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## Consumers' growing appetite for natural foods: Perceptions towards the use of natural preservatives in fresh fruit

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### ABSTRACT

Recent changes in food purchasing and consumption have led consumers to place greater importance on aspects such as convenience and the impact of food production and processing on health and the environment. This, in turn, poses a challenge for the food industry, especially with respect to highly perishable foods such as fruit. Great efforts have been made by the industry to reduce post-harvest losses by using natural preservatives that can replace traditional chemical fungicides, which are increasingly rejected by both citizens and governments. In this context, the purpose of this study was to obtain an overview of consumer perceptions towards the application of these novel products in fruit. In order to achieve this goal, five focus group sessions were held in multiple Spanish cities from December 2019 to February 2020. A total of 48 people with a mixed socio-demographic background took part in the study. The results showed both positive and negative consumer perceptions towards fruit, on the one hand being healthy and natural, and on the other lacking convenience. Packaging increases fruit convenience at the cost of its perception as a natural food product. In addition, consumers reported negative opinions associated with both the use of chemicals to improve fruit preservation and the environmental impact of the packaging. Participants showed interest in the use of natural preservatives in fruit, as these are considered more natural, healthier and more environmentally friendly. Although natural preservatives can influence consumers' fruit purchasing decisions, lack of information about such preservatives can cause doubts about their effectiveness and misjudgements about the price premium they add. Therefore, information about these types of preservatives, their characteristics and their benefits is key to overcoming mistrust and communicating to consumers the differentiation that their use adds to foods.

### 1. Introduction

In recent years, there have been major changes in food purchasing and consumption habits. Although the reasons behind these changes are many, some of the most significant are current work patterns, the increased participation of the female population in the labour market, the rising number of families in which both partners work, and income growth (Eldesouky & Mesias, 2014). All of the above have resulted in families having less time available for cooking and thus a greater demand for convenience and ready-to-eat foods.

The changes in family lifestyles, along with the gradual abandonment of the almost-daily food purchasing habit and the preparation of food immediately before mealtimes, have come about due to rapid development of food technologies, including the increasing use and

development of food additives. Food additives can be defined as natural or synthetic substances added to food with technological (e.g. counteracting food perishability and bacterial degradation) or sensory (e.g. enhancing food taste or colour) purposes (Bearth et al., 2014; Miao et al., 2020). Food additives have become indispensable in the production of processed foods (Shim et al., 2011) and are increasingly relevant in providing the “convenience” that consumers seek. This trend has led to a rapid increase in the production of numerous food additives, of both artificial and natural origin (Seo et al., 2008). In addition, food additives are essential for the food industry to be able to provide food that reaches the market in compliance with increasingly demanding legal and consumer requirements (Carocho et al., 2015).

Although food safety experts generally tend to agree on the safety of food additives, research suggests that consumers are concerned about

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the use and consumption of food additives and would like to be better informed about their potential effects on health (Bearth et al., 2014; Gebhardt et al., 2020). This behaviour is reinforced by the frequent health scandals that arise in the food industry, both related and unrelated to the use and consumption of food additives, such as the *Escherichia coli* crisis in soybeans in Germany in 2011, the marketing of pesticide-contaminated eggs in several European countries in 2017 or the outbreak of listeriosis in larded meat in Spain in 2019.

Moreover, consumers are becoming increasingly interested in fresh, natural, less processed and additive-free foods (Lavilla & Gayán, 2018). Although this poses a technological and logistical problem for agribusinesses, recent research has proven that consumers are often willing to pay a premium for food of high-sensory quality (Zhu et al., 2018).

Food additives can be divided into six types according to their function: preservatives, nutritional additives, colouring additives, flavourings, texturizers and miscellaneous (Carocho et al., 2015). Depending on the type of food, one or more of these types of additives can be used at the same time. However, in fresh produce, such as fruit and vegetables, the use of additives is almost exclusively limited to preservatives, that is, the substances added to food to prevent spoilage by microbial growth or by unwanted chemical changes.

In Spain, the fruits and vegetables sector stands out not only for its economic importance, but also for the diversity of its produce and for its relevance as a generator of wealth in rural areas. Spain is the leading exporter of fruit and vegetables in the European Union and one of the top three in the world along with China and the United States (MAPA, 2020). The sector has a clear exporting mandate, since 50% of its production is exported. In addition, exports have increased in recent years both in volume and in value, having reached a record 13.8 million tonnes and 15 billion euros in value in 2017. Therefore, any actions aimed at better marketing and extension of the shelf-life of fruit can have a great impact at all levels in the country.

However, the perishability of fruits and vegetables means that losses of these types of products can reach very significant levels, as they are amongst the foods with the highest loss rates at the farm level (Ludwig-Ohm et al., 2019). Although post-harvest losses are very difficult to estimate due to the great diversity of the products being marketed and their distribution amongst a large number of final consumers, some data can be found in this regard. Thus, for instance Usall, Torres, & Teixidó (2016) indicate that in the United States the global average of fresh fruit and vegetable losses is likely to be around 12% between production and consumption, although this percentage can exceed 50% in less developed regions. In addition, Kitinoja & Kader (2015) state that fruits and vegetables, along with roots and tubers, present the highest rates of food loss (45%) of any type of food.

Within this framework, one of the most important challenges faced by the fruit industry is to avoid significant post-harvest losses due to fungal diseases (rotting). Today, the most efficient way to tackle these losses is the application of synthetic fungicides. However, the growing awareness of human exposure to these products, with the subsequent implications for health (carcinogenic, teratogenic effects, etc.) and the environment, has caused increasing concern in society and has led to restrictions in post-harvest use (Spadaro & Gullino, 2004; Wisniewski et al., 2016).

This scenario has recently led to the development of abundant research aimed at obtaining natural substances that could be used to prevent fruit spoilage while being less harmful and more acceptable to consumers. Biopreservation or biocontrol through the use of protective cultures, which contain biocontrol agents (BCA), is a remarkable alternative to synthetic fungicides (Droby et al., 2016; Leyva Salas et al., 2017). Protective culture can be defined as a set of live microorganisms that are deliberately added to foods in order to control their microbiological status without changing their technological and sensory qualities (Ben Said et al., 2019).

Various mechanisms of biological control by antagonistic microorganisms have been described (Spadaro & Droby, 2016). Among them,

the existing background has shown that both the inoculation of the BCAs responsible for the generation of antifungal volatile organic compounds (VOCs) and the direct application of active compounds could become promising means of extending the shelf-life of fruits and vegetables. Furthermore, from a market perspective, there are signs providing promising prospects for BCAs, such as the increasing concern about food safety -chemical residues, environmental impact, etc.- both at the consumer and at the policy-maker levels, which have resulted in substantial regulatory changes (Droby et al., 2016). In response to these new trends, many large supermarket chains are setting enforceable new standards for their suppliers, which in fact involve the reduction of the authorised levels of chemical residues below the Maximum Residue Limits (Usall et al., 2016).

Although these new developments in the food industry may deserve researchers' trust, as they consider them to be safe and effective, their attitude is not necessarily reflected in consumer behaviour. Consumers tend to be cautious about new products and technologies, mainly because of the potential risks they may pose and the lack of perceived benefits, but also as a show of neophobia, a common rejection reaction towards new things (Frewer et al., 2011). These negative perceptions and attitudes towards innovation in the food sector, such as the use of BCAs, can prevent their adoption and cause products to fail (Martins et al., 2019). Therefore, it is essential to know consumers' perceptions of these novel preservatives used in the fruit industry.

However, this task can become extremely complicated if multiple factors affecting consumers' perceptions towards food and food additives are to be considered: health, wholesomeness, food safety, food culture, traditions, etc. All these factors can make the analysis of people's perceptions towards novel products difficult to carry out by means of traditional quantitative research approaches. Various aspects, such as lack of trust in the interviewer, lack of knowledge about the topic under analysis, or reluctance to share one's views -which is known as social desirability bias - may make the respondent unable or unwilling to answer complex questions about his or her perceptions or attitudes toward certain foods or technologies with complete openness (Donoghue, 2000; Eldesouky & Mesías, 2014).

Subsequently, qualitative research was considered a valid approach for this study, since it is a flexible and adaptable type of research that can address a specific issue and its driving forces (Stewart et al., 1994). It is also suitable for discovering the nature of a problem and contributes to the identification of action alternatives (Guerrero et al., 2009). Qualitative research has been largely used in the food sector, with applications in the study of consumers' perceptions towards imported fruits (Vaca & Mesías, 2014), the development of new food products (Banović et al., 2016) or the analysis of motivations regarding food choices (Velema et al., 2019).

Among several qualitative research techniques, the focus group is one of the most frequently used to develop the preliminary stages of a research study (Eldesouky & Mesías, 2014). This technique is based on group dynamics led by a moderator, whose mission is to stimulate discussion through the exchange of views amongst the participants which in the end allows for new topics and ideas to emerge. Hence, its main advantage over other more structured research methods, such as structured questionnaires, is that it allows and promotes greater freedom of expression amongst the attendees (Gaspar et al., 2016) and is a suitable technique for studies involving the identification of concerns and the development and application of new products or services (Chalofsky, 1999; Stewart & Shamsasani, 2014). Within this context, this work aims to explore consumers' perceptions towards the use of natural food preservatives based on biocontrol agents or bioprotective cultures in fruits. Studies on biocontrol as an efficient and reliable method to extend the shelf-life of fruits during commercialisation have gained relevance in recent decades. Specifically, in Spain different studies have proposed various microbial species as efficient antagonists against postharvest fruit pathogens. Thus, within bacteria, *Pantoea agglomerans* CPA-2 and *Bacillus amyloliquefaciens* BUZ-14 have been proposed as BCA against

different moulds in damaged pears (Nunes et al., 2001), citrus fruits and apples (Calvo et al., 2017). Additionally, different yeast strains have showed the potential for application as BCA against major postharvest moulds such as *Metschnikowia pulcherrima* L672, *Hanseniaspora opuntiae* L479 and *Hanseniaspora uvarum* L793 (de Paiva et al., 2017; Ruiz-Moyano et al., 2016), *Pichia kudriavzevii* PK18 (Cabañas et al., 2020), and *Candida sake* CPA-1 (Usall et al., 2001) among others. However, perceptions of Spanish consumers towards the application of BCA on fresh fruits have not been assessed. Previous studies have shown that Spanish consumers demand information on production methods, applied treatments and effects on the environment (Fernández-Serrano et al., 2021). In this sense, there is a segment of the population increasingly concerned about healthy eating and respect for the environment (Gil et al., 2000), which could be interested in purchasing fresh fruit treated with BCAs. With this purpose and through the application of focus groups, various topics will be analysed, such as the factors impacting fruit purchasing habits, the effect of packaging, health concerns relating to the use of food additives or knowledge and perceptions towards natural food additives. The findings could contribute to the development of the fruit industry, with fruit companies becoming better prepared to meet consumers' demands for healthier and safer food products.

## 2. Materials and methods

### 2.1. Focus group design

A focus group should consist of 6 to 12 participants for adequate development since fewer than 6 people do not facilitate group dynamics, whilst the flowing of natural debate in a group of more than 12 participants can be difficult and the moderator may have problems conducting the discussion towards the research topics (Gaspar et al., 2016; Malhotra & Birks, 2006). It is also recommended that the group composition represent the socio-demographic diversity of the population under study, although in some cases, it may be advisable to use homogeneous groups. Moreover, the venue is equally relevant, since an informal, relaxed atmosphere helps participants forget that they are being observed and questioned (Gaspar et al., 2016).

Taking all this into account, five focus group sessions were held from December 2019 to February 2020 in multiple Spanish cities, with a total of 48 participants in the study. The number of focus groups was defined by the financial availabilities of the research project in which this task was conducted. Nevertheless, several authors have found that this number of sessions allows the so-called "saturation point", i.e. the point at which no more information is obtained with new sessions, to be reached (Hartman et al., 2013; Onwuegbuzie et al., 2009). Moreover, both the number of participants and the number of focus group sessions are in line with other research using this methodology (Behrens et al., 2010; Chambers et al., 2008; Hartman et al., 2013; Horrillo et al., 2019; Santosa et al., 2013; van Dijk et al., 2012)

A public relations (PR) company was charged with selecting the participants and conducting the discussions. Considering the topic of research and the differences that could be expected in purchasing and consumption patterns between consumers in small towns and large cities, the five focus group sessions were held in one small town (Losar de la Vera, with less than 5,000 inhabitants, Focus Group 2), two mid-sized cities (Jaraiz de la Vera, Focus Group 4 and Navalmoral de la Mata, Focus Group 5, with a population between 5,001 and 25,000 inhabitants) and two large cities (Valladolid, Focus Group 1, and Salamanca, Focus Group 3, with more than 150,000 inhabitants). The different locations were selected by the PR company following the guidelines regarding size that were provided by the research team.

The participants were selected by way of convenience sampling, which is common in qualitative research (Eldesouky & Mesías, 2014). The main criterion for selecting participants was their willingness to participate in the study, since no special qualifications or prior

knowledge of the topic under study was required. The number of participants ranged between 6 and 12 and efforts were made to include a variety of people in the various focus groups according to the socio-demographic and purchasing characteristics of the participants. Table 1 shows the characteristics of the focus group participants.

### 2.2. Development of the focus groups

The research was conducted in compliance with the University of Extremadura Bioethics and Biosecurity Committee regulations regarding studies with human participants. All participants gave informed consent before taking part in the study. Participants were assured that their responses would remain confidential and would be fully anonymised so that it would not be possible to trace them back. As compensation for their time, participants received a small gift valued at 5–10 euros at the end of each session.

All the sessions were held in public venues, using a large room where the participants could be comfortably seated while maintaining eye contact, thus enabling interaction. The moderator started by explaining the framework of the research study (within a Spanish Research Project seeking to replace the synthetic fungicides currently used to prevent fruit spoilage with biological control agents that are naturally present in fruit). Participants were encouraged to express their opinions freely on the topics under discussion, and it was stressed that there were no right or wrong answers. Additional tools, such as cards where participants had to write down different aspects about a topic that would later be discussed, were also used to encourage participation and the generation of ideas.

The discussion began with questions about the participants' perceptions on fruit purchasing and consumption, with the aim of opening the debate. Later on, with the purpose of focussing the discussion and providing some background information, the moderator presented the following report about the traditional post-harvest management of fruit, its drawbacks and the innovations regarding more environmentally friendly and healthier fruit preservatives:

*"One of the most important challenges the fruit industry is facing is to avoid heavy post-harvest losses due to fungal diseases (rot). The most efficient techniques for the control of fungal pathogens today are synthetic fungicides, however their use is being increasingly restricted due to the emergence of microbial resistance, residues in food and negative implications for the environment.*

*Therefore, in recent years various effective, safe and environmentally friendly strategies have been developed to extend the shelf life of fruits, including a group of techniques known as biocontrol (application of yeasts naturally present in the fruit, harmless to the consumer and that control the development of moulds)".*

Table 2 shows the script followed by the moderator during the various focus group sessions.

### 2.3. Data analysis

Following each focus group session, a report was prepared to show the main points that had been highlighted during the discussion. The recordings were then transcribed and analysed through the content analysis technique (Stewart & Shamsasani, 2014) which seeks to draw replicable and valid inferences from texts (or other significant material) in order to reduce the original material (Flick, 2009). Thus, the information was first processed and organised into common themes, with all the terms and their meanings being considered in the analysis. Finally, the the answers for each point of discussion were examined in order to determine the similarities and differences. Subsequently, in order to gain insight into the relative importance of the various concepts that emerged during the research, their frequency of mention was calculated by counting the number of comments related to each concept that had emerged during the discussion of the different topics (Eldesouky et al., 2020). Fig. 1 shows the complete procedures that were followed during

**Table 1**

Sociodemographic characteristics of the participants in the different focus groups (between brackets, date when session was carried out).

		Focus Group 1 N = 6 (18 Dec 2019)	Focus Group 2 N = 11 (27 Dec 2019)	Focus Group 3 N = 12 (29 Jan 2020)	Focus Group 4 N = 9 (30 Jan 2020)	Focus Group 5 N = 10 (03 Feb 2020)	Total number of participants (N = 48)	(%)
Gender	Women	3	6	6	5	5	25	52.1
	Men	3	5	6	4	5	23	47.9
Age	18–30 y.o.	1	3	3	1	2	10	20.8
	31–60 y.o.	4	6	6	5	6	27	56.3
	greater than 60 y.o.	1	2	3	3	2	11	22.9
Actively working	Yes	4	4	7	2	7	24	50.0
	No	2	7	5	7	3	24	50.0
In charge of food shopping	Yes	2	7	6	5	4	24	50.0
	No	4	4	6	4	6	24	50.0

**Table 2**

Structure of the focus group discussions.

Section	Contents
1. Fruit perceptions	- Fruit consumption and fruit purchasing formats. Opinions on fruit: factors affecting consumers' decisions to purchase fruit. Opinions on packaged fruit: positive/negative aspects about packaged fruit.
2. Health and fruit consumption	- Influence on health and purchasing behaviour of additives and preservatives used in fruit. Knowledge and importance of chemical and natural preservatives. Natural additives as an alternative. Labelling information and consumer behaviour. Willingness to buy fruit labelled with information on the biological treatment or chemical preservatives.
3. Perceptions of fruit packaging	- Concerns about the environmental effects of the packaging materials. Preferences for the forms of application of the natural preservatives according to types of packaging. Intelligent packaging systems.

the focus group sessions carried out for this piece of research.

### 3. Results

The findings presented in this section follow the above-mentioned script used to conduct the focus group sessions. Tables 3 to 7 show the main comments relating to the various topics of discussion and prepared taking the participants' quotes. It should be noted that a chi-square test applied to the frequencies of mention did not reveal gender- or age-differentiated comments.

#### 3.1. Fruit perceptions

The moderator began by asking the participants about the types of fruit they consumed. The types of fruit mentioned were very diverse, including both seasonally and locally produced fruit, as well as imported fruit. When later asked about the packaged fruit they consumed, initially there was a tendency to talk about canned fruit, but gradually the concept of packaging was extended and many of the types of fruit mentioned at the beginning of the discussion were pointed out. Although some participants seemed reluctant to acknowledge to the group that many of the fruits they consumed were packaged, others quickly mentioned all the aforementioned types. In fact, only in one of the groups were there negative comments about packaging, reflecting that, in principle, the participants had quite embraced this purchasing format, which is closely related to modern distribution and is increasingly widespread among food consumers.

Subsequently, the discussion moved towards the participants' behaviour and perceptions towards fruit, focusing on the factors shaping their purchasing and consumption decisions. Table 3 shows the main concepts stated in the focus group sessions together with their frequency

of mention, with the factors "nutritious" (25.5%) and "healthy" (12.8%) standing out. On the other hand, the frequency of mention for "convenient" was only 3.5%.

At a subsequent stage of the discussion, the topic of packaged fruit was raised. To help generate ideas, participants were given a card where they had to write down all the aspects they liked and disliked about packaged fruit, which were discussed afterwards. Table 4 presents the main positive and negative comments about packaged fruit that the various focus groups mentioned. Regarding the positive comments, the concepts "convenience" and "appearance and presentation" showed frequencies of mention higher than 10%, whereas the highlighted negative comments were "environmental impacts" and "quality mistrust" with 16.4% and 14.4%, respectively.

#### 3.2. Health and fruit consumption

This section intended to delve into the consumer's health perceptions and purchasing behaviour deriving from the presence of additives and preservatives in fruit. With this purpose in mind, the moderator initially provided a brief description of the post-harvest losses incurred by the fruit industry due to fungal diseases, the most common techniques used to control them (synthetic fungicides), their drawbacks and the recent trends to develop safe and environmentally friendly strategies to extend fruit self-life such as biocontrol<sup>1</sup>.

Participants were then asked about their knowledge regarding the presence of additives and preservatives in fruit. A total of 89.4% of the people attending the sessions indicated that they were aware of this fact and that it was relevant to their purchasing decision (72.3%). However, the situation changed drastically when their knowledge of natural preservatives was enquired about, and these were unknown to 66% of the participants.

Despite the limited knowledge of natural preservatives, during the discussion on the perception of these kinds of products, numerous positive views emerged, such as their relationship with naturalness and organic production or their association with the traditional taste of fruit. However, some controversial issues also arose, mainly related to their perception of lower effectiveness or higher price. Table 5 presents the concepts and comments which emerged in relation to the use of natural preservatives in fruit.

It was considered that if consumers were to value the use of these substances, they would need to obtain adequate information through the labels. Therefore, participants were asked whether they looked at the label when buying packaged fruit and whether the information on the label had any impact on their purchasing decision. A large majority of participants (80.9%) indicated that they did look at the label and that

<sup>1</sup> Due to the relevance of biocontrol to the project under which this research was developed, specific reference was made to it and it was defined as "the application of yeasts that are naturally present in the fruit, which are harmless to the consumer and which control the development of moulds".

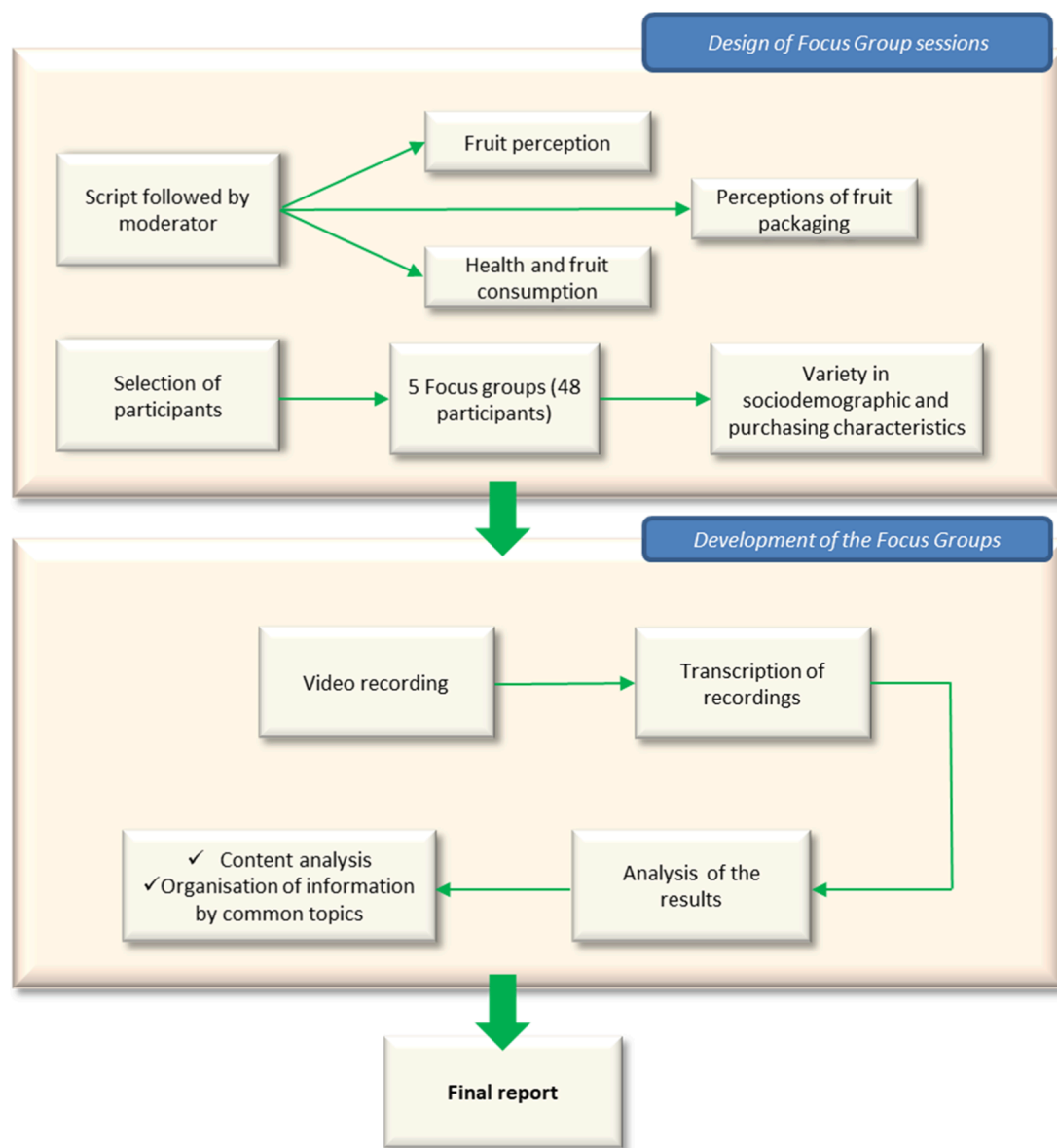


Fig. 1. Methodological procedures followed during the focus group sessions.

**Table 3**  
Reasons affecting fruit consumption (frequency of mention in %).

Factors	Verbatim comments	% <sup>a</sup>
Nutritious	<i>"It's a source of vitamins and fibre; fruit is both digestive and filling"</i>	25.5
Healthy	<i>"People who eat fruit are healthier; fruit consumption improves bowel transit"</i>	12.8
Tasty	<i>"It is refreshing and tasty"</i>	8.5
Seasonal and ripened	<i>"I can always select ripe and seasonal fruit"</i>	8.5
Affordable price	<i>"Its price is affordable; fruit is cheaper than other foods"</i>	7.1
Locally produced	<i>"I prefer locally/regionally, or otherwise nationally produced fruit"</i>	6.4
Convenient	<i>"Fruit can be consumed immediately, without further preparation"</i>	3.5

<sup>a</sup> Percentages in this column refer to the total number of comments that arose during the discussion of this topic.

the label largely impacted their purchasing choices (6.6 out of 10, where 0 was "not at all important for my purchasing decision" and 10 "very important for my purchasing decision"). However, participants stated

that even when they looked at the label, they were not always able to interpret the information included in it. In this sense, a discussion was opened on the information that participants wanted to find on the label when purchasing packaged fruit. Table 6 presents the concepts and comments about the labelling on packaged fruit.

The discussion continued to ascertain the potential interest that the mention on the label of the use of biological preservatives could raise in consumers. Almost all the participants agreed that the label should display the messages "biologically treated fruit" or "antifungal-chemical-free fruit". To a lesser extent, there was also a majority who agreed on the positive effect that both messages could have on the willingness to purchase fruit that was labelled thusly, which also corresponded to a clear unwillingness to purchase fruit that was marked as having been treated with chemical preservatives.

### 3.3. Perceptions of fruit packaging

The last section of the focus group sessions focussed on the consumer perception of fruit packaging and how the use of biological preservatives could result in the use of various packaging formats.

**Table 4**  
Positive and negative comments about packaged fruit (frequency of mention in %).

Positive comments			Negative comments		
Concepts	Verbatim comments	% <sup>a</sup>	Concepts	Verbatim comments	% <sup>a</sup>
Convenience	“Convenience; purchase speed; practical to transport and store; practical for people living alone”	12.3	Environmental impacts	“Excess of plastic in the package and the wrapping; they use a lot of plastic, cause more waste and contamination; they do not use reusable packaging; I am not interested in plastic packaging”	16.4
Appearance and presentation	“Better appearance (homogeneous size, look...); nice to the eye, tidy organisation; homogeneity”	10.8	Quality mistrust	“It is hard to ascertain whether they are at their best ripping point; they may have been packaged long and perhaps they lost some of their qualities; they are less flavoursome than unpackaged fruit; you cannot touch or smell the fruit”	14.4
Hygiene/Health	“They look more hygienic; prevents other consumers from touching them; fruit is cleaner”	5.6	More expensive	“They tend to be more expensive than bulk fruit; when they are handled and packaged, they are more expensive”	12.3
Price	“Better value for money”	2.6	Not convenient	“The weight does not adapt to my needs; I cannot choose the fruit and the amount I buy”	7.7
Labelling	“It is always labelled; the label shows origin (national/imported) and the best before date; information on additives”	2.6	Presence of chemical additives in fruit	“They contain more chemicals than bulk fruit; they come with additives to improve their appearance and preservation”	4.1
Shelf-life	“Fresher and lasting longer; lasts longer; I buy it when I am not going to use it immediately”	2.1	Presence of damaged/rotten fruit	“There is always rotting fruit; fruit tends to spoil when it is in a package; you cannot see all the pieces of fruit and some of them tend to be rotten”	3.1
			Origin	“It may not be local or seasonal; if it comes from very far away, I tend not to buy it; fruit from other countries”	3.1
			Unnatural appearance	“Not very natural; very shiny; the pictures on the packaging are deceitful and the fruit is less ripe”	3.1

<sup>a</sup> Percentages in this column refer to the total number of comments that arose during the discussion of this topic.

**Table 5**  
Concepts and comments concerning the use of natural preservatives in fruit.

Concepts	Verbatim comments	% <sup>a</sup>
Natural	“Natural; as food should always be; organic; makes the fruit taste as it always has”	33.7
Healthier	“Completely healthy; healthier and safer”	18.9
Environmentally friendly	“Beneficial to nature; environmentally-friendly; less polluting; sustainable; zero residues”	14.7
Dependable	“These products make me feel more confident about the food I eat”	12.6
Harmless to health	“Better for one’s health; they do not cause allergies or intolerances”	9.5
Lower effectiveness	“These products may be less effective than other chemical preservatives; fruit will be more perishable”	7.4
Price	“More expensive”	3.2

<sup>a</sup> Percentages in this column refer to the total number of comments that arose during the discussion of this topic.

**Table 6**  
Concepts and comments about the labelling on packaged fruit (frequency of mention in %).

Concepts	Verbatim comments	% <sup>a</sup>
Origin	“Where the fruit was grown and where it was packaged; information about the company which grew the fruit; clear origin”	27.2
Processing practices	“Presence of preservatives and additives; preservation method; types of fungicides or pesticides used”	24.5
Time from harvesting to retailing and shelf-life	“Harvesting time; packaging time; sell-by date; best before date”	24.5
Fruit characteristics/nutritional facts	“Fruit characteristics and nutrients must be specified; variety and size”	10.2
Cultivation practices	“How the fruit was grown; organic; Fair Trade; identification of the producer”	8.8
Social information	“Price paid to the producer; fair farm prices; middlemen involved in fruit trading must be specified”	4.8

<sup>a</sup> Percentages in this column refer to the total number of comments that arose during the discussion of this topic.

Prior to this section, participants received information about the most common types of packaging used with fruit and how they could affect the way preservatives are used (Fig. 2). Fig. 2a shows a plastic tray

**Table 7**  
Concepts and comments about intelligent packaging.

Concepts	Verbatim comments	% <sup>a</sup>
Superfluous	“I don’t see the need; I could do without this type of packaging”	31.1
Fruit freshness	“It is often difficult to ascertain the level of freshness of packaged fruits; sometimes it is difficult to judge the ripening point of the fruit”	20.0
Wholesomeness	“It would make me eat the fruit more safely; it is more natural and beneficial for my health; product quality”	15.6
Consumer guarantee	“This information is a guarantee for the consumer”	13.3
Reduce packaging use	“I prefer to buy fruit frequently and not use more unnecessary containers; because we have to avoid using containers”	11.1
Convenience	“It is convenient for the consumer”	8.9

<sup>a</sup> Percentages in this column refer to the total number of comments that arose during the discussion of this topic.

available for bioprotective cultures with any mechanism of biological control (competition for space and nutrients, parasitism, antibiosis, production of lytic enzymes, induction to host defence, and production of volatile organic compounds, according to (Spadaro & Droby, 2016). Fig. 2b and 2c depict plastic trays intended for the use bioprotective cultures based on volatile organic compounds (Santiago Ruiz-Moyano et al., 2020), which was the main objective of the research project.

When discussing the forms of application of natural preservatives according to the types of packaging (Fig. 2), the participants showed a slightly higher preference for the traditional tray (50%) followed by type c (47.8%), which is the one that most prevents contact between the fruit and the preservative.

Finally, in the context of the growing consumer demand for more convenient foods (e.g. those with a longer shelf-life, in the case of fruit) and more natural foods (those without preservatives or containing natural alternatives), the use of intelligent packaging was considered potentially positive. Therefore, the moderator presented the attendants with the concept and a sample of “intelligent packaging systems” (systems that provide the user with information on the conditions of the food, i.e. on the freshness of the fruit). Participants were then asked about their interest in this type of innovation and their willingness to purchase it, and 57.4% of them stated they were interested and willing to pay a 7% premium for this type of packaging. Table 7 shows the main

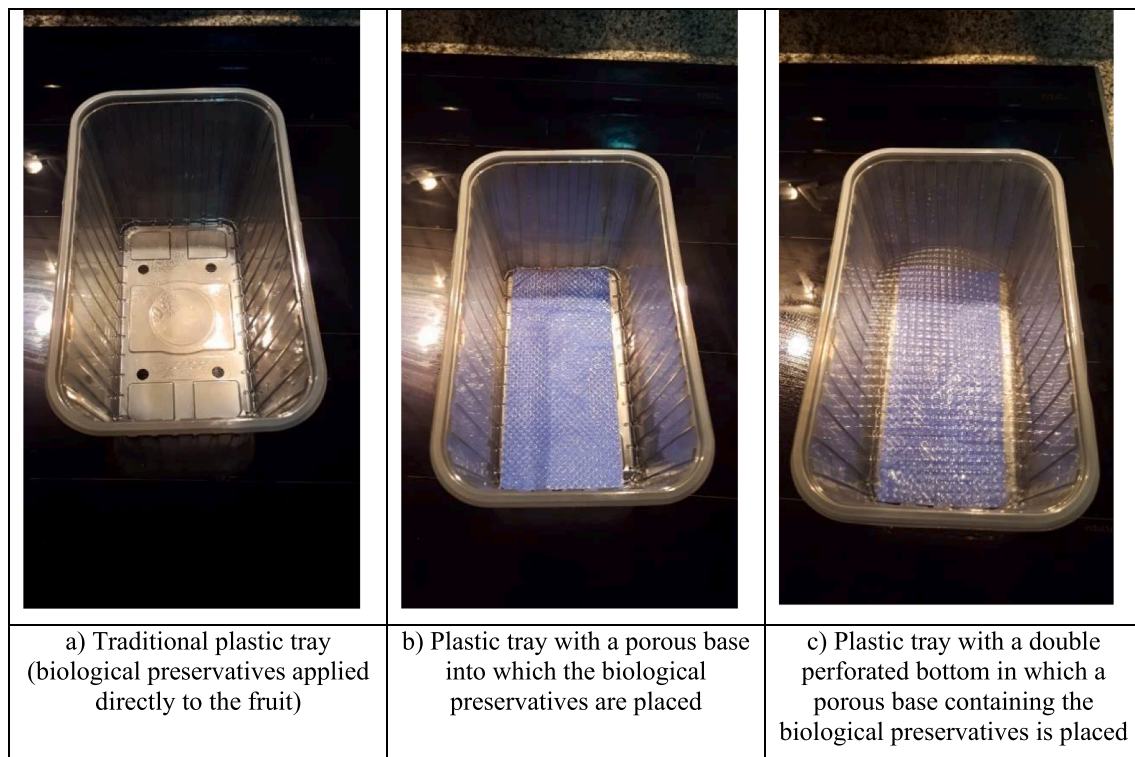


Fig. 2. Images of plastic fruit trays presented to the participants.

themes and comments about intelligent packaging made by the attendants to the focus group sessions.

#### 4. Discussion

##### 4.1. Fruit perceptions

Consumers are clearly aware of the health and nutritional benefits derived from fruit consumption, which are extensively documented in the literature (Baselice et al., 2017). In fact, previous qualitative studies have already found that staying healthy was a driver for fruit and vegetable consumption in many adults (Hartman et al., 2013). Also, Ünüsan (2004) found that perceptions about the taste, satiety or digestibility of fruit were important factors in consumption. In terms of price, Owen, Griffith, & Wright (2002) stated that most fruit and vegetables are cheaper than other foods and are also frequently purchased, which may help reduce consumer uncertainty about their quality at purchase.

On the other hand, fruit, as such, is not considered a convenience food (Hartman et al., 2013), and unless it is processed to a certain degree (e.g. already washed, cut and packaged), it is not suitable for eating at work or in educational settings. Their findings are therefore consistent with how scarcely the term “convenient” is mentioned in this study.

On the subject of packaged fruit the participants brought up positive and negative aspects. It should be highlighted that the most positive aspects for consumers are convenience and product appearance and presentation. On the negative side they questioned the quality of the product and showed concern about the environmental impact of the packaging. Along with those remarks about the unnatural appearance of packaged fruit, these were the comments most often heard from the participants. This is in line with Ragaert, Verbeke, Devlieghere, & Debevere (2004) who, on analysing the perception of minimally processed vegetables and packaged fruit, found that consumers of these products seek reasonable trade-offs between quality (which can only be assessed indirectly through appearance and presentation) and

convenience.

The environmental impact of packaging is the most frequently mentioned aspect of packaged fruit and reveals the need for the industry to adapt to current social trends, where recycling and environmentally friendly practices are increasingly relevant. This trend in consumer behaviour has been found in other studies on food packaging, such as that of Eldesouky, Pulido, & Mesías (2015), where recyclable or environmentally friendly packaging was very important for the consumers under study.

The fact that packaged fruit is more hygienic/healthy was not considered very relevant, which is consistent with Ragaert et al. (2004), who indicated that health was not an important purchasing motivation in the case of packaged fruit.

Interestingly, price appears both as one of the main negative factors of packaged fruit and, to a lesser extent, as a positive one. The latter is probably related to the better appearance and presentation, which justifies the higher price in the eyes of some consumers. In fact, Pollard, Kirk, & Cade (2002) refer to the change that has occurred in the fruit and vegetable market, where there has been a shift from bulk products to pre-packaged, prepared and ready-to-cook products, which are more adapted to current consumer habits. Although due to their processing these products are more expensive than their bulk equivalents, consumers accept this surcharge in exchange for greater convenience.

##### 4.2. Health and fruit consumption

The results of this study have shown a high level of consumer knowledge about the presence of additives and preservatives in fruit and their relevance to purchasing decisions, which are in line with previous research (Beareth et al., 2014). In this regard, it is interesting to point out that some authors (Carocho et al., 2014) have found that consumers initially prefer additive-free food, but if this is not available, they tend to opt for food containing natural rather than synthetic additives.

The fact that natural preservatives are seen as “natural” and “healthy” suggests that they are identified with some of the main

features and benefits that consumers attribute to fruit (Baselice et al., 2017; Hartman et al., 2013). This association can be the driver of positive consumer attitudes towards the use of these types of additives, which in turn may provide the basis for their widespread implementation in the fruit market. In this respect, the mention that they are “environmentally friendly” products is also interesting, as this implies an adaptation to current food trends as consumers seek to integrate environmental and sustainable aspects in their food choices (Eldesouky et al., 2020; Galati et al., 2019).

The concepts about labelling on packaged fruit that were most frequently mentioned by the participants in the focus group sessions were consistent with those found in various other studies (Campbell et al., 2013; Migliore et al., 2015; Moor et al., 2014), which showed that price, origin, production methods and quality indicators are the most relevant attributes in fruit purchasing. With respect to origin, consumers in developed countries have been noted to be willing to pay a premium for local foods, which are assumed to be of higher quality than imported ones (Loureiro & Umberger, 2003; Peterson et al., 2013). On the other hand, the importance given to processing practices, especially to information about the preservatives and additives being used, is in line with the growing social demand for less-processed and preservative-free foods -such as the so-called “clean label” foods- and towards the use of natural alternatives (Leyva Salas et al., 2017).

#### 4.3. Perceptions of fruit packaging

When participants discussed the types of fruit packaging -and the way preservatives are used in them, a slightly higher preference was shown for traditional trays versus new types of packaging which could be seen as less environmentally friendly. This choice could be related to the fact that the analyzed preservatives were natural ones and provided sufficient confidence for most consumers, who, in turn, use the environmental aspect of the packaging as a selection criterion. However, another important segment of consumers preferred packaging that limits contact between the fruit and the preservative, which is consistent with the general consumer behaviour that tends to limit food contact with foreign.

Regarding intelligent packaging systems, and although the highest percentage of comments mentioned the superfluousness of this type of packaging, it is worth noting that other categories with positive implications accounted for almost 50% of the participant comments (freshness, wholesomeness, consumer guarantee). This level of response reveals the potential of intelligent systems in the fruit market. In fact, it has been previously shown that quality indicators are one of the most relevant attributes in the purchase of fruit (Campbell et al., 2013; Migliore et al., 2015; Moor et al., 2014). However, the difficulty of its being appreciated in packaged fruit is one of the handicaps of this product. Therefore, the widespread use of intelligent packaging could provide consumers with information they are currently missing and that would support them in their decision-making when purchasing fruit.

Biocontrol as an alternative to synthetic chemicals is a strategy far from complete development (Droby et al., 2009; Droby & Wisniewski, 2018), although great advances and insights have been brought to light lately. Thus, the actual and potential uses of biocontrol agents (bio-preservative cultures, bioprotectives) as a strategy to improve yield and shelf-life have been widely discussed in numerous review manuscripts (Droby et al., 2016; Sharma et al., 2009; Siroli et al., 2015; Sui et al., 2015). Moreover, most of these works focused on the description of the mechanism of biological control by antagonistic microbes (Carmona-Hernandez et al., 2019; Freimoser et al., 2019; Spadaro & Droby, 2016). Among the different mechanisms of biological control, production of antifungal volatile organic compounds is one of the least known among the scientific community, as well as for industries and consumers, which brings remarkable novelty to the results of the present work. Other research has also reviewed the synergistic effects of biocontrol agents used in conjunction with other strategies (Di Francesco & Mari, 2014;

Marín et al., 2017; Zhang et al., 2017). Despite all these advances in the selection and application of biocontrol agents to reduce the incidence of fungal diseases, the scientific approach to biocontrol agents in fruits has not yet been addressed to assess the perception and willingness to consume fruits preserved with bioprotective yeasts. In this regard, information on consumers' perceptions on label information or packaging format for marketing fruits treated with bioprotective yeasts offers new information to researchers and producers.

## 5. Conclusions

According to the findings of this research, fruit is perceived as a nutritious, healthy and tasty food, but it is not seen as very convenient, which is a barrier to its consumption against current shopping and eating habits. This situation is further complicated by rather contradictory consumer demands: there is a need for more natural, less processed foods with fewer additives, which are also more convenient (e.g. extended shelf-life, ready to eat). In this regard, fruit processing, e.g. by packaging, improves convenience but at the cost of the consumer no longer perceiving its naturalness.

Moreover, consumers perceive negative connotations relating to both the use of chemicals to improve their appearance and shelf-life and to the environmental impact generated by such processes. Natural preservatives, such as biocontrol agents or bioprotective cultures, may be a solution to these problems faced by fruit producers. In this context, consumers are interested in the use of natural preservatives in fruit, which they consider more natural, healthier and more environmentally friendly. However, the lack of awareness of these products makes them doubt their effectiveness and believe that they can increase the price of the fruit, which may indicate the need for consumer-oriented educational campaigns to overcome this mistrust and to communicate the differentiation of these products.

#### CRediT authorship contribution statement

**F.J. Mesías:** Conceptualization, Methodology, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **A. Martín:** Conceptualization, Methodology, Writing – review & editing. **A. Hernández:** Conceptualization, Project administration, Writing – review & editing.

#### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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#### References

- Banović, M., Krystallin, A., Guerrero, L., & Reinders, M. J. (2016). Consumers as co-creators of new product ideas: An application of projective and creative research techniques. *Food Research International*, 87, 211–223. <https://doi.org/10.1016/j.foodres.2016.07.010>
- Baselice, A., Colantuoni, F., Lass, D. A., Nardone, G., & Stasi, A. (2017). Trends in EU consumers' attitude towards fresh-cut fruit and vegetables. *Food Quality and Preference*, 59, 87–96. <https://doi.org/10.1016/j.foodqual.2017.01.008>
- Beareth, A., Cousin, M. E., & Siegrist, M. (2014). The consumer's perception of artificial food additives: Influences on acceptance, risk and benefit perceptions. *Food Quality and Preference*, 38, 14–23. <https://doi.org/10.1016/j.foodqual.2014.05.008>



- Behrens, J. H., Barcellos, M. N., Frewer, L. J., Nunes, T. P., Franco, B. D. G. M., Destro, M. T., & Landgraf, M. (2010). Consumer purchase habits and views on food safety: A Brazilian study. *Food Control*, 21(7), 963–969. <https://doi.org/10.1016/j.foodcont.2009.07.018>
- Ben Said, L., Gaudreau, H., Dallaire, L., Tessier, M., & Fliss, I. (2019). Bioprotective Culture: A New Generation of Food Additives for the Preservation of Food Quality and Safety. *Industrial Biotechnology*, 15(3), 138–147. <https://doi.org/10.1089/ind.2019.29175.lbs>
- Cabañas, C. M., Hernández, A., Martínez, A., Tejero, P., Vázquez-Hernández, M., Martín, A., & Ruiz-Moyano, S. (2020). Control of *Penicillium glabrum* by Indigenous Antagonistic Yeast from Vineyards. *Foods*, 9(12), 1864. <https://doi.org/10.3390/foods9121864>
- Calvo, H., Marco, P., Blanco, D., Oria, R., & Venturini, M. E. (2017). Potential of a new strain of *Bacillus amyloliquefaciens* BUZ-14 as a biocontrol agent of postharvest fruit diseases. *Food Microbiology*, 63, 101–110. <https://doi.org/10.1016/j.fm.2016.11.004>
- Campbell, B. L., Mhlanga, S., & Lesschaeve, I. (2013). Consumer preferences for peach attributes: Market segmentation analysis and implications for new marketing strategies. *Agricultural and Resource Economics Review*, 42(3), 518–541. <https://doi.org/10.1017/S1068280500004974>
- Carmona-Hernandez, S., Reyes-Pérez, J. J., Chiquito-Contreras, R. G., Rincon-Enriquez, G., Cerdan-Cabrera, C. R., & Hernandez-Montiel, L. G. (2019). Biocontrol of postharvest fruit fungal diseases by bacterial antagonists: A review. *Agronomy*, 9(3), 121.
- Carocho, M., Barreiro, M. F., Morales, P., & Ferreira, I. C. F. R. (2014). Adding molecules to food, pros and cons: A review on synthetic and natural food additives. *Comprehensive Reviews in Food Science and Food Safety*, 13(4), 377–399. <https://doi.org/10.1111/1541-4337.12065>
- Carocho, M., Morales, P., & Ferreira, I. C. F. R. (2015). Natural food additives: Quo vadis? *Trends in Food Science and Technology*, 45(2), 284–295. <https://doi.org/10.1016/j.tifs.2015.06.007>
- Chalofsky, N. (1999). *How to conduct focus groups*. American Society for Training and Development.
- Chambers, S., Lobb, A., Butler, L. T., & Traill, W. B. (2008). The influence of age and gender on food choice: A focus group exploration. *International Journal of Consumer Studies*, 32(4), 356–365. <https://doi.org/10.1111/j.1470-6431.2007.00642.x>
- de Paiva, E., Serradilla, M. J., Ruiz-Moyano, S., Córdoba, M. G., Villalobos, M. C., Casquete, R., & Hernández, A. (2017). Combined effect of antagonistic yeast and modified atmosphere to control *Penicillium expansum* infection in sweet cherries cv. *Ambrunes*. *International Journal of Food Microbiology*, 241, 276–282. <https://doi.org/10.1016/j.ijfoodmicro.2016.10.033>
- Di Francesco, A., & Mari, M. (2014). Use of biocontrol agents in combination with physical and chemical treatments: Efficacy assessment. *Stewart Postharvest Review*, 1(2).
- Donoghue, S. (2000). Projective techniques in consumer research. *Journal of Family Ecology and Consumer Sciences*, 28(1), 47–53. <https://doi.org/10.4314/jfec.v28i1.52784>
- Droby, S., & Wisniewski, M. (2018). The fruit microbiome: A new frontier for postharvest biocontrol and postharvest biology. *Postharvest Biology and Technology*, 140, 107–112.
- Droby, S., Wisniewski, M., Macarasin, D., & Wilson, C. (2009). Twenty years of postharvest biocontrol research: Is it time for a new paradigm? *Postharvest Biology and Technology*, 52(2), 137–145.
- Droby, S., Wisniewski, M., Teixidó, N., Spadaro, D., & Jijakli, M. H. (2016). The science, development, and commercialization of postharvest biocontrol products. *Postharvest Biology and Technology*, 122, 22–29.
- Eldesouky, A., & Mesias, F. (2014). An insight into the influence of packaging and presentation format on consumer purchasing attitudes towards cheese: A qualitative study. *Spanish Journal of Agricultural Research*, 12(2), 305–312. <https://doi.org/10.5424/sjar/2014122-5520>
- Eldesouky, A., Mesias, F. J., & Escibano, M. (2020). Perception of Spanish consumers towards environmentally friendly labelling in food. *International Journal of Consumer Studies*, 44(1), 64–76. <https://doi.org/10.1111/ijcs.v44.110.1111/ijcs.12546>
- Eldesouky, A., Pulido, A. F., & Mesias, F. J. (2015). The Role of Packaging and Presentation Format in Consumers' Preferences for Food: An Application of Projective Techniques. *Journal of Sensory Studies*, 30(5), 360–369. <https://doi.org/10.1111/joss.12162>
- Fernández-Serrano, P., Tarancón, P., & Besada, C. (2021). Fresh Fruit Packaging. *An Exploratory Study in Spain*. *Foods*, 10, 72.
- Flick, U. (2009). *An Introduction To Qualitative Research* (4th Edition). SAGE Publications Ltd.
- Freimoser, F. M., Rueda-Mejía, M. P., Tilocca, B., & Migheli, Q. (2019). Biocontrol yeasts: Mechanisms and applications. *World Journal of Microbiology and Biotechnology*, 35(154). <https://doi.org/10.1007/s11274-019-2728-4>
- Frewer, L. J., Bergmann, K., Brennan, M., Lion, R., Meertens, R., Rowe, G., ... Vereijken, C. (2011). Consumer response to novel agri-food technologies: Implications for predicting consumer acceptance of emerging food technologies. *Trends in Food Science and Technology*, 22(8), 442–456. <https://doi.org/10.1016/j.tifs.2011.05.005>
- Galati, A., Schifani, G., Crescimanno, M., & Migliore, G. (2019). "Natural wine" consumers and interest in label information: An analysis of willingness to pay in a new Italian wine market segment. *Journal of Cleaner Production*, 227, 405–413. <https://doi.org/10.1016/j.jclepro.2019.04.219>
- Gaspar, P., Escibano, M., & Mesias, F. J. (2016). A qualitative approach to study social perceptions and public policies in dehesa agroforestry systems. *Land Use Policy*, 58, 427–436. <https://doi.org/10.1016/j.landusepol.2016.06.040>
- Gebhardt, B., Sperl, R., Carle, R., & Müller-Maatsch, J. (2020). Assessing the sustainability of natural and artificial food colorants. *Journal of Cleaner Production*, 260, 120884. <https://doi.org/10.1016/j.jclepro.2020.120884>
- Gil, J. M., Gracia, A., & Sánchez, M. (2000). Market segmentation and willingness to pay for organic products in Spain. *International Food and Agribusiness Management Review*, 3(2), 207–226. [https://doi.org/10.1016/s1096-7508\(01\)00040-4](https://doi.org/10.1016/s1096-7508(01)00040-4)
- Guerrero, L., Guardia, M. D., Xicola, J., Verbeke, W., Vanhoneracker, F., Zakowska-Biemans, S., ... Hersleth, M. (2009). Consumer-driven definition of traditional food products and innovation in traditional foods. *A qualitative cross-cultural study*. *Appetite*, 52(2), 345–354. <https://doi.org/10.1016/j.appet.2008.11.008>
- Hartman, H., Wadsworth, D. P., Penny, S., van Assema, P., & Page, R. (2013). Psychosocial determinants of fruit and vegetable consumption among students in a New Zealand university. *Results of focus group interviews*. *Appetite*, 65, 35–42. <https://doi.org/10.1016/j.appet.2013.02.005>
- Horrillo, A., Gaspar, P., Mesias, F., Elghannam, A., & Escibano, M. (2019). Understanding the barriers and exploring the possibilities of the organic livestock sector in dehesa agroforestry systems: A multi-actor approach for effective diagnosis. *Renewable Agriculture and Food Systems*, In press, 1–15. <https://doi.org/10.1017/S1742170519000334>
- Kitinaja, L., & Kader, A. A. (2015). Measuring postharvest losses of fresh fruits and vegetables in developing countries. In *PEF White Paper 15–02 (Issue February)*.
- Lavilla, M., & Gayán, E. (2018). In *Innovative Technologies for Food Preservation* (pp. 233–253). Elsevier. <https://doi.org/10.1016/B978-0-12-811031-7.00007-8>
- Leyva Salas, M., Mounier, J., Valence, F., Coton, M., Thierry, A., & Coton, E. (2017). Antifungal Microbial Agents for Food Biopreservation—A Review. *Microorganisms*, 5(3), 37. <https://doi.org/10.3390/microorganisms5030037>
- Loureiro, M. L., & Umberger, W. J. (2003). Estimating consumer willingness to pay for country-of-origin labeling. *Journal of Agricultural and Resource Economics*, 28(2), 287–301. <https://doi.org/10.2307/40987187>
- Ludwig-Ohm, S., Dirksmeyer, W., & Klockgether, K. (2019). Approaches to reduce food losses in German fruit and vegetable production. *Sustainability (Switzerland)*, 11(23), 6576. <https://doi.org/10.3390/su11236576>
- Malhotra, N. K., & Birks, D. F. (2006). *Marketing Research*. Pearson Education, Harlow: An Applied Approach.
- MAPA. (2020). *Spanish statistics for fruits and vegetables*. Spanish Ministry of Agriculture, Fisheries and Food. *Agricultural Products: Fruits and Vegetables*. <https://www.mapa.gob.es/es/agricultura/temas/producciones-agricolas/frutas-y-hortalizas/informacion-general.aspx>
- Marín, A., Atarés, L., & Chiralt, A. (2017). Improving function of biocontrol agents incorporated in antifungal fruit coatings: A review. *Biocontrol Science and Technology*, 27(10), 1220–1241.
- Martins, I. B. A., Oliveira, D., Rosenthal, A., Ares, G., & Deliza, R. (2019). Brazilian consumer's perception of food processing technologies: A case study with fruit juice. *Food Research International*, 125(June), Article 108555. <https://doi.org/10.1016/j.foodres.2019.108555>
- Miao, P., Chen, S., Li, J., & Xie, X. (2020). Decreasing consumers' risk perception of food additives by knowledge enhancement in China. *Food Quality and Preference*, 79 (August 2018), 103781. <https://doi.org/10.1016/j.foodqual.2019.103781>
- Migliore, G., Galati, A., Romeo, P., Crescimanno, M., & Schifani, G. (2015). Quality attributes of cactus pear fruit and their role in consumer choice: The case of Italian consumers. *British Food Journal*, 117(6), 1637–1651. <https://doi.org/10.1108/BFJ-04-2014-0147>
- Moor, U., Moor, A., Pöldma, P., & Heinmaa, L. (2014). Consumer preferences of apples in Estonia and changes in attitudes over five years. *Agricultural and Food Science*, 23(2), 135–145. <https://doi.org/10.23986/afsci.40936>
- Nunes, C., Usall, J., Teixidó, N., & Vias, I. (2001). Biological control of postharvest pear diseases using a bacterium, *Pantoea agglomerans* CPA-2. *International Journal of Food Microbiology*, 70(1–2), 53–61. [https://doi.org/10.1016/S0168-1605\(01\)00523-2](https://doi.org/10.1016/S0168-1605(01)00523-2)
- Onwuegbuzie, A. J., Dickinson, W. B., Leech, N. L., & Zoran, A. G. (2009). A Qualitative Framework for Collecting and Analyzing Data in Focus Group Research. *International Journal of Qualitative Methods*, 8(3), 1–21. <https://doi.org/10.1177/160940690900800301>
- Owen, K. M., Griffith, G. R., & Wright, V. E. (2002). One little Lebanese cucumber is not going to break the bank: Price in the choice of fresh fruits and vegetables. *Australian Journal of Agricultural and Resource Economics*, 46(2), 209–231. <https://doi.org/10.1111/ajar.2002.46.issue-210.1111/1467-8489.00026>
- Peterson, H. H., Bernard, J. C., Fox, J. A., & Peterson, J. M. (2013). Japanese consumers' valuation of rice and pork from domestic, U.S., and other origins. *Journal of Agricultural and Resource Economics*, 38(1), 93–106. <https://doi.org/10.22004/ag.econ.148248>
- Pollard, J., Kirk, S. F. L., & Cade, J. E. (2002). Factors affecting food choice in relation to fruit and vegetable intake: A review. *Nutrition Research Reviews*, 15(2), 373–387. <https://doi.org/10.1079/nrr200244>
- Ragaert, P., Verbeke, W., Devlieghere, F., & Debevere, J. (2004). Consumer perception and choice of minimally processed vegetables and packaged fruits. *Food Quality and Preference*, 15(3), 259–270. [https://doi.org/10.1016/S0950-3293\(03\)00066-1](https://doi.org/10.1016/S0950-3293(03)00066-1)
- Ruiz-Moyano, S., Martín, A., Villalobos, M. C., Calle, A., Serradilla, M. J., Córdoba, M. G., & Hernández, A. (2016). Yeasts isolated from figs (*Ficus carica* L.) as biocontrol agents of postharvest fruit diseases. *Food Microbiology*, 57, 45–53. <https://doi.org/10.1016/j.fm.2016.01.003>
- Ruiz-Moyano, S., Hernández, A., Galvan, A. I., Córdoba, M. G., Casquete, R., Serradilla, M. J., & Martín, A. (2020). Selection and application of antifungal VOCs-producing yeasts as biocontrol agents of grey mould in fruits. *Food Microbiology*, 92 (August, 2019). <https://doi.org/10.1016/j.fm.2020.103556>
- Santosa, M., Clow, E. J., Sturzenberger, N. D., & Guinard, J. X. (2013). Knowledge, beliefs, habits and attitudes of California consumers regarding extra virgin olive oil.

- Food Research International, 54(2), 2104–2111. <https://doi.org/10.1016/j.foodres.2013.07.051>
- Seo, K. W., Yang, Y. S., & Cho, B. S. (2008). The survey on food additives in frequently consumed food. *Journal of Food Hygiene and Safety*, 23, 142–148.
- Sharma, R. R., Singh, D., & Singh, R. (2009). Biological control of postharvest diseases of fruits and vegetables by microbial antagonists: A review. *Biological Control*, 50(3), 205–221.
- Shim, S. M., Seo, S. H., Lee, Y., Moon, G. I., Kim, M. S., & Park, J. H. (2011). Consumers' knowledge and safety perceptions of food additives: Evaluation on the effectiveness of transmitting information on preservatives. *Food Control*, 22(7), 1054–1060. <https://doi.org/10.1016/j.foodcont.2011.01.001>
- Siroli, L., Patrignani, F., Serrazanetti, D. I., Gardini, F., & Lanciotti, R. (2015). Innovative strategies based on the use of bio-control agents to improve the safety, shelf-life and quality of minimally processed fruits and vegetables. *Trends in Food Science & Technology*, 46(2), 302–310.
- Spadaro, D., & Droby, S. (2016). Development of biocontrol products for postharvest diseases of fruit: The importance of elucidating the mechanisms of action of yeast antagonists. *Trends in Food Science and Technology*, 47, 39–49. <https://doi.org/10.1016/j.tifs.2015.11.003>
- Spadaro, D., & Gullino, M. L. (2004). State of the art and future prospects of the biological control of postharvest fruit diseases. *International Journal of Food Microbiology*, 91(2), 185–194. [https://doi.org/10.1016/S0168-1605\(03\)00380-5](https://doi.org/10.1016/S0168-1605(03)00380-5)
- Stewart, B., Olson, D., Goody, C., Tinsley, A., Amos, R., Betts, N., ... Voichick, J. (1994). Converting focus group data on food choices into a quantitative instrument. *J. Nutrition Education*, 26(1), 34–36. [https://doi.org/10.1016/S0022-3182\(12\)80832-6](https://doi.org/10.1016/S0022-3182(12)80832-6)
- Stewart, D. W., & Shamasani, P. N. (2014). *Focus groups: Theory and practice*. SAGE Publications Inc.
- Sui, Y., Wisniewski, M., Droby, S., Liu, J., & Müller, V. (2015). Responses of yeast biocontrol agents to environmental stress. *Applied and Environmental Microbiology*, 81(9), 2968–2975.
- Ünüsün, N. (2004). Fruit and vegetable consumption among Turkish university students. *International Journal for Vitamin and Nutrition Research*, 74(5), 341–348.
- Usall, J., Teixidó, N., Torres, R., Ochoa de Eribe, X., & Vias, I. (2001). Pilot tests of *Candida sake* (CPA-1) applications to control postharvest blue mold on apple fruit. *Postharvest Biology and Technology*, 21(2), 147–156. [https://doi.org/10.1016/S0925-5214\(00\)00131-9](https://doi.org/10.1016/S0925-5214(00)00131-9)
- Usall, J., Torres, R., & Teixidó, N. (2016). Biological control of postharvest diseases on fruit: A suitable alternative? *Current Opinion in Food Science*, 11, 51–55. <https://doi.org/10.1016/j.cofs.2016.09.002>
- Vaca, S. I., & Mesías, F. J. (2014). Percepciones de los consumidores españoles hacia las frutas de Ecuador: Un estudio preliminar cualitativo con técnicas proyectivas. *ITEA Informacion Tecnica Economica Agraria*, 110(1), 89–101. <https://doi.org/10.12706/itea.2014.006>
- van Dijk, H., van Kleef, E., Owen, H., & Frewer, L. J. (2012). Consumer preferences regarding food-related risk-benefit messages. *British Food Journal*, 114(3), 387–400. <https://doi.org/10.1108/00070701211213483>
- Velema, E., Vyth, E. L., & Steenhuis, I. H. M. (2019). 'I've worked so hard, I deserve a snack in the worksite cafeteria': A focus group study. *Appetite*, 133(December), 297–304. <https://doi.org/10.1016/j.appet.2018.11.027>
- Wisniewski, M., Droby, S., Norelli, J., Liu, J., & Schena, L. (2016). Alternative management technologies for postharvest disease control: The journey from simplicity to complexity. *Postharvest Biology and Technology*, 122(November), 3–10. <https://doi.org/10.1016/j.postharvbio.2016.05.012>
- Zhang, H., Mahunu, G. K., Castoria, R., Apaliya, M. T., & Yang, Q. (2017). Augmentation of biocontrol agents with physical methods against postharvest diseases of fruits and vegetables. *Trends in Food Science & Technology*, 69, 36–45.
- Zhu, Y., Shen, M., Sims, C. A., Marshall, M. R., House, L. A., & Sarnoski, P. J. (2018). Consumer preference and willingness to pay for tomato juice. *International Food and Agribusiness Management Review*, 21(8), 1167–1183. <https://doi.org/10.22434/IFAMR2017.0117>