247585	0.14	0.885
(map vs past) Mono	1.492308	4.247585	0.35	0.725
(map vs past) Colour	-1.169231	4.247585	-0.28	0.783
(micro vs past) Mono	-15.92308	4.247585	-3.75	0.000
(micro vs past) Colour	-21.67692	4.247585	-5.10	0.000
(pef vs past) Mono	-11.58462	4.247585	-2.73	0.006
(pef vs past) Colour	-9.723077	4.247585	-2.29	0.022
(uht vs past) Mono	-2.830769	4.247585	-0.67	0.505
(uht vs past) Colour	-6.861538	4.247585	-1.62	0.107

Legend: past=pasteurization (reference); active=active packaging; edible=edible coating; hpp=high pressure processing; map=modified atmosphere; micro=microwave; uht=ultra-high temperature

Pairwise comparisons (detailed results reported in Appendix) show that packaging methods generally are perceived as more careful than processing methods.

Such results indicate that the proposed definition allows to rate the processing methods under study consistently, not falsifying Hypothesis H1.

4. Discussion

Consumers tend to exhibit mixed attitudes towards organic processed food: 'traditional' organic consumers tend to have a negative image of processed food [34]. Consumers perceive a food-health imbalance among processed food products, especially regarding their nutrition interface and its relevance within the diet-health debates [5,35]. Although there are some studies that have shown that highly processed food products might have negative consequences on human health [36], this results depend on the kind of food processing.

Organic consumers expect their products to be processed with "care" [18], while health is the main motivation for organic food consumption [12,37,38]. Health-conscious consumers are expected to prefer 'minimally' processed food, since they are expected to preserve the nutritional quality of food [39]. Besides, consumers who are health conscious tend to prefer visuals of unprocessed foods on the packaging, since they symbolize naturalness [40].

Our study evaluated organic consumers' perspective about several processing and packaging methods according to a "careful processing" definition, which was presented to respondents through different communication schemes. No significant differences were found between the two communication schemes (monochromatic vs polychromatic).

However, differences were found in how participants scored the level of carefulness of the various processing and packaging methods. In general, packaging methods (MAP, active packaging, edible coating) were evaluated as "careful" by the participants and perceived alike regardless of their characteristics. This can be explained by the fact that organic consumers give substantial weight to the perceived naturalness of the product. Packaging methods require minimal human intervention over the properties of the food product, given consumers a sense of an "unprocessed" and "natural" product [41,42].

Among processing methods, pasteurization is one of the oldest and most widely used in the food industry [43], which makes it quite familiar to consumers, given that they have had enough time to appreciate and experience the benefits of this processing technology [44]. Previous research have shown that familiarity and trust appear to affect the organic consumers' perception much more than the tangible benefits of the processing methods [45,46].

No statistically significant difference in terms of carefulness was found between pasteurization and all the other methods except for microwave and PEF. Microwave processing was considered the least careful method according to the "careful processing definition". An explanation for this result can be the fact that the primary motivation of organic consumers is health, which is commonly linked to "naturalness" and "purity" [38]. Given the limited knowledge that organic consumers have regarding processing technologies, they associate organic processing with food produced naturally, home-grown food, and environmentally friendly [13]. As a consequence, any technology that in the consumers' mind might affect the "purity" or "naturalness"[42,47] of the organic product will be perceived as not in harmony with the nature of organic production and will be rejected by organic consumers. Another possible explanation could be general skepticism about new food technologies, regardless of how these processes affect various dimensions of organic food quality [48,49]. Communication, transparency and a trusted knowledge source are paramount in shaping consumer perceptions regarding organic processed food [49,50].

Likewise, consumers might perceive alternative technologies applied to food processing as risky and unfamiliar [51,52]. The unfamiliarity and uncertainty linked to introducing new technologies might lead organic consumers to resist such innovations, perceiving themselves as victims rather than beneficiaries [53]. These results show that the skeptical attitude toward new food processing technologies is caused mainly by a knowledge deficiency, which fits with earlier findings [54,55]. In general, trust in the (natural) food supply chain positively influences purchase intention, especially when consumers lack familiarity and knowledge towards a specific food category [56].

Therefore, accurate and simplified information could minimize consumers' concerns and improve their acceptability and consumption of food produced with alternative methods. However, given the fact that the risks and benefits are related constructs which are not independently evaluated by consumers [45], as Fischer and Frewer [44] stated, the benefit information may only influence if this information is presented before the risk information, and the food is perceived to be unfamiliar.

5. Conclusions

In this study, a working definition of careful organic processing was provided and communicated to consumers. We provided evidence that this definition allows consumers to consistently distinguish and rate alternative processing and packaging methods, notwithstanding how carefulness is communicated. Results are relevant for the debate initiated by Kahl et al. [57] on the 'starting' definitions of organic food processing.

The working definition proposed and tested in this study encompass both the definitions of 'minimal' and 'careful' processing [58] which are usually referred to when defining organic food processing. The definition also broadly encompass the concept of 'food naturalness'[47,59], which has been recently defined and tested. We believe the definition may be useful to further develop an operational, multi-dimensional approach to organic food processing, aiming to: (a) limit the impact of processing on the nutritional and sensory qualities of organic food, while (b) enhancing shelf life and (c) taking care of people and any biotic and abiotic factors both directly and indirectly involved in the processing.

Future research could investigate if communicating the level of carefulness of processed organic food could create value for organic consumers [13]. Since communicating carefulness may be associated with different risk perceptions, the role of associated consumer emotions should also be addressed in future research.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table 2. Pairwise-comparisons of predictive margins for monochromatic color scheme

	Delta-method		Unadjusted	
Method	**Contrast**	**std. err.**	**t**	**P>t**
edible vs active	0.0615385	3.654901	0.02	0.987
hpp vs active	-3.076923	3.654901	-0.84	0.4
map vs active	3.184615	3.654901	0.87	0.384
micro vs active	-14.23077	3.654901	-3.89	0
past vs active	1.692308	3.654901	0.46	0.643
pef vs active	-9.892308	3.654901	-2.71	0.007
uht vs active	-1.138462	3.654901	-0.31	0.756
hpp vs edible	-3.138462	3.654901	-0.86	0.391
map vs edible	3.123077	3.654901	0.85	0.393
micro vs edible	-14.29231	3.654901	-3.91	0
past vs edible	1.630769	3.654901	0.45	0.656
pef vs edible	-9.953846	3.654901	-2.72	0.007
uht vs edible	-1.2	3.654901	-0.33	0.743
map vs hpp	6.261538	3.654901	1.71	0.087
micro vs hpp	-11.15385	3.654901	-3.05	0.002
past vs hpp	4.769231	3.654901	1.3	0.192
pef vs hpp	-6.815385	3.654901	-1.86	0.063
uht vs hpp	1.938462	3.654901	0.53	0.596
micro vs map	-17.41538	3.654901	-4.76	0
past vs map	-1.492308	3.654901	-0.41	0.683
pef vs map	-13.07692	3.654901	-3.58	0
uht vs map	-4.323077	3.654901	-1.18	0.237
past vs micro	15.92308	3.654901	4.36	0
pef vs micro	4.338462	3.654901	1.19	0.236

uht vs micro	13.09231	3.654901	3.58	0
pef vs past	-11.58462	3.654901	-3.17	0.002
uht vs past	-2.830769	3.654901	-0.77	0.439
uht vs pef	8.753846	3.654901	2.4	0.017

Table 3. Pairwise-comparisons of predictive margins for color-coded scheme

	Delta-method		**Unadjusted**	
Method	**Contrast**	**std. err.**	**t**	**P>t**
edible vs active	5.830769	3.654901	1.6	0.111
hpp vs active	4.276923	3.654901	1.17	0.242
map vs active	2.492308	3.654901	0.68	0.495
micro vs active	-18.01538	3.654901	-4.93	0
past vs active	3.661538	3.654901	1	0.317
pef vs active	-6.061538	3.654901	-1.66	0.098
uht vs active	-3.2	3.654901	-0.88	0.382
hpp vs edible	-1.553846	3.654901	-0.43	0.671
map vs edible	-3.338462	3.654901	-0.91	0.361
micro vs edible	-23.84615	3.654901	-6.52	0
past vs edible	-2.169231	3.654901	-0.59	0.553
pef vs edible	-11.89231	3.654901	-3.25	0.001
uht vs edible	-9.030769	3.654901	-2.47	0.014
map vs hpp	-1.784615	3.654901	-0.49	0.625
micro vs hpp	-22.29231	3.654901	-6.1	0
past vs hpp	-0.6153846	3.654901	-0.17	0.866
pef vs hpp	-10.33846	3.654901	-2.83	0.005
uht vs hpp	-7.476923	3.654901	-2.05	0.041
micro vs map	-20.50769	3.654901	-5.61	0
past vs map	1.169231	3.654901	0.32	0.749
pef vs map	-8.553846	3.654901	-2.34	0.019
uht vs map	-5.692308	3.654901	-1.56	0.12
past vs micro	21.67692	3.654901	5.93	0
pef vs micro	11.95385	3.654901	3.27	0.001
uht vs micro	14.81538	3.654901	4.05	0
pef vs past	-9.723077	3.654901	-2.66	0.008
uht vs past	-2.830769	3.654901	-0.77	0.439
uht vs pef	8.753846	3.654901	2.4	0.017

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