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Consumers' preferences for Integrated Pest Management: Experimental insights

C. Biguzzi¹, E. Ginon¹, S. Gomez-y-Paloma², S. Langrell², M. Lefebvre², S. Marette³, G. Mateu¹, A. Sutan¹

1 ESC Dijon, LESSAC, Dijon, France

2 European Commission, Joint Research Centre (JRC), Institute for Prospective Technological Studies (IPTS), Agrilife Unit, Edificio Expo. c/ Inca Garcilaso, 3, 41092 Seville, Spain

3 INRA, Economie Publique, Grignon, France

Corresponding author: Marianne.lefebvre@ec.europa.eu



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Abstract

This article aims to analyse consumers' preferences for Integrated Pest Management (IPM), in comparison to conventional and organic food products. It analyses the case of tomatoes, based on experimental data of 189 French consumers. We find that consumers are more interested in information on the production system than on the characteristics of the final product in terms of pesticide residue levels, and more in IPM than organic. While information on IPM production increases consumers' willingness to buy IPM products, extra information on the residue levels in IPM tomatoes has not significant impact. We find that the reduction of the shelf space for conventional tomatoes benefits equally to organic and IPM, whatever the prices. However, in a scenario of prohibition of conventional crop protection methods, the winning market segment between organic and IPM depends on the price difference between these products. These results contribute to the understanding of consumers' reaction to the transition towards IPM as the standard in European farming. It provides interesting results on the nature of information that should be communicated to consumers to increase understanding of IPM.

JEL code: C91, D12, Q13, Q18

Keywords: Integrated Pest Management, Integrated production, Organic, Tomatoes, Experiment, Pesticide, Sustainable Use of pesticides Directive

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M. Lefebvre S. Gomez y Paloma, and S. Langrell formulated the original question. The experiment has been designed by E. Ginon, S. Marette, and A. Sutan with the help of M. Lefebvre, S. Gomez y Paloma and G. Mateu. The experiment has been programmed by G. Mateu in Ztree. The sessions were organized by C. Biguzzi with the help of E. Ginon, G. Mateu, A. Sutan and H. Saysithideth. M. Lefebvre performed data analysis with the help of G. Mateu and wrote the first version of the manuscript. All authors provided feedback on previous versions of the paper and contributed to the final version of the paper. M. Lefebvre coordinated the project all along.

I. Introduction

Many scientific and regulatory claims have been made over recent years about the potential harmful effects of pesticide intensive farming systems for both environment and human health. The search for sustainability of agriculture has led to explore potential alternatives to crop protection and to the adoption by the European Union in 2009 of the Sustainable Use of pesticides Directive (SUD). This directive provides a framework for action to achieve a sustainable use of pesticides and to promote the adoption of low pesticide input pest management and in particular Integrated Pest Management (IPM), retained as one of the possible approaches to achieve low pesticide-input pest management in the EU, together with organic farming (EU 2009). IPM, as described in the SUD, is a system based on three main principles: i) the use and integration of measures that discourage the development of populations of harmful organisms (prevention); ii) the careful consideration of all available plant protection methods, including biological control using natural predators of pests, mechanical control using specific tilling and cultivation techniques, as well as chemical control with pesticides, herbicides, and fungicides; and iii) their use to levels that are economically and ecologically justified. IPM has been described as "a middle course between the extreme constraints of organic farming standards and the increasingly unacceptable pursuit of intensive agriculture" (Wibberley 1995), a third way both economically realistic and environmentally beneficial (Morris and Winter 1999).

Widespread adoption of IPM by farmers will depend, among other drivers, on the profitability of this alternative crop protection strategy for farmers (Lefebvre, Langrell et al. 2014). Do consumers recognize the benefits of this "third way"? Are consumers be willing to pay a price premium it and how big is this premium compare to the one for organic products? Predicting the proportion of consumers in the market who will try IPM products when other products are available is a key question in the actual context. This article aims to analyse consumers' preferences for Integrated Pest Management, in comparison to conventional and organic agriculture.

Marketing Integrated Pest Management products for the end-consumer is not an easy task for several reasons. First, pest control based on economic thresholds and decision models, without a clear commitment regarding the reduction in overall pesticides use, appears difficult to communicate. Moreover, given the varieties of principles covered by the term "IPM" (as illustrated by the long list of general principles of IPM in the Annex III of the Sustainable Use Directive (EU 2009)), there is a risk of multiplication of labels, with quite different interpretations and approaches. Not least, such a situation may add to the possible market saturation of certification schemes and labels and information overload for end consumers. Indeed, in this context, producers are encouraged to apply to different certifications for the same product in order to have access to different market segments, resulting in increased production costs whilst simultaneously contributing to consumer confusion (Canali 2011). These different arguments may explain why retailers have been reluctant to create a specific market segment for IPM. Currently, in Europe, products grown using IPM are rarely identified as such in the market place for the end-consumers. However, retailers use IPM as a prerequisite for producers to deliver products to market segments with stricter environmental specification or to be in the group of suppliers supermarkets will preferentially call upon (ENDURE 2010). Complying with these general principles of Integrated Pest Management can lead producers to sell at higher prices but not always (Canali 2011).¹

¹ This is explicitly stated in the Global GAP business-to-business certification, which includes requirements concerning integrated crop management: "Most people confuse global gap with higher prices, that is, they think that once you have been certified you can charge higher prices than the one who hasn't been. That is not very true. Yes, global gap opens up many markets for you, but it is not an assurance for higher prices. In most European countries, certain products are not allowed

As a consequence of this market organization, market data on consumption of IPM products at household level are inexistent. As a result of the scarcity of market data for new or non-labelled products, the burgeoning literature on food choices relies increasingly on experimental data, using non-hypothetical and incentive compatible choice methods to elicit consumers' preferences and willingness to pay (WTP). Several of these studies have focused on "green" or "eco" products, obtained from more sustainable farming systems, with the aim of distinguishing market segments and estimating their market potential at premium prices. It has been shown that consumers are willing to pay more for reduced exposure to pesticide risk in general (Florax, Travisi et al. 2005) and for organic products in particular (Torjusen, Sangstad et al. 2004). However it remains unclear whether products complying with other environmental certifications are recognized by consumers. A limited number of studies have focused on estimating WTP for apples with environmental attributes but non-organic. We can cite the studies on the Food Alliance eco-label (Loureiro, McCluskey et al. 2001), national labels for integrated production in Portugal, France and Greece (Bazoche, Bunte et al. 2013), consumers preferences for an hypothetical label named "few pesticide" (highlighting 50% less pesticides compare to conventional apples) (Marette, Messéan et al. 2012) or for conventional-plus food products (that communicate a specific attribute that also applies to organic products, such as free from additional additives or free-range) (Stolz, Stolze et al. 2011). All these studies concluded that WTP for such apples is significantly higher than WTP for conventional and significantly lower than WTP for organic. Although restricted to apples, often analysed because it corresponds to an important market share of fruit sales and because apple production relies heavily on pesticides, these results suggest that IPM products can satisfy a niche market for consumers less willing to trade off price for higher environmental benefits compared with organic consumers.

Our study fills a gap in the literature by providing evidence on how IPM is perceived by consumers, compare to conventional and organic agriculture. Whereas there are some studies on environmentally friendly but non-organic products, none of them focus on Integrated Pest Management. Many cases have shown that differentiation of products with improved quality could end up with substitution effects, and a stigmatization of standard products (Loureiro, McCluskey et al. 2001; Bernard and Bernard 2009; Kanter, Messer et al. 2009; Costanigro, Kroll et al. 2012; Marette, Messéan et al. 2012; Bazoche, Bunte et al. 2013). Having that in mind, we investigate how IPM products consumption would be influenced by a reduced availability of conventional products. Such information is useful to make effective marketing and pricing decisions of IPM products in the new legislative environment, according to which all farmers should follow IPM guidelines. Secondly, the experimental design is innovative with regard to the choice of the product. Most of the existing studies have elicited willingness to pay for apples.² Very few studies have focused on vegetables whereas vegetables have high market share within organic consumption and concentrate a lot of research effort in IPM (van der Velden, Suay et al. 2012). In this study, we elicit willingness to pay for fresh tomatoes. Whereas a few authors have studied the WTP for organic tomatoes (Weaver, Evans et al. 1992; Yue, Alfnes et al. 2009; Ali Bashir 2012; Mesías Díaz, Martínez-Carrasco Pleite et al. 2012), none of them provide results on IPM tomatoes.

The paper is structured as follows. Section II presents the data and method. Results are presented in section III. Section IV provides conclusive remarks.

unless they are certified. So the benefits of global gap are more markets than more money. But then again if you push more products, you will enjoy economies of scale and make more profits" (http://www.globalgap.org/uk_en/index.html).

² Apple is a star product for such experiments since it represents an important market share of fruit sales, and apple production relies heavily on pesticides.

II. Data and method

1. Sample

The sample consisted of 189 non-expert food shoppers (129 female and 60 male), aged between 22 and 75. The sample of participants was recruited through email. They were told that they were invited to participate in an experimental session where they will be able to buy fresh products and receive a 20 euros participation fee. Then participants were screened for eligibility. Among the persons willing to participate, we selected in priority those buying tomatoes in autumn/winter in order to make sure they will be interested in buying tomatoes during the experiment.³ The participants in this study are adults, so they had made food purchases repeatedly over many years and were accustomed to considering the purchase at different prices and with different characteristics. Therefore, it should reduce the bias due to the artificial environment in which the experiment took place (in a laboratory, not in a shop).

We conducted the experiment in Dijon, France, in ten 90 minutes sessions in November 2013. Participants were randomly assigned to each session. To account for potential differences in participants characteristics across sections despite randomization, participants were asked to fill out a detailed questionnaire on their socio-demographic and consumption characteristics at the end of the experiment. We verified that the socio-demographic characteristics of the participants are not significantly different in the different sessions.

Table 1: Socio demographic characteristics and consumption habits of the participants

	Mean	St Dev	Min	Max
Female (%)	0.68	0.47	0	1
Age	39.48	14.85	22	75
Weekly consumption of tomatoes in winter (kg)	0.77	1.08	0	13
Weekly consumption of tomatoes in summer (kg)	2.20	1.71	0	10
Price usually paid for a kg of tomatoes (€/kg)	1.98	0.74	0	6
Share of organic tomatoes in total consumption (%)	0.26	0.29	0	1
Consumers never consuming organic tomatoes (%)	0.43	0.50	0	1
Consumers only consuming organic tomatoes (%)	0.04	0.19	0	1

2. Experimental design

The experiment was a succession of ten rounds as described in Figure 1. In each of the ten rounds, each participant could choose to buy tomatoes, indicating the quantity in kilograms. Participants had to buy at least 0.1 kg of tomatoes in each round.⁴ It was possible to buy only one type of tomatoes in each round. Choices were non-hypothetical. Participants were informed from the beginning that one of the ten decisions would be randomly drawn. At the end of the experiment, participants had to purchase the type and quantity of tomatoes chosen in the round drawn at the price specified. With this mechanism, each of the ten choices is considered as a real purchase decision (Lusk and Schroeder 2004; Michaud, Llerena et al. 2013). The participants were given written instructions they could keep during all the experiment. Instructions were also read aloud at the beginning of the experiment to be sure that everybody had understood.

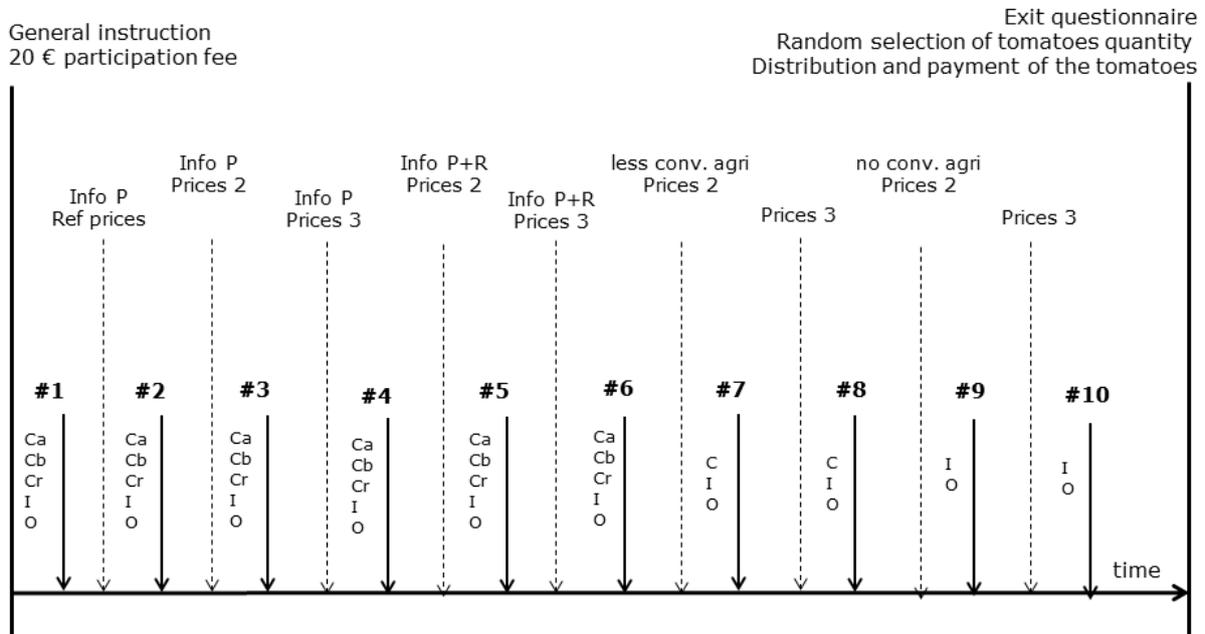
We describe here the different dimensions of the experimental design. It is based on the combination of a between-subject design and within-subject design. In the between-subject

³ In the recruitment email, respondents were asked which vegetables they were used to buy at this period of the year (autumn/winter) in a list of ten vegetables.

⁴ Allowing participants not to buy would have created a status quo bias that could have resulted in a high percentage of non-buyers. To avoid this, they had to make a minimum purchase.

comparative method, we compare the groups having received different treatments (autumn or summer prices, price change according to a voluntary contribution mechanism). In the within-subject sequential method we compare the choices of each participant in the different rounds, before and after a treatment chock (availability of new information, change in relative prices and type of tomatoes available).⁵

Figure 1: Experimental design



Legend: Round conventional tomatoes (Cr), conventional vine A (Ca), conventional vine B (Cb), IPM (I), Organic (O).

Types of tomatoes available for sale

The type of tomatoes available for sale varies in the different rounds (within-subject design). The design aims at capturing the evolution of the legislation on crops pest management. In rounds 1 to 6, participants could buy fresh tomatoes from conventional agriculture of three varieties one type of IPM tomatoes and one type of organic tomatoes. This captures the current situation where conventional farming remains the norm and conventional tomatoes are numerous on the supermarket shelves. Between round 6 and 7, participants could read the following message: "The European Union has decided that from 2014, all farmers will have to use Integrated Pest Management to protect their crops against pests and diseases. Crop protection strategy as currently used in conventional agriculture will therefore be prohibited from 2014. Since farmers are anticipating this change, we can already observe that the share of conventional tomatoes in total production is diminishing. There is now only one type of conventional tomatoes available, plus one type of integrated and one type of organic tomatoes." Between round 8 and 9, participants could read the following message: "Crop protection strategies used in conventional agriculture will be forbidden starting from 2014. From now, only integrated and organic tomatoes are available."

To summarize, the choice set was reduced from three to one type of conventional tomatoes in rounds 7 and 8, and only organic and IPM tomatoes are available in rounds 9 and 10. The reduction in the number of different conventional tomatoes available after round 6 is

⁵ Within subject design are extensively used in economic experiment since they enable to increase the number of observations at relatively low cost (only increasing the length of the experimental session). An advantage of within-subject designs is that they allow for direct comparisons of how a person views different types of products and information while controlling for a variety of individual-specific observable and unobservable elements.

interpreted as an increase in the shelf space dedicated IPM and organic tomatoes. The shelf space corresponds to the amount of space for one product in a store. In the results section, we compare the shelf space with the market share (i.e the share of one product in total sales).

Order of presentation of the different types of tomatoes

The order of presentation of the products was modified in each session to avoid the position bias (between-subject design). Five different orders were tested over the ten sessions: Cr-I-Ca-O-Cb in sessions 1 and 6, Cr-Ca-I-O-Cb in sessions 2 and 7, Cr-O-Ca-I-Cb in sessions 3 and 8, Cr-Cb-Ca-O-I in sessions 4 and 9, I-Cb-Ca-O-Cr in sessions 5 and 10.

Price of products

The prices of the different tomatoes vary both across sessions (between-subject design) and in the different rounds (within-subject design). The reference prices were those observed in the supermarket the week before the experiment (autumn prices) for the sessions 1,2,3,6,7,8. For the other sessions (4,5,9,10), the reference prices correspond to the price of tomatoes in summer (cheaper than in autumn). In rounds 1 and 2, the tomatoes are priced according to these reference prices. Then, we tested the impact of relative prices through two other price lists. In rounds 3, 5, 7 and 9, the differences between the prices of organic and integrated tomatoes was increased compare to real prices (option 2). In rounds 4, 6, 8 and 10, the price difference between organic and integrated was reduced (option 3). All the prices are presented in Table 2.

Table 2: Prices

€/Kg		Conventional (round)	Conventional (vine A)	Conventional (vine B)	Integrated	Organic	Price difference (O-I)
Summer (sessions 4,5,9,10)	Option 1 (real prices)	1.5	1.9	2	2.2	2.6	0.4
	Option 2 (large difference between I and O)	1.1	1.7	1.8	2.4	3	0.6
	Option 3 (reduced difference between I and O)	1.5	1.6	1.7	2.5	2.6	0.1
Autumn (sessions 1,2,3,6,7,8)	Option 1 (real prices)	1.5	2	2.2	2.5	3	0.5
	Option 2 (large difference between I and O)	1.1	1.8	2	2.7	3.4	0.7
	Option 3 (reduced difference between I and O)	1.5	1.6	1.7	2.5	2.6	0.1

Voluntary Contribution Mechanism

One important aspect in the diffusion of more sustainable farming practices is the interactions between producers and consumers at the stage where the market is still immature. Given the higher costs and/or the increase in risk due to adoption of non-conventional farming practices, producers will adopt organic or IPM only if there is sufficient demand on the market. By increasing their demand of such products, consumers can encourage their production, and in the medium run, prices of IPM and organic products may decrease. Few WTP experiments account for these interactions between demand and supply. We introduced a mechanism to

take into account the collective dimension in consumption choices and the interaction between demand and producers' willingness to adopt more sustainable farming practices in half of the sessions (between-subject design). The participants of sessions 6 to 10 received the following information at the beginning of the experiment: "If many of you are buying organic or IPM tomatoes, the prices of these tomatoes will decrease for the participants to the other sessions". The design can be interpreted as a modified voluntary contribution mechanism. In the traditional voluntary contribution mechanism, each member of a group of potential beneficiaries of the public good decides simultaneously on a portion of its initial endowment to contribute to a group account. Here, the contributions to the public good do not benefit directly to the group but are transferred over time to a future group (inter-temporal transfers) (Grolleau, Sutan et al. 2013). Moreover, we combine the voluntary contribution mechanism with supply and demand conditions in the market for a private good. Here, the "public good", provided thanks to individual contributions, is a reduction in the price of sustainable products for next generations. If the market share of IPM (organic) is higher or equal to 70% in round n and session X, the price of IPM (organic) is reduced by 20% in round n of the next sessions, compare to the prices in Table 2.

Information

We want to analyse the impact on consumption choices of providing extra information to the consumers on the characteristics of the final products, focussing on pesticide residue levels, on top of information on the production system and crop protection strategies. Indeed, the technical specifications for organic farming or IPM concern good farming practices (including crop protection), without any obligation in terms of outcome (e.g. requirements concerning pesticide residues). Notwithstanding, the reduction of health risks through the reduction of pesticide use and the increased intensity of residues control activity is by far the most important content that many private standards try to communicate to consumers: "we control strictly our producers", "we have made so many thousands of analysis of our products" etc. But the link between actions (reduction in pesticide use) and outcomes (impact on residues and reduction in health risk) is complex and uncertain. For example, some of the applied pesticides find their way as residue in the food, but their residual quantity differs according to the type of pesticides, the type of products and the production system (Bakery, Benbrook et al. 2002).

In order to analyse this question, we vary the information available to participants about the products in the different rounds (within-subject design). Revealing successively information to participants with regard to various characteristics of the product under study (eg. type of products, health benefits, environmental benefits ...) is a common design feature of food choices experiments (Marette, Messéan et al. 2012). But in contrast to many of these studies, rather than directly displaying different types of information and assuming that all information provided is necessarily processed in making consumption decisions, participants in this study are given options to access and view information (we follow the idea of Hu, Veeman et al. (2006)). Participants had to click to have access to the information presented in **Error! Reference source not found..** We believe that providing for voluntary information access is likely to better represent the effects of providing information on consumer behaviour, since in a real shop situation consumers have to look for the information (either on the label or on the internet). In rounds 2 to 6, participants could choose to access information on the technical specifications of the production system of each tomato (Info P). In rounds 5 and 6, extra-information was available on the properties of the final product in terms of residuals (Info R) (access to Info P was still available).⁶ After round 6, the complete

⁶ Our design does not aim at measuring whether consumers are more interested in information on the production system or on the final characteristics of the product. To provide such measures, we would have needed to run sessions where we first provide the information on the final characteristics of the final product and then on the production system to control for

information was disclosed to all participants. We introduced the extra information sufficiently early in the experiment (round 4) to account for the potential diminished attention to new information at the end of the experiment.

Table 3: Information available upon request

More information on the production method	Generic information on production method (displayed for Conventional, Integrated and Organic)	Crop protection has a key role in agriculture since it protects crops from weeds, diseases and pest which are major causes of yield losses. Many crop protection methods exist (chemical pesticides, choice of crop varieties, soil management, use of beneficial insects...) and are used according to the crop protection strategy chosen by the farmer.
	Conventional	In conventional farming, chemical pesticides are used systematically and routinely for crop protection. It is the kind of crop protection which dominated the 20th century and which accounts for most farming today. Tomatoes from conventional farming receive on average 30-35 spraying during the growing season (average for soil-less tomatoes, which represent most of tomatoes production in conventional agriculture)
	Integrated	Integrated Pest Management can be considered as a third-way between conventional and organic crop protection strategies: the use of chemical pesticides is not prohibited but limited, thanks to a more efficient and targeted spraying and to the use of other methods (physical protection, organic protection, cultural practices ...). Many tomatoes are produced nowadays with integrated pest management but the information is rarely disclosed in supermarkets. Spraying of tomatoes is reduced to less than 5 per growing season with integrated pest management. This is less than in conventional farming but more than in organic (average for soil-less tomatoes, which represent a large majority of the tomatoes produced with integrated pest management).
	Organic	The specifications for organic farming totally prohibit the use of chemical pesticides. All organic tomatoes are soil- grown and with no chemical pesticides, contrarily to crop protection strategies used in conventional farming and integrated pest management.
More information on the characteristics of the final product	Generic information on pesticide residues (displayed for Conventional, Integrated and Organic)	Pesticides tend to stay in fruits and vegetables, even after washing or peeling them. In order to protect consumers' health and promote good practices in farming, maximum residue levels have been set legally. It aims at avoiding that consumers eat more than the acceptable daily intake of the active substance. Fruits and vegetables with residue levels beyond this limit cannot be sold.
	Conventional	All conventional tomatoes contain less pesticide residues than the maximal limit imposed by regulation.
	Integrated	Tomatoes produced according to Integrated Pest Management contain less pesticide residues than the maximal limit imposed by regulation, and, in average, 10 times less pesticides residues than what is observed in tomatoes from conventional agriculture.
	Organic	Chemical pesticides not being authorized in organic farming, organic tomatoes can be considered as residue-free compare to conventional and integrated tomatoes. However, some studies have revealed that residues can be found in organic tomatoes, since pesticides can have been used in neighbour fields or in the past in the same field.

potential order effect. We did not run sessions where the information on the final characteristics of the products is available first for two reasons: i) because we think it makes no sense to provide information on residue levels without prior information on crop protection; ii) our aim is rather to analyse whether consumers are interested in getting *extra* information on the characteristics of the final product (whereas at the moment the labels visible by the consumers mostly concern the production system) and whether this extra information impacts their consumption.

3. Results

On average, participants have bought 0.70 kg of tomatoes in each round (std=0.45). This corresponds to the average weekly consumption of tomatoes in autumn/winter declared by the participants in the post experiment questionnaire. Between 10 and 13 participants choose the minimum quantity (0.1Kg) in each round (5.98% overall). This confirms participants' interest in buying tomatoes and the fact that the experiment is perceived as a real purchase opportunity.

While the quantity bought by each participant is not significantly different across rounds, participants have purchased different type of tomatoes in the different rounds. Only 13 participants (6.88%) have made the same choice during the ten rounds.⁷ In order to identify the impact of the parameters of the experimental design, we compare the market share of each type of tomatoes across rounds.⁸

1. Impact of order of presentation of the different types of tomatoes

The quantities of conventional, integrated and organic tomatoes bought in the round 1 are not significantly different across the different sessions. This indicates that there is no effect of the order of presentation of the products.

2. Impact of the voluntary contribution mechanism

According to the experimental design, in sessions 6 to 10, the price of the organic or IPM tomatoes could have been reduced by 20% compared to Appendix I prices if the market shares of these products exceeded 70% in the previous sessions for the same round. However, the threshold 70% was not reached in any of the rounds and sessions. Therefore, the prices were maintained equal across all sessions. Moreover, we do not find any significant differences across sessions 1-5 and 6-10 in the quantities of conventional, integrated and organic tomatoes bought in each round, except in round 1 (Figure 2). Participants who were told their consumption of IPM and organic tomatoes will impact future prices have purchased significantly more of these tomatoes, but only in round 1. The VCM has an impact on choices, but this impact disappears with treatment chocks such as the changes in relative prices or information available. It suggests that the information given to consumers on their potential ability to impact future prices has only a limited impact.

Result 1: Informing consumers that their consumption choices today impact future prices of IPM and organic tomatoes has only a limited impact.

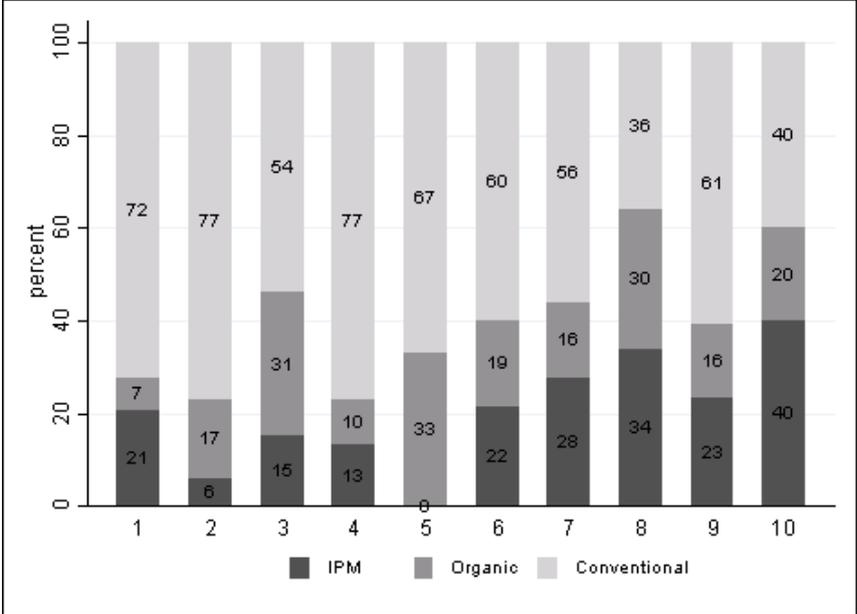
The result suggests that the option to "educate" consumers on the impact of their consumption choices on future prices is not efficient. One explanation could be that participants' incentives to contribute to the price reduction are reduced in an inter-temporal setting due to anonymity. We know from previous research that anonymity reduces voluntary contributions (Andreoni and Petrie 2004; Rege and Telle 2004; Alpizar, Carlsson et al. 2008). But other authors have found that the contributions are higher in an inter-temporal public good game (where benefits from the contribution to public good are transferred to a future group) than in a standard public good game (where contributions to the public good are immediately redistributed across contributors) (Grolleau, Sutan et al. 2013). One explanation being that distant future is more likely to activate the idealistic self, as opposed to the pragmatic one (Kivetz and Tyler 2007). Here, given that the public good created is a reduction in prices, it may be more

⁷ Among them, ten have always chosen the organic tomatoes. These ten consumers have declared to consume on average 72.5% of organic in their real life tomatoes consumption. They have strong preferences towards organic and are less influenced by the treatment chocks in the experiment.

⁸ The market share of product j in round n is defined as the total quantities of product j purchased in round n divided by the total quantities of products of all types in round n .

difficult to activate the idealistic/non-purely economic motives for the contribution to the public good.

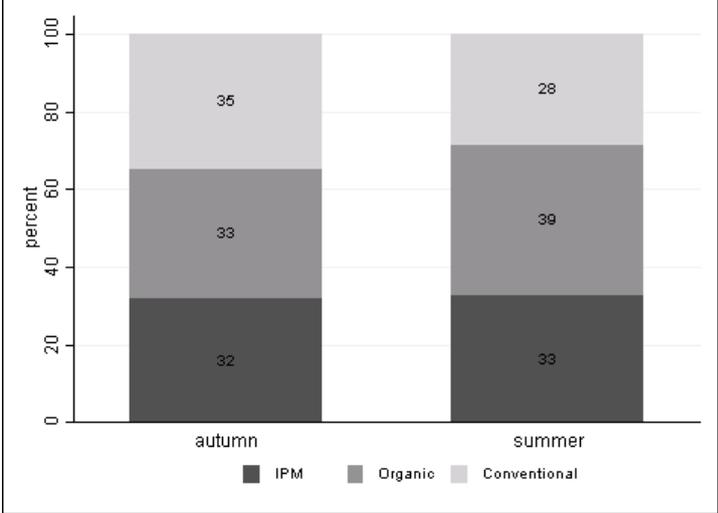
Figure 2: Market share of conventional, IPM and organic tomatoes by sessions in round 1



3. Impact of prices

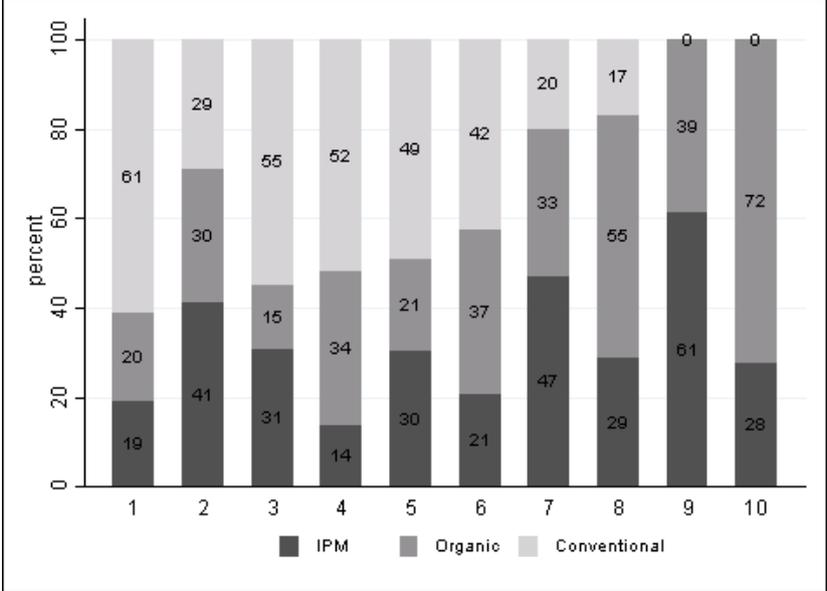
We do find differences in the consumption of tomatoes according to the prices. The average quantity purchased by round is significantly higher in autumn (0.75 kg) than summer (0.68Kg), despite the fact that tomatoes are more expensive in autumn (p-value=0.0802). Summer prices are such that the price difference between organic tomatoes and the others is reduced. As a result, the market share of organic tomatoes is higher in summer, at the expense of conventional tomatoes (Figure 3). The market share of IPM tomatoes is equal in the two seasons.

Figure 3: Market share of conventional, IPM and organic tomatoes by season (autumn/summer), average across rounds 1 to 10



For further analysis, we pool the data of sessions 6 to 10 with those of sessions 1 to 5, and analyse the impact of the within-subject treatment variables: information, types of tomatoes available for sale and relative prices on the choices of the 189 participants. Figure 4 suggests that these treatment variables have a strong impact on consumption choices since there are differences across rounds in the market shares of the different tomatoes. We have verified that similar conclusions are reached when analysing separately the results in the sessions with autumn and summer prices.

Figure 4: Market share of conventional, IPM and organic tomatoes by round



Note: We use Wilcoxon ranksum test to compare the quantities of tomatoes of each type purchased in the different rounds. The differences across rounds are significant.

In round 3, both IPM and organic are relatively more expensive (compared to conventional tomatoes) than in round 2. As a result, we observe an increase in the market share for conventional tomatoes between rounds 2 and 3. This substitution impacts more the organic market (30% in round 2 to 15% in round 3) than IPM (41% to 31%), both in relative and absolute terms. This is easily explained by the fact that there is a larger price difference between IPM and organic tomatoes in round 3 than round 2. Between rounds 3 and 4, there is a substitution between organic and IPM tomatoes (the market share of conventional tomatoes is stable). IPM market share drops from 31% to 14% and the quantities of IPM and organic tomatoes purchased are significantly lower. This is due to the fact that the price difference between organic and IPM tomatoes is smaller in round 4 than in round 3. The same result is observed in rounds 5 and 6, 7 and 8 and 9 and 10.

Result 2: Preferences for IPM are strongly impacted by the price difference with organic tomatoes: the market share of IPM drops when the price difference between IPM and organic is reduced.

4. Impact of information

In the round 1, in the absence of any information on the different tomatoes, the market share of conventional tomatoes is 61% (Figure 4). This corresponds more or less to the shelf-space dedicated to conventional tomatoes (3/5). The most consumed conventional tomatoes are the cheapest (round tomatoes, followed by vine tomatoes A). However, even if organic tomatoes are the most expensive, the market share of organic tomatoes is slightly higher than the one of IPM tomatoes. One reason could be that participants are more familiar with organic products (see also Result 5).

Result 3: In the absence of any information, consumers are more willing to buy organic than IPM tomatoes, even if organic tomatoes are more expensive.

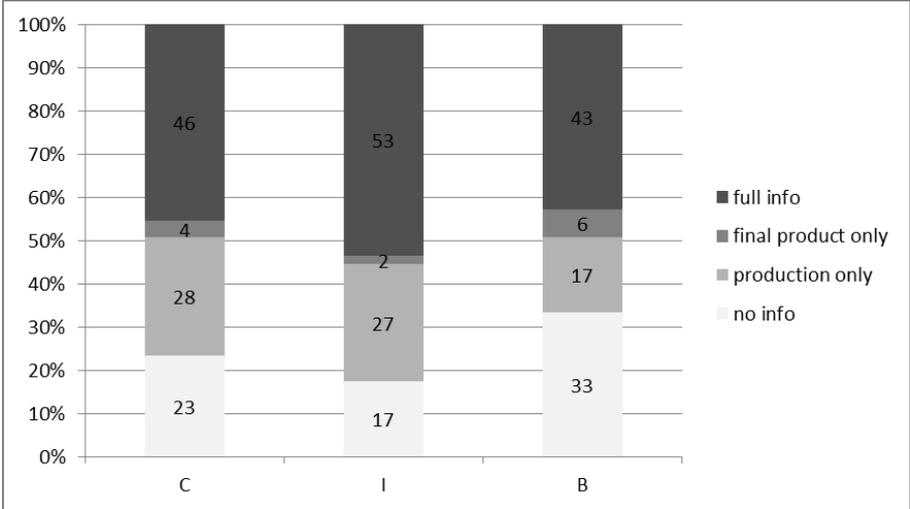
Most of the participants show interest in getting more information about the products. Remember that the novelty of the design is to display the information to participants only if they are interested in this information in rounds 2 to 6. In the last round before full disclosure of the information to all participants (round 6), only 23% of the participants did not read the information on conventional production system, 17% on IPM and 33% on organic farming. Participants were less interested in information on organic farming compared to the other two production systems. This confirms that participants are on average more familiar with the organic certification. This also confirms that participants are curious and willing to learn about new products.

Result 4: Consumers are more interested in information on IPM than on conventional and organic farming.

Among the participants looking for information, most of them have shown interest in information on both the production system and the characteristics of the final product in terms of residues. Only a small percentage of participants only looked at the information on the residues without reading the information on production.

Result 5: Consumers show interest in both the information on the production system and the characteristics of the final product.

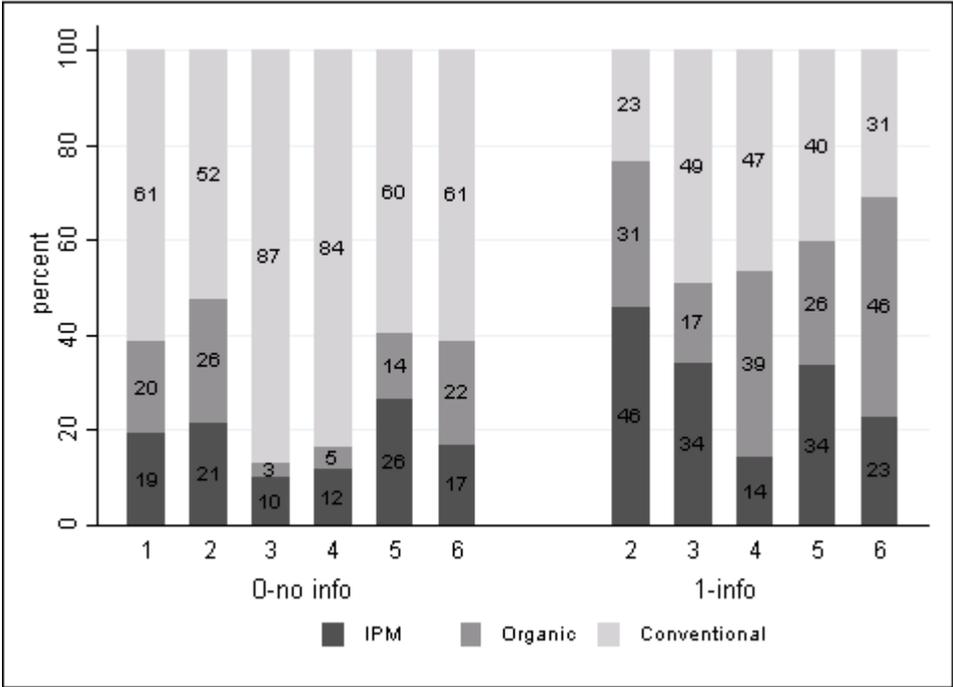
Figure 5: Information requested by participants in round 6



In order to measure the impact of information on consumption choices, we separate the sample into two groups: for rounds 2, 3 and 4, the participants who have chosen to access information on at least one of the three production systems are classified as "info" and those who did not look at any information as "no info"⁹; for rounds 5 and 6, we separate the participants who have chosen to access information on final products on at least one of the three production systems, from those who did not look at all at this information (Figure 6). Participants who have received information on one of the three production systems in round 4 but did not read any extra information on the residue levels are classified as "no info" in rounds 5 and 6. The 3 participants who were not interested in the information on the production systems but did read the information on the residue levels of at least one product are classified as "info" in rounds 5 and 6.

⁹ We have verified results are similar if we use another criterion to define the informed consumers (e.g. informed participants are those having read the information for the three types of tomatoes, while the non-informed are those who did not read all the information).

Figure 6: Market share of conventional, IPM and organic tomatoes by round and level of information



We observe a strong and positive impact of the information on the production system disclosed in round 2. The market share of IPM has significantly increased between round 1 and round 2 (from 19 to 46%) for the participants who got some information on the production system (on at least one of the type of tomatoes). This may be due to a "curiosity" effect for the novel term IPM. The same result holds for organic tomatoes but to a lower extent (from 20 to 31%). Indeed, many participants already knew the organic production system prior to the experiment and therefore did not request the information. In order to conclude that reading information on the production system has an impact on consumption choices, we need to verify the impact of making the information available for those participants who did not access to the information. We confirm that the market shares for the different tomatoes are not significantly different between rounds for those who were not exposed to the information. We can therefore conclude that the impact does not come from the simple fact to have a potential access to information, but from accessing the information.

The availability of extra information on the characteristics of the final product in terms of residues has a non-significant impact on the market share of IPM and organic tomatoes. Between rounds 3 and 5, the market share of organic increases (from 17% to 26%) for the sample of informed participants, but it is stable for IPM (34%). Between rounds 4 and 6, both the market share for IPM and organic have increased at the expense of conventional tomatoes. But none of these differences are significant.

Result 6: While information on the production system and crop protection strategies increases consumption of IPM products, the extra information on the residue levels does not further influence consumers' preferences.

One explanation could be that consumers think that information on residue levels in the final product is redundant compare to the information on pesticide application. It suggests that there is a low awareness of the general public on the complexity of the relations between actions (pesticide use) and outcomes (impact on residues and reduction in health risk).

5. Impact of the types of products available for sale

In rounds 7 and 8, the shelf space of conventional products has decreased since only one type of conventional tomatoes can be purchased. Not surprisingly, the market share of conventional tomatoes has decreased as well. Conventional tomatoes are not the main market segment anymore and this has benefited equally to organic (from 21% to 33% in rounds 5-7 and from 37% to 55% in rounds 6-8) and IPM tomatoes (from 30% to 47% in rounds 5-7 and from 21% to 29% in rounds 6-8). The quantities of IPM and organic tomatoes purchased are significantly higher between rounds 5 and 7 and rounds 6 and 8, while they are significantly lower for conventional tomatoes.

In rounds 9 and 10, only organic and IPM tomatoes can be purchased. When the price difference between organic and IPM is large, the prohibition of conventional crop protection strategies benefits more to IPM (from 47% in round 7 to 61% in round 9) than organic (33 to 39%). The quantities of IPM tomatoes purchased are significantly higher in round 7 than in round 9, while the difference is not significant for organic tomatoes. However, when the price premium for organic tomatoes is low, the suppression of conventional tomatoes is benefiting mostly to the organic market (from 55% in round 8 to 72% in round 10). The quantities of organic tomatoes purchased are significantly higher in round 8 than in round 10, while the difference is not significant for IPM tomatoes.

Result 7: The reduction of the shelf space dedicated to conventional tomatoes benefits equally to organic and IPM, whatever the prices. However, in a scenario of prohibition of conventional crop protection methods, IPM wins market shares only if the price difference with organic tomatoes is sufficiently high (at least 60 cents per kg).

III. Conclusion

We have conducted a laboratory experiment with 190 French consumers, representative of ordinary food shoppers. In each of the ten rounds of the experiment, each participant could choose to buy fresh tomatoes, indicating the type of tomatoes (conventional, IPM or organic) and quantity in kg they wanted. The experiment was designed in order to analyse: i) the impact of providing extra-information to the consumers on the pesticide residues in the conventional, IPM and organic tomatoes, on top of the information on the different production systems and guidelines in terms of crop protection strategies; ii) how IPM products consumption would be influenced by a reduced availability of conventional products due to a change in the legislation on crop protection; iii) whether these effects depend on the relative prices of the products; iv) whether consumers' modify their consumption when they know they have the power to influence future prices of organic and IPM tomatoes.

On the basis of a between-subject comparison across sessions, and within-subject comparison across rounds, we have obtained the following results:

Result 1: Informing consumers that their consumption choices today impact future prices of IPM and organic tomatoes has only a limited impact.

Result 2: Preferences for IPM are strongly impacted by the price difference with organic tomatoes: the market share of IPM drops when the price difference between IPM and organic is reduced.

Result 3: In the absence of any information, consumers are more willing to buy organic than IPM tomatoes, even if organic tomatoes are more expensive.

Result 4: Consumers are more interested in information on IPM than on conventional and organic farming.

Result 5: Consumers show interest in both the information on the production system and the characteristics of the final product.

Result 6: While information on the production system and crop protection strategies increases consumption of IPM products, the extra information on the residue levels does not further influence consumers' preferences.

Result 7: The reduction of the shelf space dedicated to conventional tomatoes benefits equally to organic and IPM, whatever the prices. However, in a scenario of prohibition of conventional crop protection methods, IPM wins market shares only if the price difference with organic tomatoes is sufficiently high (at least 60 cents per kg).

All these results suggest that price remains the more effective mechanism to influence consumption. Raising awareness on the impact of consumption choices on future prices of the product has only a limited impact in this context. Consumers show interest in getting information on IPM, but IPM products will win market shares only if their price is sufficiently low compare to organic products.

Given the low knowledge of IPM in the general public (Result 4) and therefore low interest in such products a priori (Result 3), understanding how to communicate about IPM to the end-consumers appears to be a crucial element to encourage the diffusion of such products. In our experiment, we have found that consumers increase their consumption of IPM products when they get access to information on the production system and crop protection strategies (Result 6). This suggests that retailers could start communicating to the end-consumer on IPM, rather than limiting IPM to a market-access tool. However, the low impact of the information on the final characteristics of the final product suggests that consumers are not yet ready for complex information highlighting the fact that the link between actions (pesticide use) and results (pesticide residues in food) are complex and uncertain. In the coming years, it will be interesting to confront these results with the analysis of retailers marketing and communication strategies on IPM, in reaction to the new EU legislation.

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