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Prioritization of olive breeding objectives in Spain: Analysis of a producers and researchers survey

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Abstract

Aim of study: : Trait prioritization of potential olive (*Olea europaea* L.) breeding objectives has been evaluated in this work from two surveys to researchers working on olive and olive producers / orchard managers.

Area of study: Olive growing area in Andalusia (South of Spain)

Material and methods: Twenty-five breeding objectives were associated to plant growth, fructification, oil content and composition, resistance to pest and disease and tolerance to soil and climatic conditions. Two assessment methods were applied (ranking and rating), showing similar results in both the researchers and producers surveys.

Main results: Higher productivity was the objective with the highest score, followed by Verticillium wilt resistance and higher oil content. After them, tolerance to water stress and resistance to *Xylella fastidiosa* were among the preferred objectives. Conversely, the least preferred objectives were late harvesting, high fruit size and tolerance to water lodging and calcareous soils. In the producers' survey, results have been consistent among the different types of orchards and farmers' characteristics. It is also interesting to notice that more than 50% of the producers expressed their willingness to orchard enlargement or renewal in the three coming years and 25% of them would change the olive cultivar. They would be willing to pay an average 43% overprice for new cultivar fulfilling their requirements and 75% would support the use of genetic modified olives.

Research highlights: These results should be considered to analyze the scope of current breeding programs and define the main criteria to be considered for future works aiming at developing new olive cultivars.

Additional key words: *Olea europaea*; productivity; Verticillium wilt; oil content; water stress; *Xylella fastidiosa.*

Introduction

Olive (*Olea europaea* L.) oil production has been continuously increasing in the last 30 years to reach over 3,000,000 t with a concomitant increasing in consumption (IOC, 2021). Spanish production, currently over 50% of world production, is responsible for most of this increasing production. The varietal structure of olive in Spain was traditionally characterized by the diversity and antiquity of the cultivars and their restricted distribution around its presumably area of origin. Thus, 262 different cultivars were identified in exploration survey of olive cultivars grown in Spain, 24 of which were considered as

major cultivars representing either a large portion of the acreage or predominating in one or more olive growing areas (Barranco & Rallo, 2000).

This situation remained stable until relevant changes in olive growing took part around 50 years ago. New growing techniques were developed to cope with the economic crisis faced by the olive sector at that times: increasing planting density, irrigation, new harvesting procedures, etc., thus leading to a "new olive growing" era (Fernández-Escobar *et al.*, 2012). These changes promoted the spreading of a limited number of cultivars, characterized by early bearing, high productivity and oil content and producing appreciated olive oils. New plantings were based on

those few cultivars that were replacing traditional cultivars in many areas. Thus, in the nineties, only three cultivars ('Picual', 'Arbequina' and 'Hojiblanca') represent more than 95% of plant production in nurseries in Andalusia (AGAPA, 2002).

A new revolutionary wave of change started by the end of the 20th century with new orchards characterized by increasing planting density, up to 2000 trees/ha (compared to 100 trees/ha in traditional orchards). Those high density hedgerow olive orchards were promoted mainly for the possibility of full harvest mechanization with additional advantages related to early bearing and quicker return of investments (Fernández-Escobar et al., 2012). However, most traditional olive cultivars, empirically selected by growers centuries ago, were not adapted to these new planting systems. Thus, only a few cultivars such as 'Arbequina' and 'Arbosana' have been mainly recommended for these hedgerow systems (De la Rosa et al., 2007). In fact, the limited number of cultivars available for high density planting is considered one of the main limitations of this system.

All these changes in olive growing underlined for the first time in the history of modern olive cultivation the need for new improved cultivars adapted to modern cultivation techniques. Olive breeding had received limited attention despite the historical importance of olive growing, particularly in the Mediterranean basin (Lavee, 2013). However, the demand of new cultivars adapted to new growing systems together with the development of methods to reduce the length of the juvenile period, one of the main limitations for olive breeding, promoted the development of olive breeding attempts. Classical olive breeding programs based in intraspecific cross-breeding between cultivars of known merit were initiated in many olive-producing countries (Bellini et al., 2008). As a result, several new cultivars have been released in recent years or are currently under registration (Community Plant Variety Office, https://cpvo.europa.eu/). However, only a few of them have been already marketed with relative success both in their countries of origin and abroad such as 'Barnea' (Lavee et al., 1986), 'Fs17' (Fontanazza et al., 1998) and 'Chiquitita'/'Sikitita' (Rallo et al., 2008).

This situation contrasts with other fruit trees, in which the use of new-bred cultivars is common in commercial orchards for a long time (Badenes & Byrne, 2011). It could be foreseeable that the lack of habit of cultivar renewal by olive growers could represent a hindrance for incorporating new cultivars in olive growing. It would be also interesting to know whether the current demands of growers are considered among the objectives of current olive breeding programs. In this sense, the development of studies to survey the relative importance of breeding objectives potentially interesting for growers could represent a useful tool to facilitate both the design of breeding works and later adoption of results by growers. Similarly, surveying the opinion of olive researchers not directly involved in breeding works could also represent a useful tool to broaden the perspectives to be considered in breeding. These studies have been reported regarding breeding objectives for other fruit tree species such as apple, peach, tart and sweet cherry (Yue et al., 2013; 2014a,b), but, to the best of our knowledge, are lacking in olive.

The objective of this work was to survey the importance given by both olive researchers and growers to several objectives that could be potentially considered in breeding programs, in order to analyze the scope of current breeding programs and define the main criteria to be considered for future works aiming at developing new olive cultivars.

Material and methods

To test the relative importance of 25 olive breeding objectives proposed, two surveys were set up, one oriented to researchers working on olive and other to olive growers and orchards managers. Most of these objectives have been cited in previous works from expert surveys and group discussion carried out in Spain in order to define priority R&D lines (Sanz-Cañada et al., 2011) or strategies to improve the competitiveness of olive growing (Parras-Rosa et al., 2021).

Thus, two samples were selected following a convenience sampling procedure (Malhotra & Birks, 1999), gathering the information via a self-administered questionnaire. For the first survey, researchers attending the National Meeting of the Olive Group of the Spanish Society of Horticultural Science, held in Madrid in 2019, were interviewed. For the second one, growers and orchard managers attending the training courses of the Andalusian Institute of Agricultural and Fisheries Research and Training were interviewed between September 2020 and January 2021. Sample size in the two surveys were 52 and 263, respectively.

The first part of the questionnaire was common for both surveys and consisted of the evaluation of the relative importance of the 25 different olive breeding objectives considered, following two assessment methods. The first one (rating) was to score each objective from 1 (least importance) to 7 (highest importance); and the second one (ranking), by choosing 5 out of the 25 breeding objectives and then ranking them according to their relevance. The second part of the questionnaire was only used in the second survey (growers and farm managers) and included information on the possible orchard renewal, grower's data and information on the characteristics of the orchards and management practices. A copy of the survey is available on request.

Spearman rank correlation was used to test differences in ranking among the different procedures. Intra class

correlation ICC (3.1) was also used to test differences in rating by a two-way mixed model, being the breeding objectives the random variable and the four evaluations the fixed variable (Koo & Li, 2016). In the growers' survey, comparison of means according to different categories of the main orchard characteristics and management practices was carried out for the preferred breeding objectives.

Results

Summary statistics for growers and orchards managers

In the growers and managers survey, conventional growing was the predominant production system among the interviewees (71.1%) compared to organic or integrated farming (Table 1). Most of them were located in the provinces of Córdoba and Jaén, which currently represents the main producing areas in Andalusia and, therefore, Spain and the world. In fact, forecast for 2020/21 harvest season indicates 987.000 t production of olive oil for Córdoba and Jaén provinces, which represents 73%, 62% and 33 % of the forecasted regional, national and world production respectively, for this season (CAGPDS, 2021; IOC, 2021). The interviewees were mostly males, with average 37 years old and 10 years of experience. Rainfed farms predominate among the respondents (44.7%) with an average area of 35 has, compared to irrigated farms (27.0%) with an average area of 72 ha. Overall, most of them (89%) belong to cooperatives. The average number of cultivars per orchard was only 1.5.

Joint analysis of the breeding objectives

Table 2 shows the relative importance of the different breeding objectives proposed by survey (researchers *vs* growers/managers) and the assessment methods (ranking and rating). A high level of correlation was found upon the objective importance obtained in both surveys and both assessment methods (Table 3), suggesting similar ordinal structure of preferences. Remarkable differences were obtained only for a few objectives such as higher prioritization for early bearing by researchers than growers and the opposite regarding resistance to some pest such as prays and fruit fly. Besides, by using the average value of the four evaluations to rank the 25 breeding objectives, the coefficient of intra class correlation ICC (3.k) was 0.9 ($p<0.0001$) with a confidence interval of 0.84-0.95. This is considered as an excellent level of accordance among the four measures (Cicchetti, 1994; Koo & Li, 2016).

Considering the average score based on the four measures for each of the 25 breeding objectives, higher productivity stood out as the breeding objective with highest score, followed by Verticillium wilt resistance and higher oil content (Table 2). After them, adaptation to water stress and resistance to *Xylella fastidiosa* were among the higher scored objectives. Intermediate scores were obtained for a group of traits including resistance to other diseases and pests, other plant traits, olive oil quality traits and early harvest. Finally, the less preferred objectives in both surveys were late harvesting, high fruit size and tolerance to water lodging and calcareous soils.

Analysis breeding objectives by orchard and grower/manager categorization

The second part of the survey to growers/managers allows to compare the results according to different categories of the main orchard characteristics and management practices. Results for the most valuated breeding objectives are presented in Table 4.

By province, significant differences were only found for adaptation to water stress, with higher average values in Jaén (and others) than in Córdoba. Significant differences among growing systems were obtained for resistance to *Verticillium* and high oil content, with conventional farming growers giving higher importance to these objectives than those of organic and integrated farming systems. No significant differences were obtained for the other breeding objectives included in the survey.

A final set of questions was included in the survey to growers/managers about their perspectives for improving their olive orchards in the short term. More than half of the growers (54.7%) expressed their willingness to orchard enlargement or renewal in the three coming years, being the percentage higher for irrigated (64.9%) than dry farming (43.5%) orchards. Among those considering orchard renewal, 25.5% of them express their willingness to change the cultivar currently under cultivation. Finally, the overprice that the growers were willing to pay for a new cultivar that fulfill their requirements was significant different (U de Mann-Whitney= 922. p= 0.054) between irrigated (91.5%) and dry farming (37.2 %) orchards.

Discussion

Assessing the degree of agreement of breeding objectives priorization between breeders and growers is a key element to orientate the public-sector breeding programs. The results of this study suggest a high correlation between them. Likewise, agreement between these two groups could be also inferred from surveys in apple and peach, although the different set of traits valued difficult the comparison (Gallardo *et al.*, 2012; Yue *et al.*, 2013, 2014b). In fact, breeders significantly valued the importance of producers on their decisions regarding prioritization of

Table 1. Main characteristics of the olive orchards and growers/managers included in the second survey.

Production system	Organic	10.5%
	Integrated pest management	18.4%
	Conventional	71.1%
Location (Province)	Jaén	43.0%
	Córdoba	46.0%
	Other	11.0%
Gender	Man	81.3%
	Woman	18.7%
Age (years, average)		37.7
Work experience (years, average)		10.9
Academic level	Primary school	15.5%
	Secondary school	39.8%
	University	44.7%
Professional grower?	Yes	53.1%
	No	46.9%
Belong to a cooperative?	Yes	89.0%
	No	11.0%
Belong to an Integrated Production Association?	Yes	15.1%
	No	84.9%
Belong to an irrigation community?	Yes	33.3%
	No	66.7%
Belong to a Protected Denomination of Origin?	Yes	18.7%
	No	81.3%
Relationship with the orchard	Owner	67.6%
	Lessee	18.9%
	Manager	13.5%
Type of orchard management	Dry farming	44.7%
	Irrigated	27.0%
	Dry farming/irrigated	28.4%
Data for dry farming orchards	Average surface	35.0 ha
	Average slope	10.0%
	Olive age (years, average)	68.5
	Number of cultivars	1.6
Data for irrigated orchards	Average surface	72.0 ha
	Average slope	9.1%
	Olive age (years, average)	49.9
	Number of cultivars	1.5

some of these traits (Gallardo *et al.*, 2012). A dedicated survey for breeders was not available in our work due to the limited extent of breeding activities in olive. Instead, we gathered results from researchers working in different fields, all of them related to olive growing.

Productivity and disease resistance were identified in this work as the most important objective in olive for both researchers and growers. Similarly, productivity was con-

sidered an important trait in producers' surveys in tart and sweet cherry (Yue *et al.*, 2014a) but not in apple or peaches (Yue *et al.*, 2013, 2014b). Besides, surveys to breeders in several Rosaceous crops showed that fruit texture, fruit flavor, postharvest quality, yield/season, and appearance were all considered of similar relative importance in apple, strawberry, peach, and red raspberry, with only slight differences among crops (Gallardo *et al.*, 2012).

Table 2. Score for the olive breeding objectives by group and survey method (common scale from 0 to 10)

		Researchers		Growers/managers		
		Ranking	Rating	Ranking	Rating	Average
Plant traits	Easiness of pruning	4.5	0.7	6.1	1.9	3.3
	Early bearing	7.4	3.4	5.2	1.2	4.3
	High productivity	10.0	10.0	9.6	10.0	9.9
	Low biennial bearing	8.3	3.3	7.8	3.7	5.8
	Efficient harvesting	7.6	2.3	9.1	3.0	5.5
Flowering/ fructification	High fruit set	5.3	0.8	6.7	1.7	3.6
	High fruit size	2.2	0.6	5.9	0.6	2.3
	High oil content	8.9	4.8	9.2	5.8	7.2
	Late harvesting	0.0	0.0	0.0	0.0	0.0
	Early harvesting	7.0	2.8	5.8	1.7	4.3
Oil	High stability	8.6	1.8	7.6	2.2	5.1
	Improved oil composition	7.5	2.1	6.1	0.4	4.0
	Organoleptic profile	8.8	1.9	8.4	2.4	5.4
Pests resistance	Fruit fly	7.2	0.6	9.0	3.9	5.2
	Prays	4.8	0.0	8.7	1.1	3.7
Resistance to diseases	Peacock eye	6.3	0.6	8.2	1.7	4.2
	Verticillium wilt	9.2	4.7	9.9	5.8	7.4
	Anthracnose	6.0	0.6	6.8	0.3	3.4
	Tuberculosis	5.7	0.6	7.6	0.4	3.6
	Xylella fastidiosa	8.5	3.9	10.0	3.7	6.5
Tolerance to abiotic stresses	Frost	6.5	0.8	6.2	1.7	3.8
	Water stress	8.6	5.4	8.4	4.5	6.7
	Water lodging	4.1	0.1	5.5	0.4	2.5
	High temperatures	6.4	1.2	7.9	1.8	4.3
	Calcareous soils	5.1	0.4	6.0	0.2	2.9

However, pairwise comparison produced different results by crop: *e.g.*, flavor was scored higher than yield in apple but the opposite in peach. On the contrary, disease and pest resistance and abiotic resistance were considered less important in all of them; these are quite different results than the one obtained here for olive. Apparently, fruit quality traits are more frequently prioritized in fruit fresh pro-

ducts compared to oil quality extracted from olive fruits. Besides, the high ranking obtained for Verticillium wilt resistance could be expected due the increasing importance over the last two decades of this disease in many areas, among them those provinces mainly surveyed in our work. High estimated crop losses in many areas has probably facilitated higher awareness for this disease

Table 3. Spearman Rank correlation for 25 breeding objectives for the two surveys and assessment methods

	Researchers/ Rating	Researchers/ Ranking	Growers/ Rating	Growers/ Ranking
Researchers/Rating	**1**			
Researchers/Ranking	0.865**	1		
Growers/Rating	0.685**	0.488**	1	
Growers/Ranking	0.796**	0.759**	0.791**	1

** significant at *p*<0.01.

Table 4. Average scores of the grower/manager survey of the most valuated breeding objective by province and growing system (rating scale 1 to 7)

Breeding objective	Province	Average	F	*p*-value	Growing system	Average	F	*p*-value
High productivity	Jáen	6.07	1.728	0.180	Organic	6.19	2.465	0.088
	Córdoba	6.23			Integrated	5.89		
	Other	6.45			Conventional	6.37		
Resistance to *Verticillium*	Jáen	6.32	1.277	0.281	Organic	5.86	4.152	0.018
	Córdoba	6.17			Integrated	6.32		
	Other	6.44			Conventional	6.52		
High oil content	Jáen	6.05	0.363	0.696	Organic	5.69	9.818	0.000
	Córdoba	6.06			Integrated	5.61		
	Other	6.24			Conventional	6.38		
Adaptation to water stress	Jáen	5.99	4.531	0.012	Organic	6.07	.993	0.373
	Córdoba	5.63			Integrated	5.89		
	Other	6.23			Conventional	6.17		
Resistance to *Xylella fastidiosa*	Jáen	6.39	2.203	0.113	Organic	6.14	0.765	0.467
	Córdoba	6.29			Integrated	6.50		
	Other	5.89			Conventional	6.49		

among different stakeholders, from growers to nursery companies and the olive-oil industry (López-Escudero & Mercado-Blanco, 2011).

It should be noted that, unexpectedly, traits related to early harvest, usually highly valued both from the agronomic and commercial point of view, seems not to be particularly valued in our work. Early harvest is recommended to lower alternate bearing tendency in olive and allows diminishing the potential risks associated to pest, disease and climatic events (Gracia *et al.*, 2012; Rojnic *et al.*, 2015). Concomitantly, early harvest is associated to higher oil quality both from the compositional and sensorial point of view (Alowaiesh *et al.*, 2018). This could represent market advantages and, therefore, higher returns to growers.

The relatively low importance placed for oil quality components (sensorial traits, oxidative stability, chemical composition) strongly contrast with previous works on other fruit tree species. Thus, fruit flavor and other fruit traits such as crispness, firmness, etc. were scored among the most important trait compared with disease resistance and other fruit or plant traits for apple, cherry and peach producers (Yue *et al.*, 2013, 2014a,b). These results from other fruit tree species seem to be highly in agreement with results from consumer studies, *i.e.* growers production in these crops is highly oriented to market demands, which, unfortunately, seems not to be the situation in the olive oil sector. Probably, the differential price obtained by growers according to different quality grades in these crops favors a higher consideration for these quality traits by growers. Conversely, the olive oil market suffers from the consumers' product differentiation failure (Salazar *et al.*, 2018), strongly reducing the demand

for higher quality olive oils (extra virgin olive oil compared to refined olive oil) when price gap exceeds only 1 euro/liter (Salazar *et al.*, 2021). Thus, the actual differential price in consumers' choices is usually lower and translates into even shorter differential price in origin received by growers, which altogether does not promote the searching for high quality.

Contrarily to our results, important differences in trait prioritization according to grower and orchard characteristics have been previously reported in other fruit breeding programs. Thus, significant location effect has been previously observed that could be associated to climate differences or differences on market dynamics (fresh *vs* processed), volume, destination, etc. (Yue *et al.*, 2013; 2014ab). These differences were probably less important between the two main provinces surveyed in our work (Córdoba *vs* Jaén), which could explain the limited location effect found in our work. Years of experience has also been mentioned as an important variable for trait prioritization suggesting different levels of knowledge for growing techniques such as for instance diseases and treatment options (Yue *et al.*, 2013).

Growers were willing to pay for a new cultivar that fulfill their requirements, although a differential overprice was obtained according to the type of orchard management (dry farming *vs* irrigated). However, specific willingness to pay surveys including attribute levels for choice experiment should be further designed for gaining deeper knowledge on this subject (Zhao *et al.*, 2017).

With respect to the growers and orchards managers opinion on transgenic (GMO) olive, interestingly, its

potential use was approved by a majority (74.5%) of interviewees. It should be noted that transgenic olives are not currently available in the market. Moreover, research lines in this topic in olive are scarce, mainly due to restrictions to GMO at the European Union, even though potentially interesting applications for increasing fungal resistance have been reported in olive (Narvaez *et al.*, 2018).

From a methodological point of view, both assessment methods (rating and ranking) have proven to be comparable (Sayadi *et al.*, 2005; Moors *et al.*, 2016). However, both question formats were applied in the same questionnaire (first rating then ranking a subset of objectives), which may increase the degree of agreement (Moore, 1975; de Chiusole & Stefanutti, 2011).

In summary, the two surveys (to researchers and growers/managers) and two methodologies (ranking and rating) carried out in this study allowed us to assess the importance of 25 breeding objectives. Productivity, resistance to diseases (mainly Verticillium wilt and *Xylella fastidiosa*) and adaptation to water stress were identified as the most important objectives. Quite similar results were obtained according to different categories of the main orchard characteristics and management practices. Limited importance was awarded to several traits usually considered as high priorities from different socioeconomic, commercial, environmental and political levels; such as for instance those related to olive oil quality or climate change. It should be considered whether a higher effort on knowledge transfer will provide higher conscientiousness by growers on these topics. These results should be considered to analyze the scope of current breeding programs and define the main criteria to be considered for future works aiming at developing new olive cultivars.

Acknowledgements

References

AGAPA, 2002. El olivar andaluz. Consejería de Agricultura y Pesca, Junta de Andalucía, Sevilla. 134 pp.

Alowaiesh B, Singh Z, Fang Z, Kailis SG, 2018. Harvest time impacts the fatty acid compositions, phenolic compounds and sensory attributes of Frantoio and Manzanilla olive oil. Sci Hortic 234: 74-80. https://doi.org/10.1016/j.scienta.2018.02.017

Badenes ML, Byrne DH, 2011. Fruit breeding. Springer Sci Bus Media, NY. 875 pp. https://doi.org/10.1007/978-1-4419-0763-9

Barranco D, Rallo L, 2000. Olive cultivars in Spain. Horttechnology 10: 107-110. https://doi.org/10.21273/HORTTECH.10.1.107

Bellini E, Giordani E, Rosati A, 2008. Genetic improvement of olive from clonal selection to cross-breeding programs. Adv Hortic Sci 22:73-86.

CAGPDS, 2021. Aforo de producción del olivar de almazara en Andalucía campaña 2020-2021. Consejería de Agricultura, Ganadería, Pesca y Desarrollo Sostenible. Junta de Andalucía.

Cicchetti DV, 1994. Guidelines, criteria, and rules of thumb for evaluating normed and standardized assessment instruments in psychology. Psychol Assess 6: 284-290. https://doi.org/10.1037/1040-3590.6.4.284

De Chiusole D, Stefanutti l, 2011. Rating, ranking, or both? A joint application of two probabilistic models for the measurement of values. Test Psycho Method Appl Psychol 18 (1): 49-60.

De la Rosa R, León L, Guerrero N, Rallo L, Barranco D, 2007. Preliminary results of an olive cultivar trial at high density. Aust J Agr Res 58: 392-395. https://doi.org/10.1071/AR06265

Fernández Escobar R, De la Rosa R, Leon L, Gomez JA, Testi F, Orgaz M, *et al.*, 2012. Evolution and sustainability of the olive production systems. Int Semin: Present and Future of the Mediterranean Olive Sector, Zaragoza (Spain), Nov 26-28.

Fontanazza G, Bartolozzi F, Vergari G, 1998. Fs-17. Riv Frutticoltura 5: 61.

Gallardo RK, Nguyen D, McCracken V, Yue C, Luby J, McFerson J, 2012. An investigation of trait prioritization in rosaceous fruit breeding programs. HortScience 47(6): 771-776. https://doi.org/10.21273/HORTSCI.47.6.771

Gracia P, Sánchez-Gimeno AC, Benito M, Oria R, Lasa JM, 2012. Short communication. Harvest time in hedgerow 'Arbequina' olive orchards in areas with early frosts. Span J Agric Res 10: 179-182. https://doi.org/10.5424/sjar/2012101-141-11

IOC, 2021. World olive oil and table olive figures. International Olive Council. https://www.internationaloliveoil.org/what-we-do/economic-affairs-promotion-unit/#figures

Koo TK, Li MY, 2016. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. J Chiropr Med 15: 155-163. https://doi.org/10.1016/j.jcm.2016.02.012

Lavee S, 2013. Evaluation of the need and present potential of olive breeding indicating the nature of the available genetic resources involved. Sci Hortic 161: 333-339 https://doi.org/10.1016/j.scienta.2013.07.002

Lavee S, Haskal A, Wodner M, 1986. 'Barnea' a new olive cultivar from first breeding generation. Olea 17: 95-99.

López-Escudero FJ, Mercado-Blanco J, 2011. Verticillium wilt of olive: a case study to implement an integrated strategy to control a soil-borne pathogen. Plant Soil 344: 1-50. https://doi.org/10.1007/s11104-010-0629-2

Malhotra NK, Birks DF, 1999. Marketing research. Prentice Hall, London.

Moore M, 1975. Rating versus ranking in the Rokeach Valey Survey: an israeli comparison. Eur J Soc Psychol 5 (3): 405-408. https://doi.org/10.1002/ejsp.2420050313

Moors G, Vriens I, Gelissen JPTM, Vermunt JK, 2016. Two of a kind. Similarities between ranking and rating data in measuring values. Surv Res Method 10 (1): 15-33.

Narvaez I, Khayreddine T, Pliego C, Cerezo S, Jimenez-Diaz RM, Trapero-Casas JL, et al., 2018. Usage of the heterologous expression of the antimicrobial gene afp from Aspergillus giganteus for increasing fungal resistance in olive. Front Plant Sci 9: 680. https://doi.org/10.3389/fpls.2018.00680

Parras-Rosa M, Torres-Ruiz FJ, Gómez-Limón JA, Ruz-Carmona A, Vega-Zamora M, Parra-López C, et al., 2021. Estrategias para una oleicultura jiennense más competitiva. Diputación Provincial de Jaén, Instituto de Estudios Giennenses, Jaén.

Rallo L, Barranco D, De la Rosa R, León L, 2008. 'Chiquitita' olive. HortScience 43: 529-531. https://doi.org/10.21273/HORTSCI.43.2.529

Rojnic ID, Bazok R, Barcic JI, 2015. Reduction of olive fruit fly damage by early harvesting and impact on oil quality parameters. Eur J Lipid Sci Tech 117: 103-111. https://doi.org/10.1002/ejlt.201400150

Salazar-Ordoñez M, Rodríguez-Entrena M, Cabrera ER, Henseler J, 2018. Understanding product differentiation failures: the role of product knowledge and brand credence in olive oil markets. Food Qual Prefer 68: 146-155. https://doi.org/10.1016/j.foodqual.2018.02.010

Salazar-Ordoñez M, Rodríguez-Entrena M, Arriaza M, 2021. How do consumers respond to price gaps in private brands agrifood products? Brit Food J. Forthcoming DOI: 10.1108/BFJ-12-2020-1155 https://doi.org/10.1108/BFJ-12-2020-1155

Sanz-Cañada J, Hervás-Fernández I, Sánchez-Escobar F, Coq-Huelva D, 2011. Programa Nacional de Redes del Plan Nacional de I+D+i: Alenta. Plataforma Tecnológica del Olivar. CSIC, Madrid.

Sayadi S, González-Roa MC, Calatrava-Requena J, 2005. Ranking versus scale rating in conjoint analysis: Evaluating landscapes in mountainous regions in southeastern Spain. Ecol Econ 55: 539-550. https://doi.org/10.1016/j.ecolecon.2004.12.010

Stemler SE, Tsai J, 2008. Best practices in interrater reliability. Three common approaches. In: Best practices in quantitative methods; Osborne JW (ed). pp: 29-49. Sage, London. https://doi.org/10.4135/9781412995627.d5

Yue C, Gallardo RK, Luby J, Rihn A, McFerson JR, McCracken V, et al., 2013. An investigation of U.S. apple producers' trait prioritization-evidence from audience surveys. HortScience 48: 1378-1384. https://doi.org/10.21273/HORTSCI.48.11.1378

Yue C, Gallardo RK, Luby J, Rihn A, McFerson JR, McCracken V, et al., 2014a. An evaluation of U.S. tart and sweet cherry producers trait prioritization: evidence from audience surveys. HortScience 49: 931-937. https://doi.org/10.21273/HORTSCI.49.7.931

Yue C, Gallardo RK, Luby J, Rihn A, McFerson JR, McCracken V, et al., 2014b. An evaluation of U.S. peach producers' trait prioritization: evidence from audience surveys. HortScience 49: 1309-1314. https://doi.org/10.21273/HORTSCI.49.10.1309

Zhao S, Yue C, Luby J, Gallardo K, McCracken V, McFerson J, Layne DR, 2017. U.S. Peach producer preference and willingness to pay for fruit attributes. HortScience 52:116-121. https://doi.org/10.21273/HORTSCI10966-16