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Varietal Change Dominates Adoption of Technology in Spanish Citrus Production

Maria Dolores de-Miguel [1,*], Pedro Caballero [2] and Maria Angeles Fernández-Zamudio [3]

[1] Departamento de Economía de la Empresa, Escuela Técnica Superior de Ingeniería Agronómica, Universidad Politécnica de Cartagena, Paseo Alfonso XIII, 48, 30203 Cartagena, Spain
[2] Departamento de Economía Agraria (Researcher until 2010), IVIA (Instituto Valenciano de Investigaciones Agrarias), Carretera CV 315 Km 10, 7, 46113 Moncada, Spain; pedrocaballerovillar@gmail.com
[3] CDAS (Centro para el Desarrollo de la Agricultura Sostenible), IVIA (Instituto Valenciano de Investigaciones Agrarias), Carretera CV 315 Km 10, 7, 46113 Moncada, Spain; fernandez_marzam@gva.es
* Correspondence: md.miguel@upct.es; Tel.: +34-968-325-784

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Abstract: After describing the technology adopted and its influence on production and yield, the importance of varietal change, which is essential to meet demand, is underscored. The choice of a variety by growers depends on the expected price it will fetch along with the commercial and crop characteristics and the quality. Survival of a variety in the marketplace depends on the performance as expected and on the existence of other more competitive varieties. First, in Spanish citrus farming, the navel group predominate, with 41.10% of orange production, in which the main varieties are "Navelina" and "Lanelate." The group of late white oranges is also important. The mandarin orange group includes clementines and mandarin hybrids; lemons also feature prominently. In sweet oranges, the navel group and late white group has often been renewed with varieties from the same group. In very early clementines varieties, the survival of which is usually short, the supply of new varieties is excessive. Because of its commercial characteristics and harvesting time, the group with the highest expansion possibilities are the mandarin hybrids which are in demand by hypermarkets. In the introduction of varieties, in recent years we have seen varietal clubs being established, with area control of each variety and very strict rules on cultivation and marketing.

Keywords: varietal groups; historical evolution; commercial condition; varietal obsolescence; categories of adopters; varietal clubs

1. Introduction

Any economic activity, because of its development and growth, requires permanent updating aimed at modifying its structures and the adoption of the technology required to maintain its competitiveness and efficiency [1].

A sector will bear the consequences of the way institutions evolve. It should be understood that an agricultural system is much more complex than the sum of its individual farms. The Spanish citrus sector constitutes an agricultural system [2] with monoculture in extensive areas, deeply rooted in the natural environment and also economically and socially.

Updating and modernization in citrus production, which has a very rigid property structure, is hindered by the resistance to change inherent to farming systems. To think of citrus production with a majority of full-time farmers, in family farms with sufficient size, is more than utopian; it is a situation that has disappeared or has been reduced to a minimal proportion [3]. Despite the limitations derived from the property's structure, with a predominance of smallholdings [4], there have been major changes, with the adoption of technology, through which competitiveness has been maintained,

the importance of which is particularly evident from 1960 onward, and which have had a significant impact on the production and quality [5]. Table 1 shows the current distribution by destination of productions by species.

Table 1. Situation of citrus production and its destinations (2017/2018 season).

Destinations	Oranges		Mandarins		Lemons		Grapefruit	
	Tn(ª)	% (*)	Tn(ª)	% (*)	Tn(ª)	% (*)	Tn(ª)	% (*)
Production	3,357,163		1,967,018		923,192		78,752	
Export	1,207,515	35.97	1,139,259	57.92	502,687	54.45	53,702	68.19
Domestic trade	1,430,381	42.61	616,273	31.33	250,333	27.12	15,087	19.16
Industry	636,263	18.95	161,36	8.20	140,44	15.21	5,567	7.07
Withdrawals plus faulty produce	83,004	2.47	50,126	2.55	29,732	3.22	4,396	5.58

Source: MAPA [6] and Ailimpo [7]. (*) Destinations by percentage of each species' production. (ª) Tones.

The figures in Table 2 on the production and surface area of the different citrus species indicate that all the time intervals analyzed are highly significant and in some cases spectacular, the consequence, on the one hand, of introducing new varieties that are more widely accepted by the market and also of an increase in the planted surface area and yield (Figure 1), on which growing techniques have a decisive influence.

The evolution of exports (Figure 2) has determined the growth and competitiveness of Spanish citrus production [8]. Between 1996 and 2017, exports accounted, with regard to Spanish citrus production in each species, for an average 41.10% in oranges, 63.65% in mandarins, 55.46% in lemons, and 67.11% in limes and grapefruit [6]. The quantities and proportions of fresh exported citrus fruit put Spain in first place worldwide among the exporting countries.

Table 2. Progression of Spanish citrus production and area.

		Orange	Mandarins	Lemons	Grapefruit and Other Citrus Fruits	Total
1945	S (Ha)	73,317	7165	3761		84,243
	P (Tn)	844,705	65,415	49,581		959,701
1960	S (Ha)	101,177	12,937	10,102	245	124,461
	P (Tn)	1,704,229	133,914	120,723	4252	1,963,118
1996	S (Ha)	134,485	97,072	42,644	1470	275,671
	P (Tn)	2,213,513	1,503,772	713,200	25,126	4,455,611
2000	S (Ha)	135,891	108,316	45,213	2361	291,781
	P (Tn)	2,616,198	1,801,926	915,009	22,965	5,356,098
2017	S (Ha)	142,171	109,127	41,099	2934	295,331
	P (Tn)	3,357,163	1,967,018	923,192	83,253	6,330,626
1945–1960 period	Annual Δ of P (%)	6.78	6.98	9.57		6.97
	Annual Δ of S (%)	2.53	5.37	11.24		3.18
1960–1996 period	Annual Δ of P (%)	0.83	28.41	13.63	13.64	3.53
	Annual Δ of S (%)	0.91	18.07	8.95	13.89	3.37
1996–2000 period	Annual Δ of P (%)	4.55	4.96	7.07	−2.15	5.05
	Annual Δ of S (%)	0.26	2.90	1.51	15.15	1.46
2000–2017 period	Annual Δ of P (%)	1.67	0.54	0.05	15.44	1.07
	Annual Δ of S (%)	0.27	0.04	−0.54	1.43	0.07

Source: MAPA [6]. Where P = production in tones, S = surface area in hectares, Δ = annual increase in the analyzed period.

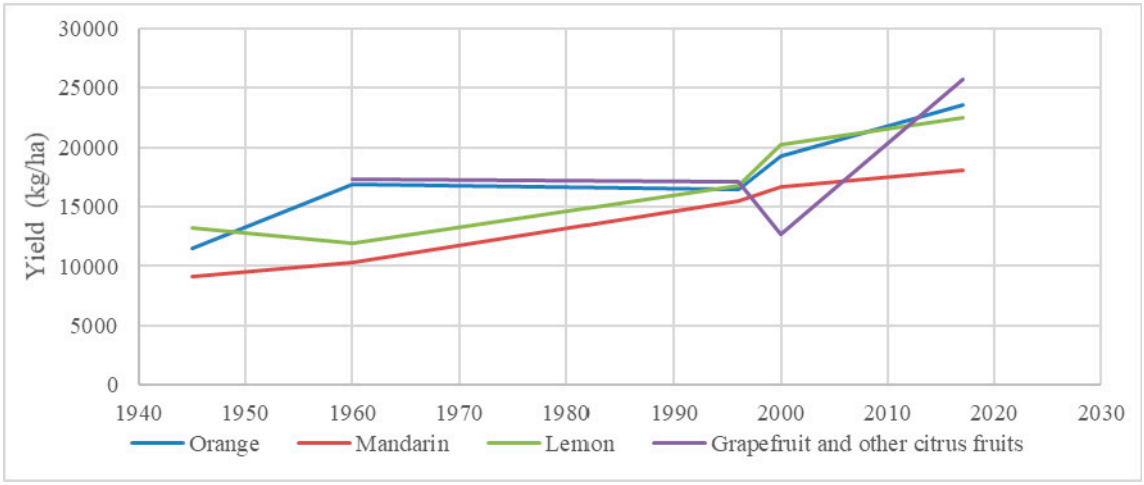

Figure 1. Evolution of yield.

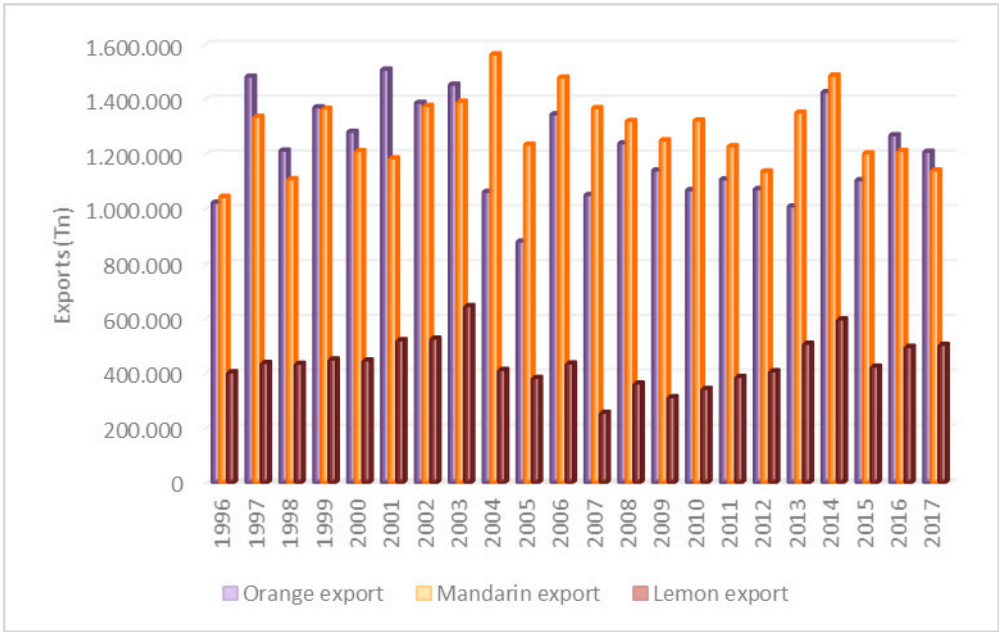

Figure 2. Progression of orange, mandarin, lemon exports.

Because of the structural characteristics of citrus production, innovations have focused more on the plot, without taking into account the small size of farms, especially in the Levante regions (Valencia and Murcia). This conditions their viability and restricts the adoption of technology and the modernization of such farms [9]. However, the adoption of technology has been easy in the production factors whose use does not depend on the size of the plot, and includes: fertilization, phytosanitary products, herbicides, phytoregulators and, above all, varietal change. With greater difficulty, changes have gradually been made in the watering system, with the application of drip irrigation [10–12], and programming with techniques based on climatic parameters, the use of sensors, or controlled deficit irrigation techniques [13–16]. Mechanization encounters more difficulties, but its application is increasing [17–20], and there are already two widely used cultivation practices, such as phytosanitary spray treatments and the mechanical chopping of branches after pruning. The use of machinery has increased because of the outsourcing of cultural operations with demand from the farms for specialized companies and mechanization sections in some cooperatives, together with the technical improvements and adaptations of the machinery being used.

Given the need for changes in the production system, modernization cannot affect the farm only. It will also affect the institutions. As for technicians and institutions, the citrus production industry is being asked for an impossible progression when, outside the farms, only variations in the development of cooperatives has been recorded. They have managed the marketing of as much as 35% of citrus production [9]. The contribution of research has also been decisive.

The production function in crops has been gradually modified to the point of having achieved greater efficiency, with a sharp increase in yields. Figure 1 shows a 104.96% increase in oranges, 97.43% in mandarins, 70.39% in lemons, and 47.98% in grapefruit in the time period analyzed. Currently, the most common farming model is one equipped with drip irrigation and controlled soil using herbicides, mainly in the form of bare soil, although there are cases in which a green cover is maintained. There are also advantages in increasing the use of geotextiles. Current European Union legislation seeks to impose limitations on the use of herbicides to maintain base soil. Arriving at this model has required going through other forms of growing operations. Before the 60s, orchards were dug manually. From the 1960s and 1970s onward, herbicides started to be applied, advances were made in mechanizing the phytosanitary treatments, with the introduction of more accurate studies on the biology of pests and diseases, and the use of phytoregulators for increased production and citrus fruit quality became widespread [21].

The level of mechanization in citrus fruit cultivation is subject to the limits imposed by the focus on marketing fresh quality produce. Pruning is necessary and manual and harvesting has a mechanical solution if the fruit is intended for industry, but if sold directly it requires considerable labor, which is a major item contributing to a high-cost type of citrus production [22].

Phytosanitary treatments were adopted immediately, dependent on the occurrence of pests and diseases, research and the existence of products. Research has played a decisive role in the fight against viruses, especially the citrus tristeza virus (CTV) in Spain in 1957. Since it leads to the death of any orange, mandarin and grapefruit plant grafted on bitter orange trees, the use of this cropping pattern was banned in 1968 except for lemon trees, which are no longer sensitive to the CTV. It was also necessary to eliminate other viral diseases that decreased the production and prevented the use of tristeza virus-tolerant cropping patterns. To this end, the micro-graft technique was developed and, once it started to be applied, the National Plan for Improved Sanitation in Citrus Varieties (PMSVA) was established to sanitize Spanish or imported citrus varieties for cultivation in Spain [23]. Other functions include: distribution of virus-free plants through the Varieties Certification Programme [24]. The results have been comprehensive, the use of tristeza virus-tolerant seedlings has become possible and the production varieties have been sanitized, with an impact on yield and quality.

Significant improvements in citrus production and quality have been achieved through the use of phytoregulators [21]. Prominent among the envisaged functions are: stimulation of the setting of parthenocarpic varieties; increase in fruit size; prevention of rind aging and abscission of ripe fruit to extend the marketing period; control of some physiological activities.

Localized irrigation techniques with fertigation began to spread in the 70s and levels of adoption soon exceeded expectations [25]. The dissemination of localized irrigation, mainly drip irrigation, has led to major technological innovation because of the investment it requires and its technical and economic effects [26]. These include, among others: Greater efficiency in water use, with total control of frequency, dose and flow rate; new plantations do not require levelling or major earthworks, reducing the intensity of herbicide treatments; it permits the application of liquid or soluble fertilizers through the water, facilitating fertigation; an increase in the size of the fruit is achieved, an aspect that is valued in terms of quality; young plantations develop faster, which reduces the formation period. Lastly, from the point of view of production costs, they are not reduced, and the main advantage is the greater ease of management, facilitated by the possibility of fertigation.

The main innovation, one presenting total independence from the production structure, especially farm or plot size, is the introduction of new varieties. If adoption is successful, the farmer is convinced that it means an increase in income with little variation in cultivation with adaptation to demand and consumption increases as a result of increased quality.

Having described the different types of technology adopted in the citrus production industry, the study proposes to address the main issues affecting the varietal change. These include the criteria which the farmer takes into account for introducing a variety and the stages of its adoption; changes and predominance over time of the main varieties or varietal groups. It is complemented with a list of characteristics of the different groups and commercial aptitudes of current varieties and future developments in citrus fruits in Spain, considering the market trends.

2. Characteristics That Condition the Introduction of a Variety and Stages of Adoption

The previous section insisted that the most important adoption of technology and the one with the greatest effects is the change in varieties. At first glance, it is also the one presenting the fewest problems, as it does not depend on the limitations caused by the structural characteristics of the Spanish citrus production system. If the reduction in income, or the financial difficulties affecting its management, dictate a change in the production function, with a change in variety, there are different criteria on which farmers base their choice. The most important one is the expected price for the new variety which, together with the most likely yield, condition income.

Next, the characteristics of the fruit that most affect its quality are considered. These mainly include: The caliber, which should be higher than that of similar varieties; the absence of seeds; color and gloss; attention is also paid to the organoleptic characteristics; flavor, sugar/acidity ratio; other qualities taken into account are the ease of degreening, suitability for cold storage, precocity in early varieties and permanence on the tree of late varieties.

Other more cultivation-related ones include: sensitivity to cold, risk to the Mediterranean fruit fly (Ceratitis) and other pests, vigor of the variety, presence of thorns and the need for thinning the fruit.

Marketing requirements are also crucial, especially the condition for transport and maintenance of quality during the sale exposure period.

If discussing species, in the introduction of a new variety, the aspects to be considered in oranges and mandarin oranges include the following:

- Oranges have more regularity in their production and are less sensitive to climatic incidents such as rain, and their production and quality are not influenced by either location or microclimate, as in the case with mandarin oranges. In general, the useful period for planting orange trees is longer than for mandarin orange trees. We can also state that orange trees are less affected by problems of graft incompatibility by variety/pattern.
- On the other hand, the tonnage consumed is higher in oranges, specifically in the case of Spain it stands at 3 (consumption of oranges)/1 (consumption of clementines). Other very important characteristics considered by the farmers are: (a) Pest incidence, which is higher in clementines; (b) manual actions such as thinning to obtain commercial quality, more necessary in mandarins than in oranges. With regard to early mandarins, although prices at the start of the season are very attractive, early varieties present serious drawbacks with regard to yields, the shorter life of the plantation and irregularities in production and quality. Commercial quality indicates that mandarin hybrids have greater resistance in their rind when they have undergone an intensive period of rain; they are also affected, albeit to a lesser extent, by rind ageing. During the marketing period, the persistence of saleability is greater, and so they tend to be introduced more widely by the large supermarkets and hypermarkets that impose their preferences.

With regard to lemon trees, the issues with marketing and location zones is very different to that of orange and mandarin trees. Most of the area is spread across the provinces of Alicante, Murcia, and Malaga. The number of commercial varieties is lower than other species, and renewal requirements

are lower. Grapefruit is of lesser interest for Spanish citrus production, above all because of the lack of ecological conditions for producing this fruit with any quality in most Spanish citrus-producing regions. The demand for new varieties is not a priority and there is currently a predominance of ruby red varieties.

The adoption of a variety, as a major technological change, first requires generating the plant, which for includes: obtainment, setting up a register or patent, production and marketing [27]. The emergence of new varieties, which is closely tied to the existence and development of citrus growing, depends on spontaneous mutations or hybridizations typical of mandarins, and in the future genetic engineering may set and meet the objectives that are less dependent on chance. If we want to avoid failures in the production and marketing of a variety, we need sufficient experimental development, which requires several years.

The introduction of a variety in the production system follows the phases and criteria of Rogers' adopter categories [28].

The consideration of these criteria in varieties representative of Spanish citrus production provides the following information:

- The "Washington Navel" variety, which from 1910, the year it was imported, represented the basis for the implementation of its group, enjoyed a long period for learning about and evaluating it which extended to the 1930s, in which the first innovators and adopters appeared; it reached the first majority from 1969 to 1975, had a final majority from 1976 to 1986, started to decline from 1986, displaced by the "Navelina," and production started to lag behind and experience commercial difficulties from the 1990s onward [29].
- The leading variety of the navel group is currently "Navelina" owing to its production. It became known in 1933. The growers' evaluation period lasted until the end of the 1960s. From the 1970s onward, the innovative and first adopters appeared; the first majority was reached in 1992; and it can currently be considered to be in the last majority; it is the most widely produced Spanish citrus variety.
- In the clementine group, with maturity in the mid-season, we find the "Nules Clementine," detected in 1953 in Nules (Castellón). The period for learning about and evaluating it was relatively shorter, 10 years, and the first adopters appeared during the 1960s. The first adopter majority occurred in the late 1970s and during the 1980s. As of the 1990s, the last majority that took away surface area from the "Oroval clementine" (now disappeared) started and continued. The production of "Clemennules" remains important in the 21st century, although in recent years difficulties have already arisen in marketing it and the surface area under cultivation will likely have to be reduced.
- The "Oroval Clementine," first observed in 1950, has evolved in parallel with the "Clemennules," completed all phases of its commercial life within 35 years and disappeared after 1992 because of loss of market acceptance, mainly because of its high acidity. From the information on the aforementioned varieties, it can be deduced that: the observation period and the different stages of adoption are usually very extensive and have approximately encompassed a period of their own biological life in the case of "Oroval" and several periods in the other three.

A very marked exception to these described forms of adoption is the formation of varietal clubs ("Varietal Clubs" are associations that control the cultivated area of a variety and, according to the rules of the different clubs, it is possible that the control determine the location, the cultivation procedures, and even the commercialization), a situation registered in the past 15 years and which currently affects six varieties. In such cases the information is swift, with highly effective dissemination, and in a few years the adoption is completed and ends in the first majority of adopters, since the management company grants no further licenses and the surface area remains limited.

3. Evolution over Time of the Different Species and Varieties

Most of the citrus species grown, from which the present varieties are derived, come from hybridizations, and their origins are found in southeast Asia. One exception is grapefruit, which originated in the Caribbean as far back as the 18th century [30]. The first citrus fruit introduced in the Mediterranean countries was the citron ("*Citrus medica*") cited by the poet Virgil.

The introduction of the bitter orange tree ("*citrus* × *aurantium*") was by the Arabs in the first half of the 10th century. In the Middle Ages there was a keen interest in lemons as a condiment and also in medicine and confectionery. The cultivation of the sweet orange tree ("*citrus* × *sinensis*") started in Europe in the 15th century. The mandarin tree ("*citrus reticulata*") was introduced in 1805 and grown from 1850 onward. Grapefruit ("*citrus* × *paradisi*") saw the start of cultivation in the early 20th century. Of the mentioned species, the ones which have acquired the greatest commercial importance are oranges and mandarins. They are consequently the ones that have given rise to the highest number of commercial varieties [31].

Although trade in citrus fruit began before the second half of the 19th century, it was only from that period onward that production and trade in citrus fruits began in Spain, with marked occasional declines but always on an upward and competitive curve. In the centuries prior to the 19th, as well as citron, bitter orange and lemon, sweet orange varieties were grown [31], introduced in Spain in the mid-15th century [32]. Throughout this long period, the main variety was "Comuna." Blood oranges entered the market in the early 19th century; and the second half of that century saw the start of cultivation of several mandarin varieties, eventually joined by the "Berna" variety.

In the citrus trade, the first export registered, of which we have knowledge dates from 1849, was with 9216 tones. There is also a register pointing to the existence of 2765 hectares of citrus fruit on the banks of the river Júcar. Years of growth succeeded each other in the last third of the 19th century, and in 1890 exports reached 260,224 tones [33].

In the 20th century, there was evidence of the history, development and role of citrus production in Spanish agriculture; in 1910, exports amounted to 500,000 tones, which was halved during the 1914–1918 period, the years of the First World War. In 1930, the first million of exported tones was exceeded, namely 1,084,537 tones. The Spanish Civil War (1936–1939) and the Second World War did not completely end this activity, but they caused a steep drop in production and exports, and the 1930 figures were not matched again until the 1952/1953 season. In 1970, the total amount exported amounted to 1,533,180 tones and in the early 1980s three million tones were reached [6].

The dates and periods in which relevant varieties were introduced have been confirmed as "W. Navel" in 1910, "Navelina" in 1933, "Valencia late" in the first half of the 20th century, and "Clementine Fine" in the same period. In 1925, the "Owari Satsuma" was imported and the "Okitsu" in 1987. The mutations that produced the "Oroval" and the "Clemennules" were detected in the early 1950s. The "Nova" mandarin hybrid was introduced in 1971 and in the 1987/1988 season the "Lane Late" of the navel group [31,32].

After the end of the 20th century and almost two decades into the 21st century, the navel group has continued to expand with new varieties, mostly late ones, and the same situation applies to the Valencia group. The number of clementine and mandarin hybrid varieties detected or obtained and being grown is very large (see Table 3).

To describe changes in fruit varieties, composition and replacements, documentation is available on percentages of fruit exported in the 1959/1960 to 1965/1966 seasons. Figure 3 has been drawn up using the statistics of the Ministry of Agriculture from the 1969/1970 season onward, representing important varieties or species or groups of varieties. Variations over time can be documented over time in percentage form with respect to Spain's total output. The information includes the productions of 48 seasons, of which only 17 are represented in Figure 3, sufficient to confirm progression. From observing Table 3 and Figure 3 we confirm that, although Spanish citrus production accounts for a very large number of varieties, there is a reduced number of groups accounting for the bulk of the production. The replacement of some varieties with others is a very frequent occurrence, particularly

up to the year 2000. The most significant variation was the exchange of the blood orange group for the navel prior to 1980. Since that year the groups have stabilized, with the exception of mandarin hybrids, which have considerably increased their proportion.

With the marked trend toward reduction because of obsolescence of common blood oranges and other whites, which started in the 1961/1962 season and was reduced to proportions of less than 1% from the 1985/1986 season onward, supply is concentrated in six varietal groups: lemons (13.47%), mandarin hybrids (8.35%), clementines (22.26%), satsumas (3.01%), late whites (7.17%), and navels (38.18%), all percentages pertaining to the 2016/2017 season. If we consider the varieties individually, the "Navelina," the "Nules Clementine," and "Valencia Late" currently account for the highest proportion.

The number of varieties that have disappeared or become obsolete is high. In the oranges: the blood oranges group has disappeared; "Thomson" of the navel group has also disappeared; Washington Navel has greatly reduced and the common oranges "Verna," "Cadenera," "Comuna," and "Sucreña" have disappeared. Disappearing because of obsolescence in the clementine group were the "Monreal" clementine because of the quantity of seeds in its fruit and the "Oroval" because of the competition from another variety marketed in the same period and of higher quality, namely the "Clemennules."

There is a downward trend in the production of "Navelate" despite being the highest quality orange variety available commercially. The navel "Lanelate," in contrast, has expanded greatly to displace other varieties, among "W. Navel" and "Navelate." The "Powell" navel has similar characteristics and is suitable for harvesting late in the season.

The group of hybrid mandarins has held strong since 1988/1989 until the present at 8–10% of the total. Both for the prices offered and also demand, this group has the potential for growth. Of the main varieties planted in the last 20 years, "Nova," "Ortanique," and "Nadorcott" remain strong. The "Nadorcott" have a controlled crop area and this is why it has been included in a "varietal club." "Fortune" is in the process of disappearing because of its susceptibility alternaria brown spot, and "Ellendale" is becoming obsolete, not having fulfilled its promised expectations.

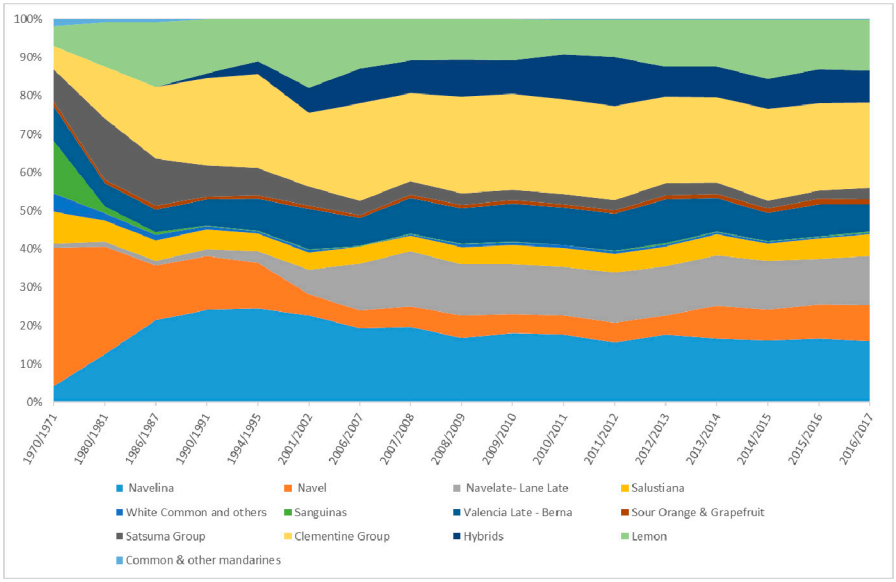

Figure 3. Progression of Spanish citrus production.

Table 3. Main Spanish citrus varieties.

Sweet Orange	**Navel group**		Navelina Newhall Navelina M.7 Washington Navel Thomson Navel (*)	Navelate Lane Late Powell Summer Barnfield Late Chislett	Ricalate Rohde Summer Caracara Fukumoto
	Blood oranges		Doble Fina (*) Entrefina (*)	Murtera (*) Sanguinelli	Moro Catania (*)
	White mid-season		Comuna (*) Cadenera (*) Castellana (*)	Salustiana Macetera (*) Vicieda (*)	Sucreña (*)
	Late white		Valencia Late Berna (*) Peret (*)	Delta Seedless Midknight Late Frost	Barberina
Mandarin	Common Mandarin (*)		Mandarin Dancy		Mandarin Ponkan
	Satsuma group		Okitsu Clausellina	Hashimoto Iwasaki	Satsuma Owari
	Clementinas group	Very early	Loretina Marisol Clemenrubí Oronules	Basol Cultifort Orogros Prenules	Capola (Mioro) Beatriz De Anna Arrufatina Clemenpons
		Middle period	Esbal Oroval (*) Cl. de Nules	Cl.Orogrande Clementina Fina Monreal (*)	Tomatera Nulessin
		Belated	Nour Hernandina		Clementard
	Hybrids		C-10, D-19, Y-25 Encore Kara (*) Mandarin King (*) Minneola (*) Moncada	Nadorcott Tangó Orri Primosole Wilking (*) Winola	Nova (Clemenvilla) Ellendale Ortanique Fortune Spring Sunshine
Lemon Tree and Lime	Lemon Fino (Mesero, Blanco, Primafiori) Lemon Eureka Lisbon		Betera Lemon Verna Lime		Lider Lemon
Grapefruit	**White varieties**		Marsh Wite		Duncan (*)
	Pink varieties		Redblush (Ruby Red)		
	Red varieties		Rio Red Herderson		Star Ruby

Source: Prepared by the authors based on different sources. (*) Varieties that have disappeared from cultivation.

4. Varieties Currently in Production

The number of citrus varieties registered in Europe exceeds 190, with sales possibilities in Spain [34]. However, there are approximately 18 that account for 77.4% of the seedlings sold. Table 3 shows a total of 94 varieties considered to be the most relevant. Given the high quantity, and to facilitate description, we will give priority to the varietal groups. Of the 94 varieties, 21 were represented and are no longer grown.

The most important group is the navel, which since 1970 has always accounted for 35 to 45% of the citrus production. Every variety gives rise to a second, small-sized fruit, usually appearing in the peel, in the style region, with a shape similar to a navel. They do not pollinate other varieties and their fruits are parthenocarpic, seedless. They do not usually have problems with size and their characteristic flavor, together with a very well-compensated sugar/acidity ratio, gives this group a marked consumer preference. They account for 71.49% of marketed oranges, with a long period starting in the first week of October, extending to the end of May. It can be extended to June with the availability of cold-stored

fruit. Farmers encounter no difficulties with production, with some exceptions, such as low harvest levels, in the "Navelate" (a variety on the way out) and the clareta, and an alteration in the rind that depreciates the fruit commercially and to which the "Navelina" is highly sensitive. The suitability for the juice industry is lower than that of other more specialized varieties. The percentage of juice is lower and the presence of limonin, especially in the first half of the season, is a serious drawback that needs to be addressed in juice making. Of the varieties listed in Table 3, those of greatest interest, for the quantity produced and exported, are the "Navelina," which is marketed in the first half of the season, and the "Lanelate" in the second half. The group's composition has widened considerably with late varieties "Powell," "Chislett," "Barnfiel," and "Rohde Summer," which have a marketing period from February to the end of May. In recent years we have seen the distribution, as part of a varietal club, of the "M-7", two weeks more precocious than the "Navelina" [35,36].

Of the blood group varieties only the "Sanguinelli" residually remains. It is highly productive, with small-diameter fruits and red pulp and juice. From the years 1964 to 1966, the blood orange group accounted for 26.49% of the Spanish orange output. It gradually lost commercial acceptance and was ultimately replaced by the navel group and the clementines.

Of the mid-season whites, only the "Salustiana" variety is grown, which has displaced all others in its group. The tree is vigorous, with vertical growth predominating. It is a productive variety manifesting alternating production; in years of high-yield harvests, their caliber decreases and it is advisable to increase it through treatment with phytoregulators. The fruit is sweet in flavor and has a thin rind, with a high juice content. As a result, the variety is doubly suitable: for fresh consumption as well as for industry. The fruit remains on the tree for a long time, since the harvesting period runs from December to March.

In the late whites, there is total predominance of the "Valencia Late," together with the "Late Frost," of nuclear origin, which displaced varieties from the Berna subgroup. They are vigorous, well-developed trees with an open treetop. The fruits are generally good-sized, with a thin, smooth rind and barely any seeds. The main characteristic of this variety is its high, slightly acidic juice content, with a pleasant aroma and flavor, which is why the "Valencia" orange is considered the most suitable one for industrialization within Spanish production. Harvest starts at the end of March and can extend to mid-June because of the fruit's adherence and its ability to maintain quality. This group includes another three varieties that partially improve the characteristics of the original "Valencia." They are the "Barberina," which comes from the mutation of a bud of the "Valencia" and is harvested two weeks earlier. Another one is the "Midknight," of unknown origin, which is also the third one is the "Delta Seedless," obtained from a seed of the "Valencia" [37]. The three mentioned varieties present high-quality fruits marketed for fresh consumption as well as for industrialization and cold storage [38].

The Spanish citrus production areas are environmentally highly suited for growing mandarins, with their multiple varieties, which provide diverse production options with a very extensive marketing calendar. In the description following the order of Table 3, starting with the "Common" mandarin grown for a long time in Spain although now no longer in existence, the "Dancy" mandarin used as a parent in many hybridizations, and the "Ponkan," a vigorous and productive tree but with a tendency toward alternation. The satsuma group, which includes five varieties, four of which are of Japanese origin: "Iwasaki," "Okitsu," "Hashimoto," and "Owari" and one of Spanish origin, the "Clausellina," which is heading toward disappearance. The group's common features are medium- to small-sized trees with flowers without pollen, which do not pollinate other varieties. The seedless fruits are a good size, but thinning may be advisable if there is excess production. The rind is a little coarse, with a tendency to puffiness once it has ripened. Organoleptic quality is low because of its low content of dissolved solids and total acids. Early ripening has been the main advantage of these varieties with regards to consumption. However, in recent years, except for the "Iwasaki," the others are seeing their marketability threatened because of the higher quality of early clementines. The trees are resistant to cold and, because of their early harvesting, they are not affected by frost. These varieties

are highly sensitive to fruit fly. The "Iwasaki" is the earliest variety in Spain; it is harvested from late August onward and is highly productive. The "Okitsu" is harvested from the last week of September. The "Owari" is the oldest, but at this time the interest of fresh produce consumers is steadily decreasing and production for the industry of processing orange segments in syrup is clearly declining [39].

The group of clementines encompasses three sub-groups: very early, ripening in the medium, and late periods. The very early subgroup is quite large. Table 3 lists the most commercial products, all of Spanish origin from mutations of other varieties. It is worth mentioning that, although trees are of normal size and vigor, in some varieties such as the "Clemenruby" and the "Clemenpons" they are less developed and have a disadvantage in the appearance of multiple buds in the trunk. Fruit size problems requiring thinning are frequent. The fruits do not have seeds, but all varieties can pollinate and be pollinated with compatible varieties. With few exceptions, after the fruit has ripened it must be harvested within a short period because staying on the tree decreases its quality, and the tendency to puffiness is frequent. In all cases, careful application of phytoregulators is required, with prior knowledge of the effects on each variety. They are all very sensitive to the fruit fly [35,39]. The introduction of new varieties will always be very frequent in this group, and the short life and disappearance of others is also common. The subgroup that includes the medium-period clementines can be considered to be the main one. The number of varieties is lower than in early clementines. All have fully developed trees that produce seedless fruits, even though they can pollinate and be pollinated with compatible varieties. Once they reach maturity they maintain their quality on the tree for some time, although in humid and wet weather they may be affected by water molds, which alter the rind [39,40]. Of the varieties under cultivation, the "Fina Clementine" has undergone a marked reduction in spite of its high quality owing to production problems and fruit size. Its contribution to citrus production has been very important, particularly because of the number of varieties that have emerged through spontaneous mutations. The "Nules Clementine," the varietal clone "Orogrande" and the "Nulessin" form the most important group of clementines because of the volume of their production, quality, and long harvesting period, from November to mid-January. Its flowering is staggered [35]. Late clementines, include the "Hernandina" and the Clementard, with harvesting in January and February, and the "Nour," originally from Morocco, which ripens 15 days earlier. The "Nour," given its behavior in Morocco, has not produced the expected characteristics in Spain and its cultivation is being abandoned. The "Hernandina" and Clementard are productive, although with some tendency to alternation. The "Hernandina," when ripe, presents a greenish area in the fruit's stem part [35,39].

The varietal group of hybrids has gradually made its way into Spanish citrus production through the commercial space left open by clementines once January has passed. Some of its common characteristics are its vigorous, leafy trees with open canopies. Another very negative feature is the possibility of pollination with nearby plantations; if the varieties are compatible, they can fertilize, be fertilized and form seeds. This property is not present if it has a triploid origin. When the "Dancy" mandarin has been involved in obtaining it, sensitivity to alternaria brown spot can also emerge. The fruits are attractive in both size and color and all maintain their commercial condition very well, with the rind having low sensitivity to alterations, although their organoleptic characteristics are inferior to those of clementines. Because of the dedication to this group by breeders from various countries, the number of varieties available is extremely high. Table 3 shows those with the greatest commercial interest at present, along with others that have disappeared or are in the process of being abandoned. The most interesting ones for the industry are: "Nova or Clemenvilla," which has the best organoleptic characteristics. Highly productive, it must be harvested in December and January without prolonging its tree life, since it loses quality. The "Ortanique" is the latest-ripening mandarin. It can remain on the tree until May 20 and is very productive. There are some reservations as to its acceptance, above all because of the difficulty of peeling it and the amount of essential oil contained in the rind. It maintains its commercial condition well. Other widely accepted varieties are the "Nadorcott," the "Tango," and the "Orri," which are offered and controlled through varietal clubs. Also

available are the "Moncalina," irradiated from the "Moncada" variety, productive though somewhat alternating, seedless, with a good size and quality in its fruits. It can remain on the tree without losing its commercial condition from January to April. The recently introduced variety in Spain and the latest-ripening on the market is the "Spring Sunshine," a hybrid obtained by mutation induced through the irradiation technique of "Murcott" buds in Israel. It belongs to a varietal club in which some 500 hectares have been authorized in less than a year [35,39,41].

With features that differ greatly from oranges and mandarins, the lemon tree, with an extensive marketing calendar, bases its activity on only three varieties: "Fino" and "Verna" and from the 1980s onward "Eureka." The "Fino," of Spanish origin, of which two clones are currently offered, "Fino 95" and "Fino 49." "Bétera" and "Lider" are two mutations of the "Fino" variety. This variety is highly productive, with vigorous trees and fruit of a size a little smaller than the "Verna". The pulp has considerable juice. It is very acidic and has some seeds. The harvesting period runs from the end of September to the end of March. The marketing calendar for this species is completed with the "Verna" variety, which is Spanish, highly productive although with alternation problems in its production. Good-sized fruit with a rind that can be slightly coarse, with few seeds. Its harvest starts in February and ends in July. In this variety a second harvest is possible during the summer, the fruits of which are denominated "verdelli." The "Eureka" originated in California, with medium-sized fruits with a high juice content, high acidity, and very few seeds. Its marketing period coincides with "Fino" [42].

Although in the past 20 years grapefruit has experienced considerable growth; in reality it started at a very low point in terms of figures and its representation in Spanish citrus production remains negligible. In order to obtain sufficient commercial and organoleptic quality, cultivation must be in very warm areas, which in Spain are in the provinces of Huelva, Almeria, and Murcia. There are three types of grapefruit varieties: yellow, pink, and ruby red, which is the main one. In all varieties harvest starts in October and the fruits can remain on the tree until March while maintaining their quality. The pink varieties have had scant acceptance and, until 1984, the year the "Star Rubí" variety was introduced, the "Marsh" variety was grown. This variety is very productive, with developed trees. The fruit is good-sized, with yellow pulp, a characteristic bitter taste, especially in the membranes of the segments, and with less than three seeds per fruit. The "Star Rubí" variety was brought from Texas, where it originated. The tree is less vigorous than the "Marsh" and is sensitive to herbicides. The fruit has no seeds and is an intense ruby red if grown in a very warm area [35,42].

5. Foreseeable Conclusions and Trends

Varietal renewal is the most important basis for maintaining competitiveness in production. However, although this is rational business behavior, insofar as possible it must be demanded that the varieties have had sufficient experimentation before the start of offers by nurseries. This will prevent growers from suffering investment failures such as in recent cases with the varieties "Ellendale" and "Clemenpons" [43].

In the progression of varietal composition, the influence which the dominance of the major chains has on the retail market is important. In a way, it is contradictory that they demand innovations in the introduction of new varieties and at the same time they tend to reduce the varieties on offer, to the point of exclusivity in some of them. More than the variability of qualities, the trend is toward standard quality, which in turn reduces price fluctuations in the course of the season. Above all there is a clear preference for saleability over organoleptic quality. Priority is given to prolonged permanence on display for sale and avoidance of any risk of rind ageing rather than to important characteristics such as sugar/acidity ratio or easy peeling.

Currently, and in the future, the different varietal clubs that have been formed will have far-reaching importance. Through these associations, the cultivated area for each variety is controlled in accordance with the rules of each one of the different clubs. This control may also have an impact on location, growing procedure, and even on marketing. If supply on the market via this route is high, it may displace freely produced varieties.

Because of the long ripening calendar and excellent qualities of its varieties, the navel group will form the basis for the supply of oranges in the fresh produce market. The dual suitability for market and industry of the "Salustiana" and Valencia group enables the future continuity of these varieties.

Both in the navel group and in the Valencia group, the introduction of new clones or varieties has enhanced their qualities without the need to change the calendar or the destination of the fruit to either the fresh produce market or industry. The new varieties introduced in each group are, in navel, "Powell Summer," "Rohde Summer," "Barnfield Late," and "Chislett." In Valencias, "Barberina," "Delta Seedless," and "Midknight." Although some navel varieties, and especially white ones, may lose their commercial acceptance, both groups continue to occupy their own space depending on the marketing period, due to the replacement of some varieties by others within the group.

The group of early clementines is very broad because of the numerous varieties arising from both spontaneous and induced mutations. The economic potential of most of these varieties is limited and they often enter obsolescence rapidly, on the one hand because of their vegetation and on the other because of quality irregularities in the retail offering, especially at the start of the season. The cost of producing these clementines is usually high because of low yield and the small diameter of the fruit. Thinning is often required and at the time of ripening they are sensitive to the Mediterranean fruit fly (*ceratitis capitata*).

Mid-season clementines, with better commercial quality, are experiencing a reduction in their availability calendar because of the increase in early clementines at the start of the season and to the mandarin hybrids from January onward. The same applies to late-period clementines: "Nour," "Hernandina," and Clementard.

The group of mandarin hybrids has developed rapidly despite its late entry in the early 1990s, and its growth potential is high. The drastic reduction and almost complete disappearance of the "Fortune" cultivar because of its sensitivity to alternaria led to a greater availability of "Ortanique" as a late hybrid, which in turn can be displaced by others that coincide with its marketing period and that are easier to peel and have better organoleptic characteristics. Other hybrid varieties being grown are the "Nova," "Nadorcott," "Tango," "Orri," and the "Moncalina," obtained by irradiation of buds from the "Moncada" variety. More recently the "Spring Sunshine" has been introduced in Spain. Because of the commercial features of hybrids in light of the preferences of supermarkets and hypermarkets, clementines may be partially displaced by hybrids, something that would cause serious disruption to the production sector.

The trend in lemons is favorable, with a notable increase in the exported proportion. Domestic consumption is being maintained and industrialization is growing. The weight of grapefruit in Spanish citrus production remains limited. There is a marked increase in exports, but domestic consumption remains low. The same applies to its use in industry [7].

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