The Role of the European Fruit Sector in Europe 2030

An OUTLOOK by EUFRIN

A document produced by the EUFRIN Working Group on Horizon 2020 Outlook.

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WORKING ABSTRACT

EUFRIN (the EUropean Fruit Resarch Institutes Network) is a voluntary network created to facilitate international cooperation among fruit researchers. The Board of this network has identified the need for a sector-wise organization of the fruit chain in Europe, with the goal of defining a Strategic Research Agenda for the sector. The present condensed document argues in favor of a coordinated action by concerned researchers and fruit chain stakeholders leading to the formulation and implementation of such Agenda with an outlook to 2030.

Current size of the EU fruit industry

The European fruit industry is a relevant sector of the EU agroindustry as, with less than 3% of total land use, it produces around 17% of the value of the total EU agricultural production. The combined fruit and vegetable sectors involve about 1.4 million farm holdings, with a total chain turnover of about 120 billion euro.

Eu fruit industry and global challenges

Fruits represent an ideal food as they deliver unique nutritional value conferring protection from cardiovascular diseases, obesity and cancer, associated to taste, freshness and naturalness. Securing a steady supply of fruit and fruit derived products for the EU consumer is a must, vis-a-vis the food challenges that lie ahead in terms of projected demographic growth, climate change, sustainability and competition from third countries. If Europe is to maintain a secure and safe supply of fruit, it must invest in research leading to technological innovation to be funneled into the chain.

Constraints in the fruit industry

The European fruit sector is faced with: (i) reduced fruit consumption; (ii) increased competition from low-labor costs, non-EU countries who are often quick to adopt state of the art technology; (iii) diminishing availability of skilled labour; (iv) high susceptibility to pests and diseases of most commercial varieties. In spite of these weaknesses, current state of the art is that horticultural research has been underfunded,

and the horticultural sector faces the risk of being unable to respond to the upcoming challenges listed above.

Vision of EUFRIN

The **EUROPE 2020 Strategy** calls for a model of growth capable of addressing Europe's future **societal**, **economic** and **environmental** issues. Such growth must be **smart** (based on education, knowledge and innovation); **sustainable** (based on a resource-efficient, greener and more competitive economy); **inclusive** (based on high employment, and economic, social and territorial cohesion). The fruit sector is in an excellent position to contribute to this growth via the **adoption of innovation** resulting in an improved and more competitive European fruit supply chain.

The Fruit sector contribution to EU Society

A broad supply of consumer-oriented, healthy, accessible, convenient fruits and fruit-derived foods will be secured. Resulting benefits will include improved health, development of specialist expertise throughout the supply chain, education through knowledge exchange, wealth creation for the rural environment, empowerment of rural areas and landscape preservation.

The Fruit sector contribution to EU Economy

The European fruit chain will retain and increase its competitiveness by adopting novel, eco-innovative technologies. These will secure greater profitability by means of increased labor efficiency, improved quality and productivity, reduced waste, innovative products and increased consumption of fruit and fruit-based products.

The Fruit sector contribution to EU Environment

European fruit production systems will contribute to the preservation of the environment through the adoption of an array of eco-innovative technologies delivering better products and reduced wastage under threats from climate change and limited natural resources. This will be achieved through energy efficient systems and innovative management tools which will optimize the use of production factors, and minimize the

carbon, water, mineral nutrients, pesticides footprint of the fruit chain while improving land-stewardship.

The fruit sector contribution to development and uptake of Innovation

Innovation adoption must become a trademark of the European fruit sector for it to achieve a Smart, Inclusive and Sustainable Bio-Economy. A common strategy is needed among the fruit sector actors for making sure that the knowledge arising from research leads to maintaining and creating employment, contributing to consumer-demand-related food quality and safety, contributing to unique landscapes, delivering novel fruit-based products that respond to the needs of future European societies, continued adaptation of the sustainability concept in the fruit sector and minimizing energy consumption.

Moving Forward

As Horizon 2020 is approaching, the tools and ways to interact with the EU Commission are changing, and are expected to rely more and more on innovative forms of involvement of local, regional, national and international resources. Stakeholders in the Fruit Chain throughout Europe will be called upon to assess and endorse this Vision, and to cooperate in forging the Strategic Research Agenda. EUFRIN is at an ideal interface in the Fruit Chain to act as a collector and coordinator of this demand for research, and also to be proactive in organizing the supply of research, creating the critical mass needed to tackle the complex issues facing the Sector in the future.

1. Preface

The Fruit Sector is an important part of the European Agroindustry, which is the major economical sector in Europe. The relevance of fruit extends beyond the sheer economic size of the industry, as fruit can play a pivotal role in promoting EU consumers' health, thus reducing costs associated to the so called "social diseases" (cardio-vascular disease, some forms of cancer, obesity). This sector is therefore one of strategic importance for Europe, and warrants that attention be paid at all levels to its needs. Also, its labor-intensive approach at managing the rural environment puts fruit growing in an excellent position to provide EU Society with essential land preservation and stewardship.

In a global market, Europe would be at a loss competing with countries that can readily adopt novel techniques and couple them with low labor and production costs, if it did not maintain a continuous supply of innovation into its Fruit Chain. Yet, maintaining a European fruit production is of strategic importance also in terms of food security and safety, as the World population will max out in the next 40-50 years. The pressure for food placed by such demographic increase will need to be met by maintaining or increasing the quality, variety and nutritional levels of the current European fruit production. These challenges can only be met via a continuous input of technological innovation in the entire European Fruit Chain. To ensure that resources be dedicated to the most important matters, mechanisms must be in place to listen and react to the chain-driven demand of innovation, as this is fundamental to maintain a viable Fruit Chain in Europe. With its research potential, Europe is in an ideal position to address this demand of innovation via dedicated research, thus contributing to the European Knowledge Based Bio-Economy.

The present document presents the collective outlook of EUFRIN, the **EU**ropean **F**ruit **R**esearch **I**nstitutes **N**etwork (http://www.eufrin.org) which has taken a proactive stance in leading the effort to bring together the various stakeholders of the European Fruit Chain, with the goal of coordinating and implementing the Strategic Research needs of the sector.

This outlook is the result of twelve months of consulting and confrontation between a dedicated EUFRIN Working Group and its Board, and has been prepared at a time during which the EU has been conducting Consultation Exercises in order to better define the Horizon 2020 Program, and the tools and funding schemes that will be adopted from 2013 onward. The ultimate goal of EUFRIN is to act as a promoter and coordinator of the appropriate forms of international cooperation, responding to the political guidelines of the EU in the implementation of the European Research Area, bridging the gap between the actual need of innovation of the Fruit Chain and the EU commitment to improve Europeans' wellbeing through research and innovation.

2. Summary

The European Fruit Sector delivers an essential and unique contribution to the economic, social, and environmental future of the EU as it is technologically advanced and includes a complex chain of production, storage, marketing, logistics, wholesaler and retailer input providers.

The competitiveness of the EU Fruit Sector in the global market is highly dependent on continuous delivery of innovation from research and development activities that leverage the low cost of labour from competing countries. These activities are required to address several challenges facing the EU fruit sector, to secure its growth and future contribution to the Knowledge Based Bio-Economy (KBBE). Such challenges include the need to: deliver a safer and more secure supply of quality fruit to urban based populations; ensure productivity and profitability to compete with non-EU fruit sectors; secure long term competitiveness through continuous innovation in the fruit chain; secure knowledge exchange and implementation via strengthening existing national and transnational networks within Europe; increase consumption of fruit by delivering products that better fulfill consumer needs.

The EUROPE 2020 Strategy has defined clear goals to deliver on a smart, sustainable and inclusive economy capable of promoting high levels of employment and productivity, and of increasing social stability. The EU fruit sector is ideally positioned to positively contribute to this Strategy via societal, economic, environmental and innovation benefits.

Future fruit consumption in the European society will have to greatly increase to have a significant contribution to Europeans' wellbeing and health. The increase will be brought about by a reliable supply and consumption of healthy, accessible, convenient, novel fruit and fruit-based products for European consumers. To meet this demand, the European fruit chain will contribute by providing a secure, continuous supply of consumer-oriented healthy fruits. This will be delivered through innovation from European interdisciplinary research, encompassing social and natural sciences.

Resulting benefits will include the development of specialist expertise throughout the supply chain, education through knowledge exchange, wealth creation for the rural environment, the empowerment of rural areas and the preservation of the landscape.

Strengthening the EU economy, all the components of the European fruit chain will have increased competitiveness by intensive use of novel, eco-innovative technologies. These will secure greater profitability by means of increased labor efficiency, improved quality and productivity, innovative products and increased consumption of fruit and fruit products.

Innovative European fruit production systems will contribute to the preservation of the environment through the adoption of an array of eco-innovative technologies which will deliver better products and reduced wastage under threats from climate change and limited natural resources. This will be achieved through energy efficient systems and innovative management tools which will optimize the use of production factors, and minimize the carbon, water, mineral nutrients, pesticides footprint of the fruit chain while improving land-stewardship.

Barriers for innovation adoption will be overcome and this will deliver wealth for key stakeholders in the European fruit chain. European fruit research and innovation networks will be strengthened and will facilitate the exchange and implementation of knowledge at the regional, national and transnational level.

This document presents the Outlook by Stakeholders in the Fruit Chain whose objective is to secure the availability of a wide range of healthy, high quality fruit and/or fruit products for the European Consumer through Research-Driven Innovations that help the European Fruit Chain to be Competitive and Sustainable.

3. Current situation of fruit industry

3.1. Fruit production in Europe

Fruit crops account for 17% of the value of the EU's agricultural production. Fruit are a high-value crops with a wide diversity in species grown in relatively small production areas. Permanent crops (including grapevines and olives) add up to 5%, whereas fruit and vegetables represent 3% of the EU's cultivated area. The total production value of fruit and vegetables is estimated to be more than 50 billion €. The fruit and vegetables supply chain has an estimated turnover of more than 120 billion € with approximately 550,000 employees and 1.4 million farm holdings[1].

The main dessert fruits grown in the EU 27 are apples, oranges, peaches and nectarines, tangerines, mandarins and clementines, pears, table grapes, plums, lemons, strawberries, kiwi fruit, apricots and cherries (Fig. 1). Total production of these fruits is 34 million tonnes across an area of 2.2 million ha[2]. In addition, 23 million tonnes of grapes are grown for wine over 3.5 million ha, and 11 million tonnes of olives are harvested over 4.8 million ha for table and oil use. This compares to an area of 54 million ha for production of the main arable crops (wheat, barley, maize and rape).

A large part of the production is consumed locally in the country where it has been grown, while this is complemented by fruit and vegetables coming from the other member states. Around 26 million tonnes are traded on a yearly basis (Table 1) among member states out of a total production of about 79 million tonnes[3]. The EU also imports more than 11.1 million tonnes of fresh produce from third countries worth 8.8 billion euros (Freshfel, 2010). Bananas are the largest fruit category imported, followed by

[1]Freshfel 2011 Freshfel Europe Activity Report May 2010 – May 2011, cited from Eurostat. http://www.freshfel.org/asp/newsroom/l1.asp?doc_id=175
Freshfel 2011 Monitor 2010 Freshfel Europe Fresh fruit and vegetable production, trade, supply & consumption monitor in the EU 27 (covering 2004-2009). Freshfel, Brussels.
[2]Eurostat 2010 Pocketbook Agricultural Statistics – main results 2008-9, 2010 Edition, ISBN 978-92-79-15246-7, Eurostat, Luxembourg.
Eurostat http://epp.eurostat.ec.europa.eu/portal/page/portal/agriculture/data/main_tables
Faostat http://faostat.fao.org/site/567/default.aspx#ancor.
[3]Freshfel 2010 Freshfel Europe Activity Report May 2009 – April 2010, cited from Eurostat. http://www.freshfel.org/asp/newsroom/l1.asp?doc_id=175.

pineapples, oranges and apples (Table 2). Exports amount to 4.4 million tonnes worth 3 billion euros (Freshfel, 2010). The main exported categories include apples and citrus. The Netherlands, Italy, Poland and France are the biggest exporters of fruit to the EU, whereas France, Netherlands, Italy and Germany are the largest importers (Table 3). Clearly the Netherlands is trading fruit that it does not produce.

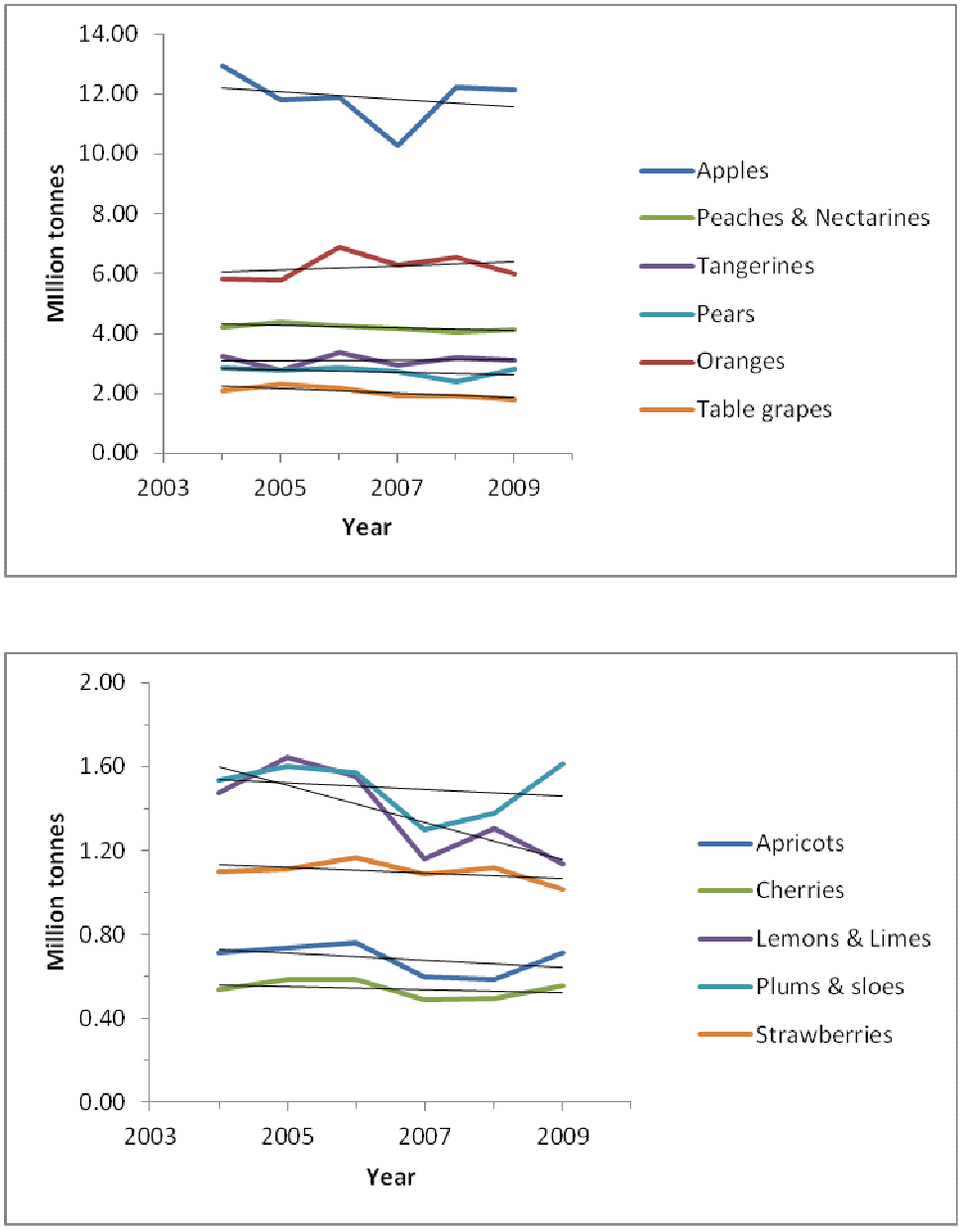

Fig. 1. Trends in total fruit production in EU 27 Member states 2004 - 2009 (FAO statistics except table grapes, Eurostat).

Citrus fruits are grown mainly in southern states, whereas apples, pears, stone fruit and strawberries are grown also in northern states (Tables 4 & 5). Italy and Spain have the largest fruit production jointly producing 52% of the top twelve dessert fruits (Table 5). The bulk of fruit production is concentrated in a few member states. For example, some 57% of EU 27 apple production in 2009 was located in Poland, Italy and France, whilst 86% of oranges were produced in Spain and Italy. Strawberry and cherry production is more equitably distributed amongst member states.

Table 1. Intra EU Fruit and vegetable trade 2009 *(Freshfel 2010)*.

	Volume imports (t)	**Volume exports (t)**	**Total Value (€)**
Austria	754,622	384,672	749,785,663
Belgium	1,561,553	2,990,999	1,115,339,696
Bulgaria	97,456	46,674	38,581,702
Cyprus	30,498	39,761	33,529,287
Czech Rep.	1,042,701	215,578	619,502,277
Denmark	650,925	38,661	671,551,258
Estonia	105,250	2,148	72,142,204
Finland	319,688	1,278	359,192,802
France	3,395,118	1,925,181	2,810,976,235
Germany	6,616,266	1,067,834	6,147,928,185
Greece	173,048	602,296	161,771,008
Hungary	266,510	236,399	163,613,849
Ireland	338,872	82,648	359,981,883
Italy	1,365,934	2,843,008	1,164,263,358
Latvia	138,515	16,195	88,269,667
Lithuania	410,600	57,424	317,654,429
Luxembourg	51,217	4,021	95,633,689
Malta	25,087	0	18,677,211
Netherlands	1,863,364	5,593,331	1,389,271,150
Poland	1,323,902	692,624	857,714,767
Portugal	503,881	326,769	314,704,071
Romania	210,327	44,021	125,429,691
Slovakia	816,679	52,179	287,656,819
Slovenia	186,668	119,292	146,377,005
Spain	929,946	8,666,170	565,645,892
Sweden	743,755	69,659	701,728,983
UK	2,6,47,032	227,888	2,712,295,759
Total	**26,569,415**	**26,346,710**	**22,089,218,540**

Fruit production has been stable over the last few years (Fig. 1) with most fruit showing only small declines in production over the six years from 2004-2009. The exceptions are lemons and limes that have shown a sharper decline and oranges that have shown a slight increase. For the main fruit species except oranges there have been small declines in the areas of land under production. Thus, the total land area under these species has reduced by 5% since 2004 (Table 4). This has been partially countered by an increase in the level of intensification (i.e. production per unit area) over recent years through the use of modern production systems which include improved varieties, better planting systems and harvest season extension. However, an additional reason for this decrease in acreage lies in the loss of profitability for fruit farming, which leads to closing down of operations

Table 2. Import and export volumes of fruit in EU 27 member states 2009 *(Freshfel 2011)*.

	Import (t)	**Export (t)**
Apples and pears	1,070,061	1,390,912
Bananas	4,560,050	14,196
Berries	69,591	43,895
Citrus	2,015,818	590,526
Exotics	1,714,457	270,136
Grapes	616,067	121,784
Melons and papayas	520,405	77,013
Stone fruit	172,964	305,466
Total	**10,739,413**	**2,813,928**

3.2. The fruit chain

The fruit chain has a complex structure (Fig. 2) involving e.g. input suppliers, growers, post harvest handlers, distributers and consumers. The production segment includes input suppliers, growers and post harvest. Input suppliers provide basic materials and services. Growers can be grouped in growers' organizations or cooperatives, in which case they often directly carry out post harvest handling and/or processing. Marketing desks/wholesalers/markets and retailers represent the

distribution segment of the chain delivering fresh and/or processed fruit to the final consumers. Other participants include importers/exporters, brokers, logistics service providers (transport) and waste managers. At every step of the chain, there is an ongoing demand for highly specific and advanced knowledge, to foster and support the necessary continuous improvements of the entire chain.

Fruit holdings in the EU 27 member states are generally small with the average size varying from country to country within the range 0.2 – 8.9 ha. There are 42,507 specialist fruit and vegetable wholesale enterprises employing 375,000 people generating a turnover of 113 billion €. The average size of these wholesalers ranges from four persons in Bulgaria to 21 in Lithuania[4].

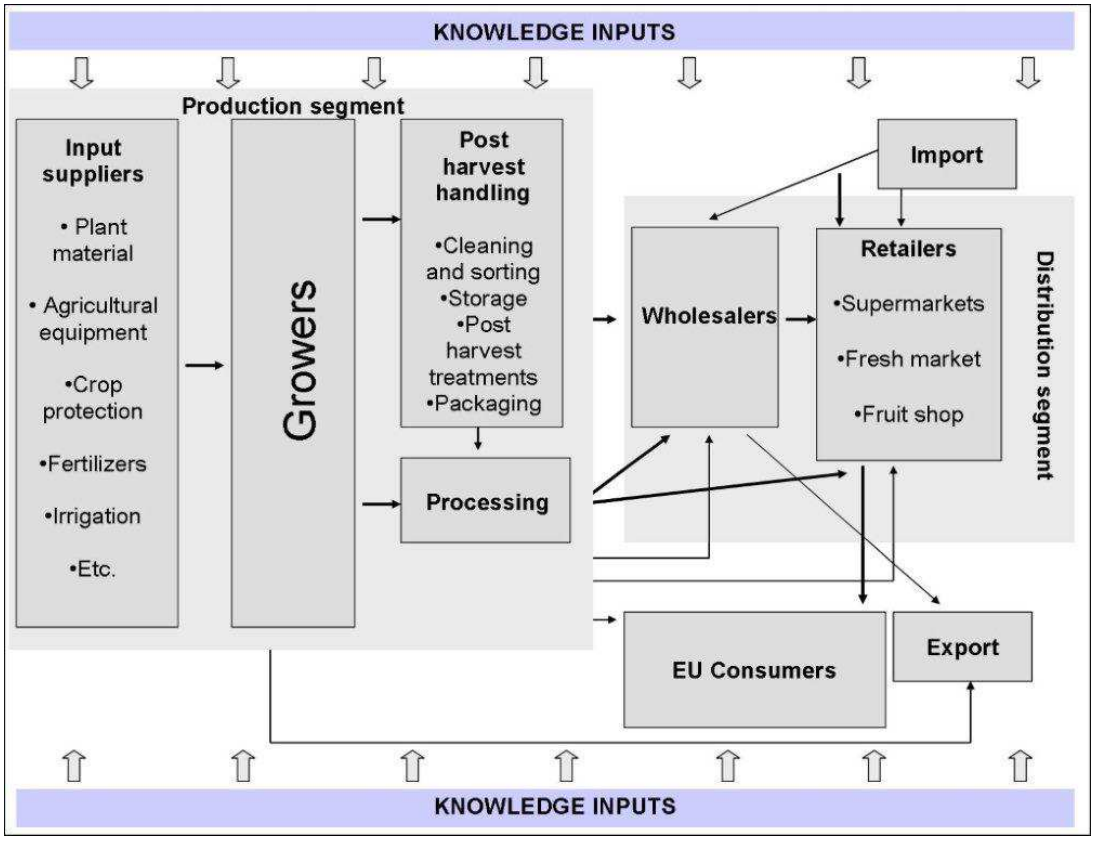

Fig. 2. The fruit supply chain.

[4]Martinez-Palou A and Rohner-Thielen E 2008 Fruit and Vegetables: fresh and healthy on European tables. Eurostat statistics in focus 60/2008. Eurostat, European Commission, Brussels.

Retailers can vary from farm shops, markets, grocers and supermarkets and can be regarded as specialist and non-specialist (i.e. supermarkets). The latter due to their large sizes may hold considerable power when negotiating prices with suppliers and wholesalers. The type of retailer varies from one country to another; however, the **multiple retailers (supermarkets)** take a large share of the fresh produce market in many countries. For example in the UK supermarkets account for about 80% of fresh produce sales. Very high quality is required by supermarkets which results in high technical demands and an increasing interest in technology that maintains quality along the whole supply chain.

The number of **specialist fruit and vegetable retailer** enterprises is 76,696, employing 170,000 people which generate turnover of 12.5 billion €. The average size of specialist fruit and vegetable retailers is small, ranging from one person in Finland to six persons in the Netherlands. (Martinez-Palou & Rohner-Thielen, cit.).

Fruit and vegetable processing has 10,200 enterprises employing 283,000 people generating a turnover of 53.2 billion €. The average number of people employed in fruit and vegetable processing enterprises ranges from about four persons in Lithuania to 90 in the UK (Martinez-Palou & Rohner-Thielen, cit.).

Per capita fruit consumption is 250 g/capita/day on average for the EU 27. It has decreased by 6% in 2009, compared with 2008 and it also shows a decrease of 5.2% in 2009 compared with the average consumption of the previous five years (2004-2008). Whilst EU average per capita consumption for fruit and vegetables is above WHO recommendation, some member states still have a lower per capita consumption than the minimum 400 g recommended by WHO (Freshfel, 2011). This is a concern set against a background of rising obesity, but also shows the potential for increased consumption.

The data reported here highlight alarming trends of a stagnating or even declining consumption of fresh products. To properly address this shortcoming, Europe needs to mobilize all the resources of the fruit chain to increase the appeal of consuming fruit in the EU society and to promote and support the European fruit industry.

Table 3. Imports and exports from EU 27, 2008. *(FAO statistics)*.

Country	Imports from EU (1000 t)						Exports from EU (1000 t)					
	Apples	Pears	Fresh peaches	Oranges	Fresh grapes	Citrus fruit	Apples	Pears	Fresh peaches	Oranges	Fresh grapes	Citrus fruit
Austria	107.9	12.5	24.7	42.5	18.9	103.3	87.4	1.8	2.2	4.2	2.6	19.3
Belgium	*	*	*	*	*	*	*	*	*	*	*	*
Bulgaria	*	*	*	*	*	*	*	*	*	*	*	*
Czech Republic	*	*	*	*	*	*	*	*	*	*	*	*
Denmark	*	*	*	*	*	*	*	*	*	*	*	*
Estonia	31.0	6.6	2.8	46.8	7.9	55.1	2.7	0.1	0.0	4.3	0.2	5.8
Finland	*	*	*	*	*	*	*	*	*	*	*	*
France	614.0	120.9	104.3	6,068.0	133.0	*	682.0	39.0	54.7	848.0	23.0	*
Germany	548.0	113.0	261.0	481.0	172.0	918.0	131.0	15.0	10.0	29.0	43.0	73.0
Greece	*	*	*	*	*	*	*	*	*	*	*	*
Hungary	61.6	10.1	13.4	151.0	18.8	81.7	165.5	0.4	0.2	1.1	2.9	15.8
Ireland	38.7	33.6	4.3	567.4	89.2	846.3	6.1	6.6	0.2	404.7	69.0	447.0
Italy	63.0	57.0	65.0	186.0	199.0	135.0	1,022.0	235.0	323.0	536.0	933.0	184.0
Lithuania	159.5	13.2	11.2	39.0	19.8	130.4	68.5	2.0	0.7	2.9	4.1	10.1
Luxembourg	10.3	2.5	1.5	57.9	3.6	65.8	0.2	0.1	0.0	3.4	0.1	3.6
Malta	3.8	0.9	1.4	10.4	0.9	6.2	0.0	0.0	0.0	0.0	0.0	0.0
Netherlands	573.0	83.0	74.0	1,038.0	141.0	718.0	719.0	246.0	14.0	2,247.0	212.0	1,959.0
Poland	187.0	24.0	96.0	210.0	97.0	538.0	1,134.0	10.0	0.0	30.0	7.0	577.0
Portugal	71.0	13.0	36.0	42.0	28.0	81.0	10.0	36.0	1.0	34.0	1.0	47.0
Romania	67.1	4.5	25.6	39.1	16.9	129.7	138.2	*	*	0.1	0.8	16.2
Slovakia	66.7	4.5	10.9	759.2	19.0	121.9	25.8	0.8	1.2	45.4	5.0	6.7
Spain	*	*	*	*	*	*	*	*	*	*	*	*
Sweden	155.1	46.8	22.2	315.7	:	1,139.5	1.0	0.4	0.2	5.9	:	37.9
United Kingdom	*	*	*	*	*	*	*	*	*	*	*	*

* Data not available

Table 4. Fruit production in member states EU 27 states (tonnes) 2009
(FAO statistics; table grapes Eurostat)
(data from 2008).

Countries	Apples	Oranges	Peaches nectarines	Tangerines, clementines, mandarins	Pears	Table grapes	Plums and sloes	Lemons and limes	Strawberries	Kiwi fruit	Apricots	Cherries
Austria	485,609		8,837		168,663		71,732		17,108		24,410	30,276
Belgium	310,600				280,600		300		33,000			5,200
Bulgaria	35,456		17,187		1,442	17,300	17,246		8,599	106	7,568	17,456
Czech Rep.	170,400		3,600		4,400		6,300		10,812		4,950	2,404
Cyprus	6,640	42,110	4,780	33,400	1,730	3,100	870	14,150	1,770	170	1,820	580
Denmark	30,328				7,712		294		6,273			226
Estonia	5,446						69		1,105			108
Finland	4,268								11,578			
France	1,953,600	650	347,476	25,478	185,857	48,700	243,746	612	46,912	75,907	190,382	53,577
Germany	1,070,680		987		52,319		73,102		158,563		350	39,463
Greece	235,000	800,000	734,000	119,354	82,800	80,500	13,979	83,269	7,966	84,000	77,000	48,051
Hungary	575,368		61,400		32,256	17,500	51,487		6,597		33,457	8,126
Ireland	42,648								1,463			
Italy	2,313,600	2,359,400	1,692,500	863,900	847,500	1,400,700	194,100	486,200	56,400	436,300	233,600	116,200
Latvia	12,828				484		92		657			69
Lithuania	53,259				2,781		2,581		4,990			1,336
Luxembourg	10,190				940		212		18			33
Malta	57	1,165	1,343	90	33	500		533	480		35	
Netherlands	407,000				295,000		5,980		52,618			475
Poland	2,626,270		12,536		83,032		120,718		198,907		5,244	50,505
Portugal	280,078	201,592	54,255	64,369	249,109	21,700	21,026	12,050	2,650	12,777	5,034	11,227
Romania	517,491		17,132		66,111	66,700	533,691		21,969		32,499	67,874
Slovakia	50,000		400		200	300	700		1,209		400	200
Slovenia	95,662		9,950		9,862		4,101		2,054	252	616	3,951
Spain	594,800	2,617,700	1,191,300	2,026,200	434,200	292,300	227,800	551,000	263,700	18,800	97,100	96,400
Sweden	22,000				1,649		309		11,800			155
UK	243,000				20,000		24,990		84,965			1,538
Total	12,152,278	6,022,617	4,157,683	3,132,791	2,828,680	1,949,300	1,615,425	1,147,814	1,014,163	628,312	714,465	555,430

Table 5. Production % in member states of EU 27 states 2009. *(FAO statistics)*.

Countries	Apples	Oranges	Peaches, nectar-ines	Tangerines, mandarins, clementines	Pears	Table grapes	Plums and sloes	Lemons and limes	Straw-berries	Kiwi fruit	Apricots	Cherries
Austria	4.00		0.21		5.96		4.44		1.69		3.42	5.45
Belgium	2.56				9.92		0.02		3.25			0.94
Bulgaria	0.29		0.41		0.05	0.89	1.07		0.85	0.02	1.06	3.14
Czech Rep.	1.40		0.09		0.16		0.39		1.07		0.69	0.43
Cyprus	0.05	0.70	0.11	1.07	0.06	0.16	0.05	1.23	0.17	0.03	0.25	0.10
Denmark	0.25				0.27		0.02		0.62			0.04
Estonia	0.04								0.11			0.02
Finland	0.04								1.14			
France	16.08	0.01	8.36	0.81	6.57	2.50	15.09	0.05	4.63	12.08	26.65	9.65
Germany	8.81		0.02		1.85		4.53		15.63		0.05	7.10
Greece	1.93	13.28	17.65	3.81	2.93	4.13	0.87	7.25	0.79	13.37	10.78	8.65
Hungary	4.73		1.48		1.14	0.90	3.19		0.65		4.68	1.46
Ireland	0.35								0.14			
Italy	19.04	39.18	40.71	27.58	29.96	71.86	12.02	42.36	5.56	69.44	32.70	20.92
Latvia	0.11				0.02		0.01		0.06			0.01
Lithuania	0.44				0.10		0.16		0.49			0.24
Luxembourg	0.08				0.03		0.01					0.01
Malta	0.00	0.02	0.03			0.03		0.05	0.05			
Netherlands	3.35				10.43		0.37		5.19			0.09
Poland	21.61		0.30		2.94		7.47		19.61		0.73	9.09
Portugal	2.30	3.34	1.30	2.05	8.81	1.11	1.30	1.05	0.26	2.03	0.70	2.02
Romania	4.26		0.41		2.34	3.42	33.04		2.17		4.55	12.22
Slovakia	0.41		0.01		0.01	0.02	0.04		0.12		0.06	0.04
Slovenia	0.79		0.24		0.35		0.25		0.20	0.04	0.09	0.71
Spain	4.89	43.46	28.65	64.68	15.35	15.00	14.10	48.00	26.00	2.99	13.59	17.36
Sweden	0.18				0.06		0.02		1.16			0.03
UK	2.00				0.71		1.55		8.38			0.28

Table 6. Changes in fruit production areas (ha) in member states EU 27 states 2004 -2009 *(FAO statistics, table grapes Eurostat))*

Crop	Year					
	2004	**2005**	**2006**	**2007**	**2008**	**2009**
Apples	620,355	614,105	574,347	577,781	565,535	558,534
Apricots	79,464	78,975	75,271	75,014	74,941	75,700
Cherries	131,210	126,344	126,474	126,893	129,512	133,375
Table grapes	142,500	144,900	137,000	130,700	No data	No data
Kiwi fruit	31,933	32,757	32,700	33,250	33,947	35,551
Lemons and limes	89,188	87,577	85,591	83,092	88,620	84,281
Oranges	305,237	306,992	307,696	312,399	317,874	310,274
Peaches	262,576	258,046	253,260	252,674	239,646	244,716
Pears	147,620	142,733	138,900	137,928	136,666	131,879
Plums and sloes	221,204	209,111	192,834	189,937	186,629	188,901
Strawberries	107,402	114,017	114,857	110,078	111,942	110,857
Tangerines, mandarins, clem.	164,583	167,056	170,772	171,388	171,373	173,902
Total	2,303,272	2,282,613	2,209,702	2,201,134	2,187,385	2,178,670
% change from 2004						
Apples		-1.0	-7.4	-6.9	-8.8	-10.0
Apricots		0.0	-4.7	-5.0	-5.1	-4.1
Cherries		-3.7	-3.6	-3.3	-1.3	1.7
Table grapes		1.7	-3.9	-8.3	No data	No data
Kiwi fruit		2.6	2.4	4.1	6.3	11.3
Lemons and limes		-1.8	-4.0	-6.8	-0.6	-5.5
Oranges		0.6	0.8	2.3	4.1	1.7
Peaches		-1.7	-3.5	-3.8	-8.7	-6.8
Pears		-3.3	-5.9	-6.6	-7.4	-10.7
Plums and sloes		-5.5	-12.8	-14.1	-15.6	-14.6
Strawberries		6.2	6.9	2.5	4.2	3.2
Tangerines, mandarins, clem.		1.5	3.8	4.1	4.1	5.7
Total		-0.9	-4.1	-4.4	-4.5*	-4.9*

*Excluding table grapes

4. European fruit industry in the context of the global challenges

The main growth drivers in the fruit sector are convenience and portability, health and safety, new products and category innovation, and low cost, as EU consumers demand products associating high quality standards to features that make fruit more suited to new and improved lifestyles. In addition, the modern fruit industry needs to retain economic competitiveness, achieve full sustainability and respond to climate change. To reach these objectives will require the development of innovative technologies integrating diverse disciplines with the goal of maintaining the prominent role of fruit growing within the EU social and economic scene.

4.1. Human Health and Wellbeing

The nutritional value of specialty crops and fruit species in particular is in their rich sources of vitamins, minerals, fibre, acids, sugars and secondary metabolites in biologically functional forms. The key significance of diets and nutrition of fruit and vegetables is in the well documented effects on prevention of obesity, diabetes and cardiovascular diseases by mechanisms that are currently only partially understood. Horticultural products are known to be important for health and wellbeing of humans by regulating digestion processes, supplying slow-release sugar, reducing blood pressure, affecting uptake and metabolism of fats, and possibly by delaying the aging processes .

Fruit fibers provide significant multiple protection against cardio-vascular diseases (CVDs), as they contribute to cholesterol lowering and more importantly they cause a reduction in the harmful LDL-cholesterol and improve gut biota. Specifically targeted studies carried out within the EU-FPVI ISAFRUIT integrated project (spawned by EUFRIN) have brought new insights on this as well as other effects of fruit fiber in the reduction of blood pressure and the control of obesity.

Secondary plant metabolites are significant non-caloric components of plant-based food products and many of these can affect health. Those bioactive compounds (e.g. polyphenols such as anthocyanins, flavones, flavonols, flavanols and phenolic carboxylic

acid as well as carotenoids and other terpenoids, stilbenes, complex cell-wall components and many others) have pre-biotic, anti-inflammatory and antioxidant potentials which are often connected with prevention of metabolic diseases, aging-related disorders, allergies, rheumatism, cardiovascular complications and possibly certain cancers. Metabolites with pharmacological effects are for example lutein (i.e. improving vision in the elderly), polyphenols and cell-wall components in apple (e.g. reduction of cholesterol), xanthohumol in hops (e.g. induction of apoptosis in prostate epithelial cells) and the stilbene resveratrol in grapes and berries (e.g. cardio-protective and anti-inflammatory properties). Growth conditions such as solar UV-radiation, slow ripening and water availability can strongly affect the biosynthesis of polyphenols and other secondary metabolites in plants which in turn affects their bio-functional properties.

The so called "social diseases" have high priority in the Europe 2020 Agenda, which places fruit at the core of new improved dietary habits European citizens should be encouraged to adopt, as an increased fruit consumption at the population level is a real opportunity to improve health and wellbeing of humans. The demand for health-giving foods can be characterised as such:

- change from "corrective" medicine to "preventative" medicine and self care through diets and nutritional eating and exercise
- increasing demand of functional ingredients/food products and dietary supplements
- individuals taking more health responsibility, with health foods considered the most important instrument

4.2. Food Security & Safety

The World Bank (WB 2008) estimates that one in four people, or 1.4 billion, in the developing world are affected by extreme poverty. In particular and in consequence of the world food crisis, the number of undernourished people living in developing countries reached 907 million, and 923 million worldwide, in 2007 (FAO, 2008). The large number of undernourished people, however, marks only the peak of the global nutrition problem. A great many more suffer from food insecurity in general – a

situation characterized by an inadequate access, both in physical and economic terms, to sufficient, safe, and nutritious food for an active and healthy life (FAO, 1996). Food insecurity is not only related to animal-based products and arable crops, but also to horticultural produce with health related properties. Despite a range of European policies and intervention programs, poverty and food insecurity, which are closely related and may even reinforce each other, remain also critical issues within the European societies. Aside from undernourishment in severe cases, food insecurity often leads to a less evident form of malnutrition than the simple lack of sufficient food quantities, namely to micronutrient malnutrition ('hidden hunger') that is mainly caused by a lack of food of adequate dietary quality. Rough estimates suggest that about one-third of the world's population – mostly children and women – are deficient in at least one essential vitamin or trace mineral (UNICEF/MI 2004).

Labelling is required for nutritional/compositional information and ISO certification/tracking of food production for safety reasons is increasing. There is a shift from what product is, to what product can do. These developments require the use of new technologies (e.g. "omics") to monitor and document foods, both for regulatory reasons and for product safety reasons. The development of safe processes and methods of detection of unsafe processes is becoming increasingly important, as is the ability to demonstrate their use in development of a new product.

The production of safe products largely rests on innovation that combines advanced technologies with environment respecting approaches. The adoption of improved cultivars featuring genetic resistance to pests can easily complement Integrated Pest Management programs, with the goal of safer production of healthy fruit. Along the same lines, innovative, precise management technologies, such as the ISAFRUIT-developed intelligent CASA Sprayer (http://www.jhortscib.com/isafruit/isa_pp107_112.pdf; http://www.youtube.com/watch?v=FFD0znlba50&noredirect=1), illustrate how state-of-the-art engineering can be complemented with biological knowledge of pests and pest cycles, to achieve control of fruit parasites with up to 50% reduction in chemicals applied. In the research pipeline, the adoption of natural control methods (e.g. microbial competitors, hot water treatments) looms ever closer to be added to the tools that can

help control fruit diseases while significantly increasing fruit safety in commercial orchards.

4.3. Strategic Relevance of fruit

Fruit quality research is strongly aligned with many of the strategic growth trends currently identified in the global food and agribusiness sector. Scientists, partners along the food chain and industry end-users need to be aware of these trends as they represent the best opportunity for the European market. The key trends are as follows:

- Significant opportunities in the special food markets, including those foods that are 'differentiated' through health (including hypoallergenic), functional, organic or indulgent aspects.
- Consumer expectations of 'positive eating' experiences.
- Increasing interest in 'self-medication' through diet.
- Increasing middle and high income consumers (including those in low income countries) who are seeking an 'added value' component to their food purchases.
- A complex food chain that has moved from a production push to a consumer pull, thus demanding increased focus on consumer needs.

Two pathways are already existing which connect plant-based research providers and end-users through partnerships:

1. The conventional route to quality (primarily achieved through research partnerships with fruit industry and growers) has a history of innovation and technology uptake (new cultivars, Integrated Fruit Production - IFP, organic growing, marker-assisted breeding). The key indicator of contributions to relevant end-user outcomes is the high level of industry investment, adoption and further development of new technologies, innovations and products.
2. The genetic route to quality follows the plant biotechnology value chain. This involves forming new in-house and external partnerships for germplasm evaluation, construction of databases and gene sequences, identifying candidate genes that control key plant responses, and testing the performance of such candidate genes in

trees and in model systems. This is a more 'in-depth' knowledge-driven path that requires a strongly integrated, multi-disciplinary science approach, including conventional methods, to ensure a 'quantum leap' for the fruit industry and related plant-based industries.

4.4. Social Economy

Fruit growing is a long-term endeavour, as orchards go through an early unproductive phase lasting a few years, before they begin the positive part of their economic cycle, which often lasts more than a decade. This requires careful turn-over planning, to renew aging orchards and/or adopt new improved varieties as they become available, and the market may require. This turn-over is ingrained within fruit growing and mandates stability of the agricultural enterprise, placing fruit growing at risk whenever economic and/or social scenarios are created that favor abandoning this activity. The risks to society associated to this loss of technical, cultural, economic and social heritage are beyond description in their consequences.

The coexistence of orchards and natural landscapes is the backgrounds of many environmentally gifted regions of Europe. The continuous adoption of advanced technologies to reduce the environmental footprint of fruit growing goes hand in hand with time-honored growing practices that are recognized and appreciated as part of the cultural heritage and tradition of these fruit-growing regions. This adds no small measure of economic impact to those regions where the beautiful landscapes are a factor contributing to wellbeing and to boost the tourist industry. Furthermore, fruit growing provides protection to the environment from losses due to meteorological and climatic factors, contributing to reducing the effects of extreme environmental hazards, such as erosion, flooding, etc.

Because of its high intensity of cultivation, fruit growing is an important provider of employment to skilled labor, as pruning, picking, and in general performing growing practices require a high degree of specialization. In addition to this direct effect, fruit growing provides further economic opportunities related to the allied activities that fruit production, handling, trade and consumption warrant.

4.5. Competitiveness

Current trends in the horticultural sector are frequently a dichotomy with opportunities arising in both directions e.g. globalization vs. regionalisation, convergence vs. divergence and consolidation vs. fragmentation.

There is a trend towards consolidation of production and supply with a parallel increasing emphasis on global/regional partnering and commercial alliances. The trend reflects the increasing power of retail brands to meet buying power and logistical demands. The convergence includes the food, health, agricultural, industrial and biotech sectors. This brings with it a need for a multidisciplinary, flexible and integrated approach to science and technology development. The trend is also evident in research providers/funding systems as they move towards collaborative programmes and virtual networks.

Many of the trends are driven by the increasing competitiveness of the business environment. This competitiveness is particularly strong where there are few markets or entry barriers, where markets are saturated or demand is flat and where low-cost-structure regions/countries compete. Global trade barriers are/may be lowered/overcome by merging of key players within trading blocks, resulting to increasing amount of international global competition.

There is a steady increase in global fruit production in parallel with population growth worldwide. The key challenge will be how to compete in the long run, as without sufficient growth in demand cannibalisation results across all fruit markets and causes strong downward pressure on fruit prices. In order to stay competitive despite falling prices, production costs may have to be reduced through efficiency gains.

Fruit producers and suppliers therefore need to differentiate themselves from their competitors by demonstrating better cost structures, higher quality/consistency of product, ability to meet demand, efficient production systems, flexibility to incorporate new technologies, continuous and faster stream of new products, and decreasing product life cycles. Retailers want suppliers who are actively integrated into the entire production-to-consumer cycle.

4.6. Sustainability

Sustainability involves economic, environmental and social aspects. Economic criteria used in modern market-oriented agriculture such as the yield or gross margin are no longer sufficient for an evaluation of horticultural/agricultural practices, which should include an assessment of their environmental impact (e.g. carbon footprint, life cycle assessment, energy use, biodiversity, etc.). Separation of economic and environmental sustainability is undesirable, as any economic activity inevitably affects the environment and those impacts are currently paid for by society at large. These environmental impacts are now raising consumer concerns over product standards (is it safe to eat?) and, more recently, process standards i.e. the production system. Rising interest in good farm practices (e.g. EUREPGAP) is a response to this concern for process standards. Both short and long-term environmental impacts of existing and future horticultural practices need to be quantified, yet it is recognized that all stakeholders along the food chain do not share the same interests and values. Europe is well placed to take advantage of sustainability issues due to climate diversity, product and process innovation, and a reputation for quality and differentiated products. The rising demand for limited energy supply associated with production and transport leads to increased production costs and this will favour the local producer/supplier over the global trader.

4.7. Climate change

Under changing climates, several phenomena are expected to occur, at global and regional scales, which have the potential to impact European fruit production, including increased heat-water stress conditions,[5] changes in crop phenology, but also geographical shifts of the growing areas of several fruit species. Long term comparisons of meteorological data indicate earlier occurrence of blooming, harvest and leaf drop in

[5]IPCC 2007. Contribution of Working Group II to the Fourth Assessment Report. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds) Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

apple of up to 10 days for central Europe[6]. The expansion of grapevine and olive cultivation towards Northern and Eastern parts of Europe has been reported over the last twenty years[7].

Higher ambient temperature will lead to increased plant organ respiration and reduced plant water use efficiency with detrimental consequences on biomass production (yield) and product quality (fresh and processed produce)[8]. Higher evapotranspiration and reduced precipitation will result in a strongly negative climatic water balance[9] which has to be compensated through irrigation systems to ensure sustainable horticultural field production. These changes are expected to impact more the European Mediterranean countries which are the most exposed to temperature rises and water scarcity while irrigation needs in this area are expected to increase up to 20-30% by 2020[10].

Unrestricted water availability is not expected through Summer months due to price increases of cereals and other arable crops, which make irrigation of grain and maize more and more profitable, and to the possibility to overcome logistical and energetic challenges in an economically justifiable manner. Consequently, it is expected that total water consumption and the competition for water will increase in agricultural and horticultural production systems. A drastic decline of water consumption is therefore needed in the future; a demand which can only be met through crop specific and optimal mitigation and adaptation strategies such as irrigation and other production processes.

An increase in the frequency of extreme weather events, like severe drought stress, hail or heavy storms, presents further risks to fruit production, increasing variability in fruit yields/availability within years and regions of Europe. This scenario outlines the

[6]Kunz, A. and Blanke, M.M. 2011. Effects of global climate change on apple "Golden delicious" phenology - Based on 50 years of meteorological and phenological data in Klein-Altendorf. Acta Horticulturae 903, 1121-1126.
[7]Olesen, J.E. and Bindi, M. 2002. Consequences of climate change for European agricultural productivity, land use and policy. European Journal of Agronomy 16, 239–262.
[8]See above.
[9]Rosegrant, M.W., Ringler, C. and Zhu, T. 2009. Water for Agriculture: Maintaining Food Security under Growing Scarcity. Annual Review Environmental Resources 34, 205–22.
[10]Doll, P. 2002 Impact of climate change and variability on irrigation requirements: A global perspective. Climatic Change 54, 269-293.

increased likelihood of the threat to produce a steady supply of high quality fruit for the European consumers.

5. The strengths of R&D on fruit in Europe

The onset of the EU Framework Programmes (FP) in the early 90s prompted fruit scientists (geneticists, breeders, fruit physiologists, tree physiologists, ecophysiologists, nutritionists, pathologists, agricultural engineers, etc.) to realize the need and opportunity to cooperate and coordinate research in the fruit sector, if they were to be able to successfully answer EU-FP calls. The scope, complexity, number of partners that needed to be involved in a successful bid were a strong driver to the formation and/or consolidation of partnerships among researchers and research institutions. Such coordination efforts led to several successful projects covering a broad range of important topics crucial for the fruit sector: resistance to biotic stresses (Dare, Sharco), fruit quality (Hidras, Isafruit), tree physiology (Isafruit), human health (Flavo) and more recently climatic changes (Climafruit, FruitBreedomics). Most of these projects have been focused on the main two fruit species apple and peach, but also on berries (EuroBerry, EUBerry, Climafruit), apricot (Sharco) and pear (Erwinia), among others.

Most if not all of these projects were spawned within EUFRIN: an informal voluntary network created in 1992 gathering university departments and research institutes that specialize in research, development, and extension on temperate fruit crops and which are based within countries of the European Union, Switzerland, and Eastern Europe. The main objectives of EUFRIN are to enhance and facilitate coordinated research, development and technology transfer focused on aiding sustainable production of quality fruit (and fruit products) and to establish and improve cooperation between those involved in fruit R&D.

EUFRIN has a Board which typically includes two Country representatives (from approximately 25 countries) and the Chairpersons of the various Working Groups. The Board meets once a year, to discuss an agenda focused towards the exchange of information on fruit research. Over the years this has included the organization of international workshops and conferences but, perhaps more importantly, the organization of regular meetings of Working Groups dedicated to major topics such as Apple and Pear variety testing, Fruit quality, Fruit thinning, Plum and Prune, Soft fruit, Spray application techniques, Stone fruit variety evaluation, Sustainable fruit production

to minimize residues. Several of these WGs have been instrumental for successful EU bids, such as COST Actions and RTD Programs in specific areas.

5.1. List of the main successful EU-projects

Over the years, a number of expressions of interest have been put forward by EUFRIN, as prompted by the EU, for consideration and possible inclusion in the calls published by the Commission. On the other hand, EUFRIN WGs have also been able to successfully answer several of these calls. A short description of some (but not all) of the main projects that have been awarded over the years is given below as an example of the capacity of EUFRIN to generate successful applications.

Projects already concluded

D.A.R.E. *(Durable Apple Resistance in Europe) - 1998-2002*

An Integrated Project focused on sustainable resistance of apple to scab and powdery mildew. It included the characterization of the resistance in local and old European cultivars and also assessed the variability of the pathogens (mainly scab) all over Europe. Its main aim was to decipher the genetic architecture of this resistance.

HiDRAS *(High-quality Disease Resistant Apples for a Sustainable Agriculture -* http://users.unimi.it/hidras/*) - 2003-2007*

A collaborative effort between eleven European groups aimed at the identification of genetic factors controlling fruit quality, it featured an innovative approach based on the phenotypic and molecular characterisation of a large number of related genotypes. New software was developed to fully exploit genotypic, phenotypic and pedigree data, with the aim of identifying fruit quality Quantitative Traits Loci (QTLs) and to follow the transmission of their alleles along the pedigrees. Consumer preferences were accounted for, to identify the quality parameters that determine the success of a new apple variety in different European countries.

FLAVO *(FLAVOnoids in Fruits and Vegetables: their impact on food quality, nutrition and human health) - 2005-2007*

This targeted project (STREP) focused on fruits with high flavonoid content which are widely available to European consumers: apple, grape and strawberry, together with their derivatives cider, wine and compotes. The FLAVO project aimed to provide methods and tools to monitor the flavonoid content in fruits and vegetables so as to optimise their beneficial effects on health. It covered five complementary areas:

1) Determining the optimum sources and doses of flavonoids for health,
2) Developing tools for the breeding of "improved" fruits and vegetables,
3) Developing production techniques to optimise the flavonoid content,
4) Studying consumer behaviour towards new products,
5) Disseminating results to stakeholders and information for consumers.

ISAFRUIT *(Increasing fruit consumption through a transdisciplinary approach leading to high quality produce from environmentally safe, sustainable methods - http://www.isafruit.eu) - 2006-2010*

An Integrated Project focused on the entire fruit chain, following a fork-to-farm approach. The strategic objective of ISAFRUIT was to increase fruit consumption, searching the improvement of health and wellbeing of Europeans and their environment, by taking a total chain approach, identifying the bottlenecks and addressing them by consumer-driven preferences. ISAFRUIT activities focused on:

1) Consumer driven and responsive supply chains,
2) Fruit and human health,
3) Improved appeal and nutritional value of processed fruit,
4) Improved quality, safety and sustainability,
5) Preharvest chain quality and sustainability,
6) Genetics of fruit quality.

Current Projects

Sharco *(Sharka Containment in view of EU expansion - http://www.sharco.eu/sharco/) - 2009-2012*

The concept of SharCo is to combine prophylactic and genetic solutions to prevent or limit the spread of the sharka disease. The project covers the entire chain from planting material (seedlings, scions …) production to orchard management. It addresses all concerned stakeholders, breeders, nurserymen, fruit producers, and plant protection services with relevant outcomes including resistant varieties, management guidelines, cultivation guidelines, optimised survey and detection methods and tools.

ClimaFruit (https://www.climafruit.com) - *2009-2013*

Climafruit is a regional project which aims to establish transnational cooperation between research institutions and the North Sea Region (NSR) berry fruit industry in order to maximize the implementation of innovative technologies. The project will produce methods to reduce the carbon footprint of the industry, superior plant material and future production strategies better suited to the NSR climate, as well as a virtual Soft Fruit Climate Change and Environment Centre, ensuring the continuous uptake of methods by the berry fruit industry. As a first output, a new transnational cultivar trial was established across the five partner countries and considerable activities were carried out on increasing the knowledge on sustainability of berries. Focusing on adaptation strategies, studies were carried out to determine the potential impact of climate change on fruit quality.

FruitBreedomics *(an integrated approach for increasing breeding efficiency in fruit tree crops* - http://www.fruitbreedomics.com/*) - 2011-2015*

The aim of FruitBreedomics is to provide the European fruit tree sector with cutting-edge breeding tools for the efficient and accelerated creation of new apple and peach varieties with excellent fruit quality characteristics, improved resistances to diseases and pests, and that can be grown in sustainable agriculture systems in the context of climate change. Additionally, the project aims at increasing the accessibility of

breeders to the genetic diversity present in GeneBank germplasm collections, thus contributing to widening the genetic basis of cultivated fruit trees. FruitBreedomics will use a multidisciplinary approach that includes genetics, genomics, ecophysiology and bioinformatics, and will liaison international partners with complementary expertises.

In addition to research-projects, fruit researchers have also been very active in collaborative networks (Endure) but also in COST actions. Some of them gave birth to new integrated European projects:

ENDURE *(http://www.endure-network.eu/) - 2007-2010*

The objectives of the ENDURE network were to define research priorities on pest control and reduction at the European level, to gather knowledge, facilities and human resources according to the needs of agricultural extension, industry, and the non-profit sector and become a source of reference satisfying farmer needs and societal expectations.

One of the outputs of ENDURE has been the creation of **PURE** (http://www.pure-ipm.eu/), a recently started EU project (2011) on the development of more and better crop protection techniques. The results will contribute to the implementation of the national action plans that European countries have to draw up in the context of the EU Directive on Sustainable Pesticide Use. In four years, Pure should lead to accepted and sustainable solutions for farmers and growers in controlling pests and diseases in crops such as wheat, maize, field and greenhouse vegetables, and fruit.

COST-Action 864: PomeFruitHealth *(Combining traditional and advanced strategies for plant protection in pome fruit growing) (http://uniwien.4297.srv09.kombjuder.de/index.php):- 2006-2011*

A network of plant protection specialists dedicated to gaining a deeper understanding of the major disease and pest constraints on apple and pear. It aims to develop integrated and sustainable orchard systems that deliver high-quality, healthy pome fruit to European consumers, promoting ecologically-sound agricultural practices.

Tackling existing, chronic problems as well as emerging threats from invasive and spreading pests and diseases will be the central theme. This Action networks bacteriologists, entomologists, epidemiologists, biochemists, microbial ecologists, molecular biologists, mycologists, tree breeders, national plant protection agencies and industry with the aim of integrating their efforts to design holistic pome fruit health management systems.

Cost Action 863: Euroberry *(Toward an organisation of the integrated research of berries - http://www.euroberry.it/)*

The main objective was to improve the quality and production of berries to benefit consumer health and maintain European production using sustainable systems. By using an interdisciplinary approach the programme focused on selected topics of major importance for the European berry production system and quality control: genomics, variety evaluation, nursery production systems, plant physiology and culture management, health for the consumer. The EUROBERRY Cost action has been at the basis of the new European project EU-Berry

EU-Berry *(The sustainable improvement of European berry production, quality and nutritional value in a changing environment: Strawberries, Currants, Blackberries, Blueberries and Raspberries - http://www.euberry.univpm.it/) - 2011-2014*

To provide the necessary knowledge and tools to facilitate development of high quality, consumer-desirable fresh berry fruits of high nutritional quality optimal for human health at a competitive cost. A further objective is the development and validation of a set of tools to improve competitiveness of European berry production and consumer accessibility to berry fruits. The EUBerry platform will be developed and validated by using strawberry, raspberry and blueberry as model species. Specific work related to improvement of berry fruit quality and reduction of production costs will also be performed for currants and blackberries.

5.2. Roles of EUFRIN in the fruit chain

Aside from its engagement in facilitating collaborative research, EUFRIN is involved in providing expertise to the fruit supply chain via advisory services to growers and support to suppliers, marketing desks and retailers. Most of the WGs of EUFRIN meet once a year, and participation to them is open to any researcher active in the specific field. They have strong interaction with chain stakeholders, such as in the case of the chemical or nursery industries. Some of the WGs adopt common protocols, so that results can be compared across different environments and used to deliver to growers technical consulting suited to their local condition. This internationally coordinated activity, in turn, has led to the recognition of these Working Groups as a *de-facto* authority in Europe on specific fields by relevant industry stakeholders. For example, some of these Working Groups have carried out groundbreaking work in establishing protocols and memoranda of understanding between interested partners that have been widely adopted (e.g. variety evaluators and nurseries owning exploitation rights).

Further examples of the EUFRIN legacy include the widespread uptake of European research outcomes on a global scale, which has allowed significant technical improvements in the fruit chain worldwide. Witness to this are the adoption of high density planting systems; new cultivars; spray technology; integrated fruit production; quality assurance programs; non-destructive technology for quality assessment; etc.

6. Constraints to the development of the European Fruit Sector

6.1. Current status and risks

The importance of primary production in our food supply is often underestimated, despite its essential role in delivering fresh fruit and vegetables, and underpinning the supply of ingredients for food manufacturing companies[11]. Many Governments have endorsed the consumption of fresh fruit and vegetables as a critical part of a balanced diet and to ensure health and wellbeing of consumers[12]. However, the European fruit sector is facing risks due, among other factors, to: (i) reduced fruit consumption; (ii) increased competition from low-labor-cost, non-EU countries (who are increasingly adopting state-of-the-art technology); (iii) diminishing availability of skilled labour; (iv) the high susceptibility to pests and diseases of most commercial fruit varieties. In spite of these risks, current state of art is that agricultural research has been underfunded and there are questions being raised as to whether current production systems are equipped and prepared for the highly dynamic changes that are expected, if the sector is to successfully face impending increased environmental regulations, extreme climatic conditions and limitation of input resources[13]. To date production of primary products has focused on incremental gains[14], including better targeting of fertilizers and water use, prediction systems to reduce chemical use, and evaluation of new cultivars. According to the European Commission a transformation to sustainable societies in a changing environment is a priority[15]. Therefore we need a paradigm shift in how food is produced in order to meet future requirements and targets[16].

[11] http://ec.europa.eu/research/agriculture/scar/pdf/scar_2nd_foresight_exercise_en.pdf.
[12] http://www.5aday.nhs.uk, http://www.5aday.co.nz, http://www.5aday.com, http://www.5aday.net, www.6omdagen.dk
[13] See 5.
[14] See 5.
[15] Europe 2020: A European strategy for smart, sustainable and inclusive growth – COM2020, KBBE Europe 2020.
[16] http://ew.eea.europa.eu/research/info_resources/reports/Final_Literature_Review_Report_FINNov07_9473.pdf and see 5.

6.2. Fruit attributes and consumer expectations

Fruit production in Europe is facing many challenges in the market place due to increased consumer expectations for quality, taste and uniformity, combined with significant changes in lifestyle and food consumption patterns. Although purchase is still largely driven by appearance, the greatest driver for repeated consumption of fruit is taste, therefore focus on development and delivery of high taste cultivars, combined with technologies and solutions to manipulate, sustain and deliver products to the consumer is essential. In addition, consumer awareness of the multiple health-related benefits of fruit consumption is not sufficient to boost fruit consumption. This lack of knowledge is, at least in part, due to the limited efforts to promote them by the fruit chain (the proportion of TV commercials promoting fruit as opposed to snacks is illuminating). Many consumers, despite checks by regulatory authorities attesting to the contrary, are instead concerned about the safety of fruit which are perceived as "residue carriers", unless they are produced in "old, traditional ways". This happens mostly because in the eye of the general public fruit growing is reminiscent of idyllic scenes, recalling past traditions and bucolic settings, as always represented by the media. This makes consumers sceptical about the benefits deriving from the uptake of technological innovation in the fruit chain, which often leads to the rejection of significant improvements in the production systems, while accepting outdated cultural practices that have lost their effectiveness due to their economic, or their environmental impact.

Consumers are also demanding increased convenience in products and there has been a significant trend for increased consumption of prepared fruit snacks and fruit based beverages. Fresh fruit is struggling to compete with the convenience and homogeneity of other less healthy manufactured snack products, e.g. potato crisps and chocolate. Manufactured snack products tend to have a relatively short product development lifecycle and a short product life. In contrast breeding and development of a fruit cultivar to commercialisation is a long-term commitment and requires significant investment. To conceptualise the size of this weakness we should compare 'apples' to 'a manufactured chocolate bar', the chocolate is highly uniform, the taste experience is consistent, and the product is readily available independent of climate and natural

extremes. If a production change is made during manufacturing of the chocolate bar, this change can be implemented on a global scale and it can create an instant impact in the position of the end product in the market place and the competitiveness of that product. If a new technology is introduced into the production systems for apples, this technology will then need to be evaluated for the various apple varieties, growing region, climatic variability and national regulatory restrictions within the many, diverse fruit growing regions where apple is grown. Due to the existing environmental and climatic variability it can take several years to collect the data to justify a production change and the likelihood that this advancement in technology will be implemented on a global scale is very low because the global fruit industry is fragmented and competitive.

One of the most significant weaknesses in fruit production is the biological variation that exists between individual fruit, which is of no help in overcoming the overall challenge for the industry to meet consumer expectations. Product variation leads to variable taste experiences and consequently variable – often reduced – consumer satisfaction. Technologies, solutions and progress in overcoming or managing product variability are essential to underpin the competitiveness and trustworthiness of the fruit sector. Ensuring that fruit quality is consistent will secure a premium, increase the likelihood for repeat purchases and ensure a competitive position for fruit products against less healthy manufactured food goods.

There is also a significant need for scientific evidence documenting the health benefits of fruit consumption. Development of advanced and increased efficiencies and technologies at different stages in the production chain is needed. An improved understanding of the genetic traits that influence the development of novel and superior cultivars is essential. Consumers also have an increased awareness and requirement for locally produced fruit and fruit based products; this focus on 'regionality' is underpinned by a need to deliver a reduced carbon and water footprint and to increase the sustainability of production practises. Consumers also demand that the fruit industry be accountable for safety and traceability with respect to chemical use, chemical residues, and environmental impacts of the production systems. Therefore, there is an increasing need for new cultivar development with improved disease tolerance that can be grown under low chemical input systems or organic production systems, and for cultivars with increased efficiencies with respect to water and nutrient use. It is essential that these

cultivars also deliver superior taste and quality attributes in addition to an economic yield.

6.3. Fruit production and industry challenges

Fruit producers in Europe are faced with reduced economic returns, due to having a reduced control in the market place. Consolidation within the fruit industry has led to a small number of larger storage and packing facilities that tend to focus on a narrow range of products, varieties etc. This has led to fewer products and less diversity in the market. Consolidation of supermarkets has followed a similar trend, resulting in supermarkets having an increased decision-making power in the market place with respect to pricing and product availability to consumers. Consequently, fruit producers have focused on increasing productivity and being able to differentiate their products through delivering novelty into the market place in an attempt to secure a premium. However, the market is currently controlled by the supermarkets, who deliver low priced products to consumers at the expense of the fruit industry. Low returns to fruit producers negatively impact on the ability of the industry to implement competitive changes because of a limited capacity to invest in new technologies. Regulatory changes are needed within the structure of the food chain, to ensure a future role for fruit producers in the food chain. Regulatory changes will encourage investment within the fruit industry, will increase return on investment in research and development and will secure implementation of research outcomes that will increase the competitiveness and efficiency of the industry.

Biological variation arising during the production phase also creates significant challenges to the distribution segment of the chain. Variation during production leads to compromises in harvest, packaging and storage decisions. Decisions on when to harvest, what to harvest into, how to grade and store the fruit is all compromised based on variability across a normal distribution. This poses a very serious hurdle to the possibility of creating fruit brands, which might offer a competitive advantage to growers in terms of obtaining better prices. The experience of “fruit clubs” until today is probably positive for the growers, but it has the obvious limitations inherent to the

concept of "controlled scarcity of supply", i.e. the concept only works if just a handful of growers is producing the crop. In contrast, the manufactured goods are highly uniform and can be optimally packaged, handled and transported as all the products are the same. On the contrary, during the fruit production chain 30% of all fruit is wasted. Given future societal challenges on the imbalance between the volume of food produced and population, a focus on how to minimise wastage is critical. The EU Integrated Project ISAFRUIT has for example carried out ground work on developing a Decision Support System capable of integrating information from the pre- and post-harvest sectors of the chain, with the aim of providing storage managers/wholesalers with estimates of the storing potential of each fruit, so that they can be differentially managed according to their specific quality traits, and the potential for storing without loss of eating quality[17]. Such systems are still in their infancy and more work is needed before they can fully implemented.

Fruit production and its associated production challenges pose many research questions. The chain is complex and each researcher has expertise in a fraction of the total chain. Therefore there is a need for science based solutions focused on the development and advancement of primary production itself. Increasing environmental regulations has led to fewer solutions available to producers and they are reliant on research solutions to be able to deliver a quality product. Alternative approaches to spraying and use of energy are needed to deliver sustainable tools for producers. Reduced access to pesticides and a focus on decreasing chemicals use and residues means that new knowledge and exchange of knowledge between research and industry is essential to sustain the fruit industry into the future. Due to the complexity of the fruit production system and the diverse research skills and expertise needed, only a few countries, if any, can cover all research topics within the fruit food chain. Small countries or minor crops have a lack of research funding to cover all aspects of the chain; this is a limitation as the ability to develop some of these crops into significant industries is therefore also very limited. Consequently, collaboration between countries is an essential tool to exchange knowledge and ensure access to scientific expertise that any

[17] http://www.peaple-dss.pl/Home,1.html

single institute, region or country does not have. Establishing a platform for the integration of fruit research in Europe will provide a significant opportunity to strengthen fruit research, fruit production and to exploit nationally based knowledge resources and to secure dissemination of new research solutions at an international level.

6.4. Challenges related to the research structure

All European countries are conducting research on fruit. Fruit research includes a wide range of disciplines: market research, consumer behaviour, genetics of fruit plants and breeding of new cultivars using a suite of technologies. Technical attributes of plants are also a major focus within fruit research including physiology, production methods, fruit quality, safety, security, storage, nutrition, bioactivity effects, health of fruit and fruit consumption, pests and diseases, effects of pesticides, sustainable production methods, organic production methods, and production technologies including automation, ICT, robotics and sensors. Despite several notable examples of EU-wide research collaborations exist (fruit genetics; post-harvest; crop protection systems), where integration across Europe has been achieved and a trail of common research projects funded by the EU already exists, research is often focused on the production of a fruit crop within a region. Furthermore, research is often carried out in partnership with growers or grower industries to ensure knowledge exchange and capability development to enable industries to be nationally and internationally competitive. Breeding of new cultivars or evaluation of new fruit cultivars is usually carried out at a national level. A consequence of this fragmentation is that often this research suffers from lack of critical mass in order to be able to generate important results, that may positively impact the fruit chain. Therefore stimulating strong collaborative research initiatives that cross national borders is critical to accelerate knowledge exchange between countries and to lift the overall success and to secure the future of the European fruit industry.

7. Strategic Research & Innovation for the European fruit industry

Despite its limited acreage compared to other crops, fruit production is one of the prevalent agricultural activities in Europe for its economic, social, environmental relevance. Being a technologically advanced sector, the fruit chain provides employment to a large number of EU citizens, as it encompasses the production, storage, marketing, logistics, wholesaler and retailer sectors. Its competitiveness on the global market is highly dependent on research and development activities that can lead to improved knowledge and professional proficiency of all stakeholders involved.

Fruit has a privileged place on the table of EU consumers for its taste and appeal. However, stimulating fruit consumption should receive a high priority among EU goals, since this source of food is capable of conferring important health benefits, particularly in the prevention of many so called “social diseases”.

Despite a global market and competition that is met via state-of-the-art technologies throughout the chain, fruit growing is part of the legacy of local traditions and favors the preservation of beautiful landscapes throughout Europe.

Those outlined above are but a few traits that set the fruit sector on par with the other major food products grown in Europe, and for whose development and inclusion in the KBBE several Technology Platforms have been created, and further organized. However, the fruit sector and its specific needs for innovation are not appropriately represented in existing Technology Platforms. Part of this resides in several specific traits that can be associated with fruit, and are not the norm for other crops. These include:

- Fruit is a unique commodity, as it is being mostly traded and consumed fresh, although processing is quite extensive. Fresh fruit is highly perishable and needs high-technology logistics.
- Fruit species mostly comprise perennial plants, whose lifecycle spans several years, and in which an initial unproductive period adds to the financial burden sustained by the grower. Moreover, often orchards cannot be replanted on the same site because of diseases and soil sickness.

- Fruits and fruit-derived products have highly effective health components that confer antioxidant properties, weight control properties, protection from cardio vascular diseases, and from cancer. Several fruit are considered "superfoods" because of their potential in contributing towards meeting daily intake quotas of important dietary components.
- Fruit growing requires high financial commitment (initial investments, operating cycles) and under current commercial and financial conditions this puts the fruit sector in Europe under very strong competition from non-EU countries. Neglecting the sector needs for innovation and development will expose Europe to a loss in terms of economy, land preservation and culture.
- Fruit growing is a knowledge based, very intensive activity and one that requires high levels of professional knowledge and skills to be carried out successfully. This is a positive, in that it leads to a natural need for innovation to be brought to the sector.
- Research in the fruit sector has historically been led at national or regional (subnational) level. Despite EUFRIN's engendering many successful international bids that have received EU funds, at the international level much is still lacking in terms of research coordination.
- The fruit chain will benefit from better integration to appropriately exploit the technological progress and the positives that each player in the chain is able to contribute to it.
- Fruit consumption is decreasing, as a result of many factors, including price, limited convenience and availability, lack of consistent quality, lack of innovative fruit types or fruit-derived products.

The EUROPE 2020 Strategy calls for a model of growth capable of addressing Europe's future societal, economic and environmental issues. Such growth must be **smart** (based on education, knowledge and innovation); **sustainable** (based on a resource-efficient, greener and more competitive economy); **inclusive** (based on high employment and economic, social and territorial cohesion). The fruit sector is in an excellent position to pursue smart, sustainable and inclusive growth, as illustrated by the following sections, which provide more in-depth analysis of some issues where

research and technological innovation may benefit the European KBBE by benefiting the fruit chain of Europe.

7.1. The Fruit Sector contribution to society

7.1.1. Our Vision for 2030

By 2030 fruit consumption will have considerably increased, contributing significantly to Europeans' well being and health. The increase will be brought about by a reliable supply and consumption of healthy, accessible, convenient, novel fruit and fruit-based products for European **consumers**.

To meet this demand, the European **fruit production** will contribute by providing a secure, continuous supply of consumer-oriented healthy foods. This will be delivered through European interdisciplinary research, encompassing social and natural sciences. As well as improving health, resulting benefits will include the development of **specialist expertise throughout the supply chain**, education through knowledge exchange, wealth creation for the rural environment, the empowerment of rural areas and the preservation of the landscape.

7.1.2 General rationale

The fruit sector is well positioned to have an impact on compelling societal issues in Europe. Because it is an economic- and labor-intensive activity, in several European countries fruit farms tend to be small-medium in size, and that enhances their capacity and role in preserving the landscape and maintaining local culture, traditions and products. Fruit growing is often a driver of local economies, which provide skilled labor and many services: education, logistics, technologies, marketing, etc. Over the years, this role has expanded to other societal aspects. For example, regional/national cooperatives of fruit farmers have been formed almost a century ago (and still exist), with the initial goal of providing market access to farmers that would otherwise not have had it, but more and more recently, access to technological improvement. Today, the largest of these outfits have reached a size that allows them to be strong economic players both

nationally and internationally, providing employment and economic welfare to many EU citizens.

Projected increase in global urban based populations and unprecedented climate extremes emphasize the need to focus on food security and food safety. If fruit production is moved to non EU countries due to lower production costs the EU will become dependent on importing essential foods. Relying on imported fruit will negatively impact on the regions and will leave the EU at risk during times of global competition for food as we will be unable to secure a supply of food for EU consumers.

7.1.3 How R&D in the fruit sector will deliver on EU societal issues

- Introduction of "omics"-based breeding, including development of new fruit ideotypes addressing consumer preferences, providing growers with varieties that are easier to grow and manage along the chain, while preserving superior taste attributes will secure the EU fruit supply.
- New innovations will be delivered into the fruit sector driving profitability and competitiveness to secure young highly skilled growers. This will prevent the loss of a generation of older fruit growers and their expertise because younger generations prefer to be urban based. Innovation and value will be implemented throughout the EU fruit chain, an interdisciplinary approach will be followed to validate the food chain, thereby increasing the trustworthiness of the food chain, and driving an increased consumption through increased consumer confidence.
- R&D focused on delivering EU fruit products that are aligned to consumer needs. Consumer needs must be defined through consumer-driven R&D. The EU fruit sector must deliver a reliable, healthy, convenient and tasty fruit product that is a superior alternative to manufactured food products.
- Increased consumer awareness on the value of seasonal, healthy and fresh food choices will underpin growth of the EU fruit sector.
- R&D is needed that focuses on the benefit of the EU fruit industry in retaining the natural capital in Europe. Validation of the terroir value of locally grown fruit and validation of the EU fruit sector in eco-tourism and in protecting the environments via land stewardship will improve consumer awareness of the value of EU fruit choices.

- R&D focused on strengthening the role and contribution of urban horticulture to secure a healthy food supply in urban environments.
- R&D delivering increased productivity and efficiencies and uniformity to ensure that the EU fruit sector can deliver competitively priced products for EU consumers and that the quality of products exceeds consumer expectations.
- R&D to underpin the delivery of fruit and fruit based products with enhanced functional health properties to drive an increased fruit consumption, via innovative production practices including orchard light conditioning via photo-selective films to enhance the production of pigments, use of natural compounds, modification of resource inputs to regulate beneficial properties will provide added value for the consumer.
- Innovative processed fruit and fruit products tailored to consumer segments: young, elderly, overweight, diabetics etc. Nanoencapsulation of bioactive components for enhancing functional properties of fruit juices and purees; flash vacuum expansion in fruit processing for juice and puree; membrane technology in concentrated juice production; non-thermal fruit products preservation (high hydrostatic pressure, pulsed electric field, ozonation, ultrasonication); edible coatings to prevent browning, microbial decay and losses of bioactive components and to enhance texture and sensory properties of ready-to-eat cut fruit; utilization of fruit processing wastes for industrial raw materials and biogas production will increase the consumption of EU fruit and fruit based products.

7.1.4. An example of research in the Fruit Chain that can address EU societal needs

Maintaining or developing the consumption of fruit and vegetables is mainly a question of offering better access to households, both psychologically (inducing a purchasing reflex) and physically (making fresh and perishable products easily available). This is an important factor, especially as the change in lifestyles and the necessary time trade-offs this entails are pushing consumers to look for more efficient supply methods. In this context, the study of the changes in trade and purchasing patterns takes on particular relevance. Consumer science resources will need to be mobilized to provide insight into the issues at stake in the distribution of fruit and vegetables, for example via consumer panels to obtain valuable information on places of

purchase (POPs) of the households, POP evolution, customer profile for the various POPs, and composition of the average shopping baskets. Some organizations (e.g., Ctifl in France) are already pioneering these studies. The barometer on the perception of points of purchase will allow to measure consumer appreciation of fruit and vegetable outlets throughout the year and to shed light on consumers' motivations and their expectations as to selling methods and services to customers. After a long period of expansion of supermarkets to the detriment of traditional specialty shops, market shares seem to be stabilising. However, within each category, thorough changes are at work. Studies will be needed to analyse and interpret these phenomena. For instance, the specialised fruit and vegetable retail sector has recently seen the emergence of fresh food specialty supermarkets, a fairly successful concept. The large supermarket chains are following the trend, trying to adapt their models. Over the last few years, they have invested heavily in convenience store formats, which seem to have gained renewed consumer interest. They are also studying sale methods that facilitate purchase (development of drive-in supermarkets and online shopping sites). And then there is the resolve of operators in the production and retail sectors to answer the wish of certain consumers to add more social awareness to their purchases of food products. This can be done by means of quality labels or warranty certificates, or by somehow rehabilitating short distribution circuits. The goodwill value of fruit and vegetables will remain intact. However, for it to fully translate into an intention to purchase, a new generation of consumers has to be attracted and retained. Thought must be given on how distribution methods can be adapted to woo those new consumers into settling into their new habits.

7.2. The Fruit Sector contribution to EU economy

7.2.1. Our Vision for 2030

By 2030 all the components of the European fruit chain will have increased competitiveness by intensive use of novel, eco-innovative technologies. These will secure greater profitability by means of increased labor efficiency, improved quality and productivity, reduced waste, innovative products and increased consumption of fruit and fruit products.

7.2.2 General rationale

The fruit sector in Europe represents one of the highest valued agricultural businesses. The importance of the industry warrants that efforts be made to maintain its competitiveness in the face of increasing pressures from countries external to the EU, which normally reap the benefits of lower labor and production costs, often coupled to the adoption of state of the art technologies that are developed elsewhere (e.g. in Europe). In the fruit sector, the European R&D has historically been quite advanced in most areas, providing cutting-edge advancements from genetics to pre-harvest techniques, to post-harvest management, to logistics and sales, often thanks to EU-supported Projects. In spite of this, EU fruit producers are facing reduced economic returns, as they have reduced control in the market place due to the strength of the retailers and competition from imported products. Therefore R&D focused on implementing new technologies into the fruit chain are needed to increase efficiencies and profitability.

7.2.3. How R&D in the fruit sector will deliver on EU economic issues

- R&D focused on delivering novel cultivars with increased productivity and reduced reliance on inputs (resource and chemical) that meet consumer requirements will drive consumption and increase profitability. These developments will be based on breakthroughs in genomics and breeding, and by bridging these two disciplines.
- R&D focused on delivering novel cultivars that are differentiated and competitive against alternative snack/food products will increase the likelihood that consumers will choose and consume fruit and fruit based products.
- R&D elucidating the physiological processes underpinning tree performance will increase the efficiency of production systems and reduce product variability and optimize fruit handling throughout the fruit chain thereby increasing profitability.
- Innovative “omics” approaches to control tree behaviour and implementation of “soft-technologies” will increase competitiveness.
- R&D focused on improving systems within the fruit chain that deliver digital communication and improved decision making tools through ICT and sensor based technologies will increase efficiencies and drive profitability.

- Increased cross-communication and linkage of the fruit sector with other food technology sectors will increase product and process innovation.
- R&D focused on increasing the linkages between industries within the entire food chain will increase connectivity and will secure a common vision for the players in the chain; this will increase efficiencies and ultimately the value of the end product when it reaches the consumer.
- R&D delivering innovation throughout the fruit chain will improve quality and reduce wastage.
- Validation of the EU fruit sector through life cycle analysis and thereafter targeted innovation to increase the sustainability of the EU fruit sector will increase its competitiveness and provide increased consumer confidence in the chain.
- R&D focused on delivering full traceability throughout the fruit sector will increase consumer confidence in the safety of fruit and fruit based products.
- R&D delivering novel fruit based products through innovative knowledge and technologies will increase the suite of products available to consumers and drive consumption.
- R&D focused on consumer choices and how to align novel fruit products to consumer segments will drive increased satisfaction and increased consumption.

7.2.4. An example of research that can address the economic needs of the Fruit Chain

Controlling and reducing biological variation in fruit quality can result in increased consumer confidence in fruit consumption, as large variation in the eating and nutritional quality of sold fruit often confuses and disappoints the consumer. Reliable markers, instruments and decision support systems will be developed to measure, control and reduce biological variation in fruit quality at the point of sale, to fulfil the expectations of the European consumer relative to produce quality including, but not limited to, its nutritional value and contribution to human health. This will be pursued with a whole-chain, i.e. from farm to fork, approach to determining the control of biological variation. Genomics, Transcriptomics and Metabolomics will be employed to gain insight into the relations between genetic, growing and postharvest practices and the variations in fruit quality. The project will provide knowledge relative to, and control of, the determinants of variation in fruit quality, affording European stakeholders a competitive advantage in the world fruit

markets. The reduction of variability in fruit quality will benefit the European consumers, providing them with healthy fruit of better, more consistent quality.

Allied research will focus on the development and implementation of omics technologies that can detect and allow to control the basic processes underpinning quality development in the product before harvest, which are known to impact the post-harvest period, and the eating quality of the fruit. Key processes in the fruit production chain, such as cultivar choice, regulation of fruit crop load, growth control, fruit maturity assessment at harvest and prediction of physiological disorders in storage and further along the supply chain will be considered. This knowledge will give the EU fruit sector a competitive hedge for the production of stable high quality fruit.

7.3. The Fruit Sector contribution to EU environment

7.3.1. Our Vision for 2030

In 2030 innovative European fruit production systems will contribute to the preservation of the environment through the adoption of an array of eco-innovative technologies which will deliver better products and reduced wastage under threats from climate change and limited natural resources. This will be achieved through energy efficient systems and innovative management tools which will optimize the use of production factors, and minimize the carbon, water, mineral nutrients, pesticides footprint of the fruit chain while improving land-stewardship.

7.3.2. General rationale

Sustainability is an important driver for many European policies, and regulations often include sustainability aspects such as 'green' public procurement: minimizing greenhouse gas emissions, reducing wastes, minimizing energy consumption and fostering efficient use of resources. Because of the interdependencies between processes involved in growing, harvesting, storing, processing, distributing and disposing of a product, sustainability requires a life cycle analysis encompassing the whole chain. "Greener" fruit orchards should incorporate the smartest, safest and most effective cultural practices developed, without any **a priori** consideration of the production

scheme under which they have been developed (integrated vs. organic), including the positive additions derived from implementing biotechnological knowledge. The goal is that of focusing the fruit sector on production methods that are truly the most advanced in terms of smart, careful use of all available technologies and knowledge. This includes not only the production of fruit and fruit-derived products, but of biomass as well, the evaluation of land use, the consumption of water, energy, pesticides and fertilizers.

7.3.3. How R&D in the fruit sector will deliver on EU environmental issues

- R&D focused on delivering novel cultivars with increased pest and disease resistance will reduce the use of chemicals throughout the fruit chain.
- R&D targeted at minimizing chemical residues on EU fruit, increasing the use of biological pest control and the use of novel and alternative technologies to chemical regulation of fruit trees will reduce the impact of the EU fruit sector on the environment.
- R&D delivering precise EU fruit growing, including real time orchard management for easy, reliable, accurate assessment of vital crop statistics, real time adjustment of production factors and precise use of water, chemicals and fertilizer, and adoption of growing practices capable of reducing resource inputs will improve the balance between the production system and the environmental resources.
- Innovative technologies to produce more with less; to produce and to deliver innovative fruit and fruit based products, to increase implementation of sensors, artificial intelligence, intelligent management systems and remote sensing technologies will minimize the EU fruit sector footprint.
- R&D delivering new detection tools for climate change issues; including smart irrigation systems, improved warning systems, and diagnostic tools for new and emerging pests and diseases.
- Innovative solutions for delivering in-orchard assessment of storage potential for reliable and longer storability will reduce fruit loss across the chain leading to lesser impact on the environment.
- Reducing waste of fruit and fruit-derived products at all points of the supply chain.

7.3.4. An example of research that can address environmental needs of the Fruit Chain

Fruit growing requires intensive cultivation to achieve the high quality and production levels that are needed for it to be profitable. Emerging technologies in various sectors could be brought together in order to reduce the carbon, water and nitrogen footprint, with the goal of achieving full environmental sustainability of fruit growing.

The integration of smart production systems that reduce energy inputs via better management of production factors with the exploitation of orchard by-products (e.g. pruning residues for biofuels; apple pomace for juice production as ingredient of novel functional foods) can have significant impact in "greening" the orchard. Research allowing real time assessment of relevant physiological traits via affordable sensor systems will be the basis for fine-tuning management decisions (i.e. pesticide applications, irrigation, fertilization, crop load adjustment, pruning etc) to current orchard needs. Field rugged, low cost sensors of plant hydration levels will automatically drive irrigation systems geared to apply the least amounts of water, that are compatible with current crop needs, in order to maximise water savings while preserving fruit quality and yields. The development of pesticide delivery systems that integrate spatial, environmental knowledge and tree health will minimize chemical applications, thus preserving the environment, reducing fruit residues, and decreasing production costs, via savings in chemical quantities. Monitoring relevant parameters and performance of individual trees will allow to map the spatial variability existing within the orchard. This information will form the basis for short/medium term management decisions so that production factors (i.e. fertilizers; water; pesticides; labour) will be applied to the various orchard sectors in diverse amounts, responding to actual tree needs with the goal exploiting their actual production potential.

8. The Fruit Sector contribution to development and uptake of innovation

A Smart, Inclusive and Sustainable Bio-Economy will be achieved only if innovation adoption will have become a trademark of the European Fruit Sector, enabling to deliver wealth for key stakeholders in the fruit chain. The European fruit research and innovation network will be strengthened and will facilitate the exchange and implementation of knowledge at the regional, national and transnational level. A common strategy is needed among the fruit sector actors for making sure that the knowledge created by the research strategy creates impact. Impact means maintaining and creating employment, contributing to consumer-demand-related food quality and safety, contributing to unique landscapes, delivering novel fruit-based products that respond to the needs of future European societies, continued adaptation of the sustainability concept in the fruit sector and minimizing energy consumption. Innovation uptake will be encouraged to make sure that more of the knowledge developments reach the commercialization stage. Examples of scientific innovation that is in the pipeline of adoption by the industry may include:

- BioDigitab: monitoring and management of biological systems for real time decision making;
- nanotechnologies for sensor development;
- plants in combination with microbes to be used as factories (e.g. biopharming, biomaterials, biocatalysis, biofuels, biofermentation);
- fruit quality indicator label technology for packaged foods and health products including pharmaceuticals, and also in manufacturing processes;
- non-destructive technologies for the measurement of a wide variety of health and fruit quality features;
- biosensors based on antibodies or their synthetic equivalents, molecularly imprinted polymers (MIPs).

8.1. An example of research that can address innovation needs of the Fruit Chain

The continuous input of innovation to the fruit chain will be of paramount importance to place and maintain the EU fruit industry in a position of leadership on a global scale. All sectors of the fruit chain express a continuous demand for innovation that can only be met by strong interdisciplinary research capable of a composite view of the problems and of addressing them by mobilizing appropriate resources. Innovative research focusing on the genetic bases underpinning plant and fruit attributes will focus on genomic studies elucidating the role of each gene in controlling traits and responses to the environment, which will open the way to the breeding and selection of new varieties better suited to consumer demands, to environmental constraints and with improved health attributes. Pre-harvest research will focus on innovative production systems based on newly developed sensors that will gather physiological and environmental knowledge, information on plant health and nutritional status, and will feed them to artificial intelligence systems that will minimize resource inputs while preserving fruit quality. The pre-harvest history of the fruit, as well as its ripening stage and quality at harvest will be used as inputs for decision-making tools that will allow the optimization of the storage and marketing strategies based on the actual fruit features. Processed fruit and fruit-derived products are expected to become more important, as "time-poor" consumers demand more practical, portable products, for out of home consumption, ready-to-eat products. Research in the process innovation will lead to significant improvements in the quality of the products obtained, and also to the utilization of by-products as novel ingredients of innovative products. Knowledge on the traits of fruit and fruit-derived products that are important for health benefits will be the stepping stone to guide varietal and management innovation, so that fruit can be produced with the highest amounts of these components. This will help placing even more fruit and fruit-derived products at a prominent spot in the prevention of social diseases, such as CVD and some forms of cancer. Knowledge arising from consumer studies, providing information on consumer preferences and expectations will be essential to orient the research in the technical sectors of the chain.

8.2. How to bridge the gap between innovation development and uptake in the fruit sector

In order to facilitate the adoption of scientific innovation, it is necessary to focus initiatives aimed at overcoming significant bottlenecks that hinder the adoption of innovation. The following are among the actions that may lead to improving the innovation profile of the fruit sector in Europe:

- Development of robust research methodologies which will allow systematic and science-based bridging between consumer- and market-demand, and natural science-derived technology.
- Systematic identification of barriers preventing implementation of innovation e.g. lack of information, knowledge or skills, time constraints, costs, organizational and structural barriers, etc.
- Systematic evaluation of prevalent regulations and standards addressing the EU fruit sector at both national and transnational levels to provide science-based advice and expertise to the relevant authorities that establish regulations.
- Developing a proof of concept from fruit research to business accounting to meet regional requirements whilst maintaining conceptual European principles, which will provide a decision making tool.
- Increased integration of the fruit sector by a systematical organization and involvement of operational groups, e.g. growers, packing houses, processing SMEs, retailers and others, to foster the creation of European bottom-up technology exchange networks connecting stakeholders and research providers.
- Assuring appropriate research and demonstration facilities e.g. experimental farms which will allow for accounting of realistic agro-ecological requirements while maintaining Common Agricultural Policy (CAP).
- Promoting public-private partnerships and other funding schemes to support innovative, high-impact technologies.
- Improving access to research-oriented pilot plants to secure knowledge exchange and implementation.

- Identification of ways to reduce the overall administrative burden to encourage greater participation of Small and Medium-Sized Enterprises (SMEs).
- Harmonisation of intellectual property and plant variety rights.

MOVING FORWARD

The potential for the Fruit Chain to deliver to the EU Knowledge Based Bio-Economy cannot be fulfilled without the full involvement of the Chain itself. The coordination of stakeholders is a long-term effort that will require commitment from all the actors in the Chain, who will be called upon to provide support to the concept that the Fruit Sector needs a continuous input of novel knowledge, to be obtained via coordinated research efforts, in partnership with the European Union. The involvement of the representatives of all the Chain actors will have the main purpose of crafting a Research Agenda for the Fruit sector, and to maintain a critical outlook towards the future needs of the Chain, so that the Agenda can be accordingly evolved.

A consensus on the present Vision document will be the first step forward. The various Stakeholders in the Fruit Chain throughout Europe will be called upon to assess and endorse this Vision, and to cooperate in forging the Strategic Research Agenda. EUFRIN, building upon its constituency of Universities, Research and Extension Centers, is at an ideal interface in the Fruit Chain to act as a collector and coordinator of this demand for research, organize the supply of research, and to create the critical mass needed to tackle the complex issues facing the Sector in the future.

As the Horizon 2020 is approaching, the tools and ways to interact with the EU Commission are changing, and are expected to rely more and more on innovative forms of involvement of local, regional, national and international resources. Possessing this flexibility will be paramount to adapt to these new instruments and to make sure that key research needs for the Fruit Sector are identified and fulfilled.

EUFRIN is willing to take a proactive role to help the European Fruit Sector to meet the challenges that lay ahead.