Quality and Consumer Acceptance on HydroSOStainable Vegetable Products

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HydroS.O.Stainable

5th EURO-GLOBAL SUMMIT AND EXPO ON FOOD & BEVERAGES
ALICANTE, JUNE 16-18

- Introduction:
  - Deficit Irrigation.
  - Crops.
- Table Olives.
- Pistachios.
- Marketing Strategies.
- Conclusions.

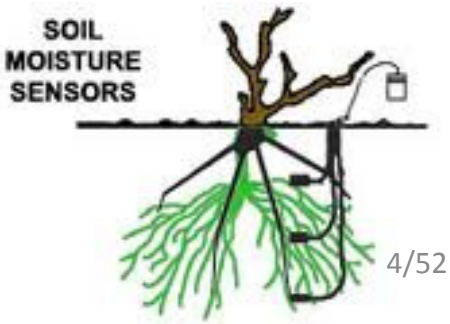
Introduction

- **Drought** periods have affected 17% of European territory causing losses of about **100 billion €** in the last 30 years.

- Specially **Mediterranean agrosystems** must cope with severe water scarcity, and develop sustainable use of water.

- **Plant** materials should be characterized as being:
  - less water demanding, and
  - more water stress-resistant.

- Besides, **DEFICIT IRRIGATION** can help allowing:
  - significant water savings,
  - minimum impact on yield, and
  - profitable production of high-quality fruits.

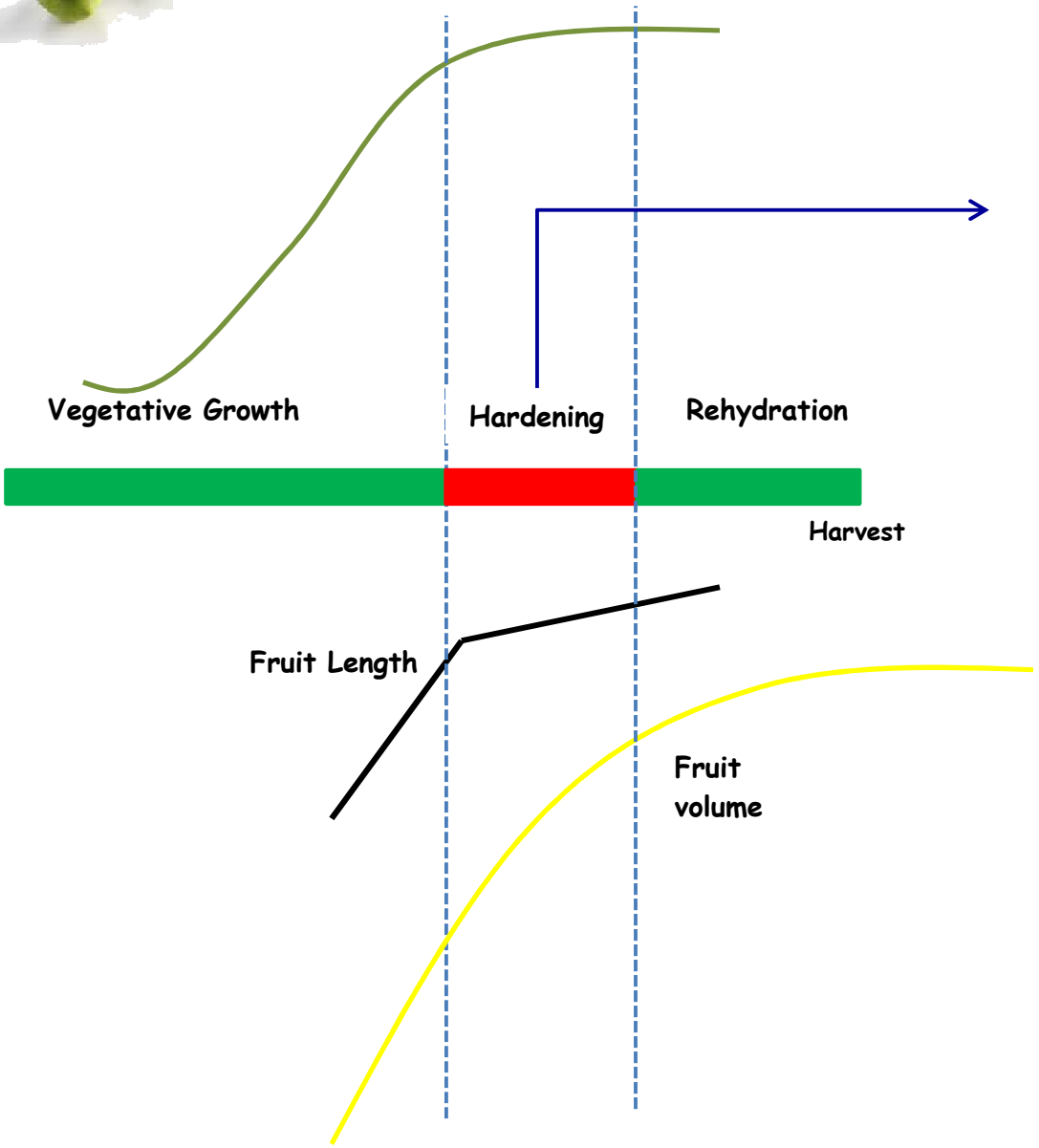


- **Controlled Deficit Irrigation (CDI)** uses application of water deficit conditions in **non-critical periods** of the crop to minimally affect crop production and perhaps even improving quality (sensory and functionality).

- Control could be made based on:
  - percentage of **evapotranspiration** of the crop, or
  - measurements made on the plant or even the fruit (water potential of stem or fruit, Ψ_{stem}, Ψ_{fruit}).

- The last option is more interesting and more effective in saving water and generating high-quality fruit.

Table Olives



Reduction of the volume of the irrigation water

Irrigation Treatments

Table 1
Irrigation and tree parameters [applied water (AW, mm), yield (t ha^{-1}), and trunk growth rate (TGR, µm day^{-1})] of '*Manzanilla*' olive trees as affected by regulated deficit irrigation treatments.

Irrigation parameter	Stage			Total	Pooled std. deviation
	I	II	III		
ETc (mm)	248 a[a]	186 b	92 c	526	47
Irrigation treatment					
Parameter/Stage	T0	T1	T2	Pooled std. deviation	
AW (mm)					
Stage 1	229 a	128 b	111 b	17	
Stage 2	214 a	6 b	5 b	15	
Stage 3	97 a	37 b	45 b	21	
TGR (µm day^{-1})					
Stage 1	−2.10 a	−2.60 a	−6.30 a	4.4	
Stage 2	3.34 a	−14.80 b	−20.70 b	6.1	
Stage 3	6.07 b	31.52 a	28.21 a	14.8	
Yield (t ha^{-1})	6.6 a	5.0 a	5.9 a	2.4	

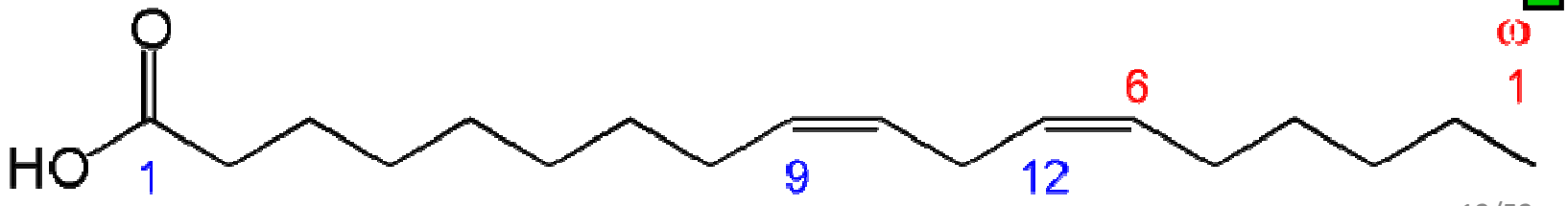
Weight, Size & Color

Treatment	Weight (g)	Diameter (cm) Longitudinal	Diameter (cm) Equatorial	Color *L**	Color *a**	Color *b**	Color *C**	Color Hue
ANOVA	***	***	***	***	NS	***	***	NS
Control	4.43 b	**2.3 a**	1.9 b	51.51 b	-1.94	28.61 b	28.68 b	93.87
T1	**4.60 a**	2.1 b	**2.1 a**	53.62 b	-1.82	31.87 b	31.92 b	93.28
T2	4.30 b	2.0 b	1.7 c	**56.14 a**	-1.87	**38.39 a**	**38.44 a**	92.82

- A slight reduction in the irrigation water (**T1**) increased the **weight** of the olives.
- This weight increase was mainly due to an increase in the **equatorial diameter**.
- The less water, the **yellowness** was intensified while the greenness was constant.

	Fatty Acid	Common Name	Control	T1	T2
1	9-Hexadecenoic acid		2.8	1.9	2.5
2	Hexadecanoic acid	Palmitic acid	17.3	17.7	18.7
3	9,12-Octadecadienoic acid	Linoleic acid	5.2	**7.3**	5.8
4	9-Octadecenoic acid	Oleic acid	68.4	68.5	68.1
5	9,12,15-Octadecatrienoic acid	Linolenic acid	**5.2**	3.9	3.9
6	Octadecanoic acid	Stearic acid	1.0	0.6	1.1
		ΣSFAs	18.3	18.3	**19.8**
		ΣMUFAs	**71.3**	70.4	70.6
		ΣPUFAs	10.4	**11.3**	9.7
		MUFAs / SFAs	**3.89**	**3.85**	**3.57**
		PUFAs / SFAs	0.57	0.61	0.49
		PUFAs+MUFAs / SFAs	4.45	4.46	4.05

Linoleic acid, C18:2



Volatile Compounds

	Compound	Control	T1 Area (%)	T2	
1	Ethanol	4.04	3.70	7.14	
2	Dimethylsulfide	3.50	7.35	9.17	→
3	Acetic acid	9.59	11.70	15.90	→
4	Heptane	4.30	7.63	5.06	
5	Propionic acid	0.28	0.46	0.60	→
6	Ethyl propanoate	0.11	0.19	0.17	
7	Propyl acetate	0.09	0.34	0.14	
8	Octane	3.25	4.63	5.73	→
9	2-Methylbutanoic acid	0.32	0.43	0.40	
10	Furfural	0.85	0.70	0.15	←
11	*cis* -3-Hexenol	5.99	2.33	4.76	
12	1-Hexanol	0.82	0.83	0.52	
13	*cis* -2-Heptenal	0.24	0.13	0.25	
14	Hexanoic acid	0.95	0.68	0.91	
15	Benzaldehyde	7.71	0.57	0.48	←
16	6-Methyl-5-hepten-2-one	0.18	0.29	0.41	→
17	β-Pinene	0.10	0.13	0.25	→
18	Octanal	0.43	0.39	0.31	
19	Hexyl acetate	0.27	0.23	0.33	
20	*p* -Cymene	0.14	0.19	0.10	

	Compound	Control	T1 Area (%)	T2	
21	Limonene	3.94	2.45	3.50	
22	*trans* -β-Ocimene	0.28	0.05	0.09	
23	Phenylacetaldehyde	0.30	0.46	0.36	
24	1-Octanol	2.64	0.67	1.73	
25	γ-Terpinene	0.46	1.86	0.34	
26	Guaiacol=2-Methoxy-phenol	2.53	1.71	0.47	←
27	Undecane	0.62	1.05	0.06	
28	Linalool	0.23	0.19	0.50	
29	Nonanal	1.62	1.77	1.71	
30	4,8-Dimethyl-1,3,7-Nonatriene	3.97	6.35	5.97	→
31	Phenethyl alcohol	1.75	0.82	2.33	
32	4-Ethylphenol	1.09	0.63	0.28	←
33	Ethyl octanoate	0.66	1.17	0.72	
34	1,4-Dimethoxy-benzene	7.97	6.25	8.07	
35	Tetrahydrogeraniol	8.58	13.72	6.61	
36	α-Citronellol	0.82	0.51	0.57	
37	Bornylene	0.41	0.20	0.55	
38	2-Decenal	9.97	11.76	6.20	
39	5-Hydroxymethylfurfural	0.72	0.99	1.13	
40	2-Decenal	0.54	1.58	0.48	
41	Tridecane	1.49	0.12	4.91	
42	Anethole	6.25	2.83	0.69	←

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16	6-Methyl-5-hepten-2-one	0.18	0.29	0.41	→
17	β-Pinene	0.10	0.13	0.25	→
18	Octanal	0.43	0.39	0.31	
19	Hexyl acetate	0.27	0.23	0.33	
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27	Undecane	0.62	1.05	0.06	
28	Linalool	0.23	0.19	0.50	
29	Nonanal	1.62	1.77	1.71	
30	4,8-Dimethyl-1,3,7-Nonatriene	3.97	6.35	5.97	→
31	Phenethyl alcohol	1.75	0.82	2.33	
32	4-Ethylphenol	1.09	0.63	0.28	←
33	Ethyl octanoate	0.66	1.17	0.72	
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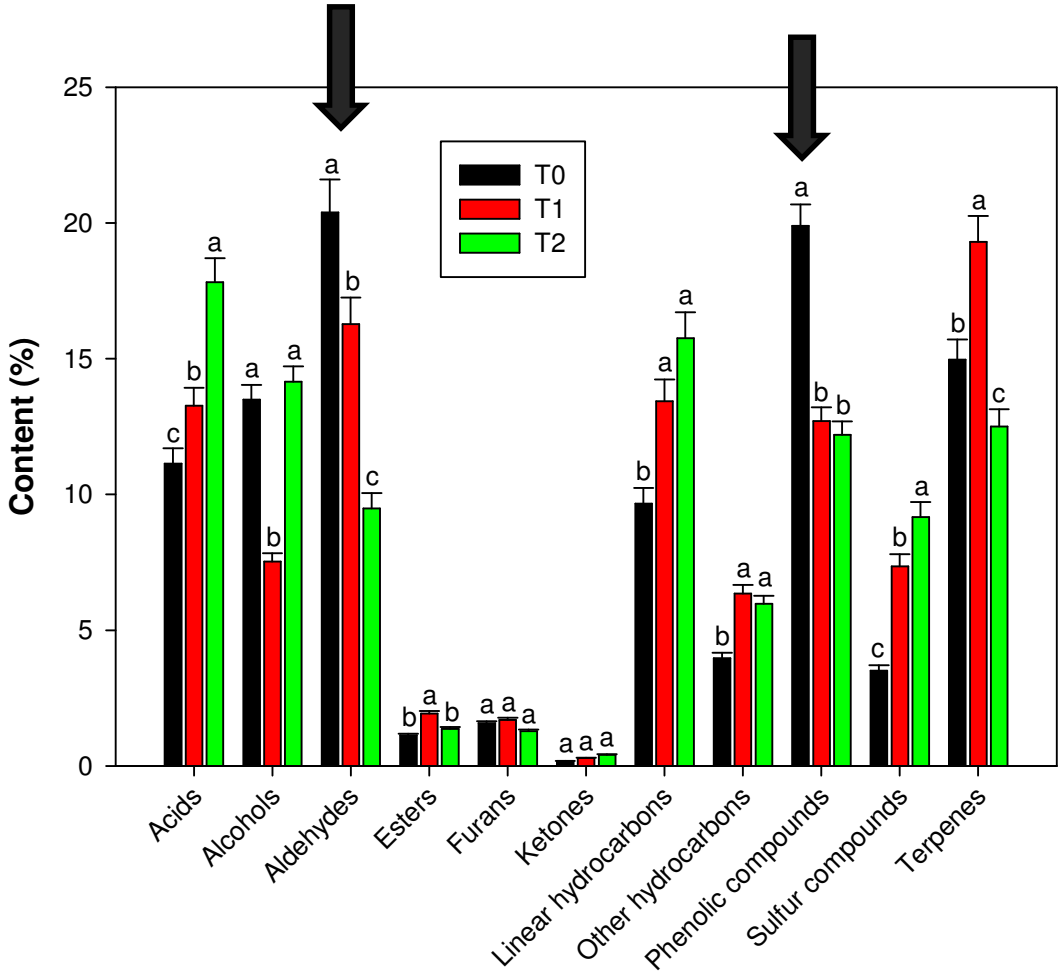
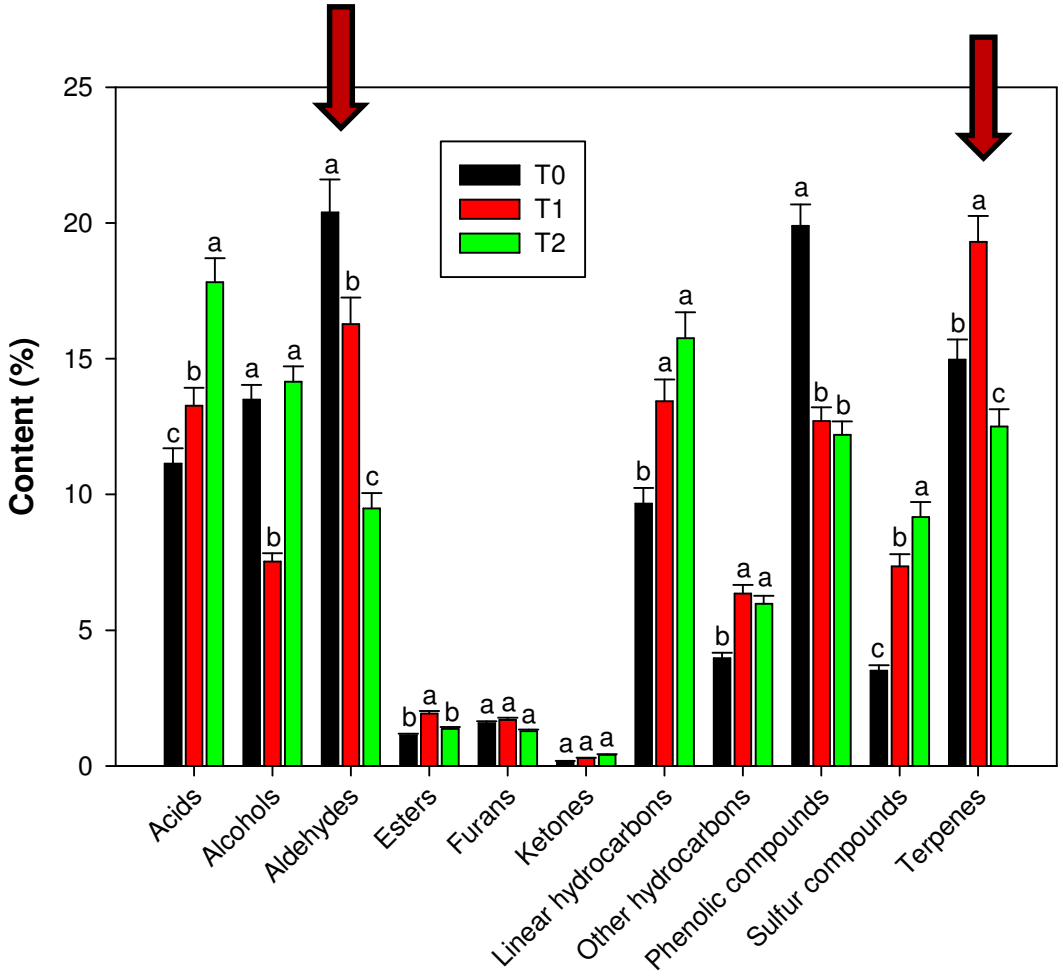
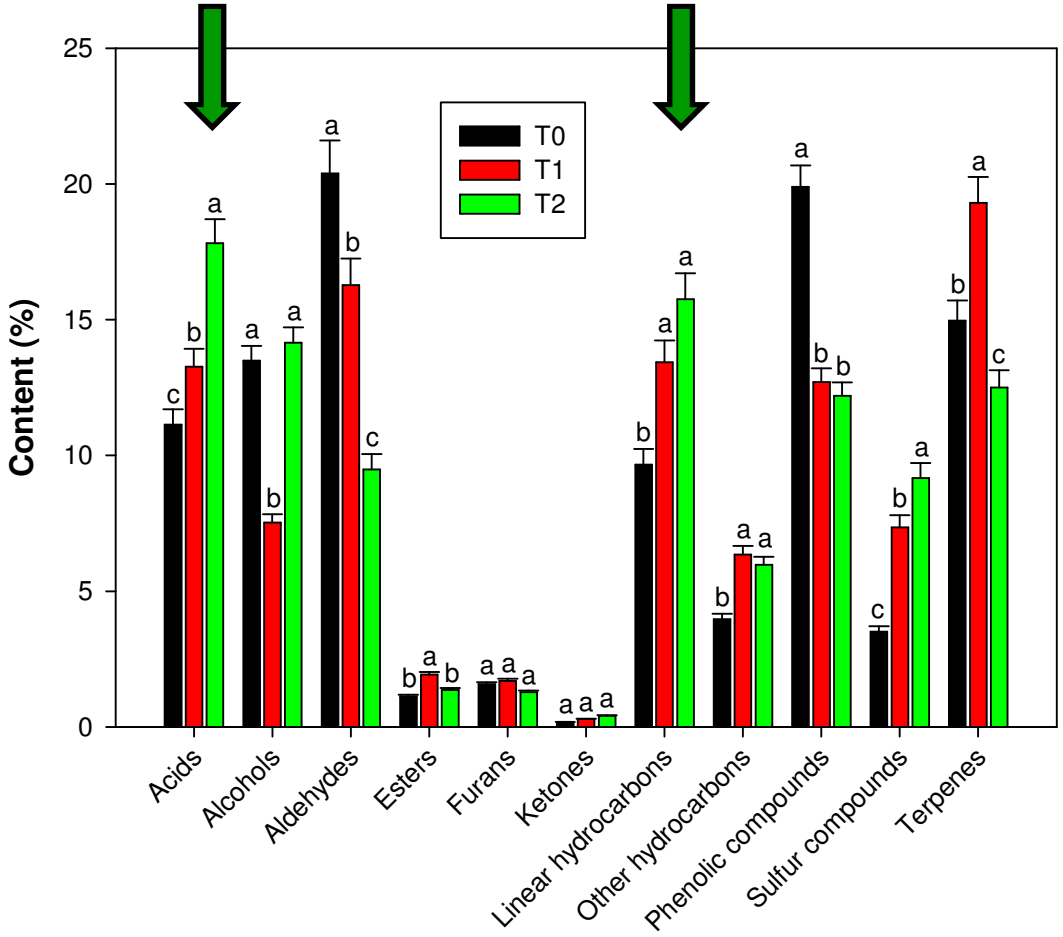
Volatile Compounds



Volatile Compounds



Volatile Compounds



PUNCTURE test

Treatment	Force (N)		Statistics
Control	**0.506**	*0.024*	b
T1	**0.651**	*0.034*	a
T2	**0.473**	*0.021*	b
			***
			(Tukey)

- This test is related to the **hardness** of the olive **skin/peel**.
- A slight reduction in the irrigation water resulted in a significant **increase of the skin hardness**.

MAGNESS-TAYLOR test

Treatment	Force (N)		Statistics
Control	**6.533**	*0.348*	a
T1	**5.401**	*0.253*	b
T2	**5.135**	*0.314*	b
			**
			(Tukey)

- This test is related to the **hardness** of the olive **pulp**.
- A reduction in the irrigation water resulted in significant **decrease of the pulp hardness**.

Sample	FLAVOR					
	Salty	Bitter	Sour	Sweet	Green-Olive	Aftertaste
ANOVA	*	**	NS	**	**	***
T0	5.8 ab	4.8 b	1.6	1.9 b	6.8 a	6.5 b
T1	**6.9 a**	**6.8 a**	2.3	1.9 b	**7.1 a**	**7.9 a**
T2	5.5 b	4.4 b	2.7	**2.9 a**	5.7 b	6.1 b

- **T1** samples had the most intense **salty, bitter, green olive notes and aftertaste**.

Sample	TEXTURE			
	Hardness	Crunchiness	Fibrousness	Separation pulp-stone
ANOVA	**	NS	NS	*
T0	6.3 b	6.5	0	**7.9 a**
T1	**7.8 a**	6.0	0.1	6.9 b
T2	6.0 b	5.4	0.1	6.9 b

- **T1** samples were the hardest, agreeing with results from the puncture test, while the control samples had easy to remove stones.

Satisfaction degree

Sample	Color	Flavor	Bitter	Salty	Hardness	Crunchiness	Aftertaste
ANOVA	NS	*	NS	NS	NS	*	NS
T0	6.1	**6.3 ab**	6.1	6.0	6.5	**6.2 ab**	6.5
T1	6.7	**6.9 a**	**6.7**	**6.7**	**6.8**	**6.9 a**	6.3
T2	6.2	**5.8 b**	5.9	6.1	6.3	**6.0 b**	5.8

- Consumers were, in general, very satisfied by the attributes of the **T1** samples. This satisfaction for specific attributes was reflected in the highest **GLOBAL satisfaction degree**:

  - T0 = 6.5 ab
  - **T1 = 6.9 a**
  - T2 = 6.0 b

Like it extremely
Like it very much
Like it moderately
Like it slightly
Neither like it nor dislike it
Dislike it slightly
Dislike it moderately
Dislike it very much
Dislike it extremely

T1 table olive:

- Fruits: had highest weight,
- had intermediate yellow color,
- had the highest content of linoleic acid,
- highest skin hardness and intermediate pulp firmness,
- descriptive sensory: had the highest intensities of saltiness, bitterness, green olive note and aftertaste, and hardness, and
- consumers: had the highest satisfaction degree of flavor, bitterness, saltiness, hardness, crunchiness and global satisfaction degree.

LWT - Food Science and Technology 62 (2015) 19–26

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Quality attributes of table olives as affected by regulated deficit irrigation

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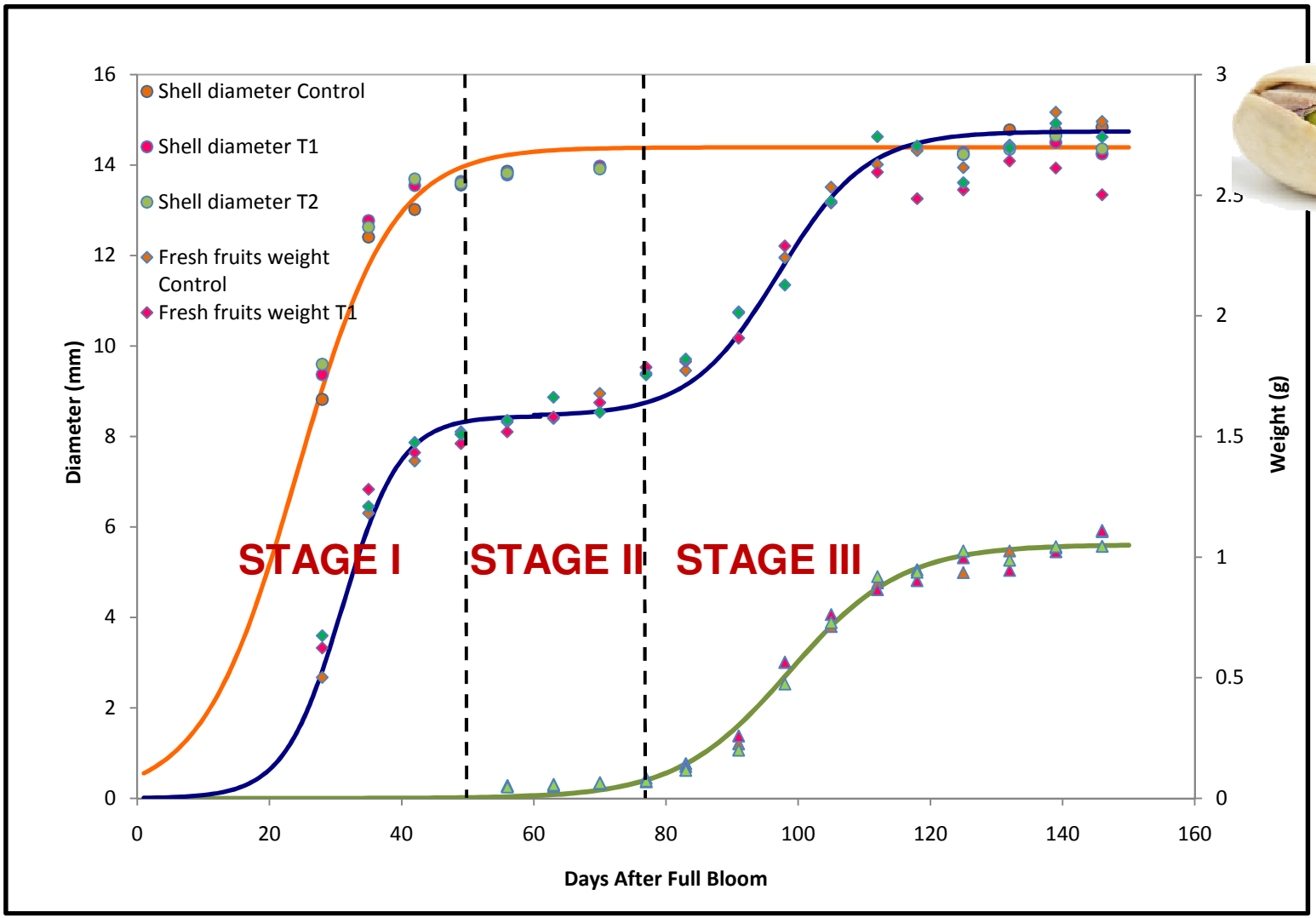
Pistachios

Farm “El chaparrillo”, Ciudad Real (Spain): ***Pistachia vera*** trees.

Two factors:

- **Irrigation treatment** (T0, T1, & T2).
- **Rootstock** (*P. Atlantica*, *P. Integerrima, & P. Terebinthus*).



	T0	T1	T2
Stage I	42.68	8.85	8.16
Stage II	**176.12**	**87.26**	**33.13**
Stage III	270.29	291.02	295.15

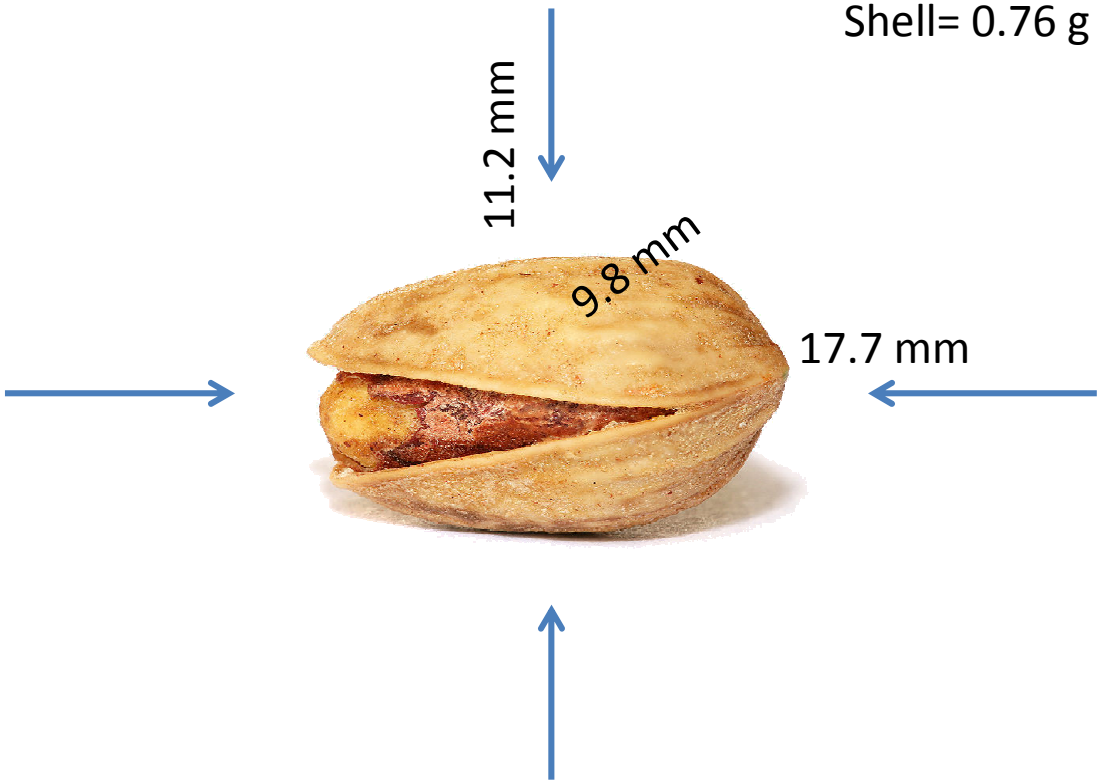
Irrigation water (mm) per stage and treatment

Yield

	Production (kg/tree) 2012	2013
T0	**48.9**	10.5
T1	35.6	12.2
T2	35.8	**13.3**
Terebinthus	38.1	8.8
Atlantica	**42.0**	**17.0**
Integerrima	40.1	10.2

Weight

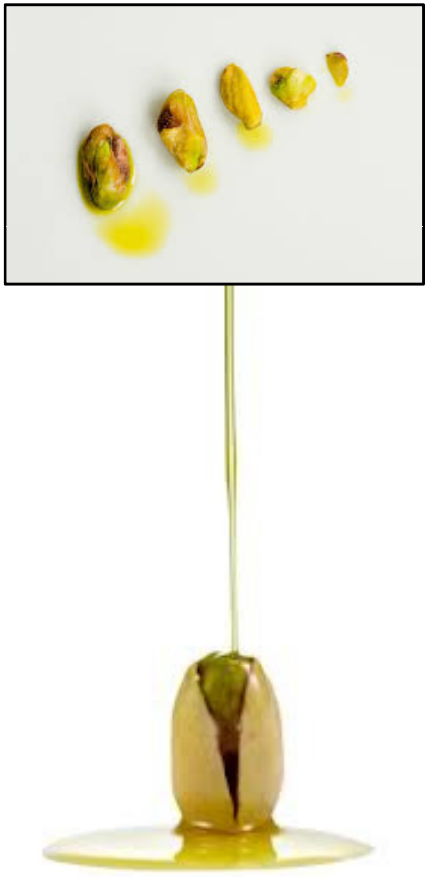
Whole pistachio= 1.52 g
Edible portion= 0.76 g
Shell= 0.76 g



The only significant effect was: Shell weight of Integerrima was smaller, 0.74 g compared to 0.78 g

Oil Yield

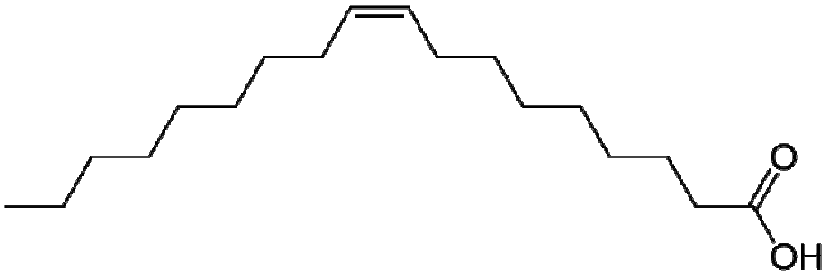
Oil Yield (%)	
T0	40.62
T1	**42.13**
T2	38.34
Atlantica	36.98
Integerrima	**42.73**
Terebinthus	41.37



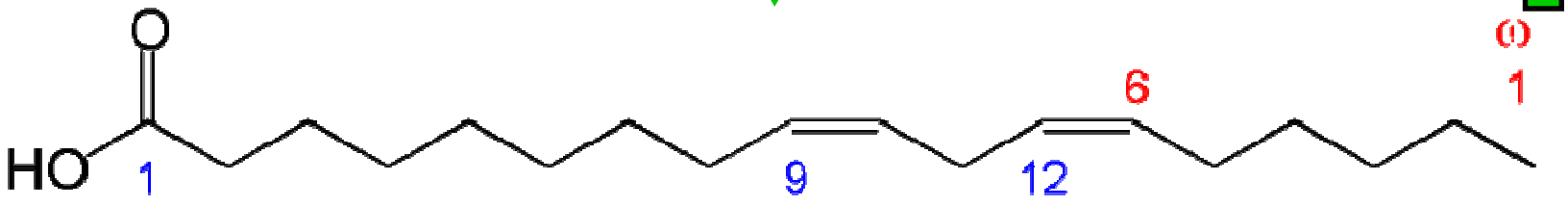
Fatty Acids

	Fatty Acid	Common Name	Atlantica		
			T0	T1	T2
1	Tetradecanoic acid	Myristic acid	0.15	0.10	0.12
2	9-Hexadecenoic acid isomer		0.08	0.07	0.08
3	9-Hexadecenoic acid		1.83	1.47	1.55
4	9-Hexadecenoic acid isomer		0.03	0.02	0.03
5	Hexadecanoic acid	Palmitic acid	14.1	13.5	13.3
6	**9,12-Octadecadienoic acid**	**Linoleic acid**	**30.3**	**32.8**	**33.3**
7	**9-Octadecenoic acid**	**Oleic acid**	**50.1**	**48.7**	**47.7**
8	9-Octadecenoic acid isomer	Oleic acid isomer	1.76	1.65	2.31
9	Octadecanoic acid	Stearic acid	1.20	1.22	1.23
10	Eicosenoic acid		0.29	0.32	0.36
11	Eicosanoic acid, Arachidic acid	Arachidonic acid	0.13	0.13	0.13
		ΣSFAs	**15.5**	**15.0**	**14.7**
		ΣMUFAs	**54.1**	**52.2**	**52.0**
		ΣPUFAs	**30.3**	**32.8**	**33.3**
		MUFAs / SFAs	3.49	3.49	3.53
		PUFAs / SFAs	**1.95**	**2.20**	**2.26**
		PUFAs+MUFAs / SFAs	**5.44**	**5.69**	**5.79**

Oleic acid, C18:1



Linoleic acid, C18:2



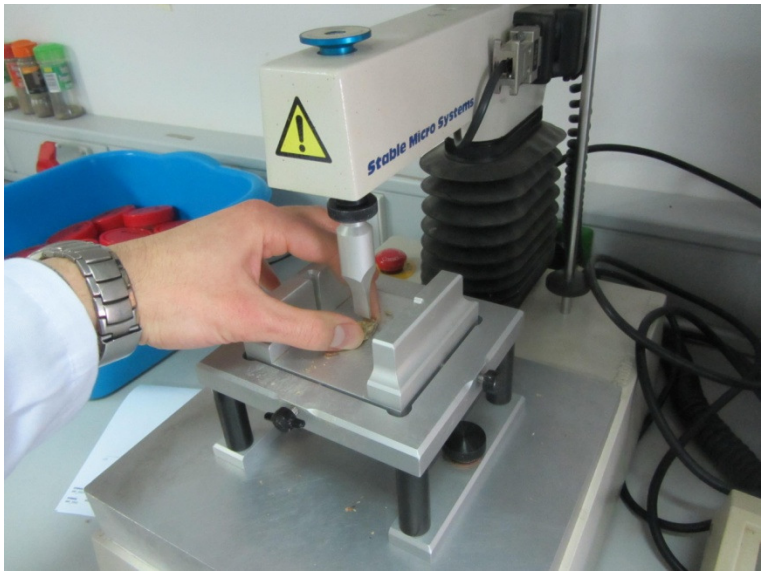
Color

	L*	a*	b*	C*	h
T0	60.77	-3.17	26.68	26.87	96.77
T1	61.77	-3.44	27.66	27.87	97.08
T2	60.48	-3.28	27.45	27.66	96.78
Atlantica	61.25	-2.96	27.11	27.27	96.22
Integerrima	61.30	-3.67	27.61	27.85	97.57
Terebinthus	60.46	-3.26	27.08	27.28	96.85

T1 fruits had slightly higher green and yellow intensities than the other pistachios.

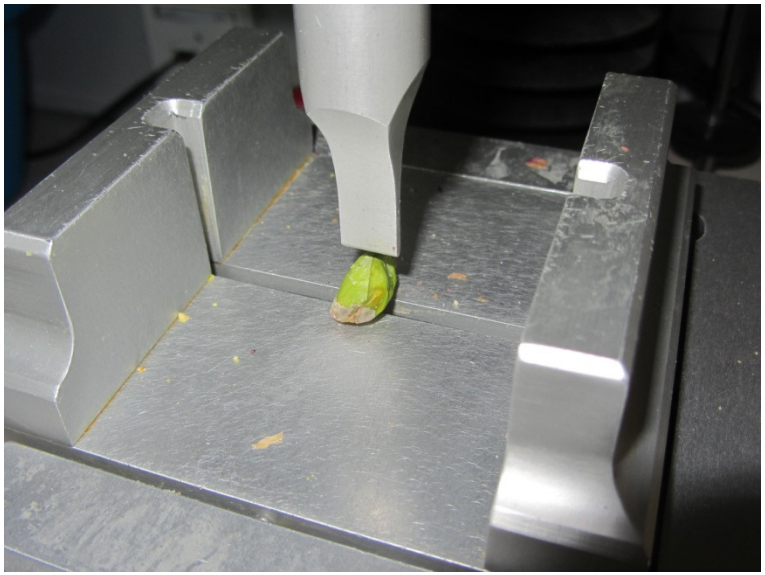
Texture

	Force (N)
Atlantica	52.44
Integerrima	**54.44**
Terebinthus	50.72
T0	50.67
T1	51.12
T2	**53.56**



However, …

Rootstock	Treatment	Force (N)
Atlantica	T0	51.87
	T1	49.30
	T2	**56.16**
Integerrima	T0	53.10
	T1	**56.36**
	T2	53.86
Terebinthus	T0	47.03
	T1	**54.45**
	T2	50.67



Countries participating:

- France (60 consumers).
- Poland (60 consumers).
- Slovak Republic (60 consumers).

Affective tests:

- Satisfaction degree.
- Ranking test.
- Preference tests.

Ranking test

Please, try again the three pistachio samples and rank your preference order (from lowest to highest)

- T0 b
- **T1 a**
- T2 b

Satisfaction degree

- T0 = 7.3
- **T1 = 7.5**
- T2 = 7.2

Like it extremely
Like it very much
Like it moderately
Like it slightly
Neither like it nor dislike it
Dislike it slightly
Dislike it moderately
Dislike it very much
Dislike it extremely

PREFERENCE test

- T0 = 29 %
- **T1 = 56 %**
- T2 = 15 %

*Differences were more significant in **Atlantica** and **Integerrima** than in Terebinthus*

Without significant effect

Water Activity	
Atlantica	0.610
Integerrima	0.602
Terebinthus	0.603
T0	0.601
T1	0.608
T2	0.607

	K (mg/kg)
Atlantica	10501
Integerrima	9887
Terebinthus	10094
T0	10062
T1	10175
T2	10244

Other parameters studied:

- Minerals contents.
- Volatile composition.
- Descriptive sensory profiles.
- Consumer study in Spain.

SUMMARY

T1 pistachios:

- Trees: had intermediate production.

- Fruits: had equivalent size and weight to those of control fruits,
- had the highest oil content,
- had intermediate contents of linoleic and oleic acids,
- had the most intense yellow and green coordinates,
- had high hardness, which is linked with high crunchiness, and
- were the preferred ones by international consumers.

Research Article

SCI

Received: 22 September 2014 Revised: 13 November 2014 Accepted article published: 27 November 2014 Published online in Wiley Online Library:

(wileyonlinelibrary.com) DOI 10.1002/jsfa.7027

Quality attributes of pistachio nuts as affected by rootstock and deficit irrigation

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J Sci Food Agric (2014)

Marketing Strategies

CONCEPTS

- **Farming**:
  - Product of Spain.
  - Sustainable.
  - Eco-friendly.
- **Health**:
  - With the energy of nuts.
  - Cholesterol-free.
  - Rich in minerals.
  - Rich in antioxidants.
  - Healthy fatty acids profile.
- **Sensory Attributes**:
  - Crunchy texture.
  - Toasted and salty combination.
  - Fun-to-eat.

Stand Out in the Crowd

Hidro S.O.S tenibles

Hydro S.O.S tainable

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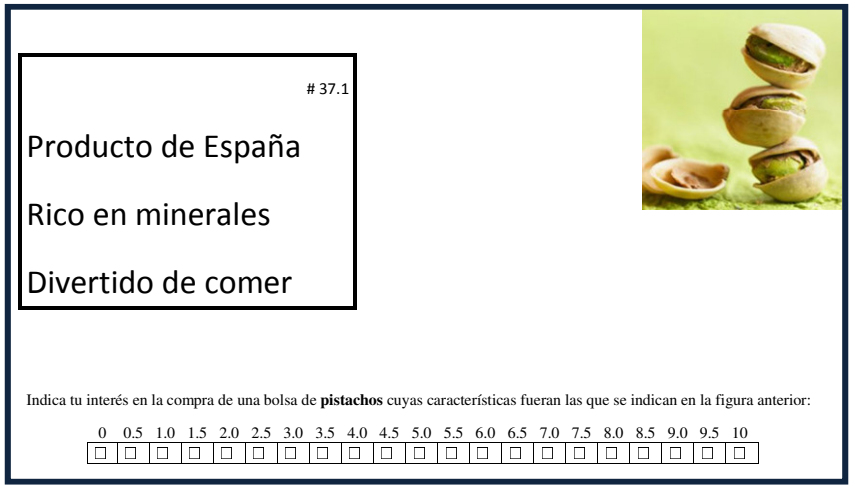

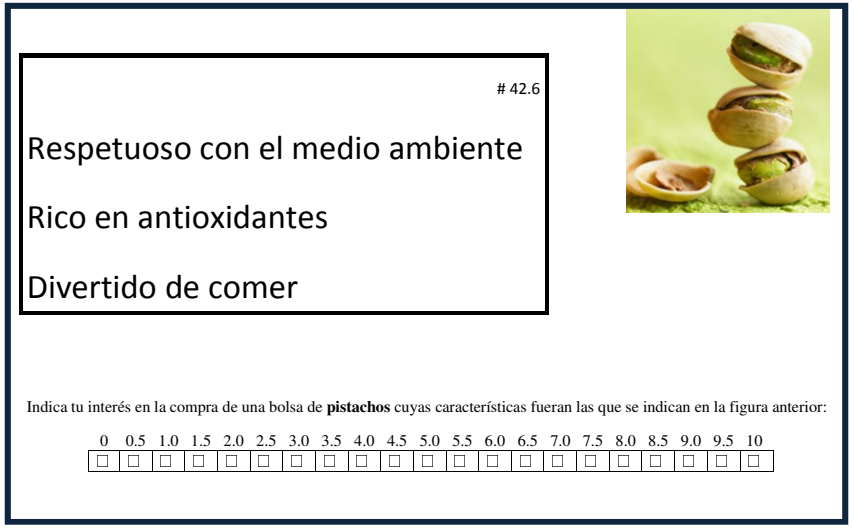

- 90 consumers were used in this study.
- Each consumer received 15 combinations.
- Each combination was evaluated 30 times.

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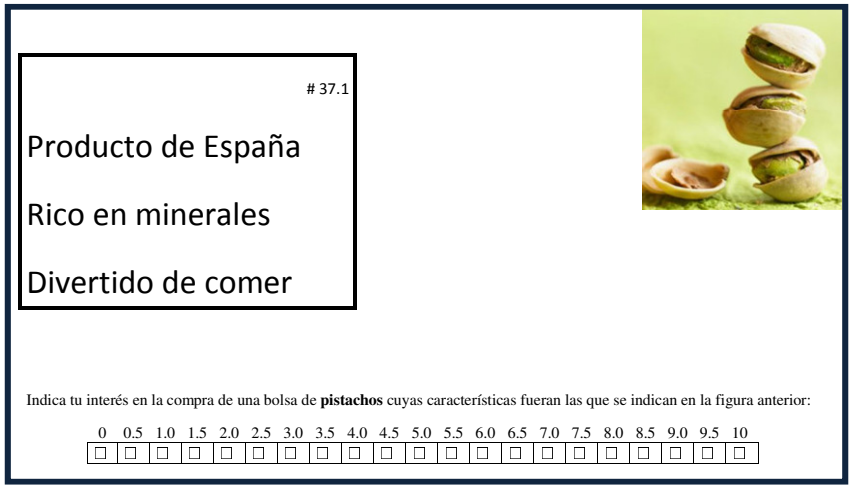

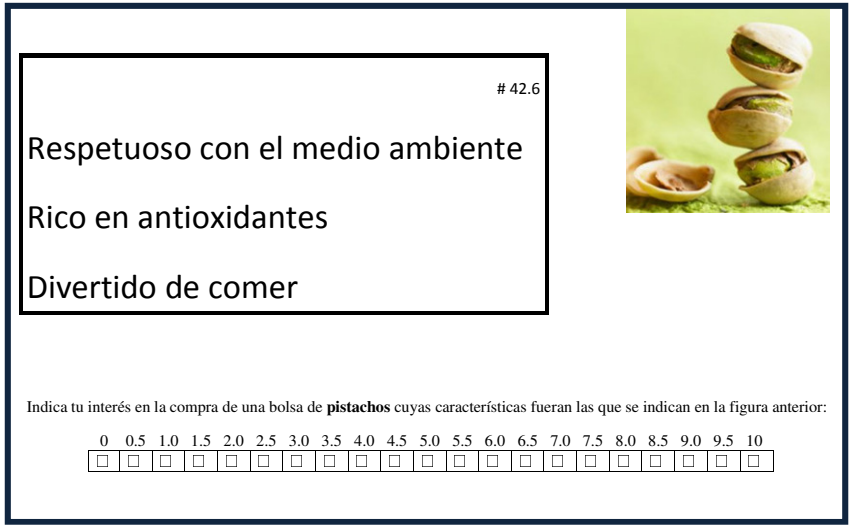

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37.1

Producto de España

Rico en minerales

Divertido de comer

Indica tu interés en la compra de una bolsa de **pistachos** cuyas características fueran las que se indican en la figura anterior:

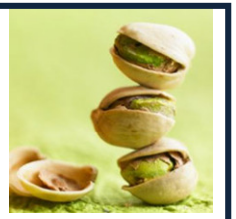
0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0 9.5 10

42.6

Respetuoso con el medio ambiente

Rico en antioxidantes

Divertido de comer



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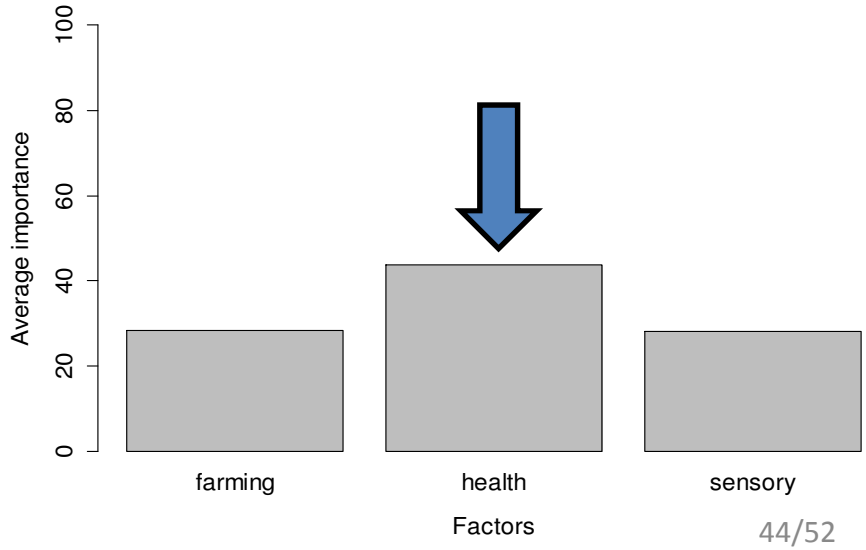
5 Best combinations

Farming	Health	Sensory	Mean
Product of Spain	Rich in antioxidants	Crunchy texture	7.85
Sustainable	With the energy of nuts	Crunchy texture	7.73
Product of Spain	Healthy acids profile	Crunchy texture	7.67
Product of Spain	Healthy acids profile	Toasted and salt combination	7.65
Sustainable	Rich in antioxidants	Toasted and salt combination	7.57



Regions of Spain participating :

- Galicia: northern Spain (n= 50).
- Valencia: eastern Spain (n=50).

Affective tests:

- Satisfaction degree.
- JAR questions.
- Purchase intention.

HydroS.O.Stainable

Satisfaction degree

Region	Product	SATISFACTION
Galicia	Hydrosustainable	6.2
	Conventional	**6.5**
Valencia	**Hydrosustainable**	**7.1**
	Conventional	6.9
Spain	**Hydrosustainable**	**6.9**
	Conventional	6.7

Different trend because of different water availability.

Like it extremely
Like it very much
Like it moderately
Like it slightly
Neither like it nor dislike it
Dislike it slightly
Dislike it moderately
Dislike it very much
Dislike it extremely

Purchase intention

Region	Product	Price (€)	
Galicia	**Hydrosustainable**	**1.72**	
	Conventional	1.64	← **0.08 €**
Valencia	**Hydrosustainable**	**1.67**	
	Conventional	1.55	← **0.12 €**
Spain	**Hydrosustainable**	**1.69**	
	Conventional	1.59	← **0.10 €**

Willing to pay a mean of 0.10 € more per a bag of 125 g of hydrosustainable pistachios.

This is equivalent to 0.80 € more per 1 kg of hydrosustainable pistachios.

Additional benefit of 0.80 €/kg

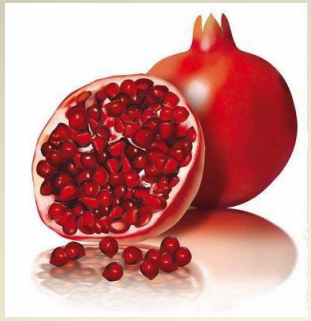
Conclusions

- **It is possible to safe water using deficit irrigation strategies.**
- **Soft water stress, at specific phenological stages, reduces the yield of fruits in a minor way but significantly benefits the quality and acceptance by consumers.**
- **Consumers are willing to pay more money for hydroSOStainable products, if they are clearly labeled.**

ACKNOWLEDGMENTS

Ángel Gil Izquierdo
Arturo Torrecillas Melendreras
Federico Ferreres
Alejandro Galindo Egea
Jacinta Collado González

CSIC
Consejo Superior de Investigaciones Científicas



David Pérez López
M. Carmen Gijón López
Houssem Memmi
José F. Couceiro López

Universidad Politécnica Madrid

Alfonso Moriana Elvira
Félix Moreno Lucas
Mireia Corell González
Ignacio F. Girón Moreno

Universidad de Sevilla

ACKNOWLEDGMENTS

Universidad Miguel Hernández

Marina Cano Lamadrid
Luis Noguera Artiaga
Nallely Nuncio-Jáuregui
Dr. Ángel Calín-Sánchez
Dr. Laura Vázquez-Araújo
Dr. Paqui Hernández
Dr. María José Frutos-Fernández
Dr. Francisco Burló-Carbonell
Prof. Ángel A. Carbonell-Barrachina

Department of Agro-Food Technology
Department of Vegetal Production and Microbiology

Merci beaucoup

Thank You

お疲れ様

Danke

Gracias

Grazie

Dank u

谢谢你

Thanks

Obrigado