Consumption of low pesticides food: implications for producers and policymakers. Results from a multi-attribute analysis

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Abstract

Purpose – This study aims to identify different consumer segments to address the strategies that can be adopted by companies and policymakers to increase the consumption of safer foods and reduce the negative externalities caused by pesticides. More than 3,000 consumers were involved in the survey, of which more than 1,000 completed in all parts.

Design/methodology/approach – The complexity of the topic required a multidimensional approach. Therefore, the authors modelled the decision support system by proposing a decision rule-based approach to analyse consumers' food purchasing choices. More precisely, the authors referred to the dominance-based rough set approach (DRSA).

Findings – Based on the DRSA results, three consumer segments were identified: green consumers, integrated pest management (IPM)-informed and active consumers, and potential low-pesticide consumers for which different policy implications have been highlighted.

Research limitations/implications – Despite the high number of survey respondents, further research should seek to obtain data from a more balanced sample. Furthermore, different methods of analysis could be applied and the results compared.

Practical implications – Identification and promotion of managerial and public policies to increase the consumption of low pesticide food.

Social implications – The main social implications can be summarised in the greater knowledge and awareness of the environmental aspects related to food, recognition of the intrinsic quality and/or functionality of food.

Originality/value – The authors contribute to the literature in two ways. First, the authors refer to the DRSA, an innovative approach in the context of consumer analysis. Second, based on the decision rules, the authors identify three consumer segments to which specific tools can be addressed.

Keywords Pesticides, Consumer analysis, Decision rule-based approach, DRSA, Sustainable agriculture, Public policies

Paper type Research paper

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1. Introduction

The adoption of sustainable farming systems positively affects the environment and health of farmers and consumers (Carvalho, 2006; Defrancesco *et al.*, 2008; Pimentel and Burgess, 2014; Lazzarini *et al.*, 2018; Petrescu *et al.*, 2019). The integrated pest management (IPM) method dates back to the 70s. Integrated pest management involves the production of healthy crops using growing methods that disturb rural ecosystems as little as possible. This limits the use of phytosanitary products (fungicides, herbicides, insecticides, etc.) and promotes natural systems and methods of phytosanitary control (Van Lenteren, 1997; Kogan, 1998; FAO, 2006; Lamine, 2011; Puente *et al.*, 2011; Peterson *et al.*, 2018; Midingoyi *et al.*, 2019). Integrated pest management (Kogan, 1998) prevents pest infestations by adopting sustainable agricultural practices, such as the rotation and selection of seeds that are more resistant to pest attacks. This method requires a monitoring system and setting of thresholds that help the farmer decide when pest control is needed. It has been mandatory in the European Union since 2014 because of Directive 2009/128/EU of the European Parliament and Council concerning the placement of plant protection products (PPP) on the market and repealing Council Directives 79/117/EEC and 91/414/EEC (Barzman and Dachbrodt-Saaydeh, 2011). As the European Commission (2017) underlines, the implementation of Directive 2009/128/EC, which aims to reduce the risk and use of pesticides, is still insufficient to achieve environmental and health improvements. According to the European Court of Auditors (2020), despite the mandatory directive at the European level, there has been little reduction in the risks derived from PPP use. Farmers are obliged to adopt IPM methods, but they are not required to record how the methods are carried out. Furthermore, the adoption of IPM is not a necessary requirement to receive payments from the European Union. Because of the strong impact of the agri-food chain on the environment (European Commission, 2020), a targeted strategy for the food system known as "Farm to Fork" was introduced in May 2020 as part of the European Green Deal, with the specific aim of making the European food system. One of the specific objectives of "Farm to Fork" is a 50% reduction in the use of chemical pesticides by 2030 and a revision of the Directive on the sustainable use of pesticides, adopted in 2009 and criticised for poor implementation in most member states, is in progress.

The need for consumer involvement in the green transition is widely recognised.

Consumers, as well as producers, are placed at the centre of the new EU Agenda. Consumer behaviour and innovation should play a crucial role in the path to a wider sustainable food system. Environmentally and health-conscious consumers can encourage producers to increase and spread sustainable production, but they are often unaware of the production techniques adopted and the extent to which the techniques may or may not be beneficial to their health. Previous studies analysing consumer behaviour and/or attitudes towards sustainable food consumption (Rimal *et al.*, 2001; Padel and Foser, 2005; Vermeir and Verbeke, 2006; Gotschi *et al.*, 2010; Grunert *et al.*, 2014; Johe and Bhullar, 2016; Žibret and Kline, 2016; Lewis *et al.*, 2017; Kautish *et al.*, 2019; Mastronardi *et al.*, 2019; Savelli *et al.*, 2019) have been primarily survey-based and have predominantly focused on organic products (Aertsens *et al.*, 2009; Kautish *et al.*, 2022).

Based on a survey of 1,103 households in different countries, mainly located in Europe, this study focused on consumers' choices regarding the purchase of IPM food products with a lower quantity of pesticides, a topic on which there is little research (Govindasamy and Italia, 1998; Stranieri *et al.*, 2017; Canavari *et al.*, 2018; Mazzarolo *et al.*, 2020). Current and potential food purchasing choices are analysed as a whole, without detailed distinctions between behaviour, attitudes and perceptions.

This study aims to identify different consumer segments to which address strategies that can be adopted by companies and policymakers to increase the consumption of safer foods and to reduce the negative externalities caused by pesticides.

The complexity of the topic requires a multidimensional approach. Therefore, we propose a decision rule-based approach to analyse consumers' food purchasing choices.

More precisely, we refer to the dominance-based rough set approach (DRSA), an innovative approach in the context of consumer analysis (Roma *et al.*, 2020). It can be used to analyse inaccurate and vague descriptions of objects, conduct an in-depth exploration of the data, evaluate the informative content of the attributes under examination and develop decision rules that can support the evaluation process (Greco *et al.*, 2001, 2002).

The paper is organised as follows. Section 2 presents the data, proposed methodology and research design. Section 3 discusses the data sample. Section 4 presents the results obtained with DRSA. Section 5 discusses the main results, and Section 6 concludes the paper.

2. Data and methods

2.1 Data

Data was collected using a web-based survey tool via an online questionnaire (Qualtrics, Provo, UT, USA). The structure of the questionnaire follows that prepared by a previous research of a Horizon project (H2020, EUCLID, 2015–2018) in which experts belonging to naturalistic and economic disciplines took part. They were asked to review the questionnaire and improve its reliability and validity. The questionnaire consists of 35 questions, each of which represents an indicator. The study was conducted over an 8-week period (1 March 2021 to 30 April 2021). Given the specificity of the topic, a virtual snowball sampling technique was used (Goodman, 1961). Using the authors' networks, the interviewees were asked to forward the survey link to family, friends, colleagues who they believe involved in food purchase choices. More than 3,000 consumers were involved in the survey, of which 1,103 were completed in all parts. The completion rate is approximately 37%. The first note concerns the greater participation of women and the higher educational qualifications of the interviewees, as if to indicate greater sensitivity to the issues of sustainable food consumption of women and people with higher educational qualifications.

The 35 questions (attributes) of the questionnaire were partitioned into three blocks, B_i (i = 1,2,3):

(1) *Basic characteristics (B_1):* These questions were used to collect data on age, gender, education level, income range, place of residence, nationality, number of people in the family and profession (9 questions).

(2) *Eating and grocery shopping habits (B_2):* These questions were used to collect data on participants' diets, what part of their diets consisted of horticultural products, whether the decision maker was responsible for food choices in her/his household, where food was regularly purchased and what factors determined the choice (7 questions).

(3) *Perception of and attitudes toward IPM products (B_3)*: These questions were used to assess the familiarity of participants with the IPM method and their knowledge of differences between IPM and organic agriculture, and to determine whether they could distinguish the IPM method from others commonly discussed in the media, such as genetically modified organisms (GMOs) and post-harvest measures (19 questions).

2.2 Method: DRSA

To provide suggestions that can support policymakers, farmers or companies, it is necessary to produce informative and easy-to-understand results, in which evaluation paths are transparent and based on indicators that can be updated; thus, the model should be dynamic and, for this reason, suitable for use as a continuous evaluation tool.

The method we propose consists of the following steps:

(1) Definition of the information system $IS = (\mathcal{U}, \mathcal{A})$, where $\mathcal{U}$ is the (Universe) set of all 1,103 survey participants and $\mathcal{A} = \bigcup_{i=1}^{3} B_i$ is the set of all information gathered in the questionnaire.

(2) The definition of the disjoint sets of the condition and decision attributes $\mathcal{C}$ and $\mathcal{D}$, respectively, such that the set of all information $\mathcal{A}$ is partitioned as $\mathcal{A} = \mathcal{C} \cup \mathcal{D}$. The choice of considering a question as a condition attribute (i.e. an attribute characterising the sample) or as a decision attribute (i.e. information marking the category of the sample) can change during the analysis. This is due to two reasons: (1) because our aim was to develop a general framework for the analysis of consumer food choices, it was necessary to consider different interrelations between the collected information. (2) Multiple answers and nested questions were presented in the questionnaire.

(3) Definition of the coefficient matrix (different choices of the partitioning condition $\mathcal{C}$ and decision $\mathcal{D}$ attributes give origin to different coefficient matrices) with reference to the particular partition of $\mathcal{A}$ under consideration: $f(x_i, a_j) \in V_{a_j}$ denotes the answer given by i-consumer ($i = 1, \ldots, 1,103$) with reference to j-question. The set V_{a_j} is called the domain set and contains all the values (i.e. given answers) assumed by attribute (i.e. question) a_j; in some cases, a fixed-point scale answer was attached to the question.

(4) Extraction of DRSA decision rules: in the form of *if* ... *then* ... sentences, the conditions that characterise the rule and the resulting decision class assignment can be explicitly displayed.

(5) Sensitivity analysis and suggestions: by explicitly representing the dependence between condition and decision criteria (conditions → decision), decision rules provide exhaustive and easy descriptions of patterns in the data and, therefore, are the best means to analyse the results and to communicate them to the operators.

In choosing the framework to model our decision support system, the possibility of considering both numerical and categorical data, the non-use of statistical assumptions on the distribution of data and the absence of the need for structures that collect data (e.g. functions or equations) were all factors that guided our analysis. We were also interested in a simple method for the description of schemes that were exhibited by the data, using a useful and flexible tool that can be easily updated and is capable of capturing the fundamental characteristics of the information system in a multifaceted representation (see case studies conducted by Celotto *et al.*, 2015; Zolin *et al.*, 2017; Ferretti *et al.*, 2020; Roma *et al.*, 2020).

The key idea of a universe $\mathcal{U}$ partitioned into equivalence classes is not sufficient when objects are described by attributes with domains that are preference orders, given that inconsistencies can be generated by violations of the dominance principle (Greco *et al.*, 2001, 2002). However, in the analysis of multi-criteria decisions, it is possible that some of the attribute domains are ordered; therefore, it is necessary to explicitly consider preference relations in attribute domains.

In DRSA, the main assumption is that each domain V_{a_j} is completely preordered by an outranking relation $\succsim_{\text{ai}}$ with the following meaning: $x \succsim_{a_j} y$ when x is at least as good as y with respect to criterion a_j. If each domain V_{a_j} is real valued, then it is $x \succsim_{a_j} y$ if and only if $f(x, a_j) \geq f(y, a_j)$.

In the case of decision criterion d, each element in $\mathcal{U}$ is assigned one class Cl_t ($t \in \mathbb{N}$) such that the classes are preference-ordered, that is, when $r > s$, each element in Cl_r is preferred to each element in Cl_s. Suppose that m denotes the finite number of decision classes. Preferences can be either strict or weak. More precisely, if $r > s$ and it is $x \epsilon Cl_r$ and $y \epsilon Cl_s$, then 'x is at least as good as y' and not 'y is at least as good as x' with respect to the decision criterion. Equivalently, given the decision criterion d, under the same assumptions, it is $f(x, d) \geq f(y, d)$ while is not $f(y, d) \geq f(x, d)$.

Related to the previous assumption are the definitions of the upward and downward unions of classes Cl_s: $Cl_t^{\geq} = \bigcup_{s \geq t} Cl_s$; $Cl_t^{\leq} = \bigcup_{s \leq t} Cl_s$. Therefore, $x \epsilon Cl_t^{\geq}$ implies that x belongs to at least class Cl_t, while $x \epsilon Cl_t^{\leq}$ means that x belongs to at most class Cl_t.

With reference to condition criteria in $\mathcal{C}$, it is possible to define a partial preordering D_P (i.e. reflexive and transitive) for each condition criterion in $P \subseteq \mathcal{C}$, with the following meaning: $x D_P y$ if $x \succeq_{ai} y$ for each criterion $a_i \in P$. In this manner, each element x in $\mathcal{U}$ is related to two sets: the P-dominating set and the P-dominated set, respectively

$$D_P^+(x) = \{y \in U : y D_P x\} \; ; \; D_P^-(x) = \{y \in U : x D_P y\}..$$

If x dominates y on all condition criteria in $P \subseteq \mathcal{C}$, it also dominates y on the decision (i.e. element x should be assigned to at least as good a decision class as y). In our study, decision makers satisfying the dominance principle were consistent, while those violating the dominance principle were classified as inconsistent.

The P-dominating and P-dominated sets represent the basis of knowledge, in fact, knowledge is approximated by the upward and downward unions of decision classes; the P-lower approximation of $Cl_t^{\geq}$ with respect to $P \subseteq \mathcal{C}$ is $P\left(Cl_t^{\geq}\right) = \{x \in U : D_P^+(x) \subseteq Cl_t^{\geq}\}$, while the P-upper approximation of $Cl_t^{\geq}$ with respect to $P \subseteq \mathcal{C}$ is $\overline{P}\left(Cl_t^{\geq}\right) = \{x \in U : D_P^-(x) \cap Cl_t^{\geq} \neq \varnothing\}$.

Analogous are the definitions for the P-lower and P-upper approximations of $Cl_t^{\leq}$ with respect to $P \subseteq \mathcal{C}$:

$$P\left(Cl_t^{\leq}\right) = \left\{x \in U : D_P^-(x) \subseteq Cl_t^{\leq}\right\} \text{and} \, \overline{P}\left(Cl_t^{\leq}\right) = \left\{x \in U : D_P^+(x) \cap Cl_t^{\leq} \neq \varnothing\right\}..$$

Accordingly, the lower approximations are composed of elements belonging to the upward and downward unions of classes, whereas the upper approximations contain elements that can belong to the upward and downward unions of classes.

Finally, the upward and downward unions of classes are related to the upward and downward unions of the decision classes by the set inclusion relations:

$$P\left(Cl_t^{\geq}\right) \subseteq Cl_t^{\geq} \subseteq \overline{P}\left(Cl_t^{\geq}\right) \text{and} \, P\left(Cl_t^{\leq}\right) \subseteq Cl_t^{\leq} \subseteq \overline{P}\left(Cl_t^{\leq}\right)$$

and on these inclusion properties are based the definitions of the P-boundaries of $Cl_t^{\geq}$ and of $Cl_t^{\leq}$:

$$B_{nP}\left(Cl_t^{\geq}\right) = \overline{P}\left(Cl_t^{\geq}\right) - P\left(Cl_t^{\geq}\right) B_{nP}\left(Cl_t^{\leq}\right) = \overline{P}\left(Cl_t^{\leq}\right) - P\left(Cl_t^{\leq}\right)..$$

The related decision rules, that is, logical statements given by a composed condition component (*if* ...) and a decision component (*then* ...), in DRSA are formalised as $D_{\leq}$–decision rules, $D_{\geq}$–decision rules and $D_{\geq\leq}$–decision rules, given that the information system can be described by decision rules based on dominance relations and associated approximations, and the related rules can be certain, possible or approximate. Certain rules follow from lower approximations, possible rules are linked to upper approximations and the approximate rules refer to the boundary regions.

Step 4 was performed using the VC-DomLEM algorithm implemented with the jMAF software (Błaszczyński *et al.*, 2013) developed by the Laboratory of Intelligent Decision Support Systems at the Poznan University of Technology (http://wwwidss.cs.put.poznan.pl).

3. The sample in a nutshell

To describe our sample, we used simple descriptive statistics. Table 1 presents the basic characteristics of the respondents, including age, gender, education, profession and monthly

		Total	Northern Europe	Southern Europe	Asia	Other[a]
Age	18–30	50.4	46.6	54.8	42.1	67.4
	31–50	34.3	39.3	28.2	42.1	17.4
	>50	15.3	14.1	17.0	15.8	15.2
Gender	Female	71.4	76.0	66.0	50.0	78.3
	Male	28.6	24.0	34.0	50.0	21.7
Education	Higher[b]	85.5	84.4	85.9	97.4	87.0
	Lower	14.5	16.6	14.1	2.6	13.0
Profession	Student	35.5	27.1	45.5	36.8	54.3
	Worker	60.4	70.1	48.5	63.2	39.1
	Other	4.1	2.8	6.0	0.0	6.6
Income	≤1,500	24.5	30.0	16.3	23.7	15.2
	1,501–3,000	41.1	46.4	36.6	31.6	19.6
	>3,000	34.4	22.6	47.1	44.7	65.2
	Total	*100.0*	*54.5*	*37.9*	*4.2*	*3.5*

Table 1.
Basic characteristics (%) of the respondents by geographic area

Note(s): [a] Respondents from countries belonging to North, Central, South Americas and Australia
[b] University education, Master's or a PhD degree

income per person by geographic group. The majority of respondents were from Northern European countries.

Young women with a higher education and medium monthly income per person made up the largest part of the sample.

Table 2 reveals that more organic products were purchased than those obtained through the IPM methods. This finding suggests a lack of knowledge among the consumers. On average, only 11.6% of the respondents had purchased IPM products in the past six months.

Among all the respondents, 64.4% had purchased organic products within the past six months, whereas only 11.6% had purchased IPM products (Table 2). Table 3 presents data on the reasons why consumers have purchased, or would purchase, IPM products. Organic products were slightly more popular in Northern Europe and other countries, whereas more Southern Europeans had purchased an IPM product within the past six months, compared with the other groups.

		Total		Northern Europe		Southern Europe		Asia		Other	
Organic	*Yes*	*710*	*64.4%*	*337*	*56.1%*	*319*	*76.3%*	*23*	*60.5%*	*31*	*67.4%*
	No	393	35.6%	264	43.9%	99	23.7%	15	39.5%	15	32.6%
IPM	Yes	128	11.6%	56	9.3%	62	14.8%	5	13.2%	5	10.9%
	No	*975*	*88.4%*	*545*	*90.7%*	*356*	*85.2%*	*33*	*86.8%*	*41*	*89.1%*
	Total	1,103	100.0%	601	54.5%	418	37.9%	38	3.5%	46	4.2%

Table 2.
Consumer purchases of IPM or organic products within the past 6 months

Table 3. Reasons (%) why consumers have purchased or would purchase IPM products

Reasons	Purchased	Northern Europe	Southern Europe	Asia	Other	Would purchase	Northern Europe	Southern Europe	Asia	Other
Ethical concerns	*46.1*	54.2	35.6	5.1	5.1	*44.8*	43.9	48.1	5.0	3.0
Healthier products	*68.0*	52.9	39.1	5.7	2.3	*52.9*	37.4	55.2	4.7	2.7
Better quality	*39.1*	48.0	46.0	2.0	4.0	*23.6*	31.7	58.7	4.3	5.2
Discounted products	*12.5*	50.0	50.0	0.0	0.0	*8.7*	23.5	71.8	4.7	0.0
Not interested in purchasing	*4.7*	16.7	83.3	0.0	0.0	*16.1*	35.0	56.7	4.5	3.8
Other	3.1	25.0	75.0	0.0	0.0	4.8	44.7	55.3	0.0	0.0

As indicated in Table 3, the primary reason among consumers for having purchased or wanting to purchase IPM products was that they considered IPM products to be healthier. This was followed by ethical concerns and better product quality. There were significant differences between the geographical areas.

Moreover, the results of the survey provided evidence of vagueness in the term "quality'. Nevertheless, the highest percentage of respondents (50.4%) considered food grown with less pesticide to be of high quality, even though the low percentage of consumers (6.2%) who considered IPM products to be high-quality products is worthy of attention. This indicates a strong gap in consumer awareness of the terminology used to describe food-growing methods.

4. Results obtained with the DRSA

All 35 questions (Q) on the questionnaire represented a starting point for defining the condition attributes. The presence of multiple answers and nested questions implies that scores for these attributes can be higher than those obtained on the original questions.

The selected extracted decision attributes can be considered to model and describe consumer behaviour and consumer attitudes [1] as follows:

d_1: Views IPM products as healthier than conventional food products

d_2: Environmentally conscious

d_3: Price conscious

d_4: Familiar with IPM products

d_5: Unfamiliar with IPM products

d_6: Purchased IPM products in the past 6 months

d_7: Did not purchase IPM products in the past 6 months

d_8: Purchased organic products in the past 6 months

d_9: Did not purchase organic products in the past 6 months.

Tables 4–6 describe the condition attributes related to the selected decision rules with the highest support [2], which are divided into blocks according to the questionnaire structure. The tables present the frequencies of the questions in each block that appear to be homogeneously distributed [3].

Based on the DRSA results, three consumer segments were identified (Table 7).

(1) *Green consumers* who correctly define IPM products as healthier than conventional products or consider the environment in the consumption choices or purchased organic products in the past six months

(2) *IPM informed and active consumers* who not only know but have purchased IPM foods in the past six months

(3) *Potential IPM/low-pesticide foods or organic consumers* who have no information or who have not purchased IMP or organic products in the last six months and take price into great consideration in food choices

Figure 1 presents data on the selected decision attributes and questions in the questionnaire for each of the decision rules considered. These relationships are particularly important because they confirm the complexity and heterogeneity of consumer choices with reference to different decision attributes.

Attribute	Description	Frequency
Q1 Gender		
Q1 = 1	Male	
Q3 Nationality		
Q3 = 5	South Europe	
Q3 = 6	North Europe	
Q5 Family composition		
Q5 = 1	1 people	
Q5 = 4	4 or 5 people	67%
Q6 Monthly income		
Q6 ≤ 3	≤ 2,000 euros	
Q6 ≥ 6	>5,000 euros	
Q7 Profession		
Q7 ≤ 3	Employee or freelance professional or entrepreneur	
Q8 Time spent studying/working per day		
Q8 ≤ 3	Not >8 h	

Table 4.
Selected condition attributes for the basic characteristics of the respondents

On the *x*-axis, the extracted decision rules are decreasingly ordered with reference to the support, and thus, each decision attribute d_i ($i = 1, \ldots, 9$) is related to the corresponding support value. In the *y*-axis, the frequencies of the B_i-questions in the decision rules are displayed. For example, with a support value of 418 (the maximum), the decision rule related to d_7 is based on Q8 (a question in B_1, *basic characteristics*) and Q23 (a question in B_3, *perception of and attitudes toward IPM products*). Note that for all the extracted decision rules with decision attribute d_5, unfamiliar with IPM products, this consumer attitude is described by questions in each block B_i; that is, it relies on basic characteristics, eating and grocery shopping habits, and perception of and attitudes toward IPM products. Moreover, the number of questions involved confirmed the multifaceted nature of this decision: four in each case. The corresponding supports were in the higher 70th percentile, confirming the descriptive importance of the rules.

Again, in the case of decision attributes d_1, views IPM products as healthier than conventional products, d_3, price conscious, d_6, purchased IPM products in the past six months, and d_9, did not purchase organic products in the past six months, no question from B_1, basic information, is involved in the considered decision rules.

Furthermore, if we consider the decision referring to the behaviour of having purchased IPM products in the past six months (i.e. d_6), the simplicity of the extracted decision rules emerges; in fact, they are all based on a single condition attribute referring to eating and grocery shopping habits or perception of and attitudes toward IPM products.

5. Discussion

This section discusses the main results obtained by DRSA according to different decision attributes.

Attribute	Description	Frequency
Q10 Diet		
Q10 = 1	Omnivorous	
Q12 Responsibility regarding food choices		
Q12 = 1	Responsible for family food choices	
Q13 Where food is purchased		
Q13_5 = 0	Usually does not consider ethical purchasing	
Q14 Food aspects in purchasing		
Q14_1 = 0	Price is not taken into consideration	
Q14_2 = 0	Appearance is not taken into consideration	
Q14_2 = 1	Appearance is taken into consideration	71%
Q14_3 = 0	Place of origin is not taken into consideration	
Q14_4 = 0	Packaging is not taken into consideration	
Q14_5 = 0	Brand is not taken into consideration	
Q14_6 = 0	Labelling is not taken into consideration	
Q14_ 10 = 1	Environment is taken into consideration	
Q15 High quality food is		
Q15_3 = 1	Organic product	
Q15_5 = 1	Product directly sold by the producer/farmer	
Q15_6 = 1	Product grown with as little chemicals	
Q15_7 = 1	Product with no GMOs	

Table 5.
Selected condition attributes for eating and grocery shopping habits of the respondents

5.1 Segment 1 green consumer

The decision attributes d_1 (Views IPM products as healthier than conventional), d_2 (Environmentally conscious) and d_8 (Purchased organic products in the past six months) describe the green consumer.

According to the decision attribute d_1, the consumer is most likely to consider IPM products to be healthier than conventional food products if he or she is responsible for purchasing food, is indifferent to the price and prefers to buy cereals obtained with IPM methods. The second rule states that IPM products are considered healthier than conventional ones if the environment is the most important factor in purchasing decisions and if the preference is for IPM grapes. Third, the situation described by the decision attribute occurs if the purchasing decisions are not based on price, the consumer is familiar with IPM products and if he or she prefers IPM grapes.

The decision rules selected and related to the decision attribute "Environmentally conscious" share one conditional attribute: the price is not among the most important elements. The strongest decision rule describes a consumer who does not consider the price important, does not consider the appearance of the product and packaging, considers organic products to be high-quality and is willing to pay a higher price for organic grapes. The

Attribute	Description	Frequency
Q17 Familiarity		
Q17 = 1	Familiar with IPM products	
Q19 Understanding of IPM products		
Q19 = 2	Greater use of pesticides than in organic agriculture	
Q21 Reasons for not purchasing organic products		
Q21 = 1	No knowledge	
Q21 = 4	Too expensive	
Q23 Purchased or did not purchase IPM products		
Q23 = 1	Did not purchase: no knowledge	
Q23 = 9	Purchased	
Q24 Reasons to purchase or wish to purchase IPM products		
Q24_2 = 1	Healthier than conventional products	
Q24_4 = 0	Not because discounted	
Q25 Reasons when purchasing IPM products		
Q25 = 10	Not interested	58%
Q27 Purchased or wish to purchase imported IPM products		
Q27 = 1	Imported IPM products	
Q27 = 2	Imported IPM products if they cost less	
Q28 Perception of IPM product safety		
Q28 = 4	No knowledge of IPM safety	
Q32 Preferences		
Q32_1 = 5	IPM cereals	
Q32_3 = 6	Organic tomatoes	
Q32_4 = 4	Organic vegetables	
Q32_5 = 5	IPM grapes	
Q32_7 = 4	Organic wine	
Q34 Willingness to pay higher prices for organic products		
Q34_5 = 2	Organic grapes (≤20% higher)	
Q34_7 = 1	Organic wine	
Q34_4 = 5	Organic leafy vegetables (>80% higher)	
Q35 Interest in IPM method training/information initiatives		
Q35 = 2	Not interested	

Table 6.
Selected condition attributes for perception of IPM among the respondents

Support	IF conditions				THEN
1. *Green consumer (d1, d2, d8)*					
d1: Views IPM products as healthier than conventional products					
21	Q14_1 = 0	Q32_1 = 5	Q12 = 1		d1
21	Q14_10 = 1	Q32_5 = 5			d1
20	Q14_1 = 0	Q32_5 = 5	Q17 = 1		d1
Support	**IF conditions**				**THEN**
d2: Environmentally conscious					
30	Q14_1 = 0	Q14_2 = 0	Q14_4 = 0	Q15_3 = 1	Q34_5 = 2	d2
12	Q14_1 = 0	Q14_2 = 0	Q15_7 = 1	Q19 = 2		d2
12	Q14_1 = 0	Q6 ≥ 6	Q3 = 5	Q32_4 = 4		d2
Support	**IF conditions**				**THEN**
d8: Purchased organic products in the past 6 months					
65	Q7 ≤ 3		Q23 = 9		d8
61	Q14_ 10 = 1		Q32_7 = 4		d8
33	Q14_ 10 = 1		Q5 = 1		d8
Support	**IF conditions**				**THEN**
2. *IPM informed and active consumer (d4, d6)*					
d4: Familiar with IPM products					
13	Q19 = 2	Q23 = 9	Q35 = 2		d4
13	Q3 = 5	Q23 = 9	Q34_4 = 5		d4
Support	**IF conditions**				**THEN**
d6: Purchased IPM products in the past 6 months					
101	Q14_6 = 0				d6
98	Q10 = 1				d6
79	Q24_2 = 1				d6
Support	**IF conditions**				**THEN**
3. *Potential IPM/low-pesticide foods or organic consumer (d5, d7, d9, d3)*					
d5: Unfamiliar with IPM products					
102	Q23 = 1	Q6 ≤ 3	Q14_3 = 0	Q28 = 4	d5
96	Q23 = 1	Q3 = 6	Q13_5 = 0	Q27 = 1	d5
66	Q23 = 1	Q3 = 6	Q1 = 1	Q14_5 = 0	d5
Support	**IF conditions**				**THEN**
d7: Did not purchase IPM products in the past 6 months					
418	Q23 = 1		Q8 ≤ 3		d7
394	Q23 = 1		Q14_2 = 1		d7
354	Q23 = 1		Q15_6 = 1		d7

Table 7. Consumer segmentation(*)

(*continued*)

Support	IF conditions			THEN
		d9: Did not purchase organic products in the past 6 months		
49	Q21 = 1	Q34_7 = 1		d9
48	Q21 = 1	Q28 = 4		d9
43	Q21 = 1	Q15_5 = 1		d9
Support	IF conditions			THEN
		d3: Price conscious		
45	Q21 = 4	Q27 = 2	Q24_4 = 0	d3
43	Q21 = 4	Q10 = 1	Q15_6 = 1	d3
31	Q21 = 4	Q27 = 2	Q35 = 2	d3

Note(s): (*) Selected decision rules and question frequencies if support was ≥10

Table 7.

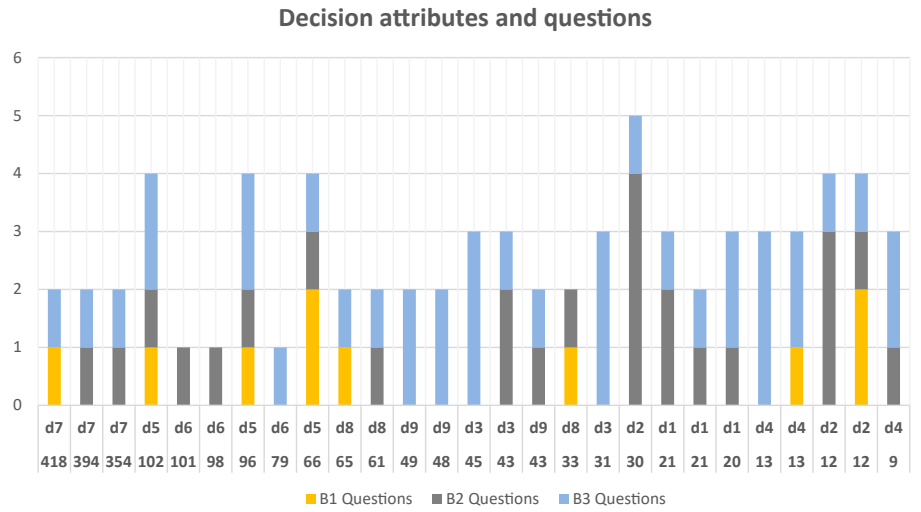

Figure 1.
Relationship between decision attributes and questions (Conditional attributes)

subsequent decision rules add more information. If the price and appearance are not taken into account, the product does not contain GMOs, and the consumer has correct information about IPM methods, then the consumer is more likely to be environmentally conscious. Furthermore, if the price is not decisive and the consumer resides in a Southern European country and has a monthly income equal to or greater than 5 thousand euros, then he or she is more likely to be environmentally conscious.

Moreover, consumers who have purchased organic products within the past six months are decision-makers who think that environmentally friendly production methods play an important role in choosing food items; moreover, they live alone. Similarly, a worker who purchased IPM products in the past six months was likely to have purchased organic products in the same period.

Policy implications: This is an informed market segment with low price elasticity and relatively high income, where extrinsic characteristics are of marginal importance. The products that this market segment considers important if obtained with low environmental impact processes are

grapes and wine. Moreover, consumers of organic products are prevalent. Consequently, producers should equip themselves with tools (labels) capable of allowing these consumers to recognise production processes with a lower environmental impact (European Commission, 2007, 2020). From the perspective of public decision makers, dissemination campaigns using digital tools (Demartini *et al.*, 2018) on the health and environmental benefits of consuming products with lower pesticide content could further strengthen this segment.

5.2 Segment 2 IPM informed and active consumer

The *IPM informed and active consumer* is outlined by the decision attributes d_4 (Familiar with IPM products) and d_6 (Purchased IPM products in the past six months).

Consumers are likely to be familiar with IPM products if they are aware that IPM methods require more pesticides than organic ones, if they have purchased them in the past six months and curiously are not available for training and/or additional information. Furthermore, he or she is familiar with IPM products if residing in a Southern European country, has purchased them in the past six months and is willing to pay double the price of organic leafy vegetables.

The rules' structure is very simple; only one condition attribute appears (unique case in all considered decisions): the decision maker who is not influenced by food labelling, has no restrictions in terms of the type of food production method, or thinks that IPM foods are healthier is likely to have purchased IPM food in the past six months.

Policy implications: This consumer segment has strong similarities to Segment 1 (green consumer). The rules describe an informed consumer who knows how to distinguish between different production processes and is indifferent to price and extrinsic characteristics. The strategies that can be adopted in this case are similar to those of segment 1 (labelling and digitalisation) and are attributable to tools for consolidating loyalty by both policymakers and producers, focusing on the intrinsic characteristics of IPM products.

5.3 Segment 3 potential IPM/low-pesticide or organic food consumer

The potential consumers of IPM or organic food are described by the decision attributes: d_5 (Unfamiliar with IPM products), d_7 (Did not purchase IPM products in the past six months), d_9 (Did not purchase organic products in the past six months) and d_3 (Price conscious).

It is the most important segment of our sample and describes a consumer who is misinformed, who has not purchased IPM or organic foods in the last six months and who is influenced, in purchasing decisions, by prices.

In the case of unfamiliarity with IPM, the decision rule with the highest support shows an influence of income (up to 2000 euros per month). The place of origin is not important, and he or she has not bought IPM products in the past six months because he or she is unaware of them and does not know that they are safer in terms of health. The other rules add further information on condition attributes, such as geographic area (Northern Europe), gender and other food aspects in purchasing.

The situation of not purchasing IPM products in the past six months is characterised by very high support rules (between 354 and 418); the decision-maker is not totally dedicated to work or studying, or he or she pays attention to the ways in which food is presented, or he or she believes that high-quality food undergoes a process that involves the least quantity of pesticides.

According to the decision rules, the consumer did not buy organic products in the past six months because of his or her lack of knowledge. In addition, this consumer is available to pay more for organic wine, ignores that IPM is safe to eat or is convinced that high quality means food purchased directly from the producer/farmer.

An analysis of the rules related to price consciousness reveals a consumer for whom price plays a key role: he or she did not buy organic food because it was too expensive.

Moreover, in the first decision rule, he or she declared a willingness to buy imported IPM products if cheaper, and if there is a discount. The second decision rule shows that consumers are more inclined to worry about price if they are omnivorous and if they prefer food with fewer pesticides. The last decision rule confirms the previous one, moreover he or she is not interested in IPM training information initiatives. The consumer described by the rules has high price elasticity and very moderate attention to environmental issues.

Policy implications: This is the most important segment and is numerically predominant. The decision-making rules selected highlight the lack of information of these consumers, to whom a specific campaign should be addressed to disseminate information on the environmental and health benefits derived from the consumption of food with little or no use of pesticides by policy makers. Producers of food with low environmental impacts should contribute to strengthening the knowledge of various production processes. In this context, multinational and national retail companies can assume a crucial role, which, when in direct contact with consumers, can influence their choices.

Given the importance of the public food service sector, green public procurement schemes (De Almeida Ferreira Neto and De Oliveira Gama Caldas, 2018; European Commission, 2016, 2020) in public tenders and catering services represent an indispensable tool to increase the knowledge and consumption of food with lower pesticide content.

This segment has a high elasticity with respect to price, which is decisive in consumption decisions. To influence the choices of this segment of consumers, producers should propose loyalty campaigns based on low prices, combined with tools to raise awareness of environmental protection. For this consumer segment, the extrinsic characteristics are of marginal importance.

6. Conclusions

Our results highlight the need for policymakers and food producers to take simultaneous and coordinated measures to raise consumer awareness and increase the consumption of food produced with fewer pesticides according to the market segmentation and policy implications described in Section 5. With regard to policymakers' efforts, citizens should receive more information on sustainable agricultural methods (IPM and organic), health and environmental consequences (Ajzen, 1991; Vermeir and Verbeke, 2006; Vlaeminck *et al.*, 2014; Stranieri *et al.*, 2017; Kautish and Sharma, 2018; Ricci *et al.*, 2018; Petrescu *et al.*, 2019; Bazzani *et al.*, 2020). Therefore, control should be strengthened (Ling, 2018). Producers and the food network (Mastronardi *et al.*, 2019), for their part, could promote information and price-based promotional campaigns to capture the share of consumers sensitive to price changes, focussing on inherent qualitative environment differences and health effects (Padel and Foser, 2005; Irianto, 2015; Kautish and Sharma, 2019). The large-scale distribution must be involved; it is the one closest to the consumer and, therefore, capable of influencing his or her choices. In view of the favourable attitude towards low pesticides products, a comprehensive strategy could be developed to promote their consumption on social and digital media for effective marketing. Moreover, our findings suggest marketers to segment the IPM food market based on consumer values and knowledge and articulate marketing strategies to convince the potential consumers about healthy and environmental benefits. According to Kautish and Sharma, "marketing activities in the green management context should focus on facilitating sustainable development experiences (e.g. consumer facilitation for used consumables, recycling behaviour and green products awareness)" (Kautish and Sharma, 2018, p. 17).

Digitisation is one of the challenges of the Green Deal (European Commission, 2019) and represents an opportunity for citizens and businesses. In the food sector, digitalisation has gained relevance only during the last few years (Demartini *et al.*, 2018), but it is not yet sufficiently widespread, even if it represents an indispensable tool for the dissemination of sustainable practices that involve all players in the food supply chain (European Commission, 2020).

Despite the high number of our survey respondents, further research should seek to obtain data from a more balanced sample with respect to nationality and/or different regions (such as rural and urban). Moreover, different methods of analysis could be applied, and the results compared. Indeed, future research can investigate other potential decision and conditional attributes, such as intrinsic and extrinsic factors and health reasons affecting consumer choices.

In line with other research on the consumption of organic and/or green foods (Kushwah *et al.*, 2019; Sharma *et al.*, 2022), further studies could be promoted to systematically examine the literature on the lower consumption of pesticides, not sufficiently developed in literature and only partially addressed here.

Notes

1. Our aim is not to make a distinction between behaviour and attitudes, but to describe consumer patterns with regards to IPM food products from a general point of view.
2. The support of a decision rule is the number of elements in the Universe $\mathcal{U}$ satisfying both condition attributes and decision attribute considered in the decision rule.
3. The following condition attributes are missing: education level (Q9), in the first block; the percentage of horticultural products in the diet (Q11), and the influence of family income on the quality of purchased fruit and vegetable products (Q16), in the second block; the meanings of IPM (Q18), having purchased organic products in the past six months (Q20), having purchased IPM products in the past six months (Q22), places to shop (or would shop) IPM products (Q26), reasons why IPM products are not safe or somewhat safe to eat (Q29), perception of organic safety (Q30), reasons why organic products are not safe or somewhat safe to eat (Q31), willingness to pay a higher price for organic products (Q33), in the third block.

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