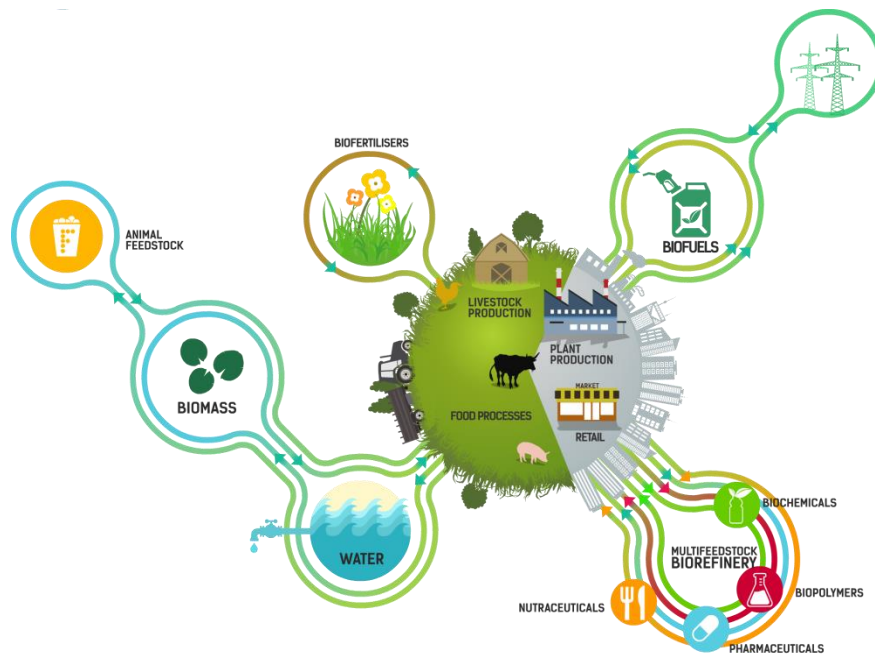


# Database/Inventory of the VEGETABLE AWCB value chain



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## Table of Content

Table of Content .....	I
List of figures.....	II
List of tables .....	VII
1 Introduction.....	1
1.1 Project background .....	2
1.2 Scope of the report .....	3
2 Methods and commodities .....	5
2.1 Tomato (whilst technically a fruit we have included in this section).....	16
2.2 Cabbage.....	27
2.3 Cauliflower and broccoli .....	46
2.4 Onions .....	69
2.5 Carrot.....	91
2.6 Potato.....	111
2.7 Sunflower seed.....	121
2.8 Rapeseed .....	139
2.9 Sugar beet .....	155
2.10 Olive.....	179
3 Current practices of commodity AWCB valorisation.....	205
4 References .....	211
5 ANNEX - Consumption per capita.....	220

## List of figures

Figure 1 Conceptual model on the food losses generated all along the food chain (Cicatiello, Franco, Pancino, & Blasi, 2016) .....	3
Figure 2 Steps in AWCB value chain .....	4
Figure 3 Different tomato cultivars (Rutgers, New Jersey Agricultural Experiment Station: Tomato Varieties, n.d.) .....	16
Figure 4 Processing tomatoes for ketchup (Food & Biotech Engineers: Tomato Ketchup Plant, n.d.).....	17
Figure 5 Rotten table tomatoes (Tech Bakbak: A Technology Blog That Is Easy To Understand, Rotten and spoiled tomatoes may soon produce electricity, n.d.) .....	17
Figure 6 Tomato AWCB value chain.....	19
Figure 7 Tonnes of harvested tomatoes per country, 2010-2015.....	22
Figure 8 Tonnes of damaged tomatoes per country, 2010-2015.....	24
Figure 9 Cabbage head eaten/damaged by rabbit (Lavender Creek: Rabbit Food or Sauerkraut, n.d.) .....	27
Figure 10 Cabbage processing facility (Agricultural Marketing Resource Center (AgMRC): Cabbage, n.d.) .....	27
Figure 11 Cabbage AWCB value chain .....	28
Figure 12 Tonnes of harvested cabbage per country, 2010-2015.....	31
Figure 13 Tonnes of damaged cabbage per country, 2010-2015.....	33
Figure 14 Tonnes of cabbage leaves left on field per country, 2010-2015 .....	35
Figure 15 Tonnes of processed cabbage per country, 2010-2013 .....	39
Figure 16 Tonnes of leaves and cabbage juice per country, 2010-2013 .....	41
Figure 17 Consumption of fresh cabbage (tonnes) per country, 2010-2015 .....	43
Figure 18 Tonnes of rotten cabbage per country, 2010-2015.....	45

Figure 19 Cauliflower and broccoli (Tehnologija Hrane: Povrće u Bosni i Hercegovini. [In Croatian], n.d.) .....	46
Figure 20 Processing line for: cauliflower (left), broccoli (middle) and carrot (right) (Polar Systems: Industries and Applications/Food/Vegetables, n.d.).....	46
Figure 21 Cauliflower and broccoli AWCB value chain .....	47
Figure 22 Tonnes of harvested cauliflower and broccoli per country, 2010-2015 .....	50
Figure 23 Tonnes of damaged cauliflower and broccoli per country, 2010-2015 .....	52
Figure 24 Tonnes of cauliflower and broccoli leaves left on field per country, 2010-2015....	54
Figure 25 Tonnes of processed cauliflower and broccoli per country, 2010-2013 .....	58
Figure 26 Tonnes of total suspended cauliflower and broccoli solids per country, 2010-2013 .....	60
Figure 27 Volume of cauliflower and broccoli wastewater in m <sup>3</sup> per country, 2010-2013 ....	62
Figure 28 Tonnes of cauliflower and broccoli leaves per country per year, 2010-2013 .....	64
Figure 29 Consumption of fresh cauliflower and broccoli (tonnes) per country, 2010-2015.	66
Figure 30 Tonnes of rotten cauliflower and broccoli per country, 2010-2015 .....	68
Figure 31 Different cultivars of onions (Vida Vitality: Onion Fun Facts, n.d.) .....	69
Figure 32 Onion damaged by worms (Allotment & Gardens: Onion Pests, Diseases & Problems, n.d.).....	69
Figure 33 Onion AWCB value chain .....	71
Figure 34 Tonnes of harvested onions per country, 2010-2015 .....	74
Figure 35 Tonnes of damaged onions per country, 2010-2015 .....	76
Figure 36 Tonnes of processed onions per country, 2010-2013 .....	80
Figure 37 Tonnes of total suspended onion solids per country, 2010-2013 .....	82
Figure 38 Volume of wastewater from onion processing in m <sup>3</sup> per country, 2010-2013.....	84
Figure 39 Tonnes of onion peel per country, 2010-2013 .....	86
Figure 40 Consumption of fresh onions (tonnes) per country, 2010-2015.....	88

Figure 41 Tonnes of rotten onions per country, 2010-2015 .....	90
Figure 42 Different cultivars of carrot (Carrot Museum: Carrot Genome, n.d.) .....	91
Figure 43 Carrot processing facility (Bertuzzi: Carrot processing, n.d.) .....	92
Figure 44 Carrot AWCB value chain .....	93
Figure 45 Tonnes of harvested carrots per country, 2010-2015 .....	96
Figure 46 Tonnes of damaged carrots per country, 2010-2015 .....	98
Figure 47 Tonnes of processed carrots per country, 2010-2013.....	102
Figure 48 Tonnes of carrot pomace and peel per country, 2010-2013.....	104
Figure 49 Volume of wastewater from carrot processing in m <sup>3</sup> per country, 2010-2013 ...	106
Figure 50 Consumption of fresh carrots (tonnes) per country, 2010-2015 .....	108
Figure 51 Tonnes of rotten carrots per country, 2010-2015.....	110
Figure 52 Potato starch (Naturawiki: Potato Starch, n.d.) .....	111
Figure 53 A part of a potato processing facility (PotatoPRO: Large Russets in Idaho in short supply, n.d.).....	112
Figure 54 Rotten potato (Mid-day: Dog meat, rotten potatoes! 5 bizarre Indian food items that you didn't know exist, n.d.) .....	112
Figure 55 Potato AWCB value chain .....	113
Figure 56 Tonnes of harvested potatoes per country, 2010-2015.....	116
Figure 57 Tonnes of damaged potatoes per country, 2010-2015.....	118
Figure 58 A bird damaged sunflower (Western Region IR-4 Program, Bird Damage sunflower, n.d.) .....	121
Figure 59 Seed oil expeller (Agico Group: Seed Oil Expeller, n.d.) .....	122
Figure 60 Sunflower cake meal (SunOpta Foods Bulgaria: Organic Sunflower Cakes, n.d.) .	122
Figure 61 Sunflower seed AWCB value chain .....	123
Figure 62 Tonnes of harvested sunflower seed per country, 2010-2015 .....	126
Figure 63 Tonnes of sunflower straw per country, 2010-2015 .....	128

Figure 64 Tonnes of damaged sunflower seed during harvesting per country, 2010-2015 .	130
Figure 65 Tonnes of processed sunflower seed per country, 2010-2013 .....	134
Figure 66 Tonnes of sunflower cake per country, 2010-2013 .....	136
Figure 67 Tonnes of slurry (ugido) from sunflower seed processing per country, 2010-2013 .....	138
Figure 68 Rapeseed field (Agrodaily: Decline in UK winter rapeseed area, n.d.).....	139
Figure 69 Rapeseed cake meal (Vinay Industries Limited: Indian Rapeseed Extraction Meal (IRSM), n.d.) .....	140
Figure 70 Rapeseed AWCB value chain .....	141
Figure 71 Tonnes of harvested rapeseed per country, 2010-2015 .....	144
Figure 72 Tonnes of damaged rapeseed per country, 2010-2015 .....	146
Figure 73 Tonnes of rapeseed stalks per country, 2010-2015 .....	148
Figure 74 Tonnes of processed rapeseed per country, 2010-2013.....	152
Figure 75 Tonnes of cake meal from processed rapeseed per country, 2010-2013.....	154
Figure 76 Sugar beet (58).....	155
Figure 77 Sugar beet cossettes (American Crystal Sugar Company: A Tale of Three Seasons, n.d.).....	156
Figure 78 Sugar beet AWCB value chain.....	157
Figure 79 Tonnes of harvested sugar beet per country, 2010-2015 .....	160
Figure 80 Tonnes of sugar beet leaves, fresh weight per country, 2010-2015 .....	162
Figure 81 Tonnes of processed sugar beet per country, 2010-2015.....	164
Figure 82 Tonnes of sugar beet molasses per country, 2010-2015 .....	166
Figure 83 Tonnes of fresh sugar beet pulp per country, 2010-2015 .....	168
Figure 84 Volume of sugar beet wash water in m <sup>3</sup> per country, 2010-2015 .....	170
Figure 85 Tonnes of sugar factory lime per country, 2010-2015 .....	172
Figure 86 Tonnes of sugar beet tops & tails per country, 2010-2015 .....	174

Figure 87 Tonnes of stones in sugar beet processing per country, 2010-2015.....	176
Figure 88 Tonnes of beet soil per country, 2010-2015.....	178
Figure 89 Hojiblanca olives (Olive Oil Times: Hojiblanca, n.d.) .....	179
Figure 90 Pruning of olive tree (64) .....	180
Figure 91 Disc crusher (left) and hammer mill (right) for olive crushing (California Olive Oil: Calivirgin Down Under...Adelaide Countryside, Olive Oil & Kangaroos, n.d.) .....	181
Figure 92 Olive pomace and olive mill wastewater (69) .....	182
Figure 93 Olive AWCB value chain .....	183
Figure 94 Tonnes of harvested olives per country, 2010-2015 .....	186
Figure 95 Tonnes of olive twigs and leaves per country, 2010-2015 .....	188
Figure 96 Tonnes of wooden olive branches per country, 2010-2015.....	190
Figure 97 Tonnes of processed olives for oil per country, 2010-2015 .....	192
Figure 98 Volume of olive mill wastewater per country, 2010-2015 .....	194
Figure 99 Tonnes of olive pomace per country, 2010-2015.....	196
Figure 100 Consumption of table olives (tonnes) per country, 2010-2014 .....	198
Figure 101 Tonnes of rotten table olives per country, 2010-2014.....	200
Figure 102 Consumption of olive oil (tonnes) per country, 2010-2014 .....	202
Figure 103 Tonnes of spoiled olive oil per country, 2010-2014 .....	204
Figure 104 A schematic of bio-diesel production from vegetable oil and methanol (El-Gendy, Deriase, Hamdy, & Abdallah, 2015).....	205
Figure 105 Pectin used as biosorbent for heavy metals (Eliaz, 2013) .....	206
Figure 106 Structure of oleuropein (Omar, 2010) .....	208

## List of tables

Table 1 Population of EU-28 countries (Eurostat: Population of the year, n.d.).....	7
Table 2 Main AWCB produced from vegetable sector .....	9
Table 3 Tonnes of harvested tomatoes per country, 2010-2015 (Eurostat: Agricultural production - crops, n.d.) .....	21
Table 4 Tonnes of damaged tomatoes during harvesting per country, 2010-2015.....	23
Table 5 Import and export quantities of tomatoes per country, 2010-2013 (FAO: Crops and livestock products, n.d.).....	25
Table 6 Tonnes of harvested cabbage per country, 2010-2015 (Eurostat: Agricultural production - crops, n.d.) .....	30
Table 7 Tonnes of damaged cabbage per country, 2010-2015 .....	32
Table 8 Tonnes of cabbage leaves left on field per country, 2010-2015 .....	34
Table 9 Tonnes of imported and exported cabbage per country, 2010-2013 (FAO: Crops and livestock products, n.d.).....	36
Table 10 Tonnes of processed cabbage per country, 2010-2013.....	38
Table 11 Tonnes of leaves and cabbage juice per country, 2010-2013 .....	40
Table 12 Consumption of fresh cabbage (tonnes) per country, 2010-2015 .....	42
Table 13 Tonnes of rotten cabbage per country, 2010-2015.....	44
Table 14 Tonnes of harvested cauliflower and broccoli per country, 2010-2015 (Eurostat: Agricultural production - crops, n.d.).....	49
Table 15 Tonnes of damaged cauliflower and broccoli per country, 2010-2015.....	51
Table 16 Tonnes of cauliflower and broccoli leaves left on field per country, 2010-2015 .....	53
Table 17 Tonnes of imported and exported cauliflower and broccoli per country, 2010-2013 (FAO: Crops and livestock products, n.d.) .....	55
Table 18 Tonnes of processed cauliflower and broccoli per country, 2010-2013 .....	57

Table 19 Tonnes of total suspended cauliflower and broccoli solids per country, 2010-2013 .....	59
Table 20 Volume of cauliflower and broccoli wastewater in m <sup>3</sup> per country, 2010-2013 .....	61
Table 21 Tonnes of cauliflower and broccoli leaves per country, 2010-2013.....	63
Table 22 Consumption of fresh cauliflower and broccoli (tonnes) per country, 2010-2015 ..	65
Table 23 Tonnes of rotten cauliflower and broccoli per country, 2010-2015.....	67
Table 24 Tonnes of harvested onions per country, 2010-2015 (Eurostat: Agricultural production - crops, n.d.) .....	73
Table 25 Tonnes of damaged onions per country, 2010-2015.....	75
Table 26 Tonnes of imported and exported onions per country, 2010-2013 (FAO: Crops and livestock products, n.d.).....	77
Table 27 Tonnes of processed onions per country, 2010-2013* .....	79
Table 28 Tonnes of total suspended onion solids per country, 2010-2013 .....	81
Table 29 Volume of wastewater from onion processing in m <sup>3</sup> per country, 2010-2013 .....	83
Table 30 Tonnes of onion peel per country, 2010-2013 .....	85
Table 31 Consumption of fresh onions (tonnes) per country, 2010-2015 .....	87
Table 32 Tonnes of rotten onions per country, 2010-2015.....	89
Table 33 Tonnes of harvested carrots per country, 2010-2015 (Eurostat: Agricultural production - crops, n.d.) .....	95
Table 34 Tonnes of damaged carrots per country, 2010-2015 .....	97
Table 35 Tonnes of imported and exported carrots per country, 2010-2013 (FAO: Crops and livestock products, n.d.).....	99
Table 36 Tonnes of processed carrots per country, 2010-2013.....	101
Table 37 Tonnes of carrot pomace and peel per country, 2010-2013 .....	103
Table 38 Volume of wastewater from carrot processing in m <sup>3</sup> per country, 2010-2013 .....	105
Table 39 Consumption of fresh carrots (tonnes) per country, 2010-2015.....	107



Table 40 Tonnes of rotten carrots per country, 2010-2015 .....	109
Table 41 Tonnes of harvested potatoes per country, 2010-2015 (Eurostat: Agricultural production - crops, n.d.) .....	115
Table 42 Tonnes of damaged potatoes per country, 2010-2015 .....	117
Table 43 Tonnes of imported and exported potatoes per country, 2010-2013 (FAO: Crops and livestock products, n.d.).....	119
Table 44 Tonnes of harvested sunflower seed per country, 2010-2015 (Eurostat: Agricultural production - crops, n.d.) .....	125
Table 45 Tonnes of sunflower straw per country, 2010-2015 .....	127
Table 46 Tonnes of damaged sunflower seed during harvesting per country, 2010-2015 ..	129
Table 47 Tonnes of imported and exported sunflower seed per country, 2010-2013 (FAO: Crops and livestock products, n.d.) .....	131
Table 48 Tonnes of processed sunflower seed per country, 2010-2013 .....	133
Table 49 Tonnes of sunflower cake per country, 2010-2013 .....	135
Table 50 Tonnes of slurry (ugido) from sunflower seed processing per country, 2010-2013 .....	137
Table 51 Tonnes of harvested rapeseed per country, 2010-2015 (Eurostat: Agricultural production - crops, n.d.) .....	143
Table 52 Tonnes of damaged rapeseed per country, 2010-2015.....	145
Table 53 Tonnes of rapeseed stalks per country, 2010-2015.....	147
Table 54 Tonnes of imported and exported rapeseed per country, 2010-2013 (FAO: Crops and livestock products, n.d.).....	149
Table 55 Tonnes of processed rapeseed per country, 2010-2013 .....	151
Table 56 Tonnes of cake meal from processed rapeseed per country, 2010-2013 .....	153
Table 57 Tonnes of harvested sugar beet per country, 2010-2015 (Eurostat: Agricultural production - crops, n.d.) .....	159
Table 58 Tonnes of sugar beet leaves, fresh weight per country, 2010-2015 .....	161

Table 59 Tonnes of processed sugar beet per country, 2010-2015 .....	163
Table 60 Tonnes of sugar beet molasses per country, 2010-2015.....	165
Table 61 Tonnes of fresh sugar beet pulp per country, 2010-2015 .....	167
Table 62 Volume of sugar beet wash water in m <sup>3</sup> per country, 2010-2015.....	169
Table 63 Tonnes of sugar factory lime per country, 2010-2015 .....	171
Table 64 Tonnes of sugar beet tops & tails per country, 2010-2015 .....	173
Table 65 Tonnes of stones in sugar beet processing per country, 2010-2015.....	175
Table 66 Tonnes of beet soil per country, 2010-2015.....	177
Table 67 Tonnes of harvested olives per country, 2010-2015 (Eurostat: Agricultural production - crops, n.d.) .....	185
Table 68 Tonnes of olive twigs and leaves per country, 2010-2015 .....	187
Table 69 Tonnes of wooden olive branches per country, 2010-2015.....	189
Table 70 Tonnes of processed olives for oil per country, 2010-2015 (Eurostat: Agricultural production - crops, n.d.) .....	191
Table 71 Volume of olive mill wastewater in m <sup>3</sup> per country, 2010-2015.....	193
Table 72 Tonnes of olive pomace per country, 2010-2015.....	195
Table 73 Consumption of table olives (tonnes) per country, 2010-2014 (IOC-International Olive Council, n.d.) .....	197
Table 74 Tonnes of rotten table olives per country, 2010-2014.....	199
Table 75 Consumption of olive oil (tonnes) per country, 2010-2014 (IOC-International Olive Council, n.d.) .....	201
Table 76 Tonnes of spoiled olive oil per country, 2010-2014 .....	203
Table 77 Characteristics, potential use and developed patents of vegetable AWCB .....	210

Consumption data for tomatoes and potatoes exist in some form, notably in the food balance sheets of FAOSTAT (<http://www.fao.org/faostat/en/#data/FBS>). These data however represent both fresh and processed consumption of Tomatos/potatos. Reliable

and consistent data for fresh European tomato/potato consumption was not available at the time of writing. Table 78 Cabbage consumption per capita in kg/year .....220

Table 79 Cauliflower and broccoli consumption per capita in kg/year .....223

Table 80 Carrot consumption per capita in kg/year .....225

Table 81 Onion consumption per capita in kg/year .....228

## 1 Introduction

The purpose of this report is to provide a database/inventory of the current agricultural value chains including quantities of various agricultural wastes, co-products and by-products (AWCB) and their regional distribution and current valorisation practices in EU countries. This is the critical first step to achieving an understanding and appreciation of the variability in AWCBs. The quantities of AWCBs that are produced in the value chain of vegetables will be determined from three main steps: cultivation, processing and consumption.

This report also contains information regarding current practices of valorisation for analysed commodities as well as consumption data for different commodities per capita. Import and export of different commodities are also included in the report in order to better showcase regional distribution of different commodities consumption and processing.

This study constitutes Deliverable 1.1 of the **Work package 1: Agricultural Waste Value Chain Assessment; Task 1.1 Agricultural value chain mapping** of the European Union's Horizon 2020 research and innovation programme "AGROCYCLE" under grant agreement N° 690142.

Task 1.1 is viewed as a '**first step**' to map AWCB streams in agricultural production and supply chains across Europe. This first task is vast, encompassing four animal types, seven cereal, five fruit, and ten vegetable value chains. In order to complete the task for the 26 value chains in 28 countries, a wide range of data sources is employed.

The methodology developed for this task acts as a template, to not only illustrate but, to best estimate the quantities of AWCB that are being generated across the various value chains in Europe. This database uses, where possible, the best available data at the time of writing (December 2017). The ultimate success and value of this database depend on the continuous revising with more up to date data it becomes available.

## 1.1 Project background

Continuing population and consumption growth is driving the demand for food globally, with agricultural activities having to increase to meet this demand. Europe has a major AWCB problem, generating some 700 million tonnes of AWCB annually.

There is an urgent need and a huge opportunity to address the efficient use of AWCB towards delivering sustainable value chains in the farming and processing sectors. As such, AgroCycle will convert low-value AWCB into highly valuable products, achieving a 10% increase in AWCB recycling and valorisation by 2020. This will be achieved by developing a detailed and holistic understanding of the AWCB streams and piloting a key number of AWCB utilisation/valorisation pathways. It will bring technologies and systems from ~TRL4 to ~TRL7 within the 3 years of the project. A post-project commercialisation plan will bring commercially promising technologies/systems to TRL8 and TRL9, ensuring AgroCycle will have an enduring impact by achieving sustainable use of AWCB both inside and outside the agricultural sector, leading to the realisation of a Circular Economy.

AgroCycle addresses AWCBs from several agricultural sectors: wine, olive oil, horticulture, fruit, grassland, swine, dairy and poultry. The AgroCycle consortium is a large (26) multi-national group (including China) comprising the necessary and relevant multi-actors (i.e. researchers; companies in the technical, manufacturing, advisory, retail sectors (Large and SMEs); lead users; end users; and trade/producer associations) for achieving the project's ambitious goals. Farming's unique regional (rural) location means that AgroCycle will help reduce the EU's Innovation Divide and address the Regional Smart Specialisation Strategies for each partner country: impact will be Regional with National and International dimensions. The presence of three partners from China ensures international synergies and a global impact.

## 1.2 Scope of the report

The agricultural value chain generates a significant amount of different AWCB types that occur during three major stages of a complex path, from farm to fork. Figure 1 presents a conceptual model illustrating where AWCB appears.

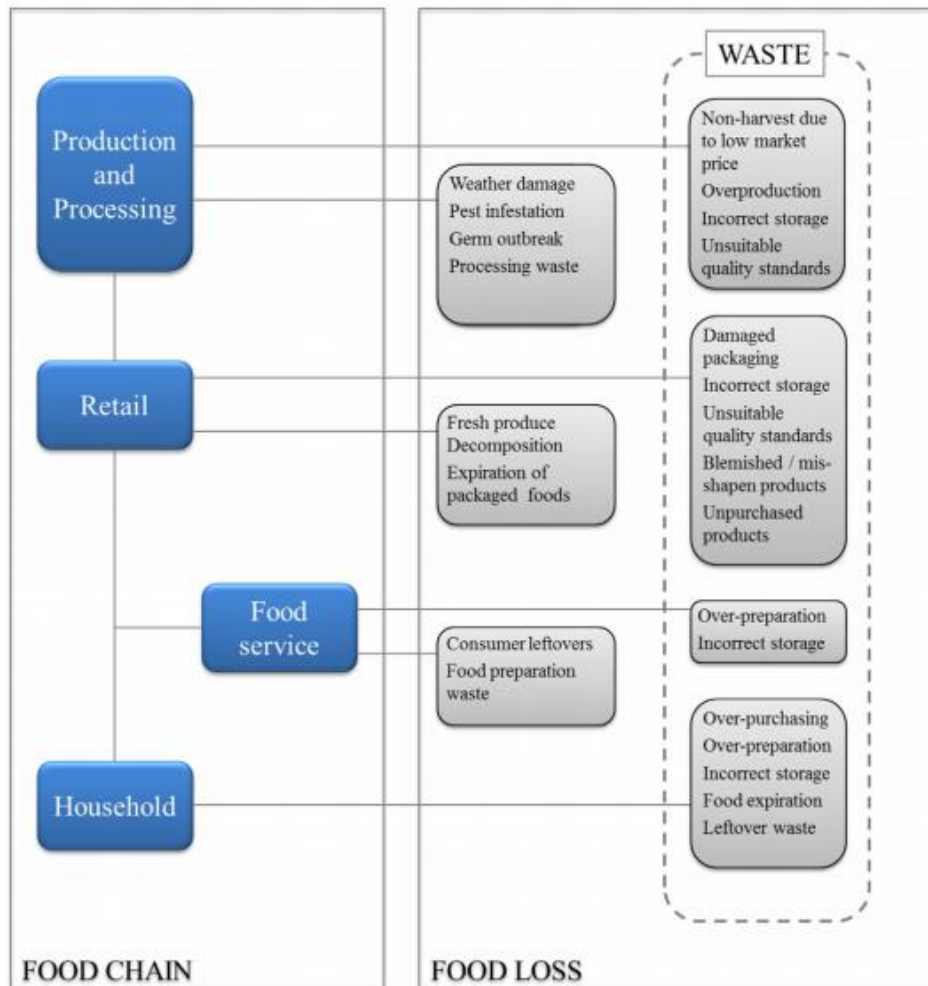


Figure 1 Conceptual model on the food losses generated all along the food chain (Cicatiello, Franco, Pancino, & Blasi, 2016)

Damaged products during harvesting or rotten food in domestic consumption are not necessarily AWCB that need to be disposed. Furthermore, many different types of the AWCB are generated during the processing stage and for that reason, they should be studied in more detail in order to valorise them in the most beneficial way.

This report presents where and how AWCB occurs during path from 'farm to fork'. The analysis also presents an overview of how to valorise AWCB, primarily for the chemical and

pharmaceutical industries. Tomato, cabbage, cauliflower and broccoli, onion, carrot, potato, sunflower seed, rapeseed, sugar beet and olives are vegetable types that are analysed in this report. The value chain of each vegetable along with the AWCB that occurs at each stage (with appropriate numerical and graphic data) for every EU-28 country is included, and finally, options on best to valorise AWCB is presented. Figure 2 shows steps in AWCB value chain: cultivation, processing and consumption.



Figure 2 Steps in AWCB value chain

Vegetables are crops grown to feed people and animals. People can consume vegetables directly after harvesting, as either a raw or a cooked food. Not all of the cultivated and harvested vegetables make it to the consumer. A certain amount of vegetables are eaten or destroyed by animals (birds, rabbits, dears, wasps, etc). Furthermore, different diseases, such as Bacterial Leaf Spot, Downey Mildew, Leaf Blotch, Bitter Rot, Black Rot, Blister Spot etc. destroy the vegetable plants, which results in low yield and subsequent lower income. In severe cases, this can result in total devastation (University of Minnesota Extension: Management of leaf spot diseases of trees and shrubs, n.d.) of a vegetable crop.

The amount of flawed vegetables due to harvesting and handling errors is an important factor in the AWCB calculation. Traditional labour intensive harvest methods are slow and its efficiency depends on worker's skills. Modern methods with appropriate machinery are useful in large agriculture areas where a large number of vegetables are being produced. Modern methods are more expensive than traditional ones, with harvesting loses dependant on the machine quality (Magagnotti, Pari, Picchi, & Spinelli, 2013). Thus, the amount of AWCB produced varies greatly on a large number of production factors.

Vegetables are also used as a source for the production of different products and semi-products (sauces, preserved and frozen products, etc). In the stages of processing raw vegetable to the final product, many AWCBs are generated.

The quantity of AWCBs produced in the last stage of the value chain is primarily the result of people's behaviour and habits. Vegetables can be discarded for the following reasons:

leftovers from cooked food; mouldy food; visually unappetising or unpalatable (Waste & Resources Action Programme (WRAP). The food we waste, A study of the amount, types, and nature of the food we throw away in UK households, n.d.). WRAP estimates the average person in the UK throws away approximately 70kg of avoidable 'wasted' food per year (Waste & Resources Action Programme (WRAP). The food we waste, A study of the amount, types, and nature of the food we throw away in UK households, n.d.).

## 2 Methods and commodities

This section gives an overview of how and where different AWCB occurs for given vegetables. For every vegetable, there is a short description of the AWCB produced at the appropriate value stage and a picture to give an illustration.

For each of the vegetables assessed below, calculations are carried out for every country of the EU28 country, according to data collected from EUROSTAT for the period 2010-2015. Import and export data is collected from FAOSTAT for the available period. Where available, consumption per capita of fresh (raw) vegetables at a domestic level is given in appropriate tables at the end of the report. A key assumption is that the quantity of consumed food does not change in the given period of time. The list below shows the notation of specific values needed for calculation of fruit that can be eatable (cooked or raw) and their relations:

PRD = Production of vegetable in country (tonnes) ( I )

CON = Consumption of raw vegetable (tonnes) ( II )

IMP = Imported quantity of vegetable (tonnes) ( III )

EXP = Exported quantity of vegetable (tonnes) ( IV )

PRC = Quantity of processed vegetable (tonnes) ( V )

PC = Consumption of vegetable per capita per year (kg) ( VI )



$$\text{CON} = \text{POP} \times \text{PC} \quad (\text{VII})$$

$$\text{PRC} = (\text{PRD} + \text{IMP}) - (\text{CON} + \text{EXP}) \quad (\text{VIII})$$

By using specific consumption data for each country and population for every year, the calculation of consumed food in period 2010-2015 is carried out. Table 1 shows the population of EU-28 countries for the period 2010-2015 (Eurostat: Population of the year, n.d.).

Fresh (raw) consumption data is critical to this analysis, as it ultimately determines the quantities of commodities that are processed. EUROSTAT and FAOSTAT databases provide regular and consistent data on fresh production and trade (import/export) of vegetables on an annual basis in all European countries. Unfortunately, fresh consumption figures are more difficult to determine and limited reliable data is available from reputable sources

For example in the case of tomatoes, the consumption values issued by FAO represent both fresh and processed consumption (in kg/capita/year). Using these values to represent fresh consumption would result in negative processing figures. Due to the lack of published data on fresh consumption, average values and best estimates are employed for each commodity. Consumption values that include both fresh and processing amounts can yield negative processing quantities. Consumption and processing values are not included for vegetables where reliable fresh consumption values are not available.

Table 1 Population of EU-28 countries (Eurostat: Population of the year, n.d.)

GEO/ POPULATION	2010	2011	2012	2013	2014	2015
Belgium	10,839,905	11,000,638	11,094,850	11,161,642	11,180,840	11,237,274
Bulgaria	7,421,766	7,369,431	7,327,224	7,284,552	7,245,677	7,202,198
Czech Republic	10,462,088	10,486,731	10,505,445	10,516,125	10,512,419	10,538,275
Denmark	5,534,738	5,560,628	5,580,516	5,602,628	5,627,235	5,659,715
Germany	81,802,257	80,222,065	80,327,900	80,523,746	80,767,463	81,197,537
Estonia	1,333,290	1,329,660	1,325,217	1,320,174	1,315,819	1,314,870
Ireland	4,549,428	4,570,881	4,582,707	4,591,087	4,605,501	4,628,949
Greece	11,119,289	11,123,392	11,086,406	11,003,615	10,926,807	10,858,018
Spain	46,486,619	46,667,174	46,818,219	46,727,890	46,512,199	46,449,565
France	64,658,856	64,978,721	65,276,983	65,600,350	65,942,093	66,488,186
Croatia	4,302,847	4,289,857	4,275,984	4,262,140	4,246,809	4,225,316
Italy	59,190,143	59,364,690	59,394,207	59,685,227	60,782,668	60,795,612
Cyprus	819,140	839,751	862,011	865,878	858,000	847,008
Latvia	2,120,504	2,074,605	2,044,813	2,023,825	2,001,468	1,986,096
Lithuania	3,141,976	3,052,588	3,003,641	2,971,905	2,943,472	2,921,262
Luxembourg	502,066	511,840	524,853	537,039	549,680	562,958
Hungary	10,014,324	9,985,722	9,931,925	9,908,798	9,877,365	9,855,571
Malta	414,027	414,989	417,546	421,364	425,384	429,344
Netherlands	16,574,989	16,655,799	16,730,348	16,779,575	16,829,289	16,900,726
Austria	8,351,643	8,375,164	8,408,121	8,451,860	8,506,889	8,576,261
Poland	38,022,869	38,062,718	38,063,792	38,062,535	38,017,856	38,005,614
Portugal	10,573,479	10,572,721	10,542,398	10,487,289	10,427,301	10,374,822
Romania	20,294,683	20,199,059	20,095,996	20,020,074	19,947,311	19,870,647
Slovenia	2,046,976	2,050,189	2,055,496	2,058,821	2,061,085	2,062,874
Slovakia	5,390,410	5,392,446	5,404,322	5,410,836	5,415,949	5,421,349
Finland	5,351,427	5,375,276	5,401,267	5,426,674	5,451,270	5,471,753
Sweden	9,340,682	9,415,570	9,482,855	9,555,893	9,644,864	9,747,355
United Kingdom	62,510,197	63,022,532	63,495,303	63,905,297	64,351,155	64,875,165

In order to present the type of AWCB and specific AWCB quantities in each stage of the value chain, Table 2 contains data for tomato, cabbage, cauliflower and broccoli, carrot, onion, potato, sunflower seed, rapeseed, sugar beet, and olive value chains. For the cultivation stage, the vegetable stalks and damaged vegetables during harvesting are the main AWCB of interest. However, not every piece of the damaged vegetable is characterised as AWCB. Damaged sugar beet may still be processed in the sugar factory or in the biogas plant. The processing step differs for every vegetable, as does the AWCB that is generated.

At the consumption stage, the main AWCB is non-edible rotten vegetables which results from inappropriate storage of vegetables and consumption habits of people. The quantity of AWCB is expressed in a mass ratio of AWCB to the quantity of vegetables used in that step. For example, 0.10 kg of tomato skin is generated when 1 kg of tomato is processed.

Table 2 Main AWCB produced from vegetable sector

Vegetable	Cultivation	Processing	Consumption	
Tomato	Damaged tomatoes to product ratio 0.20 kg/kg	(Cederberg, Gustavsson, van Otterdijk, Meybeck, & Sonesson, 2011)	Tomato skin to product ratio 0.10 kg/kg (Chandrasekaran, 2016)	Rotten tomatoes to product ratio 0.19 kg/kg (Cederberg, Gustavsson, van Otterdijk, Meybeck, & Sonesson, 2011)
			Tomato pomace to product ratio 0.03-0.07 kg/kg (United Nations Industrial Development Organisation (UNIDO): food wastes (2004), n.d.)	
			Wastewater to product ratio 8.2 l/kg (Loehr, 1984)	
			Total suspended solids to product ratio 0.06 kg/kg (Loehr, 1984)	
Cabbage	Damaged cabbage to product ratio 0.19 – 0.3 kg/kg	(Cederberg, Gustavsson, van Otterdijk, Meybeck, & Sonesson, 2011), (Žnidarčič, Kacjan-Maršič, Osvald, Požrl, & Trdan, 2007)	Leaves and cabbage juice to product ratio 0.48 -0.6 kg/kg (Ho Choi, i dr., 2002), (Hang, 2004)	Rotten cabbage to product ratio 0.19 kg/kg (Cederberg, Gustavsson, van Otterdijk, Meybeck, & Sonesson, 2011)
	Leaves to product ratio 0.4 – 1.51 kg/kg	(Stoffella & Fleming, 1990), (Haque, Islam, Islam, Ullah, &		

		Sarkar, 2015), (Nurhidayati, Ali, & Murwani, 2016), (Mochizuki, Rangarajan, & Bellinder, 2007), (Bajgai, Kristiansen, Hulugalle, & McHenry, 2011)				
Cauliflower and broccoli	Damaged cauliflower and broccoli to product ratio 0.2 kg/kg <hr/> Leaves to product ratio 2.25 – 4.9 kg/kg	(Cederberg, Gustavsson, van Otterdijk, Meybeck, & Sonesson, 2011) <hr/> (Vågen, 2005), (De Pascale, Maggio, & Barbieri, 2005), (Jett, Morse, & O'Dell, 1995)	Wastewater to product ratio 8.2 l/kg	(Loehr, 1984)	Rotten cauliflower and broccoli to product ratio 0.19 kg/kg	(Cederberg, Gustavsson, van Otterdijk, Meybeck, & Sonesson, 2011)
			Total suspended solids to product ratio 0.0025 kg/kg	(Loehr, 1984)		
			Leaves to product ratio 0.22 kg/kg	(Fresner, Dobes, Bürki, Angerbauer, & Tiefenbrunner, 2010)		
Carrot	Damaged carrot to product ratio 0.20 kg/kg	(Cederberg, Gustavsson, van Otterdijk, Meybeck, &	Pomace and peel to product ratio 0.12 kg/kg	(Loehr, 1984)	Rotten carrot to product ratio 0.19 kg/kg	(Cederberg, Gustavsson, van Otterdijk,
		Wastewater to product ratio 11.1 l/kg	(Loehr, 1984)			

		Sonesson, 2011)				Meybeck, & Sonesson, 2011)
Onion	Damaged onion to product ratio 0.20 kg/kg	(Cederberg, Gustavsson, van Otterdijk, Meybeck, & Sonesson, 2011)	Wastewater to product ratio 21.0 l/kg	(Loehr, 1984)	Rotten onion to product ratio 0.19 kg/kg	(Cederberg, Gustavsson, van Otterdijk, Meybeck, & Sonesson, 2011)
			Total suspended solids to product ratio 0.01 kg/kg	(Loehr, 1984)		
			Peel to product ratio 0.25 kg/kg	(USA Onions: (Idaho-Eastern Oregon Onion Committee): Onion Preparation and Yield Charts (2016), n.d.)		
Potato	Damaged potatoes to product ratio 0.20 kg/kg	(Cederberg, Gustavsson, van Otterdijk, Meybeck, & Sonesson, 2011)	Peel to product ratio 0.10 kg/kg	(Loehr, 1984)	Rotten potatoes to product ratio 0.19 kg/kg	(Cederberg, Gustavsson, van Otterdijk, Meybeck, & Sonesson, 2011)
			Process water to product ratio 16.0 l/kg	(Loehr, 1984)		
			Suspended solid to product ratio 0.27-0.50 kg/kg	(Loehr, 1984)		
Sunflower seed	Damaged sunflower seed to product ratio - 0.10 kg/kg	(Cederberg, Gustavsson, van Otterdijk, Meybeck, & Sonesson, 2011)	Sunflower cake meal to product ratio 0.60-0.64 kg/kg	(Department of Agriculture, Forestry and Fisheries of the Republic of South Africa: Sunflower Seed	Not applicable, as sunflower seed are not consumed directly by humans	
	Straw to product ratio 1 kg/kg					

				Market Value Chain Profile (2012), n.d.)		
			Slurry (ugido) to product ratio 0.015-0.045 kg/kg	(Department of Agriculture, Forestry and Fisheries of the Republic of South Africa: Sunflower Seed Market Value Chain Profile (2012), n.d.)		
Rapeseed	<hr/> Stalks to product ratio 1-3 kg/kg <hr/> Damaged rapeseed to product ratio 0.10 kg/kg	(USA Onions: (Idaho-Eastern Oregon Onion Committee): Onion Preparation and Yield Charts (2016), n.d.) <hr/> (Cederberg, Gustavsson, van Otterdijk, Meybeck, & Sonesson, 2011)	Cake meal to product ratio 0.64-0.74 kg/kg	(Tofanica, Cappelletto, Gavrilescu, & Mueller, 2011)	Not applicable, as rapeseed is not consumed directly by humans	
Sugar beet	<hr/> Sugar beet leaves to product ratio (depending on moisture content) 0.14-0.91 kg/kg	(Krick. A. International Confederation of European Beet Growers.	Stones to product ratio 0.001-0.005 kg/kg	(Krick. A. International Confederation of European Beet Growers.	Not applicable, as sugar beet is not consumed directly by humans	

	Stones to product ratio 0.001-0.04 kg/kg	Personal Communication, n.d.)		Personal Communication, n.d.)		
		(Krick. A. International Confederation of European Beet Growers. Personal Communication, n.d.)	Beet soil to product ratio 0.04-0.10 kg/kg	(Krick. A. International Confederation of European Beet Growers. Personal Communication, n.d.)		
			Molasses to product ratio 0.032-0.035 kg/kg	(Krick. A. International Confederation of European Beet Growers. Personal Communication, n.d.)		
			Sugar beet pulp to product ratio 0.05 kg/kg	(Krick. A. International Confederation of European Beet Growers. Personal Communication, n.d.)		
			Wash water to product ratio 0.75 l/kg	(Krick. A. International Confederation of European Beet Growers.		



				Personal Communication, n.d.)		
			Sugar beet factory lime to product ratio 0.04 kg/kg	(Krick. A. International Confederation of European Beet Growers. Personal Communication, n.d.)		
			Sugar beet tops & tails to product ratio 0.007 kg/kg	(Krick. A. International Confederation of European Beet Growers. Personal Communication, n.d.)		
Olives	<p>Twigs and leaves to product ratio 2.68 kg/kg</p> <hr/> <p>Woody branches to product ratio 2.68 kg/kg</p>	(Kailis & Harris, 2007), (Sansoucy, 1985), (European Commission, Directorate-General for Agriculture and Rural Development: Economic Analysis of the	Olive mill wastewater to product ratio 1.0-1.2 kg/kg	(Azbar, i dr., 2004)	<p>Wasted olive oil to product ratio 0.05 kg/kg</p> <hr/> <p>Rotten olives to product ratio 0.05 kg/kg</p>	(Cederberg, Gustavsson, van Otterdijk, Meybeck, & Sonesson, 2011)

		olive sector (2012), n.d.)				
		(Kailis & Harris, 2007), (Sansoucy, 1985), (European Commission, Directorate-General for Agriculture and Rural Development: Economic Analysis of the olive sector (2012), n.d.)	Olive pomace to product ratio 1.0-1.2 kg/kg	(Azbar, i dr., 2004)		(Cederberg, Gustavsson, van Otterdijk, Meybeck, & Sonesson, 2011)

## 2.1 Tomato (whilst technically a fruit we have included in this section)

Tomato is a one-year plant that is used for fresh consumption and for processing. There are many varieties of tomato, which are different in shape, colour, and application, as shown in Figure 3 (Rutgers, New Jersey Agricultural Experiment Station: Tomato Varieties, n.d.). Tomatoes are usually grown in fields and/or gardens during the spring and summer months of the year. Tomatoes can be also grown in greenhouses or hydroponics, during the whole year, requiring additional resources and thus results in higher costs.



Figure 3 Different tomato cultivars (Rutgers, New Jersey Agricultural Experiment Station: Tomato Varieties, n.d.)

Some tomato varieties are grown for fresh consumption, while others are grown for processing. Tomatoes can be processed into, juice, sauces, food additives, etc. Figure 4 shows a tomato processing facility for ketchup production (Food & Biotech Engineers: Tomato Ketchup Plant, n.d.).



Figure 4 Processing tomatoes for ketchup (Food & Biotech Engineers: Tomato Ketchup Plant, n.d.)

Not all tomatoes that are selected for fresh consumption are ultimately consumed. Tomatoes have a thin skin and a soft core, due to the high percentage of water (Diet of Life: Top 10 Vegetables With The Most Water Content, n.d.). For these reasons tomatoes cannot be stored for a long time and are susceptible to becoming mouldy. Figure 5 presents mouldy (rotten) tomatoes (Tech Bakbak: A Technology Blog That Is Easy To Understand, Rotten and spoiled tomatoes may soon produce electricity, n.d.).



Figure 5 Rotten table tomatoes (Tech Bakbak: A Technology Blog That Is Easy To Understand, Rotten and spoiled tomatoes may soon produce electricity, n.d.)

The flowchart (Figure 7Figure 6) presents the value chain for tomato and specific AWCB weight factors from Table 2.

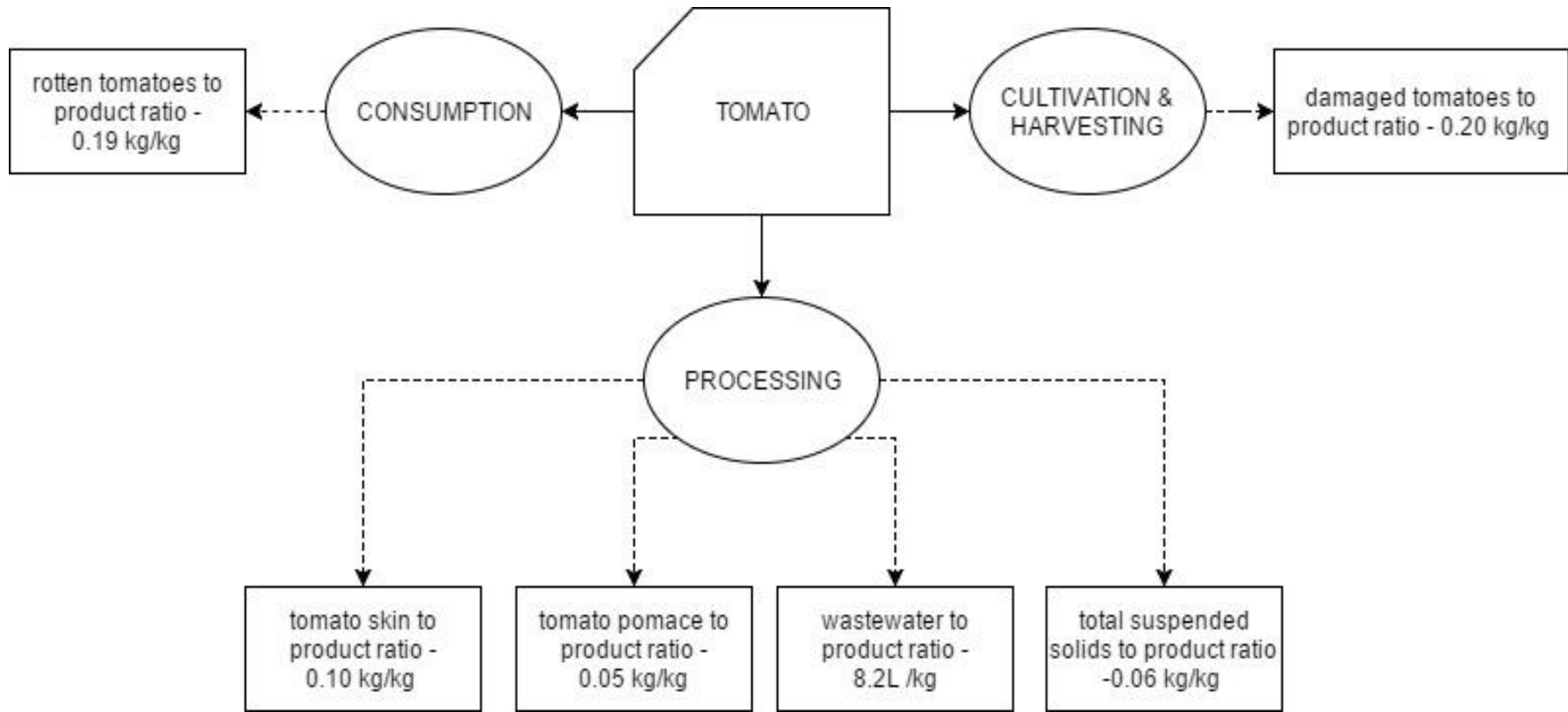


Figure 6 Tomato AWCB value chain

Data for cultivated tomatoes is taken from EUROSTAT, and data for imported and exported tomatoes is taken from FAOSTAT. The methodology used to generate this database requires specific fresh consumption data for the food commodities. Consumption data for tomatoes exist in some form, notably in the food balance sheets of FAOSTAT (<http://www.fao.org/faostat/en/#data/FBS>). These data however represent both fresh and processed consumption of tomatoes. Reliable and consistent data for fresh European tomato consumption was not available at the time of writing are therefore the AWCB arising from consumption and processing steps is not included in this report. The template for their inclusion is available in the accompanying spreadsheets, which may can be updated when more reliable data becomes available.

Table 3 Tonnes of harvested tomatoes per country, 2010-2015 (Eurostat: Agricultural production - crops, n.d.)

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	227,680	218,440	231,830	249,800	249,250	253,050	218,440	253,050	238,342
Bulgaria	114,600	103,100	94,020	117,950	120,490	121,650	94,020	121,650	111,968
Czech Republic	7,240	15,520	13,320	8,290	8,500	5,550	5,550	15,520	9,737
Denmark	15,000	13,240	13,240	12,500	12,750	10,580	10,580	15,000	12,885
Germany	73,290	76,720	61,190	69,260	84,500	80,920	61,190	84,500	74,313
Estonia	800	1,400	1,300	1,400	800	900	800	1,400	1,100
Ireland	4,660	4,660	4,660	4,660	4,250	4,430	4,250	4,660	4,553
Greece	1,406,230	1,169,920	979,620	1,110,160	1,022,150	1,086,400	979,620	1,406,230	1,129,080
Spain	4,312,710	3,864,120	4,046,410	3,776,800	4,888,880	4,832,700	3,776,800	4,888,880	4,286,937
France	808,360	845,000	763,480	775,630	786,100	787,880	763,480	845,000	794,408
Croatia	22,280	23,590	18,440	20,740	19,600	36,270	18,440	36,270	23,487
Italy	6,024,780	5,961,530	5,131,980	5,321,250	4,498,080	6,410,250	4,498,080	6,410,250	5,557,978
Cyprus	18,320	17,170	15,790	13,280	16,560	16,060	13,280	18,320	16,197
Latvia	0	0	5,700	6,400	4,900	6,100	0	6,400	3,850
Lithuania	13,600	14,600	11,500	11,800	11,900	7,670	7,670	14,600	11,845
Luxembourg	70	60	100	100	120	120	60	120	95
Hungary	134,270	163,350	108,800	135,800	153,170	200,000	108,800	200,000	149,232
Malta	14,570	13,950	11,140	12,290	12,930	11,980	11,140	14,570	12,810
Netherlands	765,000	815,000	805,000	855,000	900,000	890,000	765,000	900,000	838,333
Austria	44,240	50,390	52,030	53,330	57,250	55,670	44,240	57,250	52,152
Poland	712,300	712,300	758,900	761,500	810,600	789,600	712,300	810,600	757,533
Portugal	1,247,620	1,247,620	1,394,420	1,186,840	1,399,540	1,407,000	1,186,840	1,407,000	1,313,840
Romania	414,500	590,080	453,130	509,220	473,860	464,810	414,500	590,080	484,267
Slovenia	3,770	5,510	7,310	0	6,610	5,710	0	7,310	4,818
Slovakia	10,470	19,090	14,250	9,730	21,460	19,500	9,730	21,460	15,750
Finland	39,200	40,160	38,350	38,340	39,890	36,450	36,450	40,160	38,732
Sweden	13,770	13,540	14,490	15,090	14,580	14,790	13,540	15,090	14,377
United Kingdom	0	0	0	0	98,500	97,200	0	98,500	32,617



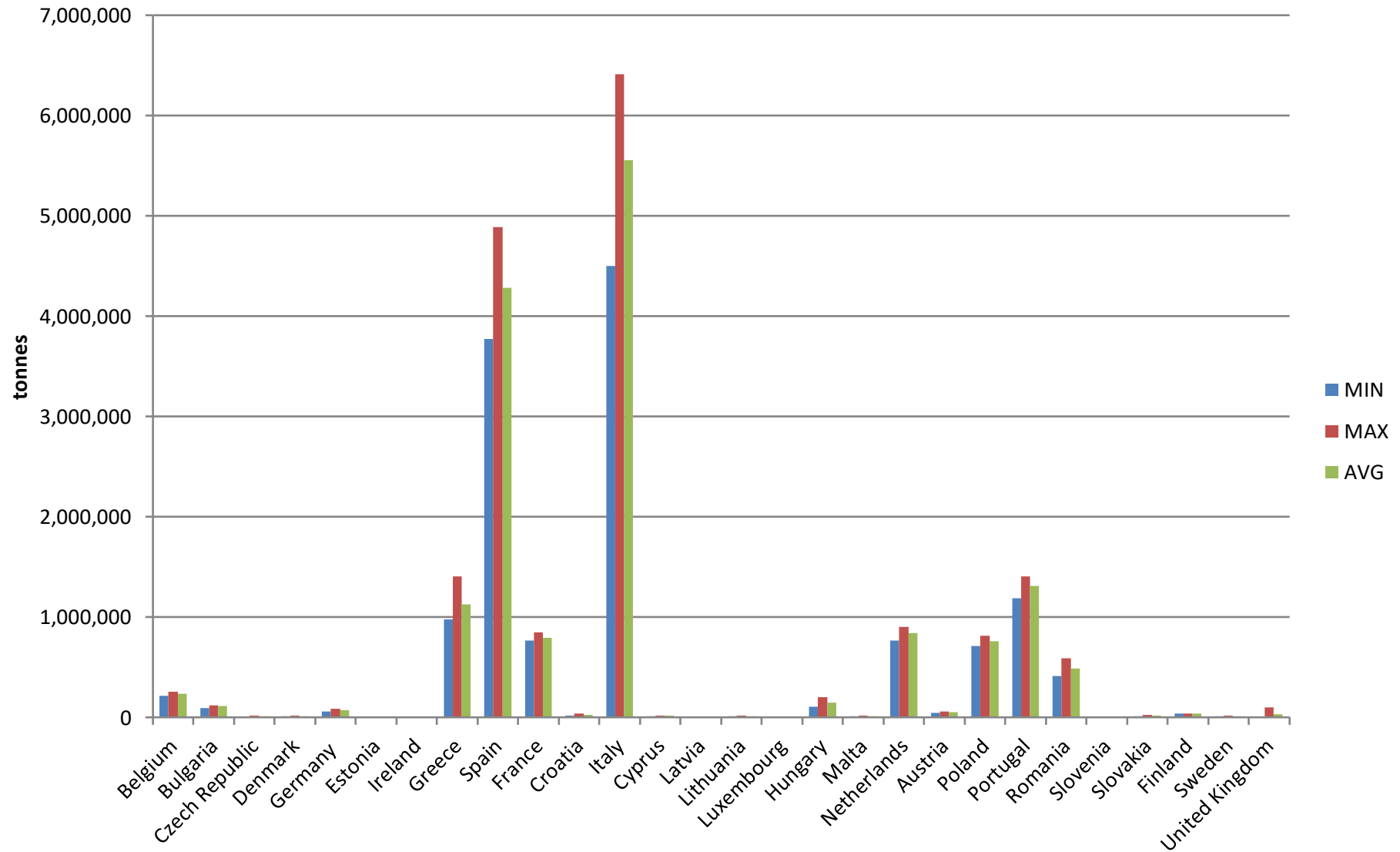


Figure 7 Tonnes of harvested tomatoes per country, 2010-2015

Table 4 Tonnes of damaged tomatoes during harvesting per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	45,536	43,688	46,366	49,960	49,850	50,610	43,688	50,610	47,668
Bulgaria	22,920	20,620	18,804	23,590	24,098	24,330	18,804	24,330	22,394
Czech Republic	1,448	3,104	2,664	1,658	1,700	1,110	1,110	3,104	1,947
Denmark	3,000	2,648	2,648	2,500	2,550	2,116	2,116	3,000	2,577
Germany	14,658	15,344	12,238	13,852	16,900	16,184	12,238	16,900	14,863
Estonia	160	280	260	280	160	180	160	280	220
Ireland	932	932	932	932	850	886	850	932	911
Greece	281,246	233,984	195,924	222,032	204,430	217,280	195,924	281,246	225,816
Spain	862,542	772,824	809,282	755,360	977,776	966,540	755,360	977,776	857,387
France	161,672	169,000	152,696	155,126	157,220	157,576	152,696	169,000	158,882
Croatia	4,456	4,718	3,688	4,148	3,920	7,254	3,688	7,254	4,697
Italy	1,204,956	1,192,306	1,026,396	1,064,250	899,616	1,282,050	899,616	1,282,050	1,111,596
Cyprus	3,664	3,434	3,158	2,656	3,312	3,212	2,656	3,664	3,239
Latvia	0	0	1,140	1,280	980	1,220	0	1,280	770
Lithuania	2,720	2,920	2,300	2,360	2,380	1,534	1,534	2,920	2,369
Luxembourg	14	12	20	20	24	24	12	24	19
Hungary	26,854	32,670	21,760	27,160	30,634	40,000	21,760	40,000	29,846
Malta	2,914	2,790	2,228	2,458	2,586	2,396	2,228	2,914	2,562
Netherlands	153,000	163,000	161,000	171,000	180,000	178,000	153,000	180,000	167,667
Austria	8,848	10,078	10,406	10,666	11,450	11,134	8,848	11,450	10,430
Poland	142,460	142,460	151,780	152,300	162,120	157,920	142,460	162,120	151,507
Portugal	249,524	249,524	278,884	237,368	279,908	281,400	237,368	281,400	262,768
Romania	82,900	118,016	90,626	101,844	94,772	92,962	82,900	118,016	96,853
Slovenia	754	1,102	1,462	0	1,322	1,142	0	1,462	964
Slovakia	2,094	3,818	2,850	1,946	4,292	3,900	1,946	4,292	3,150
Finland	7,840	8,032	7,670	7,668	7,978	7,290	7,290	8,032	7,746
Sweden	2,754	2,708	2,898	3,018	2,916	2,958	2,708	3,018	2,875
United Kingdom	0	0	0	0	19,700	19,440	0	19,700	6,523

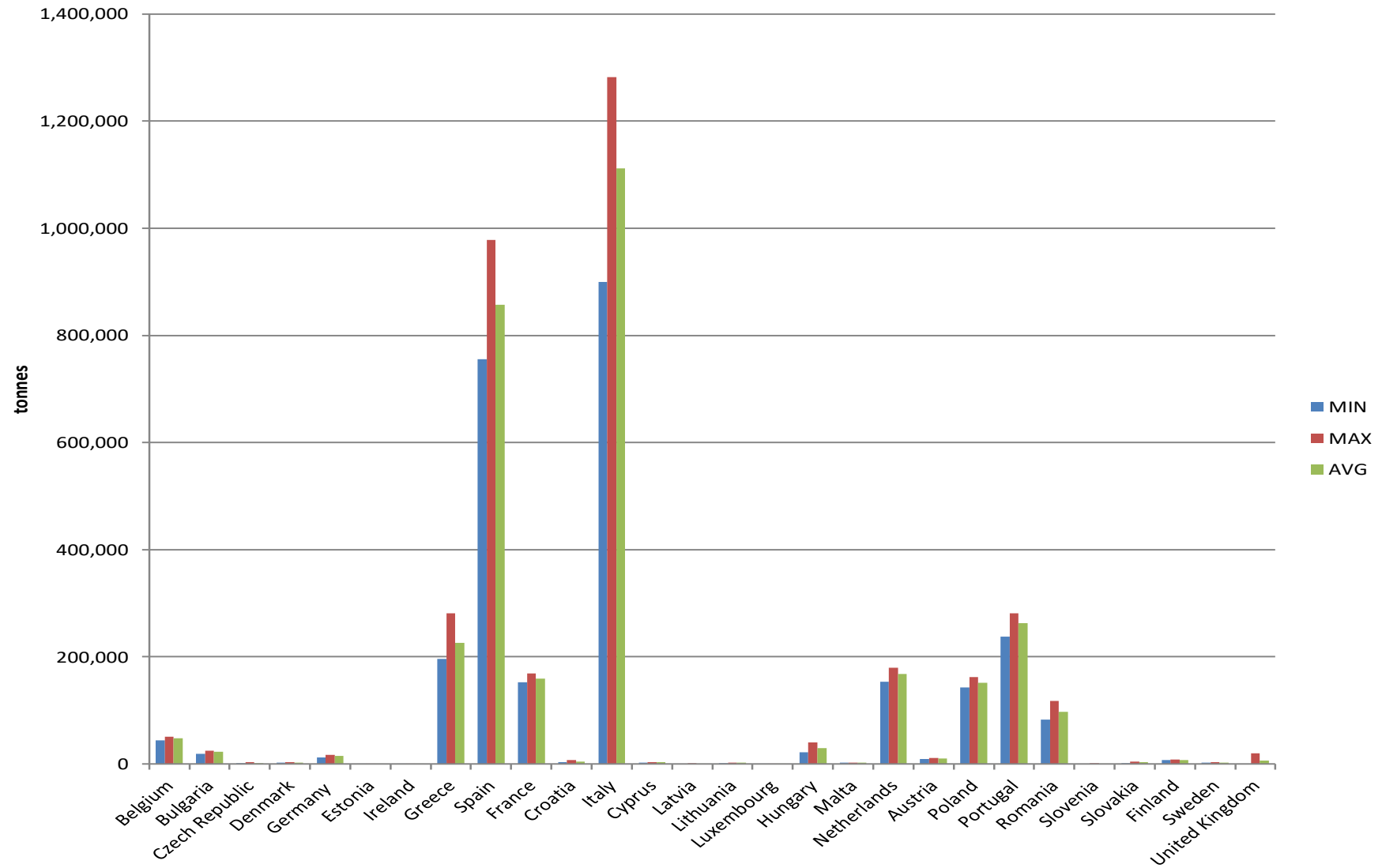


Figure 8 Tonnes of damaged tomatoes per country, 2010-2015

Table 5 Import and export quantities of tomatoes per country, 2010-2013 (FAO: Crops and livestock products, n.d.)

GEO/POPULATION	Trade	2010	2011	2012	2013
Belgium	Import	76,505	79,193	84,888	94,685
	Export	192,550	197,113	217,196	234,499
Bulgaria	Import	45,755	31,424	32,447	35,055
	Export	4,797	2,328	1,115	1,557
Czech Republic	Import	91,450	97,832	89,863	94,647
	Export	13,618	12,895	10,433	8,938
Denmark	Import	48,498	45,722	36,551	34,643
	Export	1,854	1,470	1,189	1,800
Germany	Import	681,217	706,671	710,811	739,361
	Export	29,528	20,963	24,318	23,568
Estonia	Import	11,098	11,736	11,613	11,547
	Export	158	119	97	103
Ireland	Import	29,939	26,212	26,401	27,190
	Export	1,073	697	604	605
Greece	Import	17,011	15,537	15,779	8,238
	Export	7,307	14,470	16,177	20,001
Spain	Import	163,475	144,608	148,340	110,501
	Export	738,773	964,054	908,755	1,004,009
France	Import	500,697	519,052	553,237	557,526
	Export	190,879	214,414	223,955	229,753
Croatia	Import	8,987	9,819	10,363	10,498
	Export	116	517	307	553
Italy	Import	96,591	129,916	129,475	120,705
	Export	128,830	105,638	101,838	108,328
Cyprus	Import	942	817	878	661
	Export	1	53	4	2
Latvia	Import	13,797	18,000	17,270	18,668
	Export	1,894	4,337	4,236	6,373
Lithuania	Import	44,117	61,273	87,642	127,219
	Export	32,490	49,737	72,691	107,777
Luxembourg	Import	5,182	5,135	5,014	5,346
	Export	366	453	361	514

Hungary	Import	16,053	12,668	9,161	12,691
	Export	6,234	2,618	2,145	1,952
Malta	Import	389	823	944	822
	Export	0	0	0	0
Netherlands	Import	943,119	1,023,496	977,664	1,013,529
	Export	191,544	209,434	206,996	196,880
Austria	Import	62,041	51,869	49,969	48,686
	Export	21,541	12,024	11,647	8,717
Poland	Import	101,722	117,174	115,524	135,039
	Export	71,905	72,104	95,329	104,871
Portugal	Import	28,781	28,229	30,058	34,304
	Export	80,798	101,265	98,607	97,436
Romania	Import	60,767	47,514	41,469	45,033
	Export	1,367	1,719	2,990	2,793
Slovenia	Import	22,898	19,052	16,431	15,509
	Export	10,729	8,886	10,242	8,508
Slovakia	Import	29,335	29,323	28,576	27,340
	Export	4,297	2,620	4,766	4,171
Finland	Import	22,479	24,197	25,469	27,813
	Export	174	190	177	173
Sweden	Import	85,683	89,585	87,931	93,370
	Export	377	352	571	1,382
United Kingdom	Import	386,509	414,381	409,238	422,971
	Export	4,613	5,591	6,185	3,713

## 2.2 Cabbage

Cabbage is a one year plant, which is either green or purple colour and can grow up to 4 kg in weight (FHF: Crops Handbook, 2014). It is produced for fresh consumption, or to be processed, e.g. sauerkraut. Cabbage is typically grown in a field, where it is exposed to the elements, such as pests or bad weather, as shown in Figure 9 (Lavender Creek: Rabbit Food or Sauerkraut, n.d.).



Figure 9 Cabbage head eaten/damaged by rabbit (Lavender Creek: Rabbit Food or Sauerkraut, n.d.)

A large amount of cabbage that is processed results in coleslaw (Agricultural Marketing Resource Center (AgMRC): Cabbage, n.d.). The AWCBs that occur in this processing stage are leaves and cabbage juice. Figure 10 shows a cabbage processing facility (Agricultural Marketing Resource Center (AgMRC): Cabbage, n.d.).



Figure 10 Cabbage processing facility (Agricultural Marketing Resource Center (AgMRC): Cabbage, n.d.)

The consumption of fresh cabbage is the final step of the cabbage value chain, where almost 20 % of edible cabbage goes mouldy generating a significant amount of AWCB.

The flowchart (Figure 11) presents the value chain for cabbage and specific AWCB weight factors from Table 2.

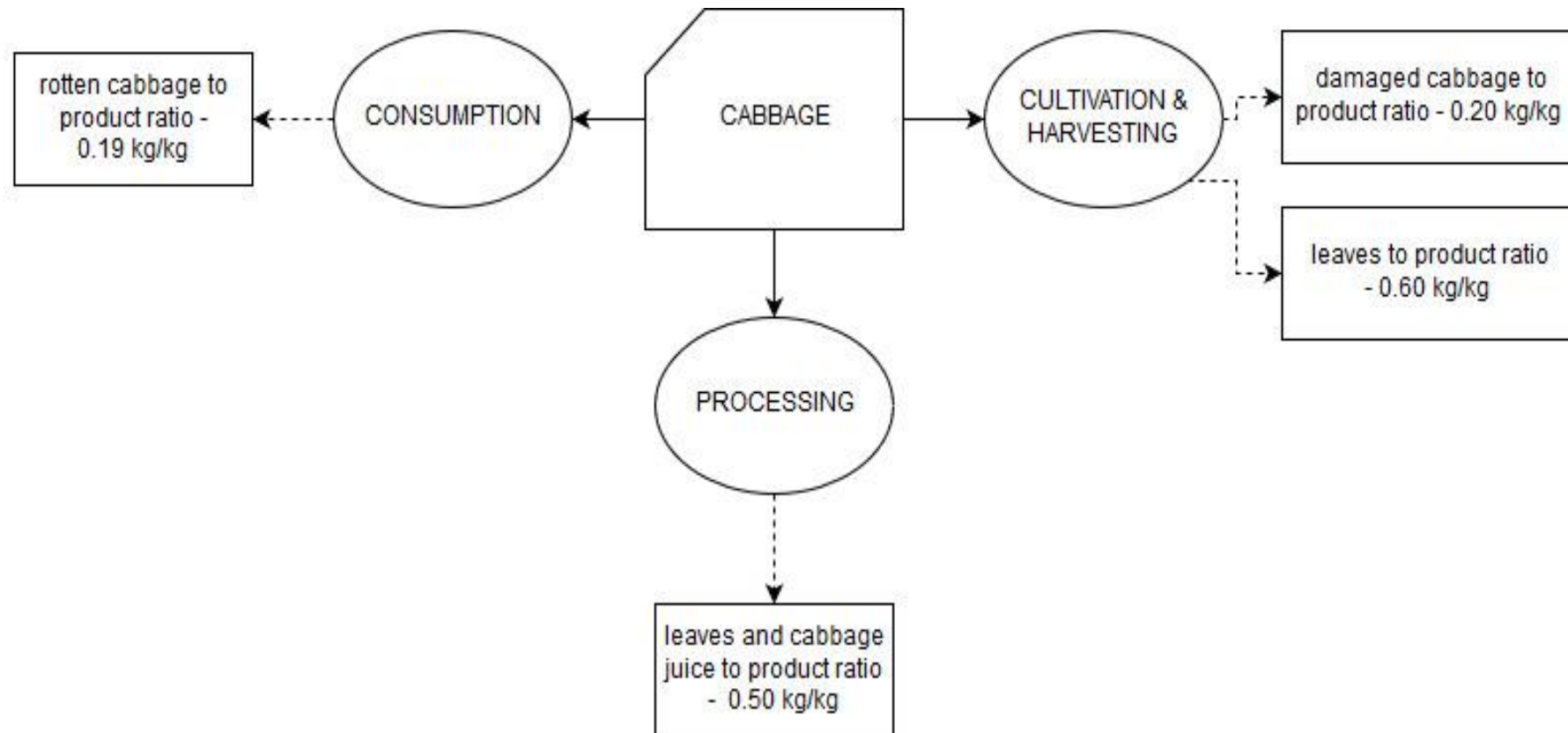


Figure 11 Cabbage AWCB value chain

Data for cultivated cabbage is taken from EUROSTAT, and data for imported and exported cabbages is taken from FAOSTAT. Using the specific consumption of cabbage and the population per country, the quantity of consumed cabbage is calculated. By using relations (I-VIII) the quantity of processed cabbage is estimated for each country in each given year. Then the quantity of AWCB is estimated for each step and each year. An example of the calculation for Ireland in 2010 is presented below:

PRD = 23,880 tonnes

IMP = 10,675 tonnes

EXP = 379 tonnes

CON = 18,198 tonnes

$PRC = (23,880 + 10,675) - (379 + 18,198) = 15,978$  tonnes

Cabbage damaged during cultivation and harvesting represents 0.20 kg per kg of harvested cabbage and for Ireland, this was 4,776 tonnes in 2010. Leaves and juice that arise in processing step account 0.30 kg per kg of processed cabbage. For Ireland, in 2010 the quantity of processing AWCB was 4,793 tonnes. The quantity of consumed cabbage was 18,198 tonnes, and 3,458 tonnes became rotten. Results for other countries and years are presented in the tables and figures below.



Table 6 Tonnes of harvested cabbage per country, 2010-2015 (Eurostat: Agricultural production - crops, n.d.)

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	26,000	25,900	26,000	31,500	31,500	58,250	25,900	58,250	33,192
Bulgaria	78,940	44,600	47,300	45,100	42,350	42,450	42,350	78,940	50,123
Czech Republic	37,960	61,530	51,630	43,820	57,560	43,550	37,960	61,530	49,342
Denmark	12,710	15,630	16,810	18,420	26,280	27,070	12,710	27,070	19,487
Germany	470,550	506,680	473,120	427,160	477,820	550,270	427,160	550,270	484,267
Estonia	11,800	14,100	10,800	19,500	11,800	14,300	10,800	19,500	13,717
Ireland	23,880	28,150	19,650	21,830	22,110	22,250	19,650	28,150	22,978
Greece	187,600	180,100	186,420	187,620	117,800	123,230	117,800	187,620	163,795
Spain	193,630	210,890	163,560	181,940	150,510	165,770	150,510	210,890	177,717
France	109,590	91,770	74,390	60,190	69,460	57,890	57,890	109,590	77,215
Croatia	30,310	32,780	19,260	26,720	21,000	34,710	19,260	34,710	27,463
Italy	84,900	95,160	88,440	86,850	76,880	177,470	76,880	177,470	101,617
Cyprus	4,340	4,390	4,190	4,110	4,650	4,350	4,110	4,650	4,338
Latvia	30,000	31,400	25,200	22,600	29,600	27,700	22,600	31,400	27,750
Lithuania	45,300	98,700	96,000	64,800	65,200	55,400	45,300	98,700	70,900
Luxembourg	60	60	70	100	140	140	60	140	95
Hungary	57,130	80,800	65,290	66,790	69,640	50,000	50,000	80,800	64,942
Malta	3,330	3,760	3,830	4,430	4,370	3,890	3,330	4,430	3,935
Netherlands	132,000	137,000	131,000	140,000	206,000	209,790	131,000	209,790	159,298
Austria	51,920	59,590	53,780	41,580	52,360	45,530	41,580	59,590	50,793
Poland	1,089,970	1,231,200	1,140,400	953,800	1,156,400	875,000	875,000	1,231,200	1,074,462
Portugal	74,930	74,930	75,380	89,240	84,090	71,020	71,020	89,240	78,265
Romania	539,490	632,340	629,540	649,540	683,050	643,240	539,490	683,050	629,533
Slovenia	20,240	20,870	17,360	16,510	16,210	20,900	16,210	20,900	18,682
Slovakia	0	0	0	14,140	15,950	9,800	0	15,950	6,648
Finland	22,160	23,170	21,280	21,820	24,210	20,970	20,970	24,210	22,268
Sweden	21,400	18,800	16,990	17,500	16,460	15,170	15,170	21,400	17,720
United Kingdom	162,000	151,000	151,000	140,000	26,000	230,400	26,000	230,400	143,400

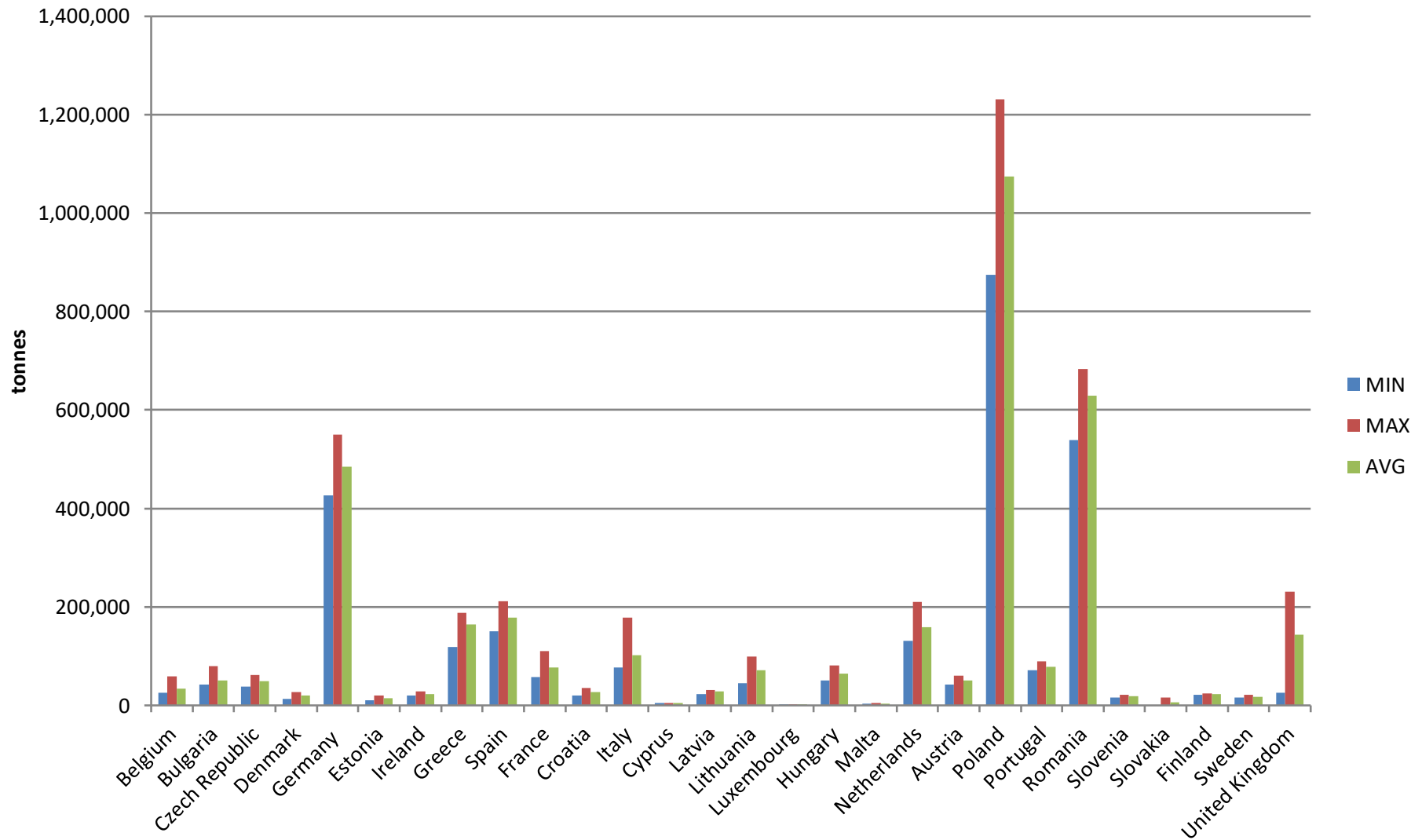


Figure 12 Tonnes of harvested cabbage per country, 2010-2015

Table 7 Tonnes of damaged cabbage per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	5,200	5,180	5,200	6,300	6,300	11,650	5,180	11,650	6,638
Bulgaria	15,788	8,920	9,460	9,020	8,470	8,490	8,470	15,788	10,025
Czech Republic	7,592	12,306	10,326	8,764	11,512	8,710	7,592	12,306	9,868
Denmark	2,542	3,126	3,362	3,684	5,256	5,414	2,542	5,414	3,897
Germany	94,110	101,336	94,624	85,432	95,564	110,054	85,432	110,054	96,853
Estonia	2,360	2,820	2,160	3,900	2,360	2,860	2,160	3,900	2,743
Ireland	4,776	5,630	3,930	4,366	4,422	4,450	3,930	5,630	4,596
Greece	37,520	36,020	37,284	37,524	23,560	24,646	23,560	37,524	32,759
Spain	38,726	42,178	32,712	36,388	30,102	33,154	30,102	42,178	35,543
France	21,918	18,354	14,878	12,038	13,892	11,578	11,578	21,918	15,443
Croatia	6,062	6,556	3,852	5,344	4,200	6,942	3,852	6,942	5,493
Italy	16,980	19,032	17,688	17,370	15,376	35,494	15,376	35,494	20,323
Cyprus	868	878	838	822	930	870	822	930	868
Latvia	6,000	6,280	5,040	4,520	5,920	5,540	4,520	6,280	5,550
Lithuania	9,060	19,740	19,200	12,960	13,040	11,080	9,060	19,740	14,180
Luxembourg	12	12	14	20	28	28	12	28	19
Hungary	11,426	16,160	13,058	13,358	13,928	10,000	10,000	16,160	12,988
Malta	666	752	766	886	874	778	666	886	787
Netherlands	26,400	27,400	26,200	28,000	41,200	41,958	26,200	41,958	31,860
Austria	10,384	11,918	10,756	8,316	10,472	9,106	8,316	11,918	10,159
Poland	217,994	246,240	228,080	190,760	231,280	175,000	175,000	246,240	214,892
Portugal	14,986	14,986	15,076	17,848	16,818	14,204	14,204	17,848	15,653
Romania	107,898	126,468	125,908	129,908	136,610	128,648	107,898	136,610	125,907
Slovenia	4,048	4,174	3,472	3,302	3,242	4,180	3,242	4,180	3,736
Slovakia	0	0	0	2,828	3,190	1,960	0	3,190	1,330
Finland	4,432	4,634	4,256	4,364	4,842	4,194	4,194	4,842	4,454
Sweden	4,280	3,760	3,398	3,500	3,292	3,034	3,034	4,280	3,544
United Kingdom	32,400	30,200	30,200	28,000	5,200	46,080	5,200	46,080	28,680

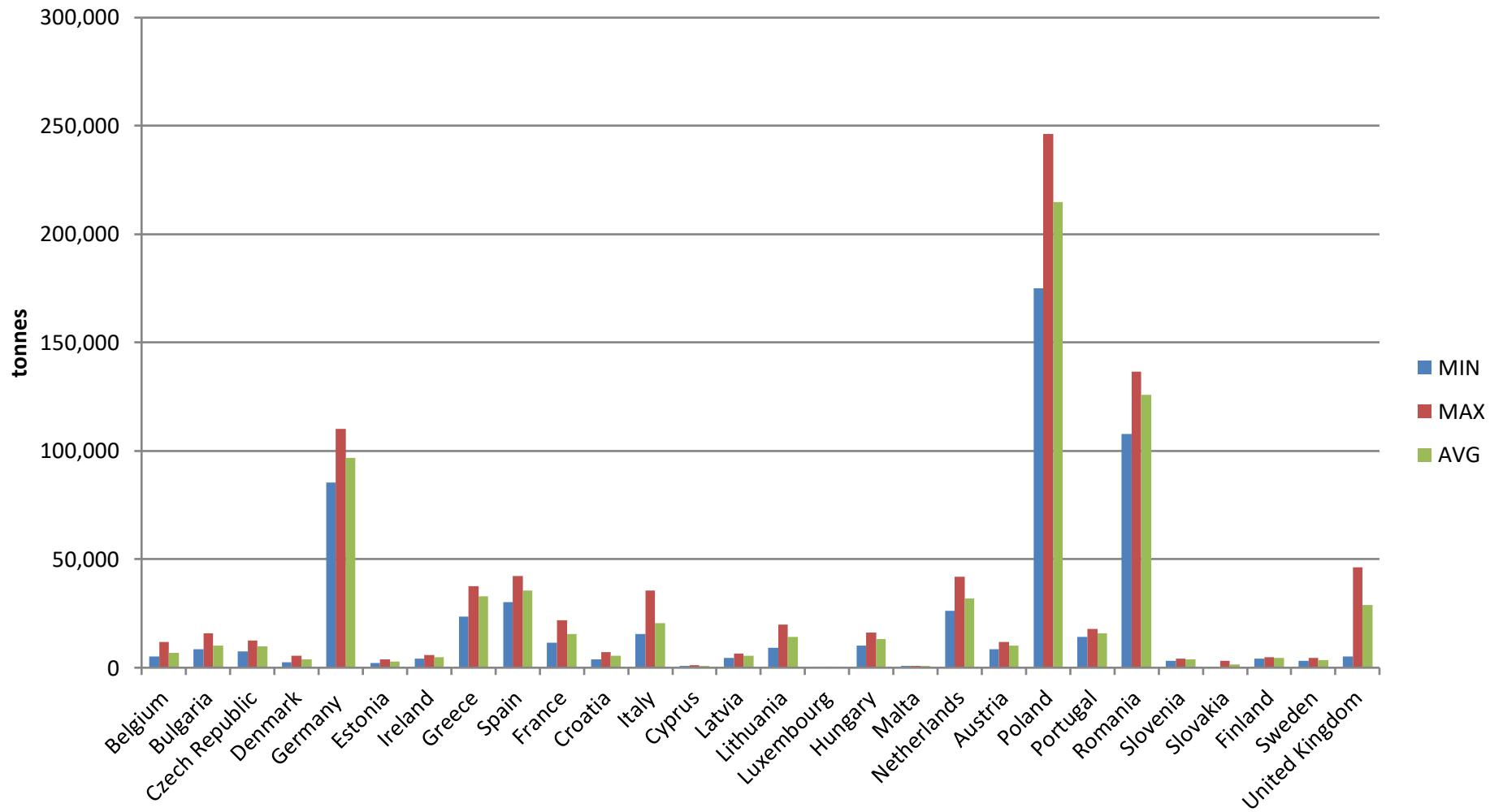


Figure 13 Tonnes of damaged cabbage per country, 2010-2015

Table 8 Tonnes of cabbage leaves left on field per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	15,600	15,540	15,600	18,900	18,900	34,950	15,540	34,950	19,915
Bulgaria	47,364	26,760	28,380	27,060	25,410	25,470	25,410	47,364	30,074
Czech Republic	22,776	36,918	30,978	26,292	34,536	26,130	22,776	36,918	29,605
Denmark	7,626	9,378	10,086	11,052	15,768	16,242	7,626	16,242	11,692
Germany	282,330	304,008	283,872	256,296	286,692	330,162	256,296	330,162	290,560
Estonia	7,080	8,460	6,480	11,700	7,080	8,580	6,480	11,700	8,230
Ireland	14,328	16,890	11,790	13,098	13,266	13,350	11,790	16,890	13,787
Greece	112,560	108,060	111,852	112,572	70,680	73,938	70,680	112,572	98,277
Spain	116,178	126,534	98,136	109,164	90,306	99,462	90,306	126,534	106,630
France	65,754	55,062	44,634	36,114	41,676	34,734	34,734	65,754	46,329
Croatia	18,186	19,668	11,556	16,032	12,600	20,826	11,556	20,826	16,478
Italy	50,940	57,096	53,064	52,110	46,128	106,482	46,128	106,482	60,970
Cyprus	2,604	2,634	2,514	2,466	2,790	2,610	2,466	2,790	2,603
Latvia	18,000	18,840	15,120	13,560	17,760	16,620	13,560	18,840	16,650
Lithuania	27,180	59,220	57,600	38,880	39,120	33,240	27,180	59,220	42,540
Luxembourg	36	36	42	60	84	84	36	84	57
Hungary	34,278	48,480	39,174	40,074	41,784	30,000	30,000	48,480	38,965
Malta	1,998	2,256	2,298	2,658	2,622	2,334	1,998	2,658	2,361
Netherlands	79,200	82,200	78,600	84,000	123,600	125,874	78,600	125,874	95,579
Austria	31,152	35,754	32,268	24,948	31,416	27,318	24,948	35,754	30,476
Poland	653,982	738,720	684,240	572,280	693,840	525,000	525,000	738,720	644,677
Portugal	44,958	44,958	45,228	53,544	50,454	42,612	42,612	53,544	46,959
Romania	323,694	379,404	377,724	389,724	409,830	385,944	323,694	409,830	377,720
Slovenia	12,144	12,522	10,416	9,906	9,726	12,540	9,726	12,540	11,209
Slovakia	0	0	0	8,484	9,570	5,880	0	9,570	3,989
Finland	13,296	13,902	12,768	13,092	14,526	12,582	12,582	14,526	13,361
Sweden	12,840	11,280	10,194	10,500	9,876	9,102	9,102	12,840	10,632
United Kingdom	97,200	90,600	90,600	84,000	15,600	138,240	15,600	138,240	86,040

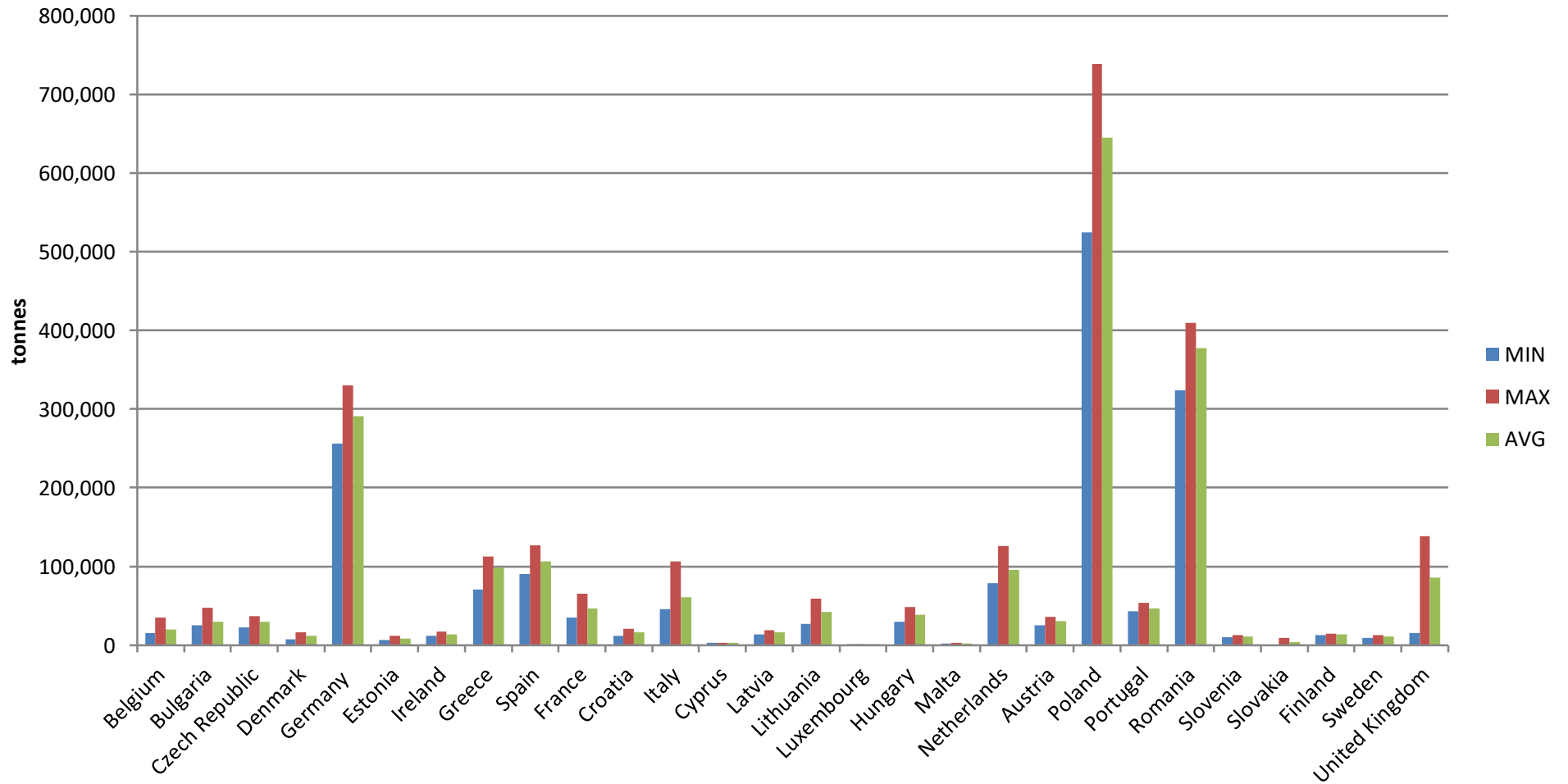


Figure 14 Tonnes of cabbage leaves left on field per country, 2010-2015

Table 9 Tonnes of imported and exported cabbage per country, 2010-2013 (FAO: Crops and livestock products, n.d.)

GEO/POPULATION	Trade	2010	2011	2012	2013
Belgium	Import	23,044	27,748	22,377	24,827
	Export	29,599	31,024	26,751	36,623
Bulgaria	Import	14,891	11,069	12,850	10,274
	Export	2,421	1,598	33	404
Czech Republic	Import	49,928	41,597	43,595	50,352
	Export	9,671	9,358	9,919	10,771
Denmark	Import	16,415	14,763	11,166	11,674
	Export	806	1,134	794	828
Germany	Import	156,320	166,055	157,052	146,131
	Export	105,162	91,907	68,769	87,423
Estonia	Import	4,684	4,801	3,412	2,866
	Export	318	64	24	77
Ireland	Import	10,675	12,035	14,215	13,767
	Export	379	339	267	324
Greece	Import	1,753	1,216	1,232	606
	Export	1,177	981	3,114	2,411
Spain	Import	7,606	6,532	9,628	9,804
	Export	61,759	65,836	62,465	68,843
France	Import	46,746	41,922	45,170	51,535
	Export	13,096	13,761	11,676	10,992
Croatia	Import	3,969	3,141	7,419	5,965
	Export	307	1,028	902	455
Italy	Import	15,569	14,373	16,613	20,548
	Export	61,864	60,912	66,123	58,519
Cyprus	Import	199	290	297	295
	Export	0	0	2	9
Latvia	Import	3,400	4,880	5,337	3,853
	Export	2,896	2,532	1,896	2,126
Lithuania	Import	14,560	15,839	12,370	12,071
	Export	9,174	8,080	8,268	7,008
Luxembourg	Import	1,534	1,457	1,453	1,575
	Export	125	125	124	140

Hungary	Import	8,540	8,195	6,666	5,816
	Export	9,487	9,938	9,505	7,668
Malta	Import	101	176	281	135
	Export	0	0	0	0
Netherlands	Import	54,824	59,920	64,940	63,313
	Export	205,033	267,570	183,724	179,159
Austria	Import	19,250	16,096	14,297	16,565
	Export	6,199	6,696	4,974	4,700
Poland	Import	27,193	21,154	8,952	12,971
	Export	110,577	104,377	131,432	138,797
Portugal	Import	4,417	2,621	2,957	5,351
	Export	9,682	13,004	17,506	21,202
Romania	Import	15,956	18,691	20,972	15,261
	Export	482	587	276	361
Slovenia	Import	4,725	5,133	5,069	7,254
	Export	595	678	845	403
Slovakia	Import	39,770	35,982	37,726	33,385
	Export	1,610	305	1,024	347
Finland	Import	4,662	5,565	5,241	5,544
	Export	27	116	331	133
Sweden	Import	30,840	27,971	30,032	29,173
	Export	313	267	295	394
United Kingdom	Import	46,449	50,226	57,048	64,105
	Export	9,860	5,933	8,203	6,117



Table 10 Tonnes of processed cabbage per country, 2010-2013

GEO/TIME	2010	2011	2012	2013	MIN	MAX	AVG
Belgium	7,521	10,523	9,422	7,426	7,426	10,523	8,723
Bulgaria	44,282	7,275	13,589	8,713	7,275	44,282	18,465
Czech Republic	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Denmark	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Germany	120,877	187,740	167,796	91,302	91,302	187,740	141,929
Estonia	14,166	16,843	12,200	20,309	12,200	20,309	15,879
Ireland	15,978	21,562	15,267	16,909	15,267	21,562	17,429
Greece	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Spain	88,342	100,252	59,223	71,500	59,223	100,252	79,829
France	52,718	28,961	16,496	8,893	8,893	52,718	26,767
Croatia	28,809	29,745	20,646	27,115	20,646	29,745	26,579
Italy	14,929	24,875	15,172	25,005	14,929	25,005	19,995
Cyprus	3,474	3,588	3,364	3,270	3,270	3,588	3,424
Latvia	28,808	32,088	27,005	22,708	22,708	32,088	27,652
Lithuania	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Luxembourg	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hungary	1,104	24,136	7,825	10,440	1,104	24,136	10,876
Malta	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Netherlands	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Austria	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Poland	725,217	866,313	736,248	546,311	546,311	866,313	718,522
Portugal	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Romania	388,548	484,812	485,449	500,275	388,548	500,275	464,771
Slovenia	20,685	21,635	17,884	19,655	17,884	21,635	19,965
Slovakia	31,152	28,667	29,676	40,144	28,667	40,144	32,410
Finland	14,487	16,256	13,767	14,750	13,767	16,256	14,815
Sweden	35,114	29,556	29,658	29,078	29,078	35,114	30,852
United Kingdom	n/a	n/a	n/a	n/a	n/a	n/a	n/a

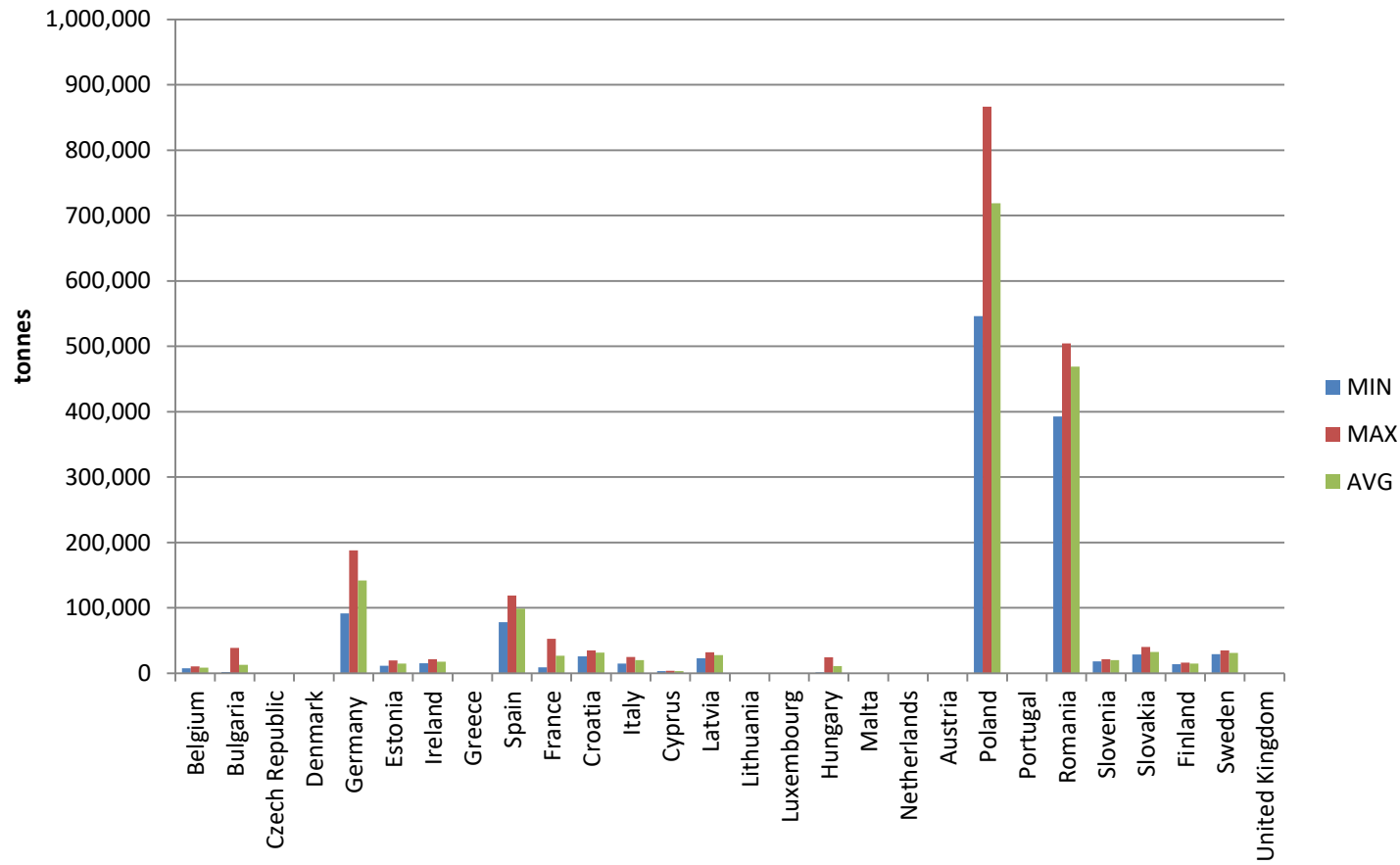


Figure 15 Tonnes of processed cabbage per country, 2010-2013

Table 11 Tonnes of leaves and cabbage juice per country, 2010-2013

GEO/TIME	2010	2011	2012	2013	MIN	MAX	AVG
Belgium	3,761	5,262	4,711	3,713	3,713	5,262	4,362
Bulgaria	22,141	3,638	6,795	4,357	3,638	22,141	9,232
Czech Republic	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Denmark	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Germany	60,438	93,870	83,898	45,651	45,651	93,870	70,964
Estonia	7,083	8,421	6,100	10,154	6,100	10,154	7,940
Ireland	7,989	10,781	7,634	8,454	7,634	10,781	8,715
Greece	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Spain	44,171	50,126	29,611	35,750	29,611	50,126	39,915
France	26,359	14,480	8,248	4,446	4,446	26,359	13,383
Croatia	14,404	14,873	10,323	13,558	10,323	14,873	13,289
Italy	7,464	12,438	7,586	12,502	7,464	12,502	9,998
Cyprus	1,737	1,794	1,682	1,635	1,635	1,794	1,712
Latvia	14,404	16,044	13,503	11,354	11,354	16,044	13,826
Lithuania	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Luxembourg	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hungary	552	12,068	3,913	5,220	552	12,068	5,438
Malta	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Netherlands	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Austria	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Poland	362,608	433,156	368,124	273,156	273,156	433,156	359,261
Portugal	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Romania	194,274	242,406	242,724	250,138	194,274	250,138	232,385
Slovenia	10,343	10,817	8,942	9,828	8,942	10,817	9,982
Slovakia	15,576	14,333	14,838	20,072	14,333	20,072	16,205
Finland	7,243	8,128	6,884	7,375	6,884	8,128	7,407
Sweden	17,557	14,778	14,829	14,539	14,539	17,557	15,426
United Kingdom	n/a	n/a	n/a	n/a	n/a	n/a	n/a

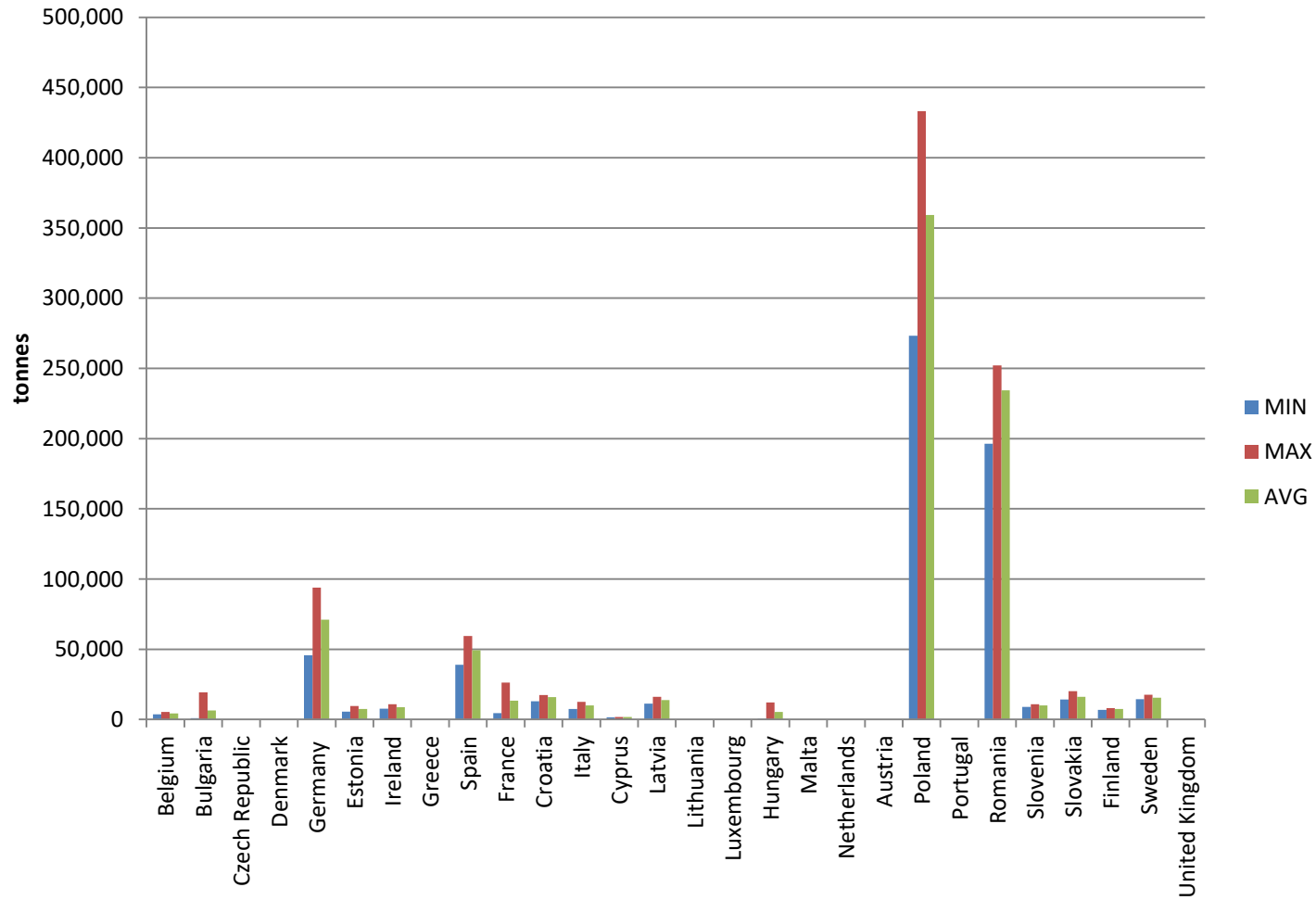


Figure 16 Tonnes of leaves and cabbage juice per country, 2010-2013

Table 12 Consumption of fresh cabbage (tonnes) per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	11,924	12,101	12,204	12,278	12,299	12,361	11,924	12,361	12,194
Bulgaria	47,128	46,796	46,528	46,257	46,010	45,734	45,734	47,128	46,409
Czech Republic	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Denmark	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Germany	400,831	393,088	393,607	394,566	395,761	397,868	393,088	400,831	395,953
Estonia	2,000	1,994	1,988	1,980	1,974	1,972	1,972	2,000	1,985
Ireland	18,198	18,284	18,331	18,364	18,422	18,516	18,198	18,516	18,352
Greece	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Spain	51,135	51,334	51,500	51,401	51,163	51,095	51,095	51,500	51,271
France	90,522	90,970	91,388	91,840	92,319	93,083	90,522	93,083	91,687
Croatia	5,163	5,148	5,131	5,115	5,096	5,070	5,070	5,163	5,121
Italy	23,676	23,746	23,758	23,874	24,313	24,318	23,676	24,318	23,948
Cyprus	1,065	1,092	1,121	1,126	1,115	1,101	1,065	1,126	1,103
Latvia	1,696	1,660	1,636	1,619	1,601	1,589	1,589	1,696	1,634
Lithuania	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Luxembourg	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hungary	55,079	54,921	54,626	54,498	54,326	54,206	54,206	55,079	54,609
Malta	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Netherlands	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Austria	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Poland	281,369	281,664	281,672	281,663	281,332	281,242	281,242	281,672	281,490
Portugal	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Romania	166,416	165,632	164,787	164,165	163,568	162,939	162,939	166,416	164,585
Slovenia	3,685	3,690	3,700	3,706	3,710	3,713	3,685	3,713	3,701
Slovakia	7,008	7,010	7,026	7,034	7,041	7,048	7,008	7,048	7,028
Finland	12,308	12,363	12,423	12,481	12,538	12,585	12,308	12,585	12,450
Sweden	16,813	16,948	17,069	17,201	17,361	17,545	16,813	17,545	17,156
United Kingdom	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

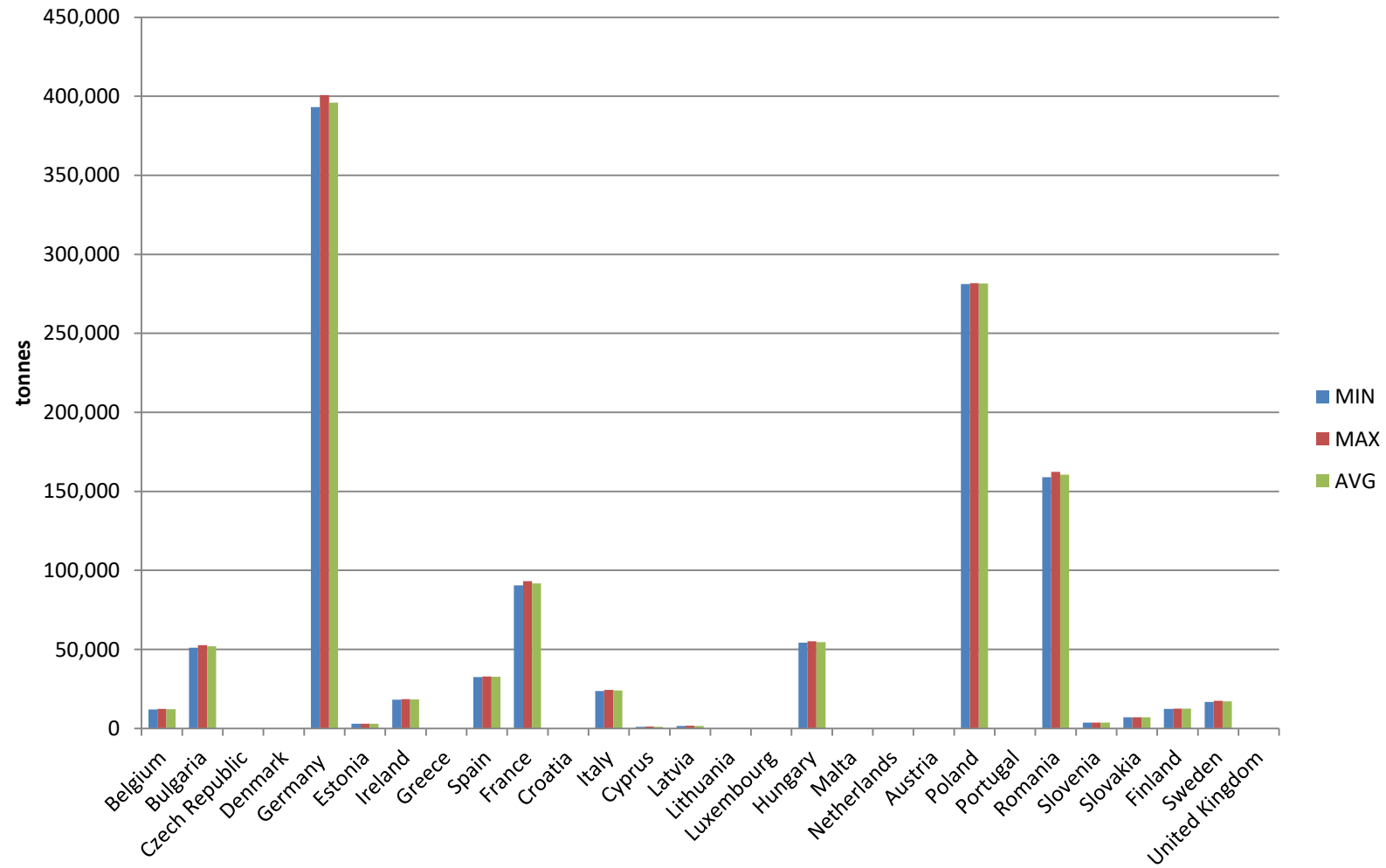


Figure 17 Consumption of fresh cabbage (tonnes) per country, 2010-2015

Table 13 Tonnes of rotten cabbage per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	2,266	2,299	2,319	2,333	2,337	2,349	2,266	2,349	2,317
Bulgaria	8,954	8,891	8,840	8,789	8,742	8,689	8,689	8,954	8,818
Czech Republic	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Denmark	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Germany	76,158	74,687	74,785	74,968	75,195	75,595	74,687	76,158	75,231
Estonia	380	379	378	376	375	375	375	380	377
Ireland	3,458	3,474	3,483	3,489	3,500	3,518	3,458	3,518	3,487
Greece	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Spain	9,716	9,753	9,785	9,766	9,721	9,708	9,708	9,785	9,742
France	17,199	17,284	17,364	17,450	17,541	17,686	17,199	17,686	17,421
Croatia	981	978	975	972	968	963	963	981	973
Italy	4,498	4,512	4,514	4,536	4,619	4,620	4,498	4,620	4,550
Cyprus	202	207	213	214	212	209	202	214	210
Latvia	322	315	311	308	304	302	302	322	310
Lithuania	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Luxembourg	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hungary	10,465	10,435	10,379	10,355	10,322	10,299	10,299	10,465	10,376
Malta	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Netherlands	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Austria	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Poland	53,460	53,516	53,518	53,516	53,453	53,436	53,436	53,518	53,483
Portugal	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Romania	31,619	31,470	31,310	31,191	31,078	30,958	30,958	31,619	31,271
Slovenia	700	701	703	704	705	706	700	706	703
Slovakia	1,331	1,332	1,335	1,336	1,338	1,339	1,331	1,339	1,335
Finland	2,339	2,349	2,360	2,371	2,382	2,391	2,339	2,391	2,365
Sweden	3,195	3,220	3,243	3,268	3,299	3,334	3,195	3,334	3,260
United Kingdom	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

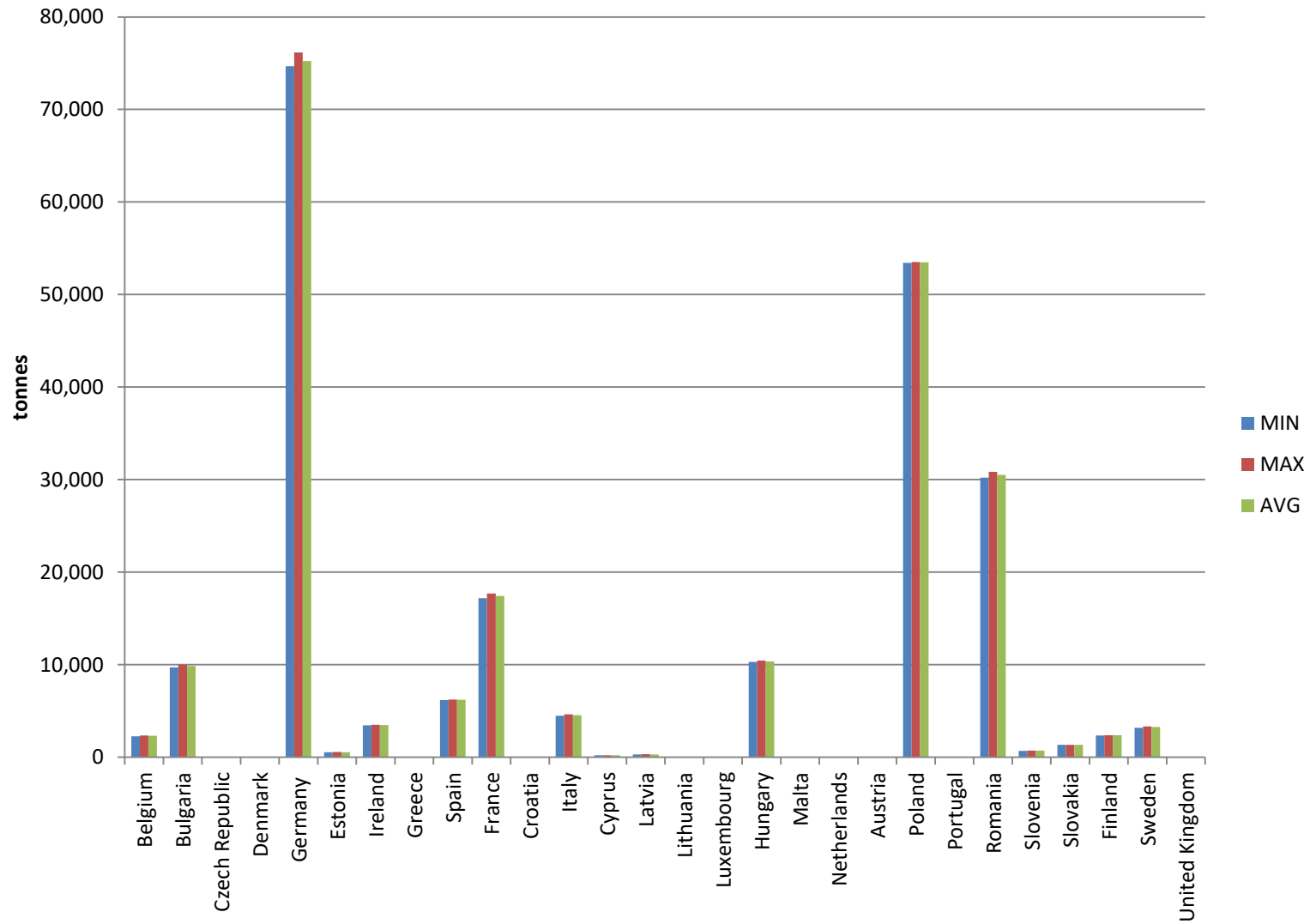


Figure 18 Tonnes of rotten cabbage per country, 2010-2015



### 2.3 Cauliflower and broccoli

A cauliflower is an annual plant. The head of a cauliflower resembles that of broccoli, which differs in having flower buds. Cauliflower (white) and broccoli (green) are shown in Figure 19 (Tehnologija Hrane: Povrće u Bosni i Hercegovini. [In Croatian], n.d.).



Figure 19 Cauliflower and broccoli (Tehnologija Hrane: Povrće u Bosni i Hercegovini. [In Croatian], n.d.)

Cauliflowers and broccoli are vegetables that are processed after harvesting with water. They are washed in order to remove parts of soil and other unwanted particles. Figure 20 shows a cauliflower, broccoli, and carrot processing line (Polar Systems: Industries and Applications/Food/Vegetables, n.d.). After the cleaning of cauliflower and broccoli, they are either distributed fresh or are frozen and packed for distribution.



Figure 20 Processing line for: cauliflower (left), broccoli (middle) and carrot (right) (Polar Systems: Industries and Applications/Food/Vegetables, n.d.)

The flowchart (Figure 21) presents the value chain for cauliflower and broccoli and specific AWCB weight factors from Table 2.

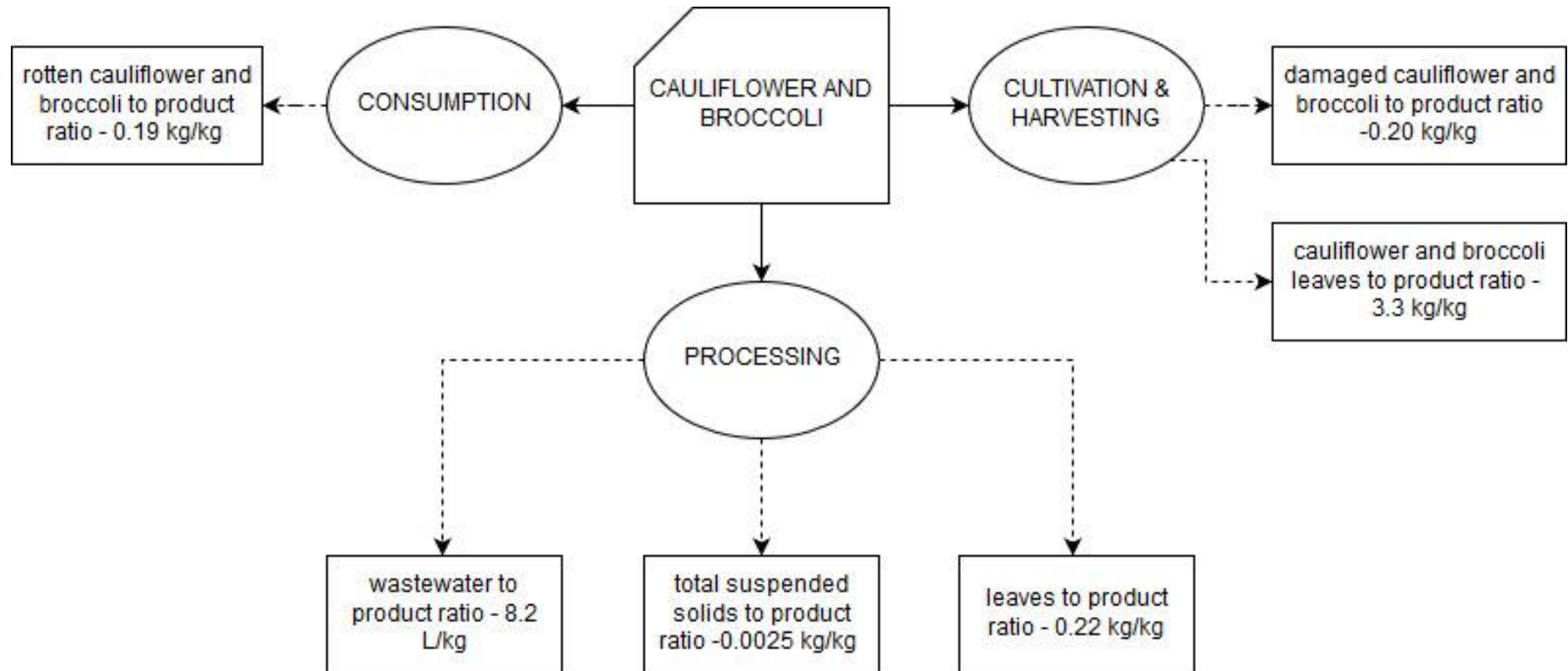


Figure 21 Cauliflower and broccoli AWCB value chain

Data for cultivated cauliflower and broccoli is taken from EUROSTAT, and data for imported and exported cauliflower and broccoli is taken from FAOSTAT. Using the specific consumption of cauliflower and broccoli and the population per country, the quantity of consumed cauliflower and broccoli is calculated. By using relations (I-VIII), the quantity of processed cauliflower and broccoli is estimated for each country in each given year. Then the quantity of AWCB is estimated for each stage and each year. An example of the calculation for Germany in 2010 is presented below:

PRD = 151,980 tonnes

IMP = 63,064 tonnes

EXP = 27,488 tonnes

CON = 24,541 tonnes

$PRC = (151,980 + 63,064) - (27,488 + 24,541) = 163,015$  tonnes

The quantity of damaged cauliflowers and broccoli is 0.20 kg per kg of harvested vegetable: for Germany, this was 30,396 tonnes in 2010. In 2010 the quantity of wastewater from cauliflower and broccoli processing in France was 1,336,726 m<sup>3</sup>. Germany consumed 24,541 tonnes of cauliflower and broccoli in 2010. 4,663 tonnes of this became rotten cauliflowers and broccoli. Results for other countries and years are presented in the tables and figures below.

Table 14 Tonnes of harvested cauliflower and broccoli per country, 2010-2015 (Eurostat: Agricultural production - crops, n.d.)

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	82,340	99,660	98,120	95,980	99,220	110,060	82,340	110,060	97,563
Bulgaria	0	0	4,800	3,300	3,210	2,590	0	4,800	2,317
Czech Republic	4,520	5,250	3,940	3,750	3,900	3,700	3,700	5,250	4,177
Denmark	7,730	5,840	5,490	4,910	4,420	5,970	4,420	7,730	5,727
Germany	151,980	144,140	176,690	154,080	149,160	134,850	134,850	176,690	151,817
Estonia	300	300	100	200	200	200	100	300	217
Ireland	11,760	13,900	10,760	12,090	12,100	11,110	10,760	13,900	11,953
Greece	73,310	85,760	88,940	87,890	57,590	59,720	57,590	88,940	75,535
Spain	507,960	513,780	505,620	540,890	596,970	607,190	505,620	607,190	545,402
France	355,550	388,630	375,810	345,210	326,360	341,470	326,360	388,630	355,505
Croatia	1,980	1,910	1,910	1,490	2,040	1,760	1,490	2,040	1,848
Italy	410,730	407,160	414,140	381,630	405,050	385,970	381,630	414,140	400,780
Cyprus	1,690	1,670	1,560	1,360	1,620	1,130	1,130	1,690	1,505
Latvia	0	0	0	600	500	500	0	600	267
Lithuania	1,600	2,100	1,900	2,000	1,800	1,740	1,600	2,100	1,857
Luxembourg	30	40	30	30	20	20	20	40	28
Hungary	17,390	17,160	15,850	23,470	19,900	20,000	15,850	23,470	18,962
Malta	6,930	6,850	5,640	6,560	6,660	5,800	5,640	6,930	6,407
Netherlands	65,000	57,000	53,000	51,000	52,000	65,460	51,000	65,460	57,243
Austria	7,060	7,020	5,960	5,320	5,790	4,900	4,900	7,060	6,008
Poland	252,330	297,600	306,800	271,300	320,600	252,900	252,330	320,600	283,588
Portugal	0	48,390	48,530	40,850	38,970	47,680	0	48,530	37,403
Romania	31,630	39,160	38,200	50,230	45,130	43,150	31,630	50,230	41,250
Slovenia	1,000	1,250	1,300	0	1,630	1,620	0	1,630	1,133
Slovakia	0	0	0	2,260	950	2,890	0	2,890	1,017
Finland	3,150	3,950	4,070	3,420	3,960	0	0	4,070	3,092
Sweden	6,090	7,970	7,470	7,940	9,370	9,300	6,090	9,370	8,023
United Kingdom	109,000	102,000	90,000	88,000	163,000	163,000	88,000	163,000	119,167

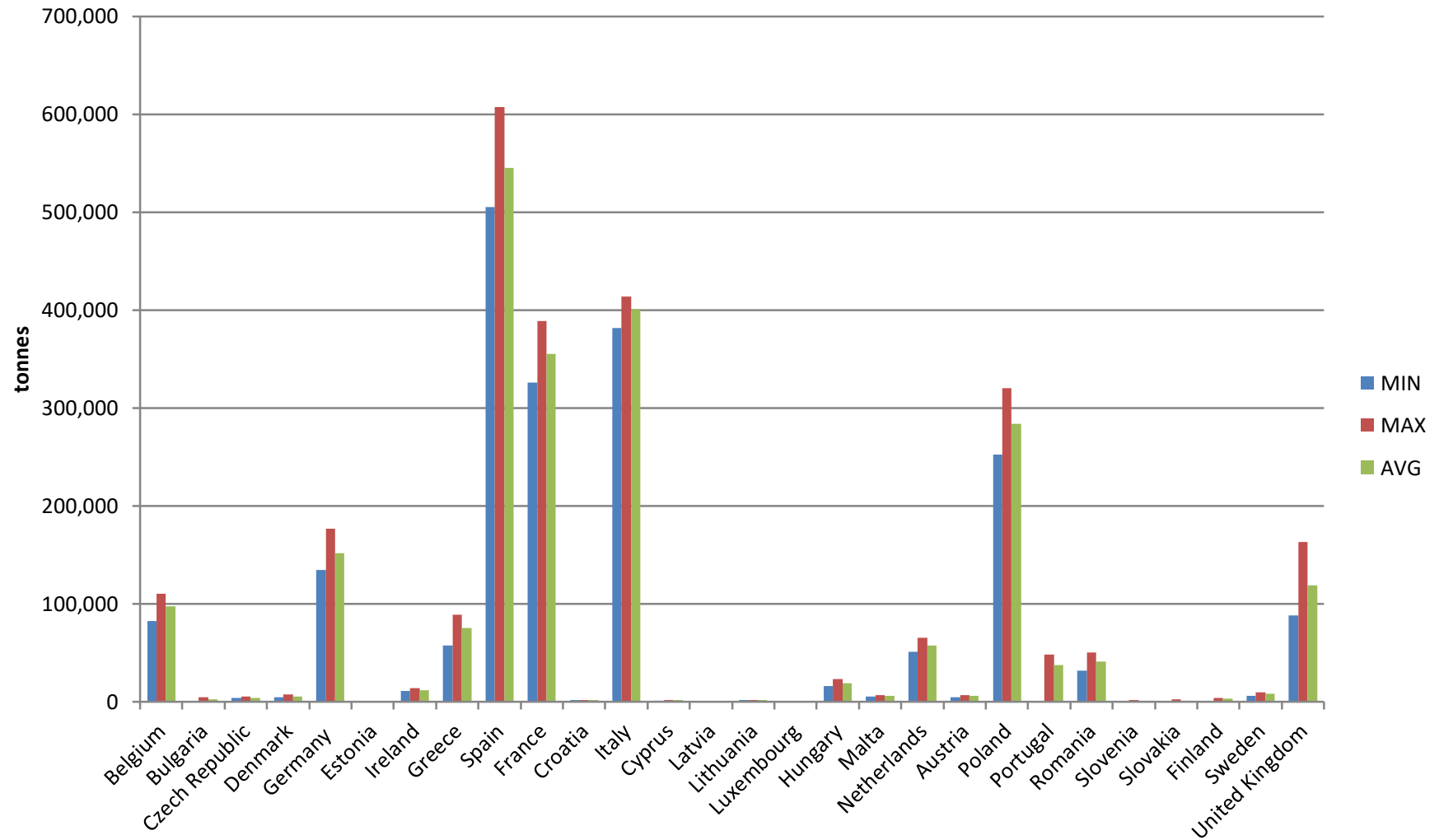


Figure 22 Tonnes of harvested cauliflower and broccoli per country, 2010-2015

Table 15 Tonnes of damaged cauliflower and broccoli per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	16468	19932	19624	19196	19844	22012	16468	22012	19513
Bulgaria	0	0	960	660	642	518	0	960	463
Czech Republic	904	1050	788	750	780	740	740	1050	835
Denmark	1546	1168	1098	982	884	1194	884	1546	1145
Germany	30396	28828	35338	30816	29832	26970	26970	35338	30363
Estonia	60	60	20	40	40	40	20	60	43
Ireland	2352	2780	2152	2418	2420	2222	2152	2780	2391
Greece	14662	17152	17788	17578	11518	11944	11518	17788	15107
Spain	101592	102756	101124	108178	119394	121438	101124	121438	109080
France	71110	77726	75162	69042	65272	68294	65272	77726	71101
Croatia	396	382	382	298	408	352	298	408	370
Italy	82146	81432	82828	76326	81010	77194	76326	82828	80156
Cyprus	338	334	312	272	324	226	226	338	301
Latvia	0	0	0	120	100	100	0	120	53
Lithuania	320	420	380	400	360	348	320	420	371
Luxembourg	6	8	6	6	4	4	4	8	6
Hungary	3478	3432	3170	4694	3980	4000	3170	4694	3792
Malta	1386	1370	1128	1312	1332	1160	1128	1386	1281
Netherlands	13000	11400	10600	10200	10400	13092	10200	13092	11449
Austria	1412	1404	1192	1064	1158	980	980	1412	1202
Poland	50466	59520	61360	54260	64120	50580	50466	64120	56718
Portugal	0	9678	9706	8170	7794	9536	0	9706	7481
Romania	6326	7832	7640	10046	9026	8630	6326	10046	8250
Slovenia	200	250	260	0	326	324	0	326	227
Slovakia	0	0	0	452	190	578	0	578	203
Finland	630	790	814	684	792	0	0	814	618
Sweden	1218	1594	1494	1588	1874	1860	1218	1874	1605
United Kingdom	21800	20400	18000	17600	32600	32600	17600	32600	23833

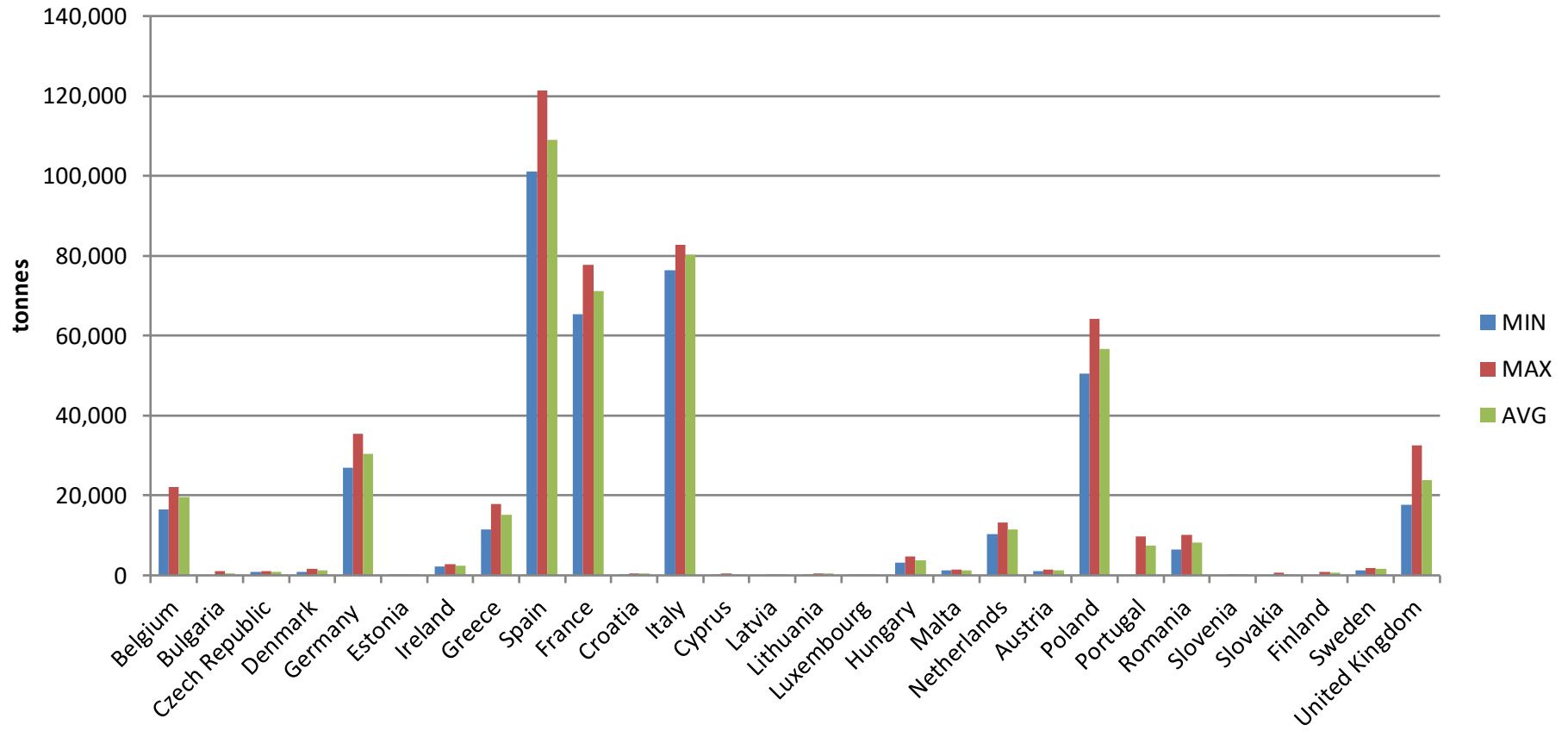


Figure 23 Tonnes of damaged cauliflower and broccoli per country, 2010-2015

Table 16 Tonnes of cauliflower and broccoli leaves left on field per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	271,722	328,878	323,796	316,734	327,426	363,198	271,722	363,198	321,959
Bulgaria	0	0	15,840	10,890	10,593	8,547	0	15,840	7,645
Czech Republic	14,916	17,325	13,002	12,375	12,870	12,210	12,210	17,325	13,783
Denmark	25,509	19,272	18,117	16,203	14,586	19,701	14,586	25,509	18,898
Germany	501,534	475,662	583,077	508,464	492,228	445,005	445,005	583,077	500,995
Estonia	990	990	330	660	660	660	330	990	715
Ireland	38,808	45,870	35,508	39,897	39,930	36,663	35,508	45,870	39,446
Greece	241,923	283,008	293,502	290,037	190,047	197,076	190,047	293,502	249,266
Spain	1,676,268	1,695,474	1,668,546	1,784,937	1,970,001	2,003,727	1,668,546	2,003,727	1,799,826
France	1,173,315	1,282,479	1,240,173	1,139,193	1,076,988	1,126,851	1,076,988	1,282,479	1,173,167
Croatia	6,534	6,303	6,303	4,917	6,732	5,808	4,917	6,732	6,100
Italy	1,355,409	1,343,628	1,366,662	1,259,379	1,336,665	1,273,701	1,259,379	1,366,662	1,322,574
Cyprus	5,577	5,511	5,148	4,488	5,346	3,729	3,729	5,577	4,967
Latvia	0	0	0	1,980	1,650	1,650	0	1,980	880
Lithuania	5,280	6,930	6,270	6,600	5,940	5,742	5,280	6,930	6,127
Luxembourg	99	132	99	99	66	66	66	132	94
Hungary	57,387	56,628	52,305	77,451	65,670	66,000	52,305	77,451	62,574
Malta	22,869	22,605	18,612	21,648	21,978	19,140	18,612	22,869	21,142
Netherlands	214,500	188,100	174,900	168,300	171,600	216,018	168,300	216,018	188,903
Austria	23,298	23,166	19,668	17,556	19,107	16,170	16,170	23,298	19,828
Poland	832,689	982,080	1,012,440	895,290	1,057,980	834,570	832,689	1,057,980	935,842
Portugal	0	159,687	160,149	134,805	128,601	157,344	0	160,149	123,431
Romania	104,379	129,228	126,060	165,759	148,929	142,395	104,379	165,759	136,125
Slovenia	3,300	4,125	4,290	0	5,379	5,346	0	5,379	3,740
Slovakia	0	0	0	7,458	3,135	9,537	0	9,537	3,355
Finland	10,395	13,035	13,431	11,286	13,068	0	0	13,431	10,203
Sweden	20,097	26,301	24,651	26,202	30,921	30,690	20,097	30,921	26,477
United Kingdom	359,700	336,600	297,000	290,400	537,900	537,900	290,400	537,900	393,250



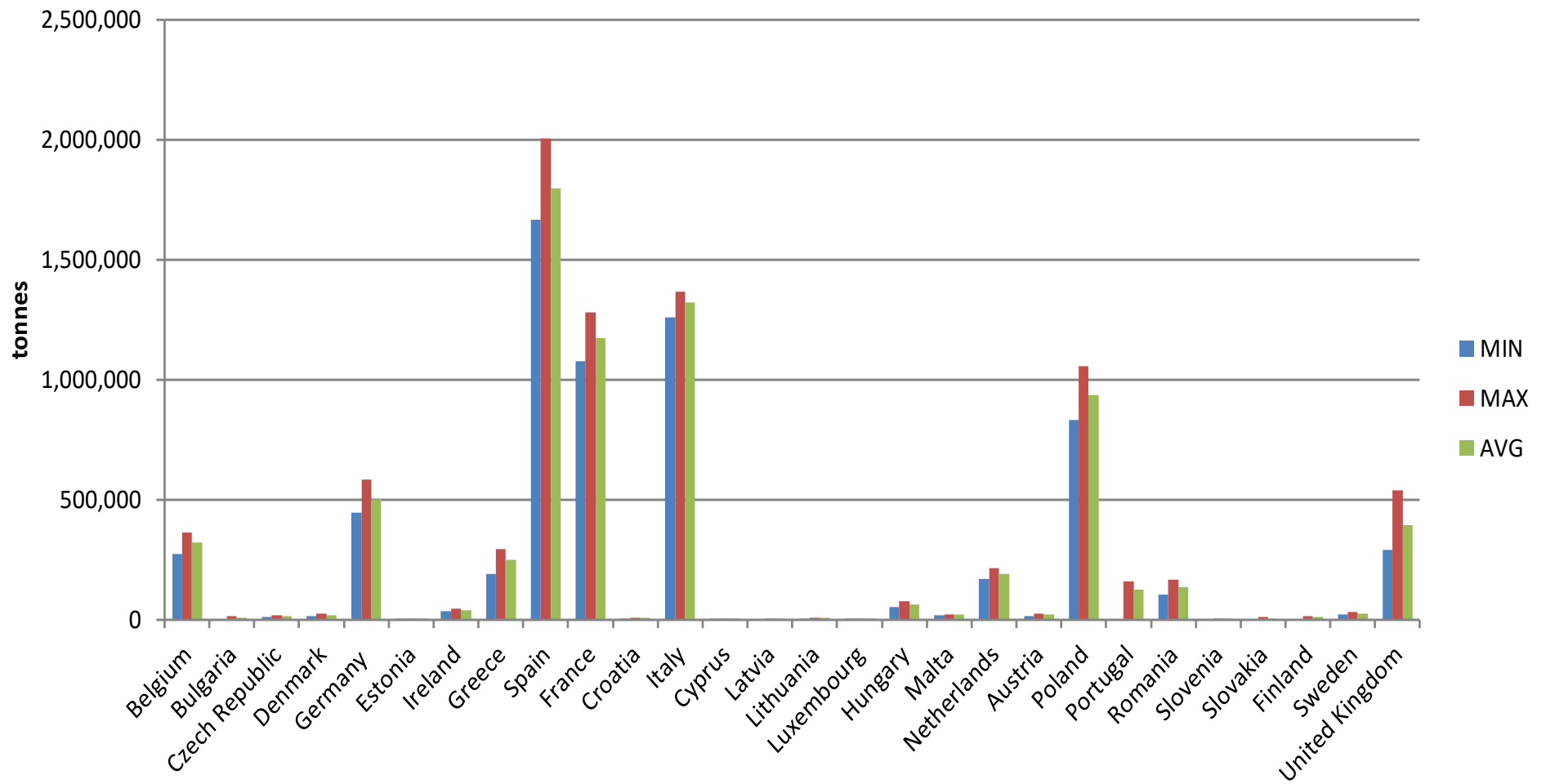


Figure 24 Tonnes of cauliflower and broccoli leaves left on field per country, 2010-2015

Table 17 Tonnes of imported and exported cauliflower and broccoli per country, 2010-2013 (FAO: Crops and livestock products, n.d.)

GEO/POPULATION	Trade	2010	2011	2012	2013
Belgium	Import	24576	24998	26256	28626
	Export	10061	6890	8797	10045
Bulgaria	Import	235	618	910	829
	Export	165	162	19	39
Czech Republic	Import	23816	28683	26738	26053
	Export	3133	4483	3904	4115
Denmark	Import	16110	17142	14145	14367
	Export	675	602	1383	975
Germany	Import	63064	73742	72791	66621
	Export	27488	20551	26011	19728
Estonia	Import	844	1304	1554	1569
	Export	1	5	0	0
Ireland	Import	11252	11348	12192	12465
	Export	177	135	130	191
Greece	Import	4200	4682	2431	2329
	Export	312	435	4308	5068
Spain	Import	7122	6632	7374	5279
	Export	252156	290735	277673	297062
France	Import	41697	45379	47004	49578
	Export	158422	179440	156627	157599
Croatia	Import	1704	2551	1993	1893
	Export	330	157	405	161
Italy	Import	15201	20310	17973	18907
	Export	81170	74749	80709	66076
Cyprus	Import	183	173	216	178
	Export	0	0	1	1
Latvia	Import	1467	2150	2327	2377
	Export	233	378	592	751
Lithuania	Import	7628	13041	13942	16752

	Export	6123	12091	12165	14435
Luxembourg	Import	1238	1245	1149	1040
	Export	75	80	73	70
Hungary	Import	3817	4529	4308	4735
	Export	502	798	727	592
Malta	Import	134	276	382	251
	Export	0	0	0	0
Netherlands	Import	34489	45721	42618	40104
	Export	26119	23491	24116	27960
Austria	Import	7323	6127	6231	6461
	Export	1410	813	751	601
Poland	Import	12695	16769	18646	17743
	Export	13714	16536	29419	25453
Portugal	Import	6962	10809	14977	14889
	Export	259	233	1699	5153
Romania	Import	1908	2609	3295	4128
	Export	72	243	249	184
Slovenia	Import	3158	2827	2676	2510
	Export	2033	2734	2469	1965
Slovakia	Import	12603	10224	10248	9062
	Export	720	951	903	289
Finland	Import	2380	3079	3056	3088
	Export	0	8	1	1
Sweden	Import	6917	8694	9781	9227
	Export	419	449	397	674
United Kingdom	Import	115508	147775	188690	183147
	Export	7951	6725	5120	6039

Table 18 Tonnes of processed cauliflower and broccoli per country, 2010-2013

GEO/TIME	2010	2011	2012	2013	MIN	MAX	AVG
Belgium	79,511	100,167	97,827	96,702	79,511	100,167	93,552
Bulgaria	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Czech Republic	8,464	12,671	9,965	8,862	8,464	12,671	9,991
Denmark	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Germany	163,015	173,264	199,372	176,816	163,015	199,372	178,117
Estonia	130	588	647	766	130	766	533
Ireland	7,367	9,572	7,241	8,754	7,241	9,572	8,234
Greece	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Spain	n/a	n/a	n/a	n/a	n/a	n/a	n/a
France	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Croatia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Italy	84,324	91,516	90,069	71,846	71,846	91,516	84,439
Cyprus	1,545	1,507	1,430	1,191	1,191	1,545	1,418
Latvia	386	942	917	1,416	386	1,416	915
Lithuania	1,534	1,524	2,175	2,831	1,524	2,831	2,016
Luxembourg	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hungary	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Malta	5,491	5,549	4,435	5,210	4,435	5,549	5,171
Netherlands	25,303	30,928	22,984	14,483	14,483	30,928	23,424
Austria	2,951	2,284	1,350	1,038	1,038	2,951	1,906
Poland	118,231	164,613	162,804	130,371	118,231	164,613	144,005
Portugal	1,416	53,680	56,537	45,342	1,416	56,537	39,244
Romania	5,053	13,247	13,112	26,146	5,053	26,146	14,390
Slovenia	0	0	0	0	0	0	0
Slovakia	7,032	4,420	4,481	6,163	4,420	7,032	5,524
Finland	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sweden	1,379	4,916	5,475	5,026	1,379	5,475	4,199
United Kingdom	n/a	n/a	n/a	n/a	n/a	n/a	n/a

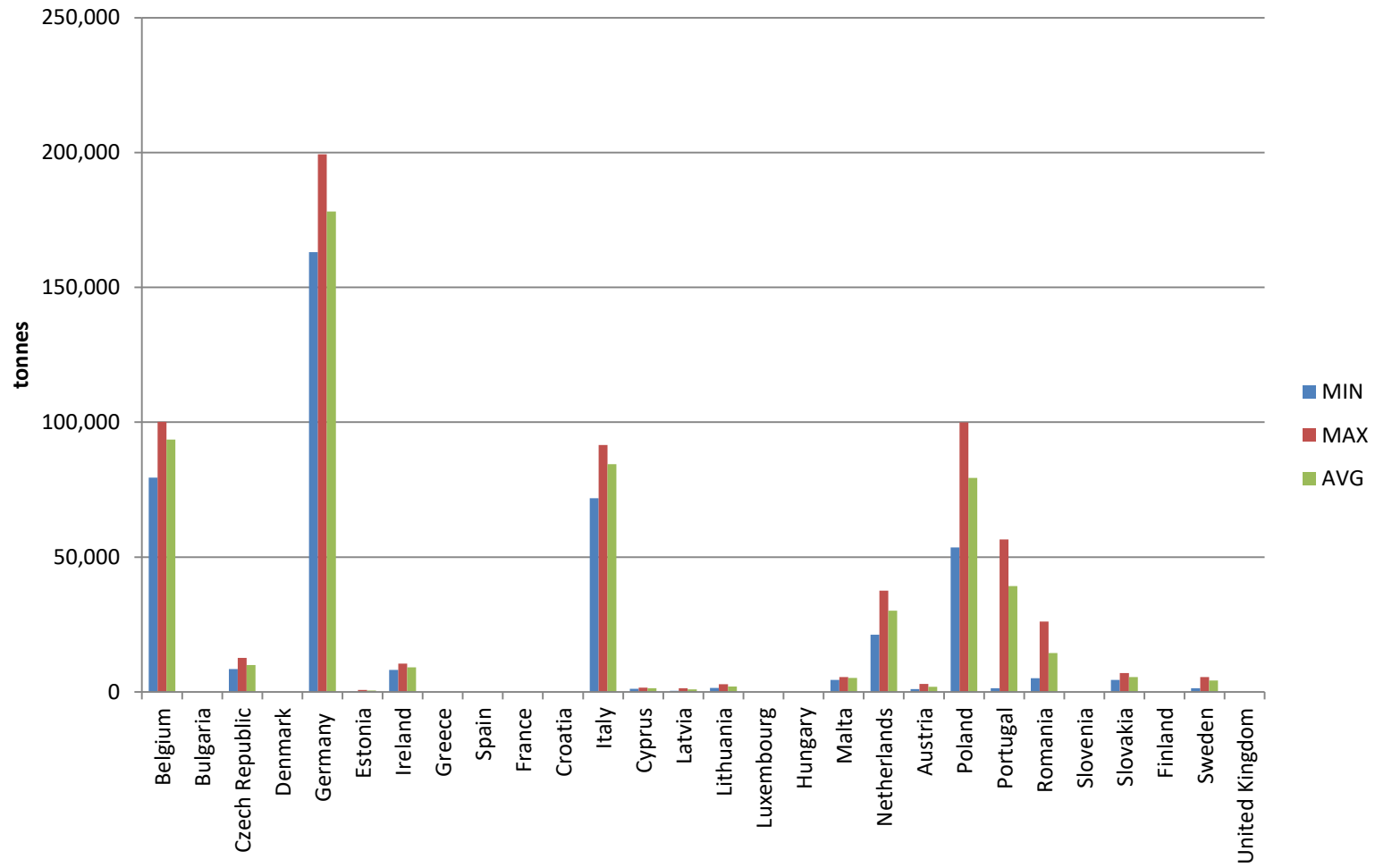


Figure 25 Tonnes of processed cauliflower and broccoli per country, 2010-2013

Table 19 Tonnes of total suspended cauliflower and broccoli solids per country, 2010-2013

GEO/TIME	2010	2011	2012	2013	MIN	MAX	AVG
Belgium	199	250	245	242	199	250	234
Bulgaria	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Czech Republic	21	32	25	22	21	32	25
Denmark	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Germany	408	433	498	442	408	498	445
Estonia	0	1	2	2	0	2	1
Ireland	18	24	18	22	18	24	21
Greece	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Spain	n/a	n/a	n/a	n/a	n/a	n/a	n/a
France	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Croatia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Italy	211	229	225	180	180	229	211
Cyprus	4	4	4	3	3	4	4
Latvia	1	2	2	4	1	4	2
Lithuania	4	4	5	7	4	7	5
Luxembourg	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hungary	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Malta	14	14	11	13	11	14	13
Netherlands	63	77	57	36	36	77	59
Austria	7	6	3	3	3	7	5
Poland	296	412	407	326	296	412	360
Portugal	4	134	141	113	4	141	98
Romania	13	33	33	65	13	65	36
Slovenia	0	0	0	0	0	0	0
Slovakia	18	11	11	15	11	18	14
Finland	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sweden	3	12	14	13	3	14	10
United Kingdom	n/a	n/a	n/a	n/a	n/a	n/a	n/a

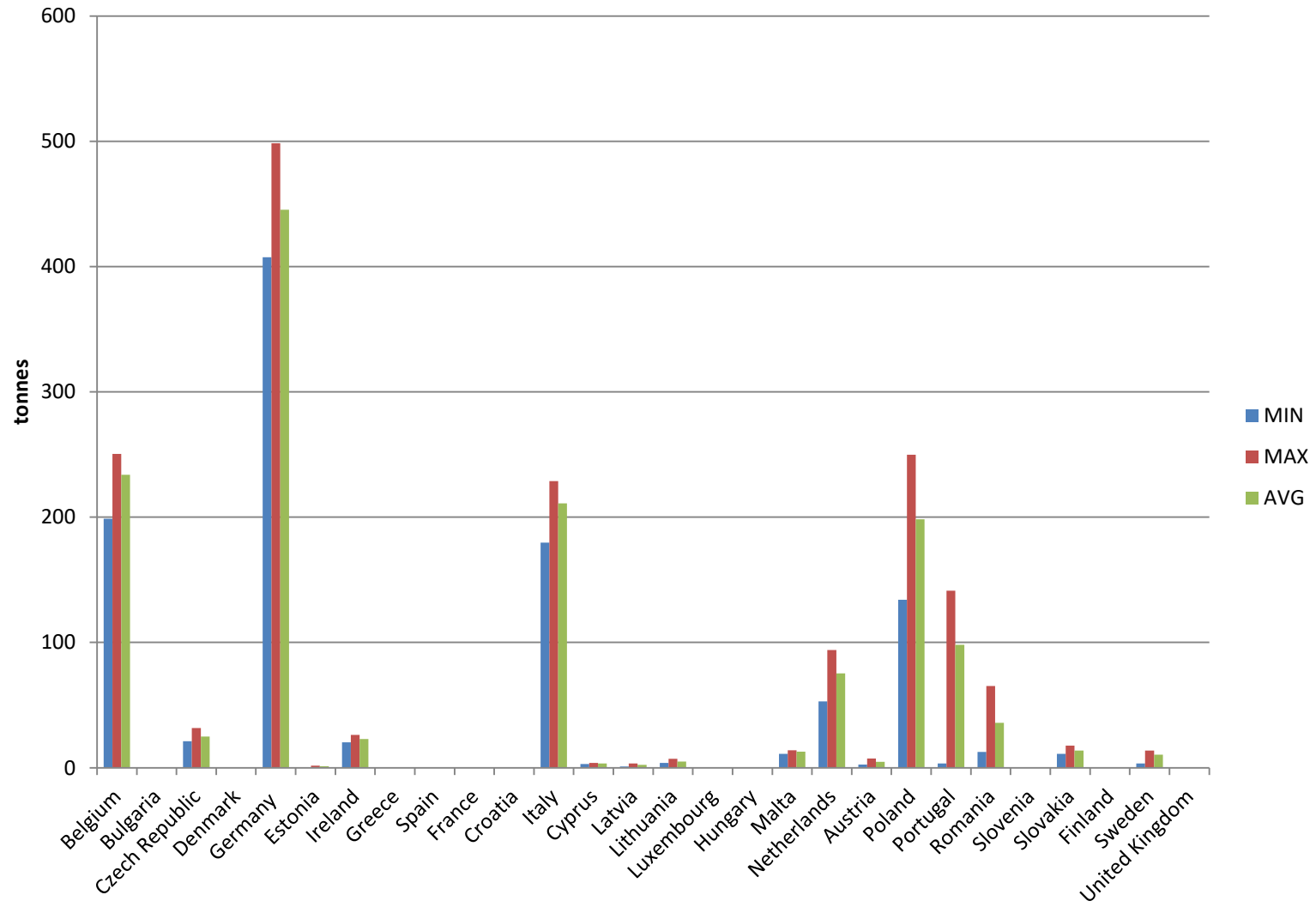


Figure 26 Tonnes of total suspended cauliflower and broccoli solids per country, 2010-2013

Table 20 Volume of cauliflower and broccoli wastewater in m<sup>3</sup> per country, 2010-2013

GEO/TIME	2010	2011	2012	2013	MIN	MAX	AVG
Belgium	651,991	821,369	802,183	792,959	651,991	821,369	767,126
Bulgaria	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Czech Republic	69,402	103,904	81,715	72,670	69,402	103,904	81,923
Denmark	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Germany	1,336,726	1,420,768	1,634,847	1,449,890	1,336,726	1,634,847	1,460,558
Estonia	1,064	4,825	5,304	6,278	1,064	6,278	4,368
Ireland	60,409	78,490	59,375	71,785	59,375	78,490	67,515
Greece	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Spain	n/a	n/a	n/a	n/a	n/a	n/a	n/a
France	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Croatia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Italy	691,460	750,434	738,570	589,137	589,137	750,434	692,400
Cyprus	12,672	12,358	11,728	9,763	9,763	12,672	11,630
Latvia	3,164	7,726	7,520	11,615	3,164	11,615	7,506
Lithuania	12,579	12,494	17,836	23,215	12,494	23,215	16,531
Luxembourg	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hungary	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Malta	45,024	45,502	36,370	42,720	36,370	45,502	42,404
Netherlands	207,481	253,611	188,469	118,763	118,763	253,611	192,081
Austria	24,198	18,727	11,072	8,510	8,510	24,198	15,627
Poland	969,494	1,349,831	1,334,991	1,069,043	969,494	1,349,831	1,180,840
Portugal	11,613	440,173	463,602	371,807	11,613	463,602	321,799
Romania	41,438	108,628	107,515	214,396	41,438	214,396	117,994
Slovenia	0	0	0	0	0	0	0
Slovakia	57,659	36,242	36,745	50,539	36,242	57,659	45,296
Finland	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sweden	11,309	40,314	44,892	41,213	11,309	44,892	34,432
United Kingdom	n/a	n/a	n/a	n/a	n/a	n/a	n/a



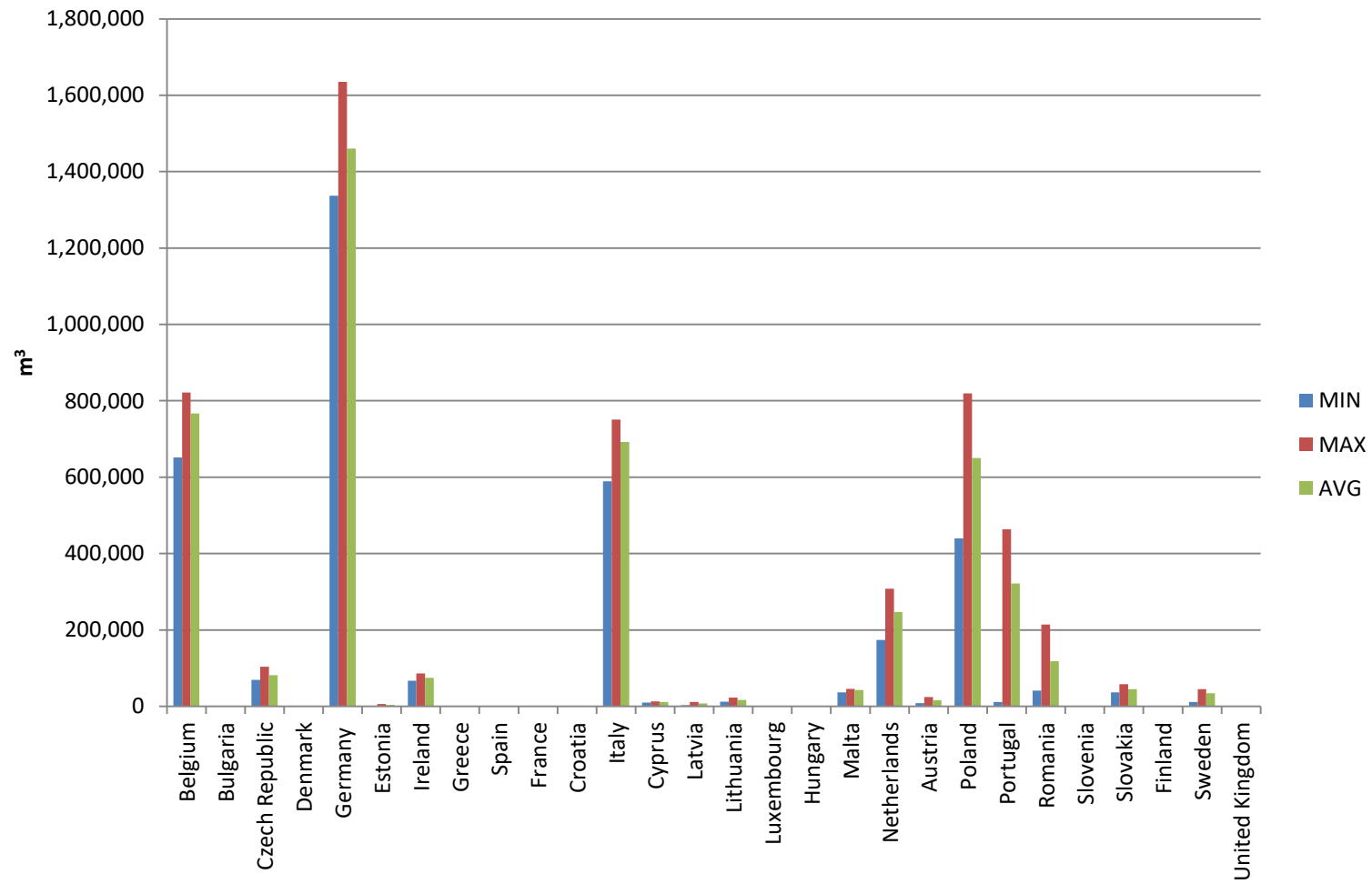


Figure 27 Volume of cauliflower and broccoli wastewater in m<sup>3</sup> per country, 2010-2013

Table 21 Tonnes of cauliflower and broccoli leaves per country, 2010-2013

GEO/TIME	2010	2011	2012	2013	MIN	MAX	AVG
Belgium	17,492	22,037	21,522	21,275	17,492	22,037	20,581
Bulgaria	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Czech Republic	1,862	2,788	2,192	1,950	1,862	2,788	2,198
Denmark	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Germany	35,863	38,118	43,862	38,899	35,863	43,862	39,186
Estonia	29	129	142	168	29	168	117
Ireland	1,621	2,106	1,593	1,926	1,593	2,106	1,811
Greece	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Spain	n/a	n/a	n/a	n/a	n/a	n/a	n/a
France	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Croatia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Italy	18,551	20,134	19,815	15,806	15,806	20,134	18,577
Cyprus	340	332	315	262	262	340	312
Latvia	85	207	202	312	85	312	201
Lithuania	337	335	479	623	335	623	444
Luxembourg	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hungary	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Malta	1,208	1,221	976	1,146	976	1,221	1,138
Netherlands	5,567	6,804	5,056	3,186	3,186	6,804	5,153
Austria	649	502	297	228	228	649	419
Poland	26,011	36,215	35,817	28,682	26,011	36,215	31,681
Portugal	312	11,810	12,438	9,975	312	12,438	8,634
Romania	1,112	2,914	2,885	5,752	1,112	5,752	3,166
Slovenia	0	0	0	0	0	0	0
Slovakia	1,547	972	986	1,356	972	1,547	1,215
Finland	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sweden	303	1,082	1,204	1,106	303	1,204	924
United Kingdom	n/a	n/a	n/a	n/a	n/a	n/a	n/a

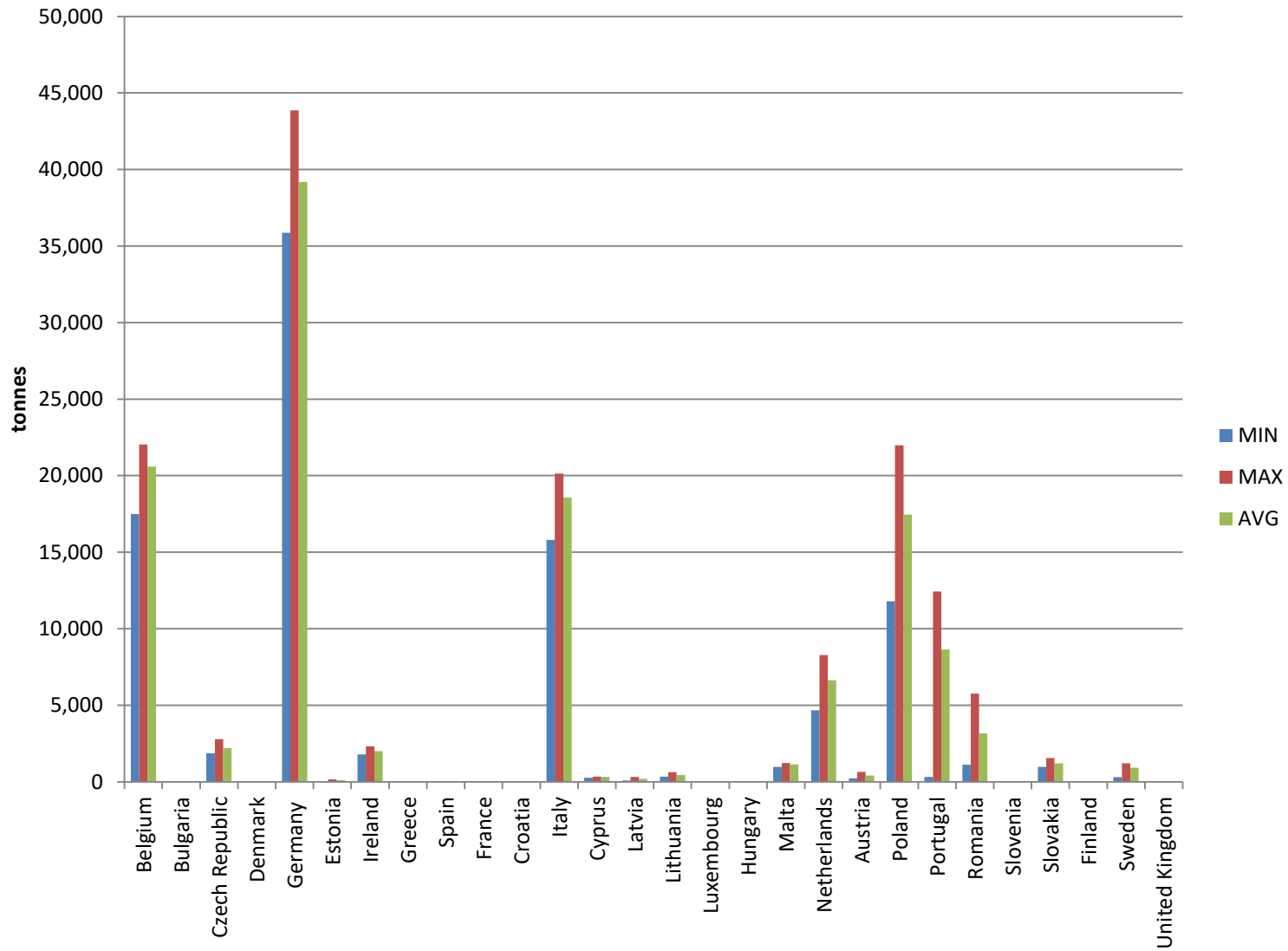


Figure 28 Tonnes of cauliflower and broccoli leaves per country per year, 2010-2013

Table 22 Consumption of fresh cauliflower and broccoli (tonnes) per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	17,344	17,601	17,752	17,859	17,889	17,980	17,344	17,980	17,737
Bulgaria	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Czech Republic	16,739	16,779	16,809	16,826	16,820	16,861	16,739	16,861	16,806
Denmark	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Germany	24,541	24,067	24,098	24,157	24,230	24,359	24,067	24,541	24,242
Estonia	1,013	1,011	1,007	1,003	1,000	999	999	1,013	1,006
Ireland	15,468	15,541	15,581	15,610	15,659	15,738	15,468	15,738	15,600
Greece	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Spain	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
France	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Croatia	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Italy	260,437	261,205	261,335	262,615	267,444	267,501	260,437	267,501	263,423
Cyprus	328	336	345	346	343	339	328	346	339
Latvia	848	830	818	810	801	794	794	848	817
Lithuania	1,571	1,526	1,502	1,486	1,472	1,461	1,461	1,571	1,503
Luxembourg	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hungary	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Malta	1,573	1,577	1,587	1,601	1,616	1,632	1,573	1,632	1,598
Netherlands	48,067	48,302	48,518	48,661	48,805	49,012	48,067	49,012	48,561
Austria	10,022	10,050	10,090	10,142	10,208	10,292	10,022	10,292	10,134
Poland	133,080	133,220	133,223	133,219	133,062	133,020	133,020	133,223	133,137
Portugal	5,287	5,286	5,271	5,244	5,214	5,187	5,187	5,287	5,248
Romania	28,413	28,279	28,134	28,028	27,926	27,819	27,819	28,413	28,100
Slovenia	NA	NA	NA	NA	NA	NA	NA	NA	NA
Slovakia	4,851	4,853	4,864	4,870	4,874	4,879	4,851	4,879	4,865
Finland	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sweden	11,209	11,299	11,379	11,467	11,574	11,697	11,209	11,697	11,437
United Kingdom	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

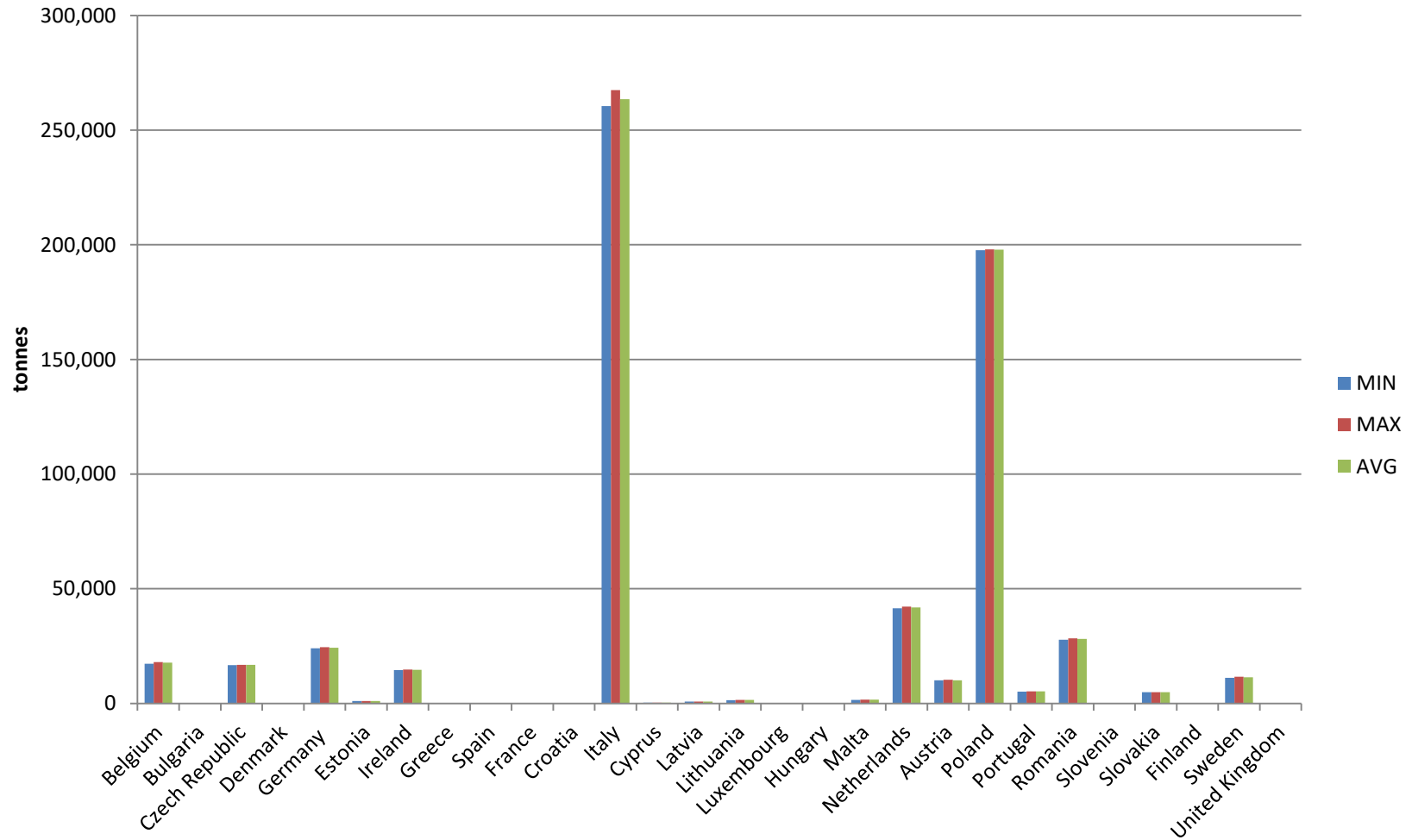


Figure 29 Consumption of fresh cauliflower and broccoli (tonnes) per country, 2010-2015

Table 23 Tonnes of rotten cauliflower and broccoli per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	3,295	3,344	3,373	3,393	3,399	3,416	3,295	3,416	3,370
Bulgaria	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Czech Republic	3,180	3,188	3,194	3,197	3,196	3,204	3,180	3,204	3,193
Denmark	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Germany	4,663	4,573	4,579	4,590	4,604	4,628	4,573	4,663	4,606
Estonia	193	192	191	191	190	190	190	193	191
Ireland	2,939	2,953	2,960	2,966	2,975	2,990	2,939	2,990	2,964
Greece	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Spain	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
France	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Croatia	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Italy	49,483	49,629	49,654	49,897	50,814	50,825	49,483	50,825	50,050
Cyprus	62	64	66	66	65	64	62	66	64
Latvia	161	158	155	154	152	151	151	161	155
Lithuania	298	290	285	282	280	278	278	298	286
Luxembourg	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hungary	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Malta	299	300	301	304	307	310	299	310	304
Netherlands	9,133	9,177	9,218	9,246	9,273	9,312	9,133	9,312	9,227
Austria	1,904	1,910	1,917	1,927	1,940	1,955	1,904	1,955	1,925
Poland	25,285	25,312	25,312	25,312	25,282	25,274	25,274	25,312	25,296
Portugal	1,004	1,004	1,002	996	991	986	986	1,004	997
Romania	5,398	5,373	5,346	5,325	5,306	5,286	5,286	5,398	5,339
Slovenia	NA	NA	NA	NA	NA	NA	NA	NA	NA
Slovakia	922	922	924	925	926	927	922	927	924
Finland	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sweden	2,130	2,147	2,162	2,179	2,199	2,222	2,130	2,222	2,173
United Kingdom	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

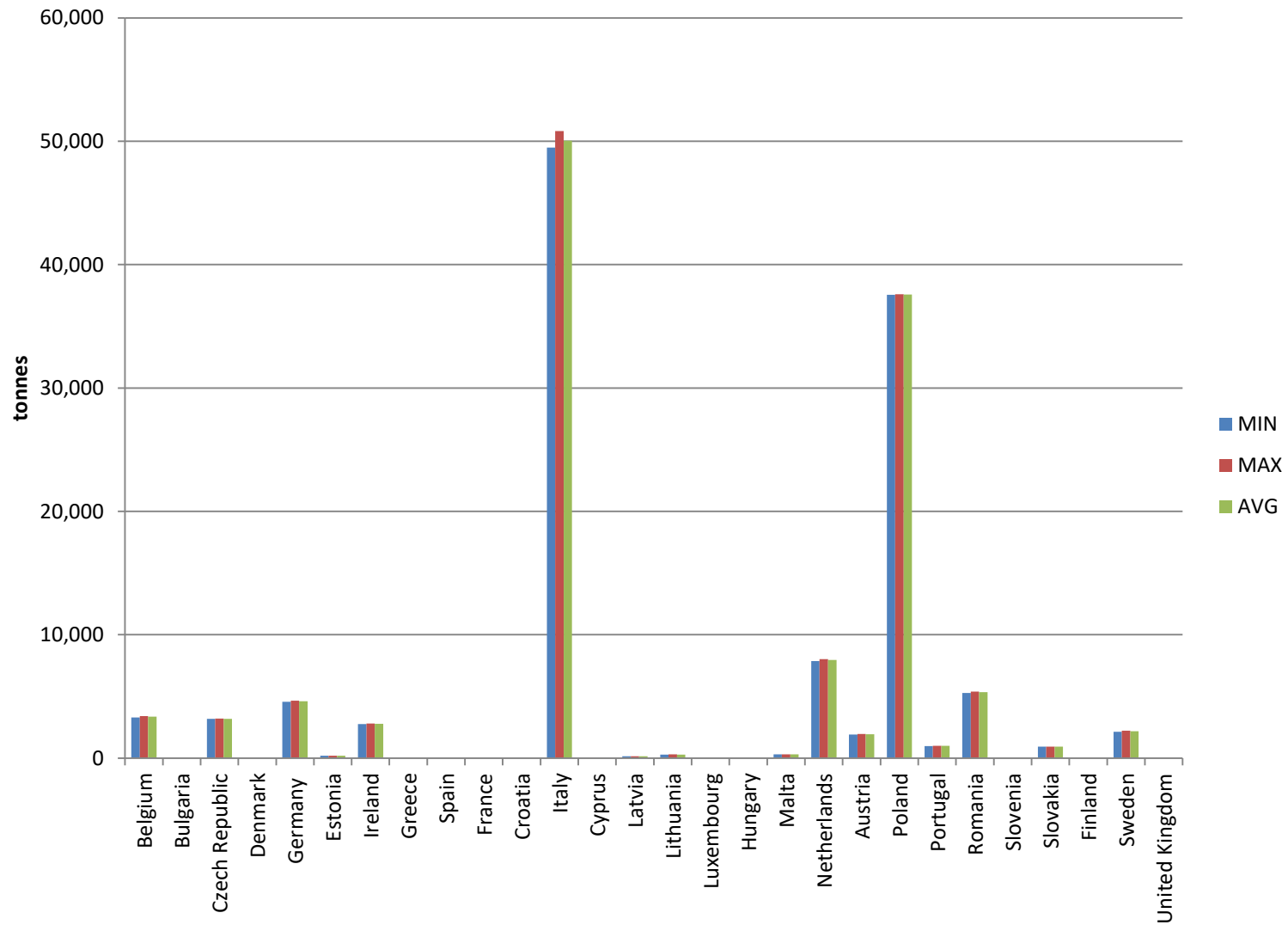


Figure 30 Tonnes of rotten cauliflower and broccoli per country, 2010-2015

## 2.4 Onions

The onion (bulb/common onion) is a one-year vegetable grown in the soil. Onions can be eaten raw, can be cooked, or can be processed (University of the District of Columbia: Onions). There are different varieties of onions that differ in size, colour and taste (Vida Vitality: Onion Fun Facts, n.d.).



Figure 31 Different cultivars of onions (Vida Vitality: Onion Fun Facts, n.d.)

Onion's bulb and roots are positioned in the soil, and stalks and leaves are above ground. In that way, the onion is exposed to both airborne and soil-borne pests. Figure 32 shows damaged onion by worms (Allotment & Gardens: Onion Pests, Diseases & Problems, n.d.).



Figure 32 Onion damaged by worms (Allotment & Gardens: Onion Pests, Diseases & Problems, n.d.)



Onions that are processed are mainly cut into smaller pieces, dried and milled, e.g. in order to produce onion powder (NIIR PROJECT CONSULTANCY SERVICE: Onion and Onion Products and Projects, n.d.), which can be used as an ingredient in salt and spice mixes.

Onions, which are consumed fresh, are usually a part of mixed salads or a flavour additive to different types of dishes. The flowchart (Figure 33) presents the value chain for onion and specific AWCB weight factors from Table 2.

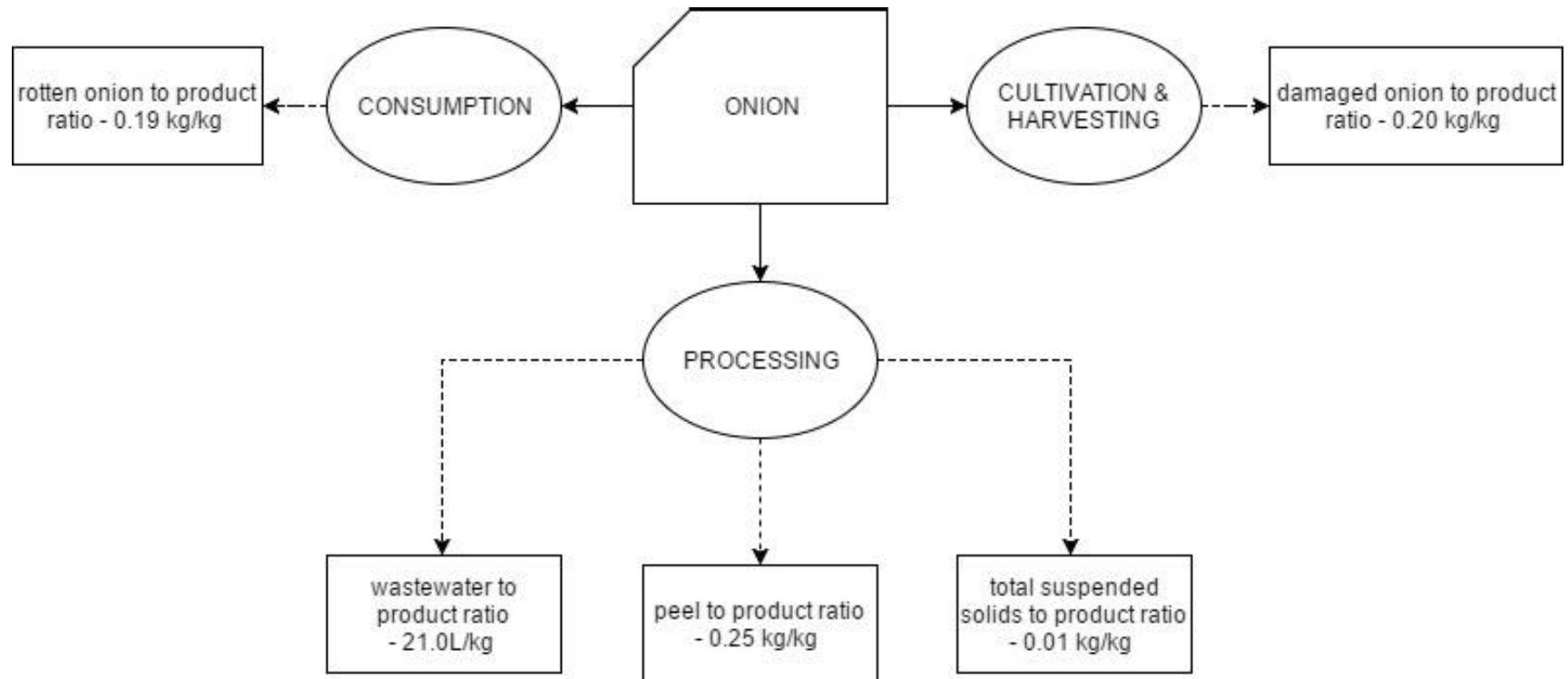


Figure 33 Onion AWCB value chain

Data for cultivated onions are taken from EUROSTAT, and data for imported and exported onions are taken from FAOSTAT. Using the specific consumption of onions and the population per country, the quantity of consumed onions is calculated. By using relations (I-VIII), the quantity of processed onions is calculated for each country in each given year. Then the quantity of AWCB is estimated for each stage and every year. An example of the calculation for Hungary in 2010 is presented below:

PRD = 40,900 tonnes

IMP = 15,903 tonnes

EXP = 2,081 tonnes

CON = 54,077 tonnes

PRC =  $(40,900 + 15,903) - (2,081 + 54,077) = 645$  tonnes

The quantity of damaged onions is 0.20 kg per kg of harvested onions; for Hungary, this was 8,180 tonnes in 2010. Onion wastewater from onion processing facilities had a volume of 13,538m<sup>3</sup>. For Hungary in 2010, the quantity of the rotten onions was 10,275 tonnes. Results for other countries and years are presented in the tables and figures below. FAOSTAT's Food Balance Sheet data was employed to estimate consumption quantities for Onions. While this data may include some processing consumption, we assume it reasonably reflects fresh onion consumption. For a small number of countries, the fresh consumption values are inflated (most likely due to larger processing quantities) which has led to negative processing values and were not included in this report. When available, more up to date and accurate fresh consumption data is required to produce a more robust and reliable dataset.

Table 24 Tonnes of harvested onions per country, 2010-2015 (Eurostat: Agricultural production - crops, n.d.)

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	80,330	74,530	74,500	79,030	102,250	108,250	74,500	108,250	86,482
Bulgaria	19,140	16,800	10,300	12,800	13,330	8,930	8,930	19,140	13,550
Czech Republic	34,650	45,630	32,110	32,820	38,230	27,210	27,210	45,630	35,108
Denmark	52,270	62,940	47,760	48,360	51,920	53,420	47,760	62,940	52,778
Germany	387,110	505,590	588,280	492,840	589,720	553,260	387,110	589,720	519,467
Estonia	NA	NA	NA	NA	NA	NA	0	0	0
Ireland	4,930	5,060	4,880	5,330	5,050	4,550	4,550	5,330	4,967
Greece	188,180	243,120	249,610	250,740	196,440	239,860	188,180	250,740	227,992
Spain	1,105,130	1,307,530	1,169,730	1,214,500	1,364,630	1,247,570	1,105,130	1,364,630	1,234,848
France	351,500	358,410	411,610	416,620	376,800	368,650	351,500	416,620	380,598
Croatia	22,790	22,300	22,930	16,850	27,830	29,400	16,850	29,400	23,683
Italy	380,860	413,790	337,450	351,030	418,610	378,300	337,450	418,610	380,007
Cyprus	7,240	7,430	7,450	6,560	7,240	7,040	6,560	7,450	7,160
Latvia	8,100	10,100	6,600	4,500	7,000	5,700	4,500	10,100	7,000
Lithuania	16,900	21,400	24,500	22,600	25,900	22,160	16,900	25,900	22,243
Luxembourg	40	80	100	140	120	120	40	140	100
Hungary	40,900	57,590	57,180	59,880	61,870	60,000	40,900	61,870	56,237
Malta	9,340	8,720	7,190	8,290	8,330	8,110	7,190	9,340	8,330
Netherlands	1,328,000	1,541,000	1,353,000	1,310,000	1,379,000	1,504,120	1,310,000	1,541,000	1,402,520
Austria	154,110	200,500	135,380	143,960	206,020	168,090	135,380	206,020	168,010
Poland	582,750	677,000	642,200	538,600	651,100	548,400	538,600	677,000	606,675
Portugal	48,100	48,100	48,320	41,340	57,130	59,370	41,340	59,370	50,393
Romania	232,740	243,870	222,330	251,370	249,470	218,230	218,230	251,370	236,335
Slovenia	4,670	6,330	5,870	0	7,560	7,180	0	7,560	5,268
Slovakia	0	0	0	14,930	24,250	16,860	0	24,250	9,340
Finland	19,990	24,750	21,470	22,980	26,300	20,220	19,990	26,300	22,618
Sweden	36,880	42,120	50,370	49,570	53,280	64,590	36,880	64,590	49,468
United Kingdom	365,000	313,000	374,000	354,000	374,000	408,100	313,000	408,100	364,683

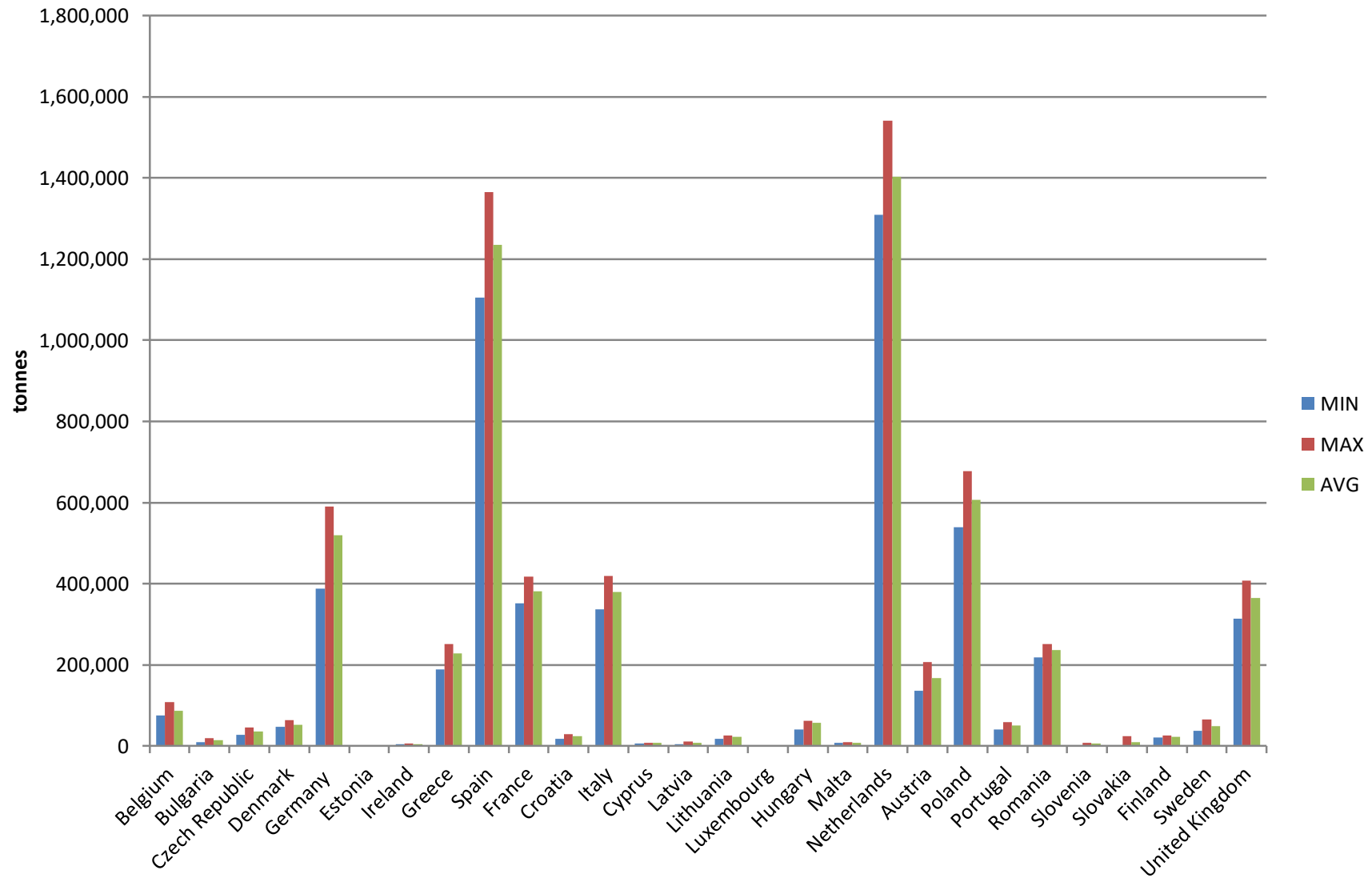


Figure 34 Tonnes of harvested onions per country, 2010-2015

Table 25 Tonnes of damaged onions per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	16,066	14,906	14,900	15,806	20,450	21,650	14,900	21,650	17,296
Bulgaria	3,828	3,360	2,060	2,560	2,666	1,786	1,786	3,828	2,710
Czech Republic	6,930	9,126	6,422	6,564	7,646	5,442	5,442	9,126	7,022
Denmark	10,454	12,588	9,552	9,672	10,384	10,684	9,552	12,588	10,556
Germany	77,422	101,118	117,656	98,568	117,944	110,652	77,422	117,944	103,893
Estonia	NA	NA	NA	NA	NA	NA	0	0	0
Ireland	986	1,012	976	1,066	1,010	910	910	1,066	993
Greece	37,636	48,624	49,922	50,148	39,288	47,972	37,636	50,148	45,598
Spain	221,026	261,506	233,946	242,900	272,926	249,514	221,026	272,926	246,970
France	70,300	71,682	82,322	83,324	75,360	73,730	70,300	83,324	76,120
Croatia	4,558	4,460	4,586	3,370	5,566	5,880	3,370	5,880	4,737
Italy	76,172	82,758	67,490	70,206	83,722	75,660	67,490	83,722	76,001
Cyprus	1,448	1,486	1,490	1,312	1,448	1,408	1,312	1,490	1,432
Latvia	1,620	2,020	1,320	900	1,400	1,140	900	2,020	1,400
Lithuania	3,380	4,280	4,900	4,520	5,180	4,432	3,380	5,180	4,449
Luxembourg	8	16	20	28	24	24	8	28	20
Hungary	8,180	11,518	11,436	11,976	12,374	12,000	8,180	12,374	11,247
Malta	1,868	1,744	1,438	1,658	1,666	1,622	1,438	1,868	1,666
Netherlands	265,600	308,200	270,600	262,000	275,800	300,824	262,000	308,200	280,504
Austria	30,822	40,100	27,076	28,792	41,204	33,618	27,076	41,204	33,602
Poland	116,550	135,400	128,440	107,720	130,220	109,680	107,720	135,400	121,335
Portugal	9,620	9,620	9,664	8,268	11,426	11,874	8,268	11,874	10,079
Romania	46,548	48,774	44,466	50,274	49,894	43,646	43,646	50,274	47,267
Slovenia	934	1,266	1,174	0	1,512	1,436	0	1,512	1,054
Slovakia	0	0	0	2,986	4,850	3,372	0	4,850	1,868
Finland	3,998	4,950	4,294	4,596	5,260	4,044	3,998	5,260	4,524
Sweden	7,376	8,424	10,074	9,914	10,656	12,918	7,376	12,918	9,894
United Kingdom	73,000	62,600	74,800	70,800	74,800	81,620	62,600	81,620	72,937

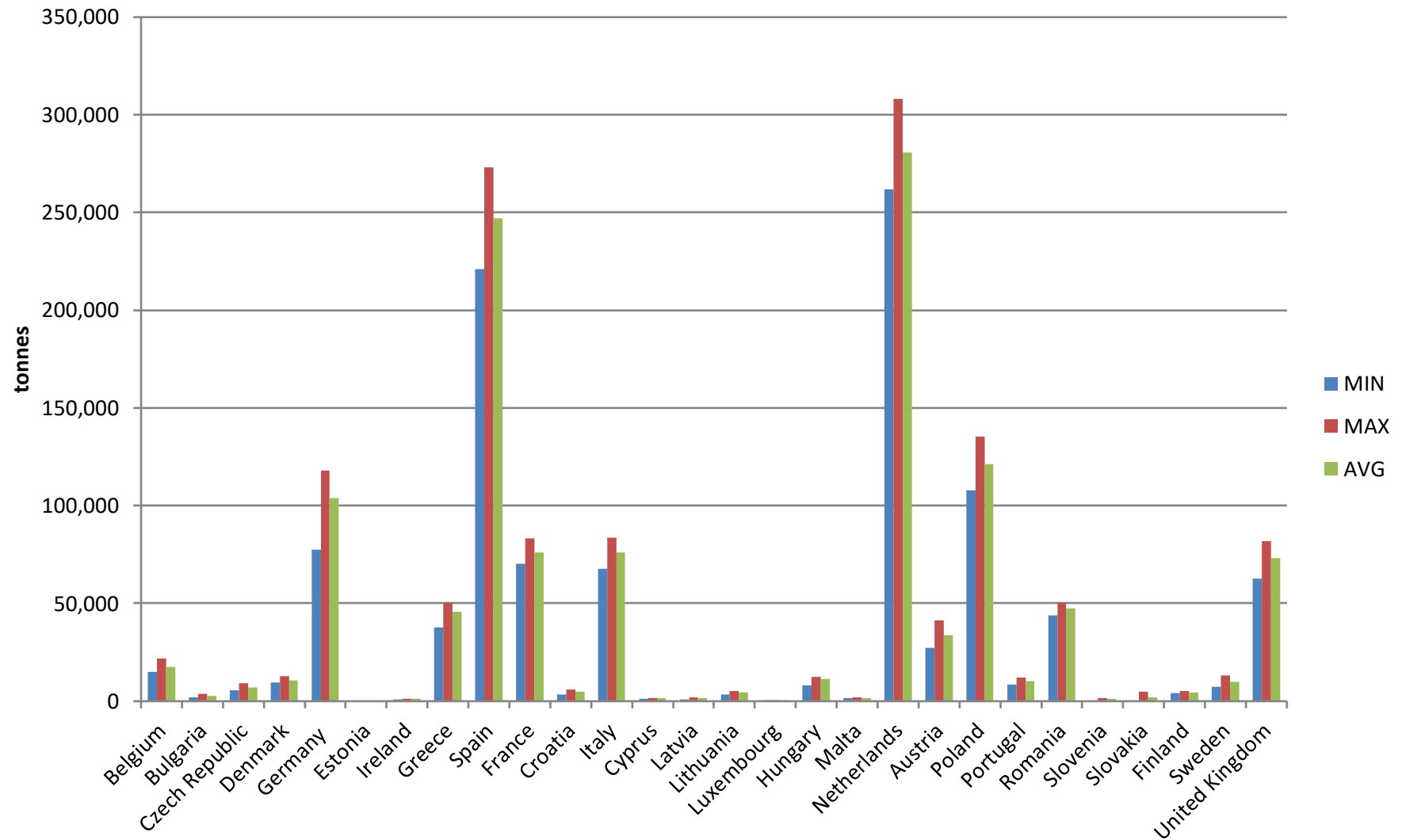


Figure 35 Tonnes of damaged onions per country, 2010-2015

Table 26 Tonnes of imported and exported onions per country, 2010-2013 (FAO: Crops and livestock products, n.d.)

GEO/POPULATION	Trade	2010	2011	2012	2013
Belgium	Import	117,423	127,643	122,626	118,650
	Export	40,244	54,494	34,971	41,707
Bulgaria	Import	17,849	18,350	18,240	22,050
	Export	346	326	222	391
Czech Republic	Import	60,411	57,115	54,348	67,827
	Export	9,582	8,626	9,804	10,218
Denmark	Import	13,069	12,913	12,316	12,260
	Export	13,303	14,856	10,688	10,578
Germany	Import	237,786	278,360	232,238	237,307
	Export	82,546	83,986	75,945	77,541
Estonia	Import	7,293	6,363	6,303	5,301
	Export	27	122	35	31
Ireland	Import	39,901	38,300	33,189	34,873
	Export	1,183	669	628	597
Greece	Import	12,359	15,095	3,890	5,402
	Export	3,297	2,096	1,370	2,802
Spain	Import	57,500	54,434	52,346	64,129
	Export	223,589	253,384	256,228	287,766
France	Import	103,462	100,683	113,652	135,833
	Export	88,175	84,251	76,728	91,496
Croatia	Import	13,919	15,303	12,151	15,601
	Export	1,261	801	256	781
Italy	Import	65,916	61,855	63,061	80,661
	Export	43,660	43,292	48,868	38,753
Cyprus	Import	3,803	4,544	4,390	3,251
	Export	0	0	0	1
Latvia	Import	8,616	7,933	8,830	9,817
	Export	1,683	2,587	1,792	2,787
Lithuania	Import	14,563	16,349	13,737	17,127
	Export	6,056	9,163	9,293	13,548
Luxembourg	Import	3,316	3,234	2,878	2,798



	Export	294	318	143	199
Hungary	Import	15,903	14,584	10,833	9,166
	Export	2,081	3,365	3,686	2,508
Malta	Import	333	505	702	418
	Export	0	0	0	0
Netherlands	Import	162,469	205,453	162,039	166,250
	Export	1,257,415	1,326,576	1,226,751	1,222,270
Austria	Import	25,709	20,163	14,768	16,115
	Export	40,372	56,456	68,289	58,949
Poland	Import	94,304	84,686	58,565	67,926
	Export	112,839	111,662	119,222	111,515
Portugal	Import	37,082	41,183	47,259	57,145
	Export	1,696	1,768	3,313	4,887
Romania	Import	35,347	45,179	38,332	38,510
	Export	2,068	1,866	1,527	2,904
Slovenia	Import	13,832	13,123	13,057	14,666
	Export	2,246	2,610	3,068	3,611
Slovakia	Import	20,730	24,039	17,428	19,057
	Export	991	674	1,205	757
Finland	Import	5,881	9,074	11,241	12,647
	Export	13	24	55	20
Sweden	Import	31,227	32,761	33,523	26,736
	Export	316	469	246	447
United Kingdom	Import	361,878	356,748	338,636	434,584
	Export	9,763	9,419	9,902	4,627

Table 27 Tonnes of processed onions per country, 2010-2013\*

\*Negative values due to uncertain consumption data

GEO/TIME	2010	2011	2012	2013	MIN	MAX	AVG
Belgium	152,089	135,578	145,735	120,479	120,479	152,089	138,470
Bulgaria	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Czech Republic	2,201	3,199	2,275	2,514	2,201	3,199	2,547
Denmark	3,939	4,668	3,628	3,652	3,628	4,668	3,972
Germany	69,533	98,299	192,720	164,632	69,533	192,720	131,296
Estonia	0	0	0	0	0	0	0
Ireland	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Greece	11,883	15,520	15,990	18,083	11,883	18,083	15,369
Spain	110,649	132,769	121,247	131,537	110,649	132,769	124,051
France	80,995	242,935	312,758	256,284	80,995	312,758	223,243
Croatia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Italy	52,710	55,981	47,545	50,942	47,545	55,981	51,794
Cyprus	1,934	2,913	2,953	2,389	1,934	2,953	2,547
Latvia	0	0	0	0	0	0	0
Lithuania	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Luxembourg	0	0	0	0	0	0	0
Hungary	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Malta	2,804	2,610	2,284	2,590	2,284	2,804	2,572
Netherlands	222,943	338,264	237,260	230,489	222,943	338,264	257,239
Austria	18,682	23,085	15,435	16,438	15,435	23,085	18,410
Poland	77,142	77,180	71,869	59,195	59,195	77,180	71,346
Portugal	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Romania	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Slovenia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Slovakia	0	0	0	0	0	0	0
Finland	1,348	1,763	1,545	1,799	1,348	1,799	1,614
Sweden	3,714	4,454	4,370	3,903	3,714	4,454	4,110
United Kingdom	70,760	50,271	67,146	72,691	50,271	72,691	65,217

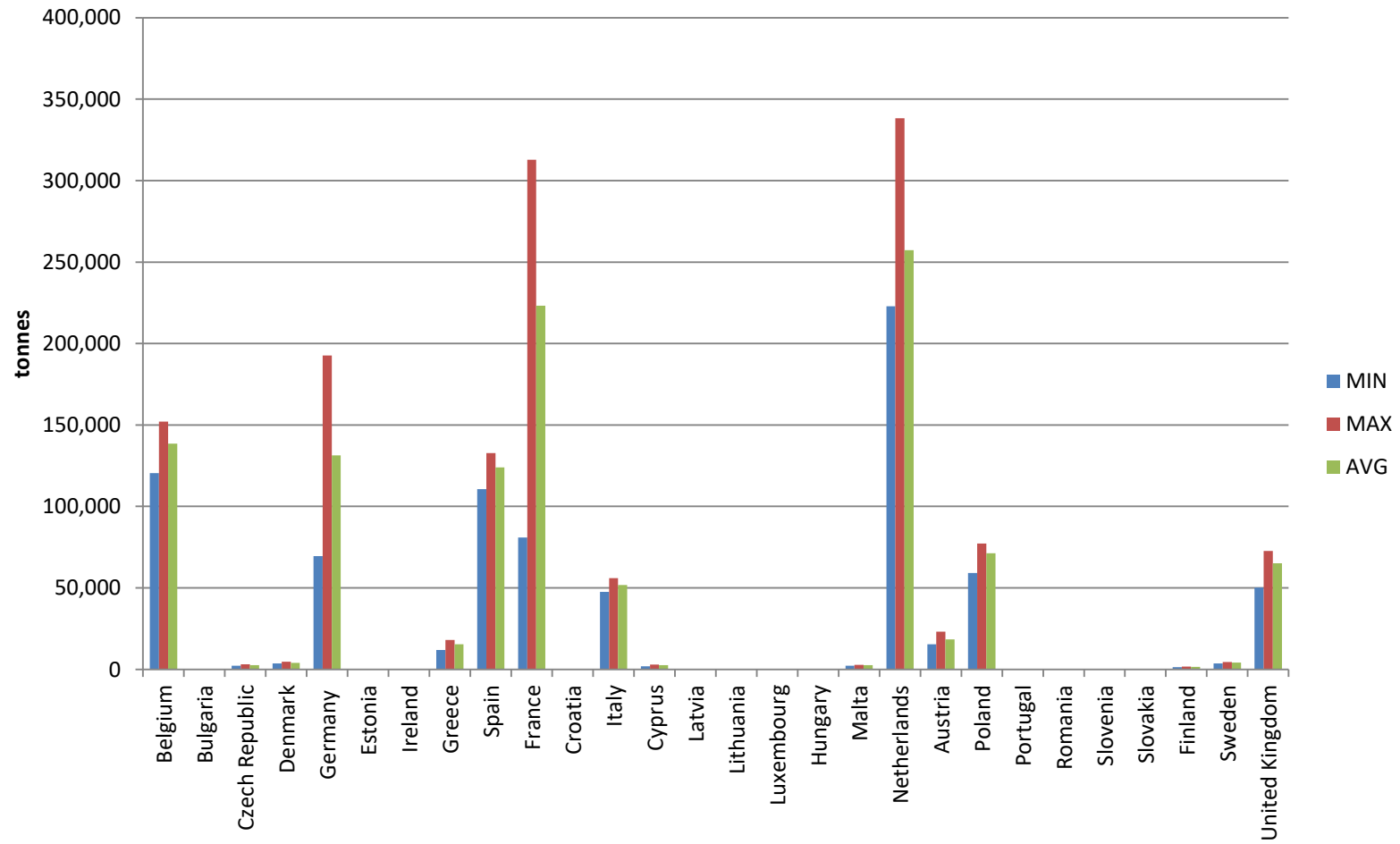


Figure 36 Tonnes of processed onions per country, 2010-2013

Table 28 Tonnes of total suspended onion solids per country, 2010-2013

GEO/TIME	2010	2011	2012	2013	MIN	MAX	AVG
Belgium	1,521	1,356	1,457	1,205	1,205	1,521	1,385
Bulgaria	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Czech Republic	22	32	23	25	22	32	25
Denmark	39	47	36	37	36	47	40
Germany	695	983	1,927	1,646	695	1,927	1,313
Estonia	0	0	0	0	0	0	0
Ireland	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Greece	119	155	160	181	119	181	154
Spain	1,106	1,328	1,212	1,315	1,106	1,328	1,241
France	810	2,429	3,128	2,563	810	3,128	2,232
Croatia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Italy	527	560	475	509	475	560	518
Cyprus	19	29	30	24	19	30	25
Latvia	0	0	0	0	0	0	0
Lithuania	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Luxembourg	0	0	0	0	0	0	0
Hungary	6	44	-11	24	-11	44	16
Malta	28	26	23	26	23	28	26
Netherlands	2,229	3,383	2,373	2,305	2,229	3,383	2,572
Austria	187	231	154	164	154	231	184
Poland	771	772	719	592	592	772	713
Portugal	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Romania	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Slovenia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Slovakia	0	0	0	0	0	0	0
Finland	13	18	15	18	13	18	16
Sweden	37	45	44	39	37	45	41
United Kingdom	708	503	671	727	503	727	652

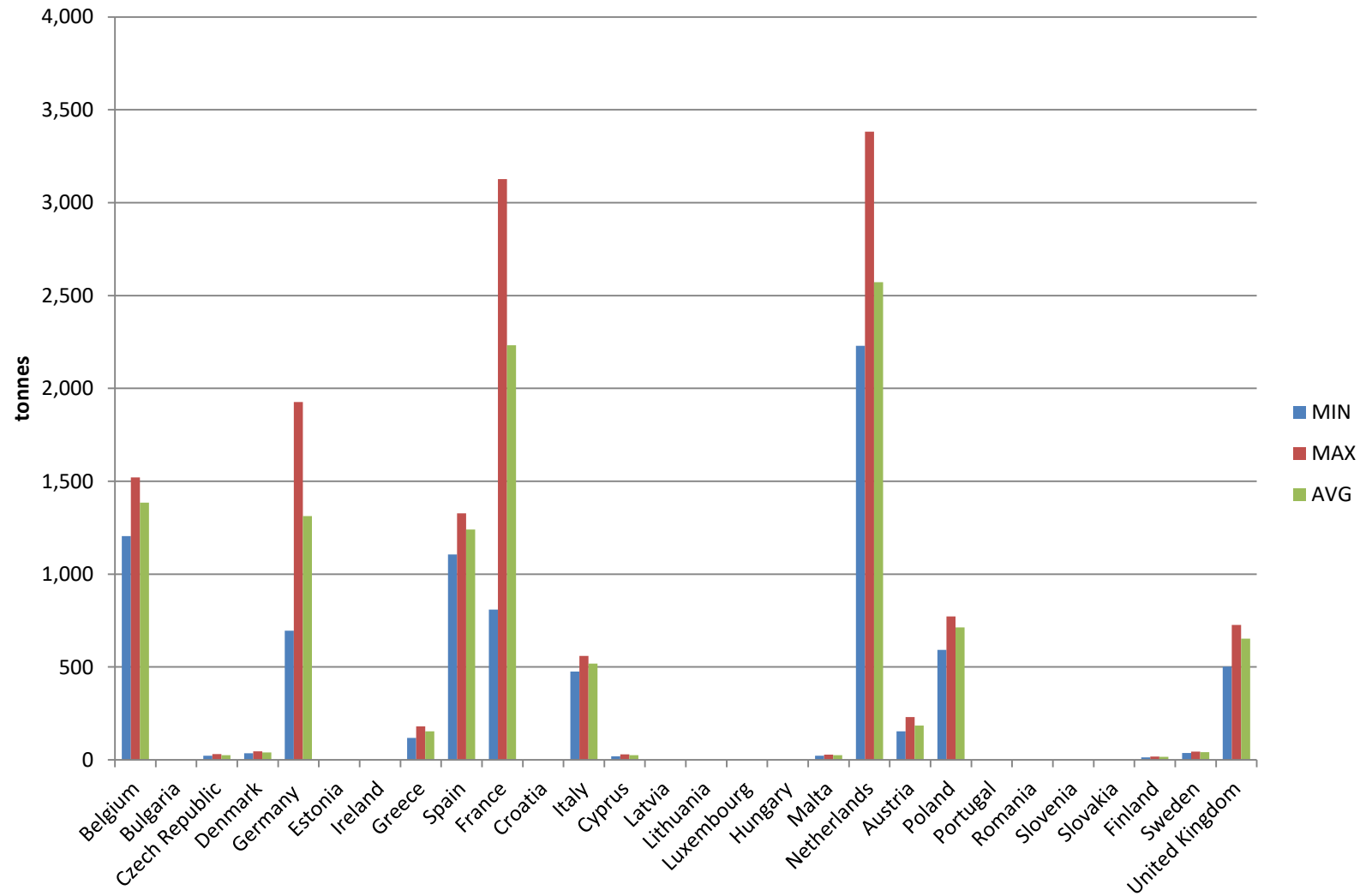


Figure 37 Tonnes of total suspended onion solids per country, 2010-2013

Table 29 Volume of wastewater from onion processing in m<sup>3</sup> per country, 2010-2013

GEO/TIME	2010	2011	2012	2013	MIN	MAX	AVG
Belgium	3,193,870	2,847,144	3,060,427	2,530,059	2,530,059	3,193,870	2,907,875
Bulgaria	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Czech Republic	46,216	67,180	47,784	52,798	46,216	67,180	53,495
Denmark	82,722	98,025	76,183	76,697	76,183	98,025	83,407
Germany	1,460,192	2,064,269	4,047,127	3,457,274	1,460,192	4,047,127	2,757,215
Estonia	0	0	0	0	0	0	0
Ireland	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Greece	249,552	325,921	335,781	379,737	249,552	379,737	322,748
Spain	2,323,638	2,788,157	2,546,194	2,762,279	2,323,638	2,788,157	2,605,067
France	1,700,892	5,101,639	6,567,915	5,381,962	1,700,892	6,567,915	4,688,102
Croatia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Italy	1,106,917	1,175,598	998,438	1,069,775	998,438	1,175,598	1,087,682
Cyprus	40,617	61,175	62,006	50,178	40,617	62,006	53,494
Latvia	0	0	0	0	0	0	0
Lithuania	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Luxembourg	0	0	0	0	0	0	0
Hungary	13,538	92,423	-23,612	50,990	-23,612	92,423	33,335
Malta	58,890	54,812	47,972	54,386	47,972	58,890	54,015
Netherlands	4,681,808	7,103,535	4,982,469	4,840,260	4,681,808	7,103,535	5,402,018
Austria	392,327	484,795	324,132	345,206	324,132	484,795	386,615
Poland	1,619,983	1,620,782	1,509,245	1,243,094	1,243,094	1,620,782	1,498,276
Portugal	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Romania	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Slovenia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Slovakia	0	0	0	0	0	0	0
Finland	28,318	37,030	32,439	37,775	28,318	37,775	33,891
Sweden	77,992	93,541	91,777	81,966	77,992	93,541	86,319
United Kingdom	1,485,951	1,055,689	1,410,066	1,526,512	1,055,689	1,526,512	1,369,554

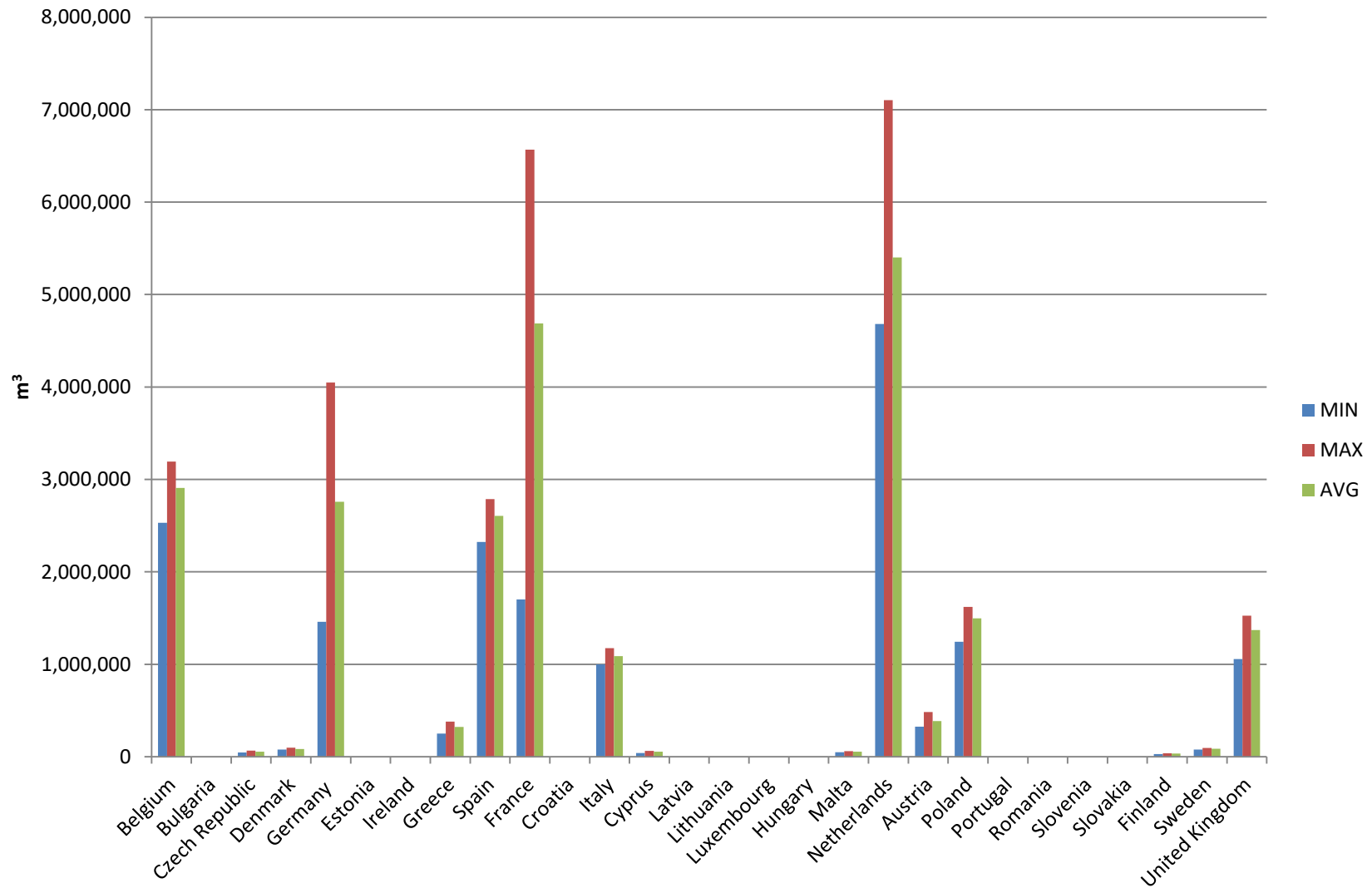


Figure 38 Volume of wastewater from onion processing in m<sup>3</sup> per country, 2010-2013

Table 30 Tonnes of onion peel per country, 2010-2013

GEO/TIME	2010	2011	2012	2013	MIN	MAX	AVG
Belgium	38,022	33,895	36,434	30,120	30,120	38,022	34,618
Bulgaria	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Czech Republic	550	800	569	629	550	800	637
Denmark	985	1,167	907	913	907	1,167	993
Germany	17,383	24,575	48,180	41,158	17,383	48,180	32,824
Estonia	0	0	0	0	0	0	0
Ireland	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Greece	2,971	3,880	3,997	4,521	2,971	4,521	3,842
Spain	27,662	33,192	30,312	32,884	27,662	33,192	31,013
France	20,249	60,734	78,189	64,071	20,249	78,189	55,811
Croatia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Italy	13,178	13,995	11,886	12,735	11,886	13,995	12,949
Cyprus	484	728	738	597	484	738	637
Latvia	0	0	0	0	0	0	0
Lithuania	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Luxembourg	0	0	0	0	0	0	0
Hungary	161	1,100	-281	607	-281	1,100	397
Malta	701	653	571	647	571	701	643
Netherlands	55,736	84,566	59,315	57,622	55,736	84,566	64,310
Austria	4,671	5,771	3,859	4,110	3,859	5,771	4,603
Poland	19,286	19,295	17,967	14,799	14,799	19,295	17,837
Portugal	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Romania	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Slovenia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Slovakia	0	0	0	0	0	0	0
Finland	337	441	386	450	337	450	403
Sweden	928	1,114	1,093	976	928	1,114	1,028
United Kingdom	17,690	12,568	16,787	18,173	12,568	18,173	16,304



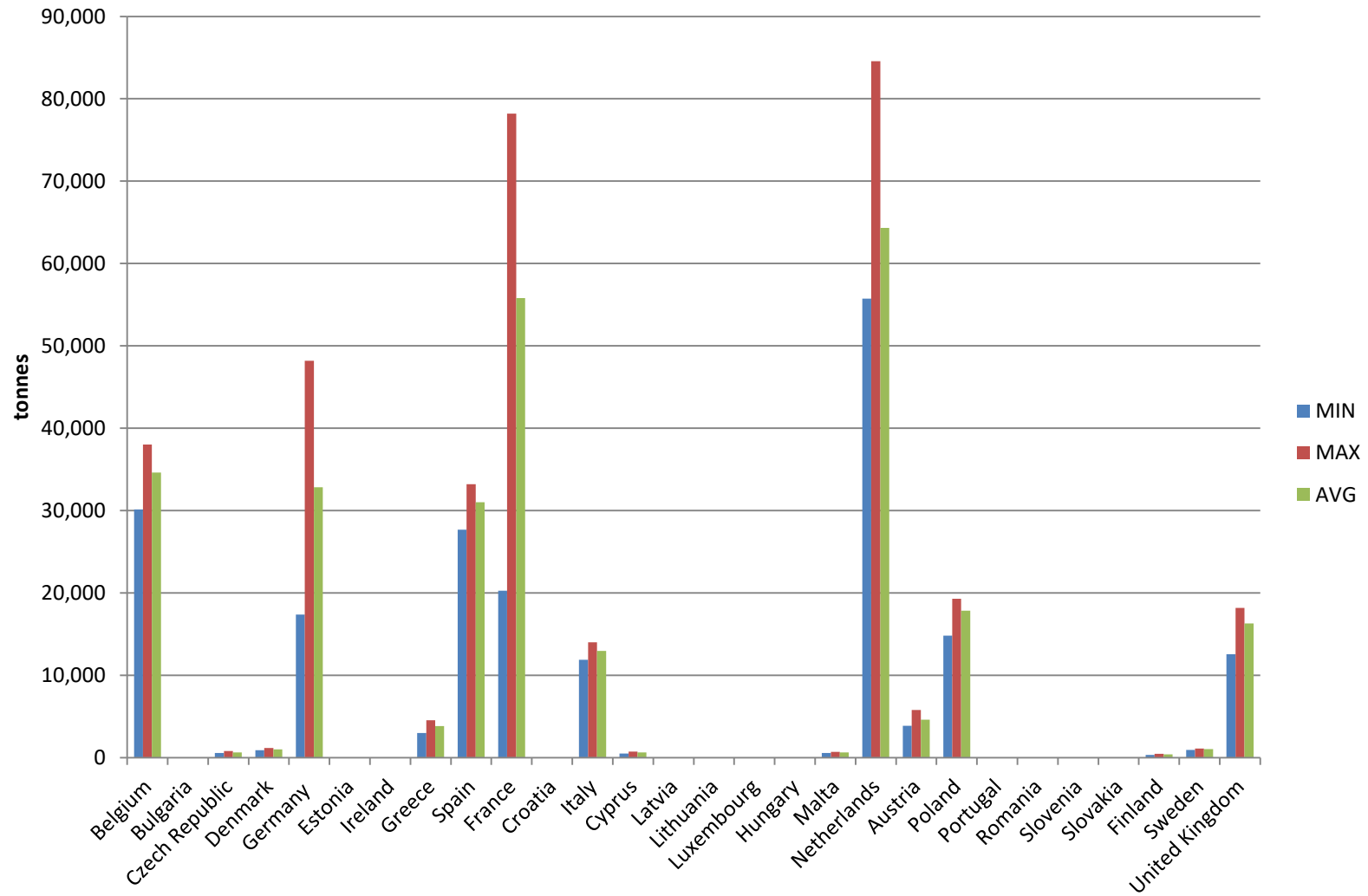


Figure 39 Tonnes of onion peel per country, 2010-2013

Table 31 Consumption of fresh onions (tonnes) per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	MIN	MAX	AVG
Belgium	5,420	12,101	16,420	35,494	5,420	35,494	17,359
Bulgaria	41,339	30,657	24,473	45,310	24,473	45,310	35,445
Czech Republic	83,278	90,920	74,379	87,915	74,379	90,920	84,123
Denmark	48,097	56,329	45,760	46,390	45,760	56,329	49,144
Germany	472,817	601,665	551,853	487,974	472,817	601,665	528,577
Estonia	9,666	7,752	8,693	6,720	6,720	9,666	8,208
Ireland	44,630	42,555	33,683	34,892	33,683	44,630	38,940
Greece	185,359	240,599	236,140	235,257	185,359	240,599	224,339
Spain	828,392	975,811	844,601	859,326	828,392	975,811	877,032
France	285,792	131,907	135,776	204,673	131,907	285,792	189,537
Croatia	36,445	41,569	37,158	35,291	35,291	41,569	37,616
Italy	350,406	376,372	304,098	341,996	304,098	376,372	343,218
Cyprus	9,109	9,061	8,887	7,421	7,421	9,109	8,619
Latvia	22,308	22,613	21,839	15,786	15,786	22,613	20,636
Lithuania	36,510	36,601	36,765	37,149	36,510	37,149	36,756
Luxembourg	2,892	2,836	2,719	2,653	2,653	2,892	2,775
Hungary	54,077	64,408	65,451	64,110	54,077	65,451	62,012
Malta	6,869	6,615	5,608	6,118	5,608	6,869	6,302
Netherlands	10,111	81,613	51,028	23,491	10,111	81,613	41,561
Austria	120,765	141,122	66,424	84,688	66,424	141,122	103,250
Poland	487,073	572,844	509,674	435,816	435,816	572,844	501,352
Portugal	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Romania	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Slovenia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Slovakia	45,172	47,885	27,454	31,329	27,454	47,885	37,960
Finland	24,510	32,037	31,111	33,808	24,510	33,808	30,366
Sweden	64,077	69,958	79,277	71,956	64,077	79,277	71,317
United Kingdom	646,355	610,058	635,588	711,266	610,058	711,266	650,817

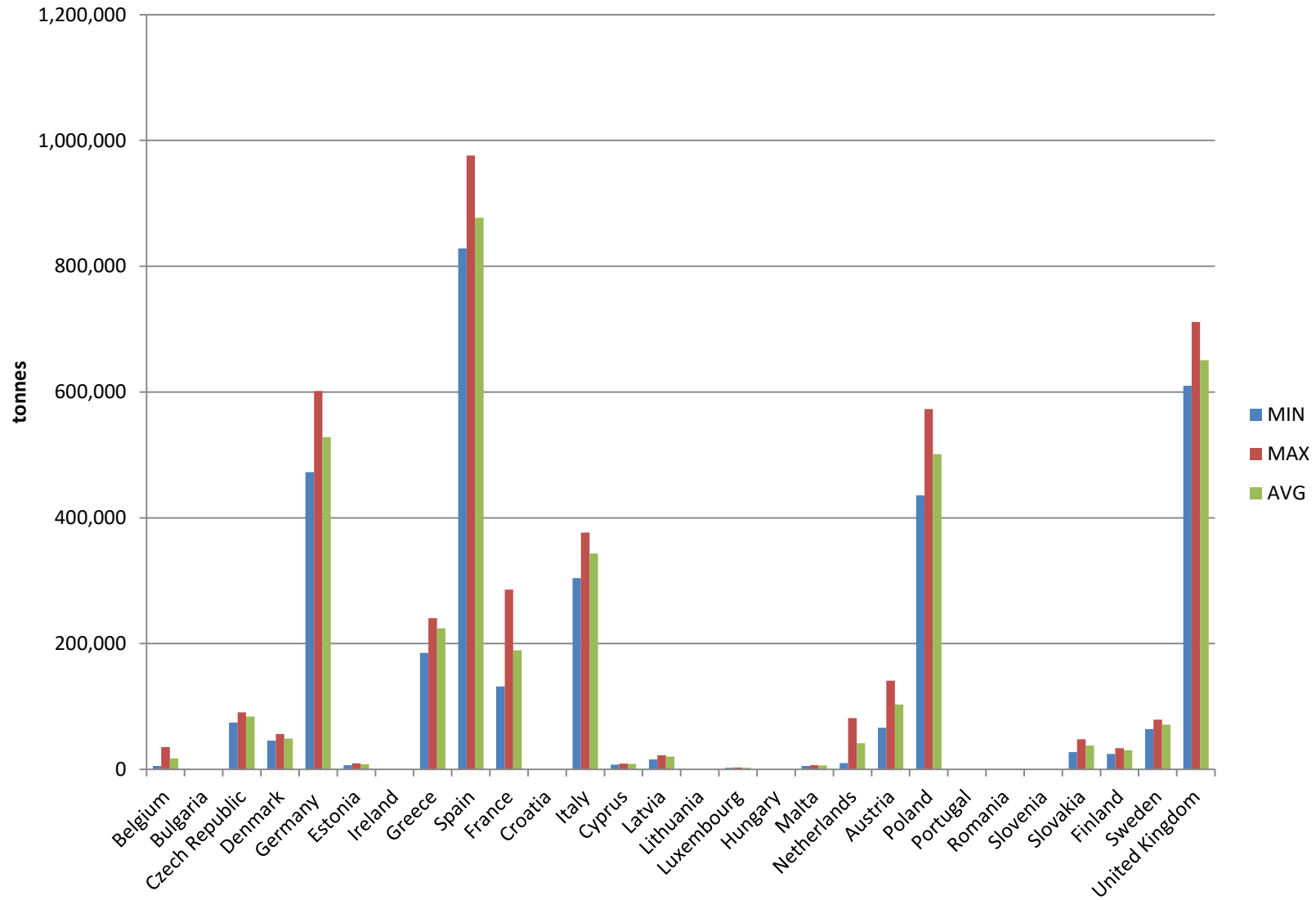


Figure 40 Consumption of fresh onions (tonnes) per country, 2010-2015

Table 32 Tonnes of rotten onions per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	MIN	MAX	AVG
Belgium	1,030	2,299	3,120	6,744	1,030	6,744	3,298
Bulgaria	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Czech Republic	15,823	17,275	14,132	16,704	14,132	17,275	15,983
Denmark	9,138	10,703	8,694	8,814	8,694	10,703	9,337
Germany	89,835	114,316	104,852	92,715	89,835	114,316	100,430
Estonia	1,837	1,473	1,652	1,277	0	0	0
Ireland	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Greece	35,218	45,714	44,867	44,699	35,218	45,714	42,624
Spain	157,394	185,404	160,474	163,272	157,394	185,404	166,636
France	54,301	25,062	25,797	38,888	25,062	54,301	36,012
Croatia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Italy	66,577	71,511	57,779	64,979	57,779	71,511	65,211
Cyprus	1,731	1,722	1,689	1,410	1,410	1,731	1,638
Latvia	4,238	4,297	4,149	2,999	0	0	0
Lithuania	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Luxembourg	549	539	517	504	504	549	527
Hungary	10,275	12,238	12,436	12,181	10,275	12,436	11,782
Malta	1,305	1,257	1,065	1,162	1,065	1,305	1,197
Netherlands	1,921	15,507	9,695	4,463	1,921	15,507	7,897
Austria	22,945	26,813	12,621	16,091	12,621	26,813	19,617
Poland	92,544	108,840	96,838	82,805	82,805	108,840	95,257
Portugal	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Romania	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Slovenia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Slovakia	8,583	9,098	5,216	5,952	5,216	9,098	7,212
Finland	4,657	6,087	5,911	6,424	4,657	6,424	5,770
Sweden	12,175	13,292	15,063	13,672	12,175	15,063	13,550
United Kingdom	122,808	115,911	120,762	135,141	115,911	135,141	123,655

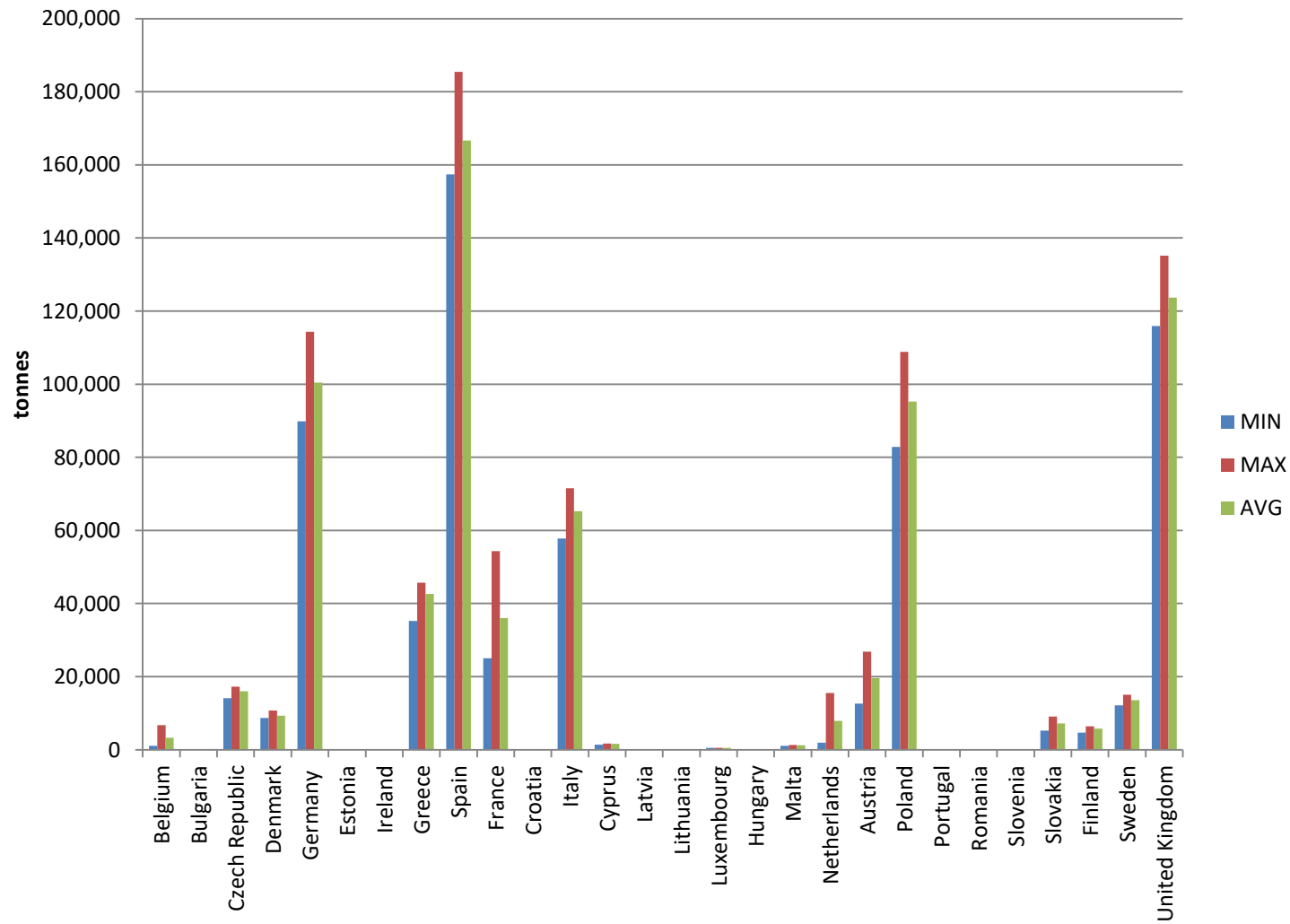


Figure 41 Tonnes of rotten onions per country, 2010-2015

## 2.5 Carrot

The carrot is a root vegetable, primarily orange and yellow in colour, but can be grown in an array of different colours (Perrin, i dr., 2016), see Figure 42.



Figure 42 Different cultivars of carrot (Carrot Museum: Carrot Genome, n.d.)

When a carrot is grown, its taproot is placed in the soil, with the leaves above the ground surface. The root is the edible part of the carrot and during cultivation, it is exposed to different pests in the soil but mostly worms. Damage due to worms renders the carrot inedible for human and animals consumption. Many carrots are processed, e.g. juiced to be



made into a sauce, or in the production of baby food. Figure 43 shows a carrot processing facility (Bertuzzi: Carrot processing, n.d.). The main AWCB that occurs during the processing of carrots is wastewater that is used for cleaning the harvested carrots. Furthermore, hot water steam is used to remove the peel from carrots.



Figure 43 Carrot processing facility (Bertuzzi: Carrot processing, n.d.)

At the consumption stage, carrots are mostly consumed as a raw or cooked food, in different sauces and in soups.

The flowchart (Figure 44) presents the value chain for carrots and specific waste weight and contains data from Table 2.

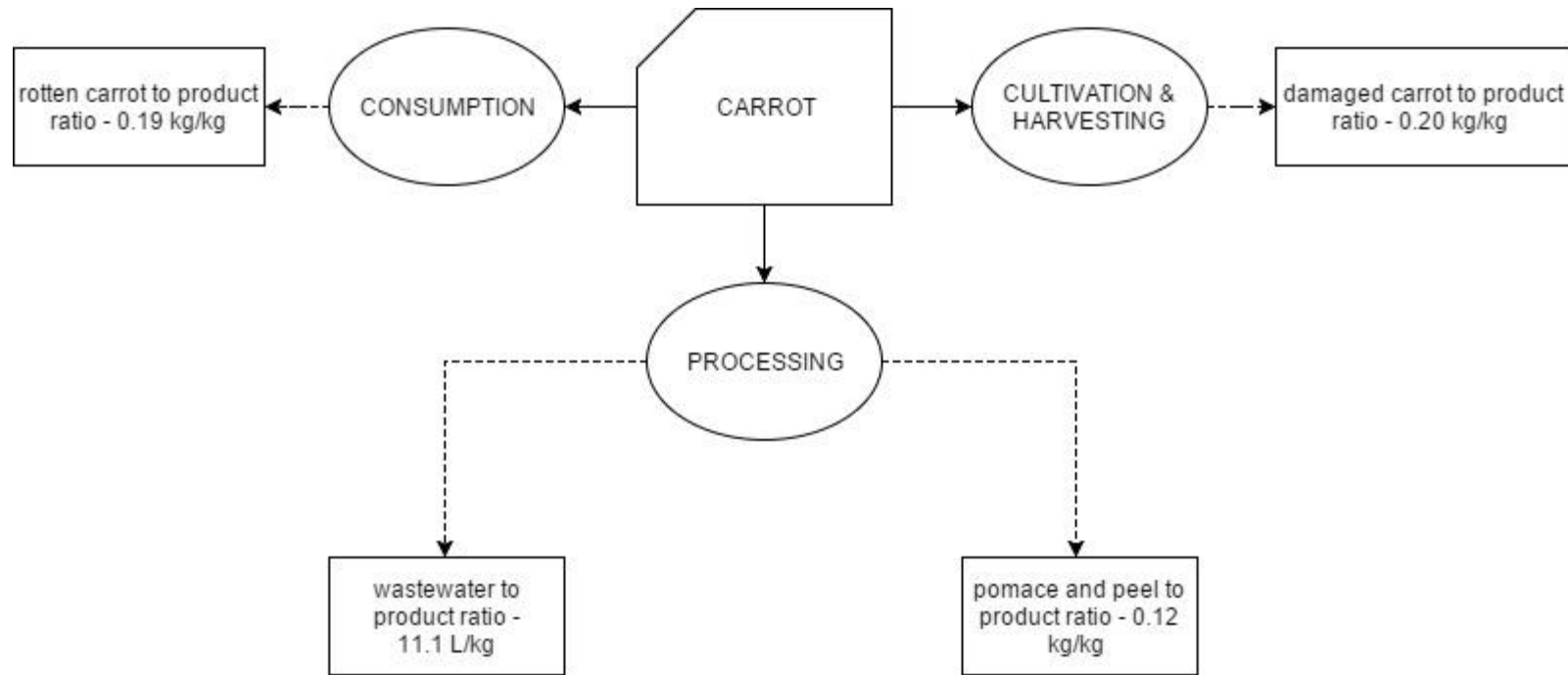


Figure 44 Carrot AWCB value chain



Data for cultivated carrots is taken from EUROSTAT, and data for imported and exported carrots is taken from FAOSTAT. Using the specific consumption of carrots and the population per country, the quantity of consumed carrots is calculated. By using relations (I-VIII), the quantity of processed carrots is calculated for each country in each given year. Then the quantity of AWCB is estimated for each step and every year. An example of the calculation for the Netherlands in 2010 is presented below:

PRD = 511,00 tonnes

IMP = 43,523 tonnes

EXP = 405,434 tonnes

CON = 49,725 tonnes

$PRC = (511,000 + 43,523) - (405,434 + 49,725) = 99,364$  tonnes

The quantity of damaged carrots is 0.20 kg per kg of harvested carrots; for the Netherlands, this was 102,200 tonnes in 2010. Carrot peel and pomace that occur in processing represent 0.12 kg per kg of processed carrot. For the Netherlands in 2010, the quantity of carrot peel and pomace was 11,924 tonnes, and the volume of wastewater was 1,112,877 m<sup>3</sup>. In 2010 the quantity of carrots consumed in the Netherlands was 49,725 tonnes, 9,448 tonnes out of it went mouldy or became rotten. Results for other countries and years are presented in the tables and figures below.

Table 33 Tonnes of harvested carrots per country, 2010-2015 (Eurostat: Agricultural production - crops, n.d.)

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	314,100	317,400	317,400	317,400	328,000	245,400	245,400	328,000	306,617
Bulgaria	10,570	12,000	9,600	5,400	9,620	7,910	5,400	12,000	9,183
Czech Republic	18,830	24,390	20,760	23,120	26,060	23,450	18,830	26,060	22,768
Denmark	104,830	107,240	84,860	96,620	107,310	89,210	84,860	107,310	98,345
Germany	553,970	533,720	592,760	583,590	609,350	526,860	526,860	609,350	566,708
Estonia	17,700	18,900	12,300	15,100	12,800	18,100	12,300	18,900	15,817
Ireland	32,530	39,030	33,370	37,080	40,170	40,170	32,530	40,170	37,058
Greece	43,640	54,770	53,330	43,470	43,900	44,140	43,470	54,770	47,208
Spain	424,310	400,630	370,260	372,710	376,310	410,870	370,260	424,310	392,515
France	541,670	604,180	541,170	534,370	543,200	560,010	534,370	604,180	554,100
Croatia	9,470	7,500	13,530	3,970	7,200	10,860	3,970	13,530	8,755
Italy	489,170	542,650	482,300	491,780	539,240	532,950	482,300	542,650	513,015
Cyprus	1,910	1,890	1,860	1,710	2,030	2,280	1,710	2,280	1,947
Latvia	17,200	19,400	11,400	13,900	19,000	8,800	8,800	19,400	14,950
Lithuania	37,700	64,200	60,200	51,100	61,200	37,990	37,700	64,200	52,065
Luxembourg	480	230	500	940	1,000	1,000	230	1,000	692
Hungary	58,530	65,150	74,720	67,430	119,310	50,000	50,000	119,310	72,523
Malta	1,370	1,330	980	1,310	1,230	1,260	980	1,370	1,247
Netherlands	511,000	482,000	511,000	555,000	548,000	563,440	482,000	563,440	528,407
Austria	85,630	109,040	98,270	95,500	106,940	66,760	66,760	109,040	93,690
Poland	814,930	887,400	834,700	735,100	822,600	677,700	677,700	887,400	795,405
Portugal	75,380	75,380	75,520	77,160	104,540	97,490	75,380	104,540	84,245
Romania	120,970	138,270	111,070	130,790	139,230	122,090	111,070	139,230	127,070
Slovenia	2,040	2,970	2,710	0	3,520	3,370	0	3,520	2,435
Slovakia	0	0	0	6,520	6,500	10,100	0	10,100	3,853
Finland	67,510	72,590	55,560	70,910	74,410	71,980	55,560	74,410	68,827
Sweden	83,010	104,860	128,740	112,810	119,020	115,630	83,010	128,740	110,678
United Kingdom	748,000	688,000	664,000	696,000	786,000	731,000	664,000	786,000	718,833

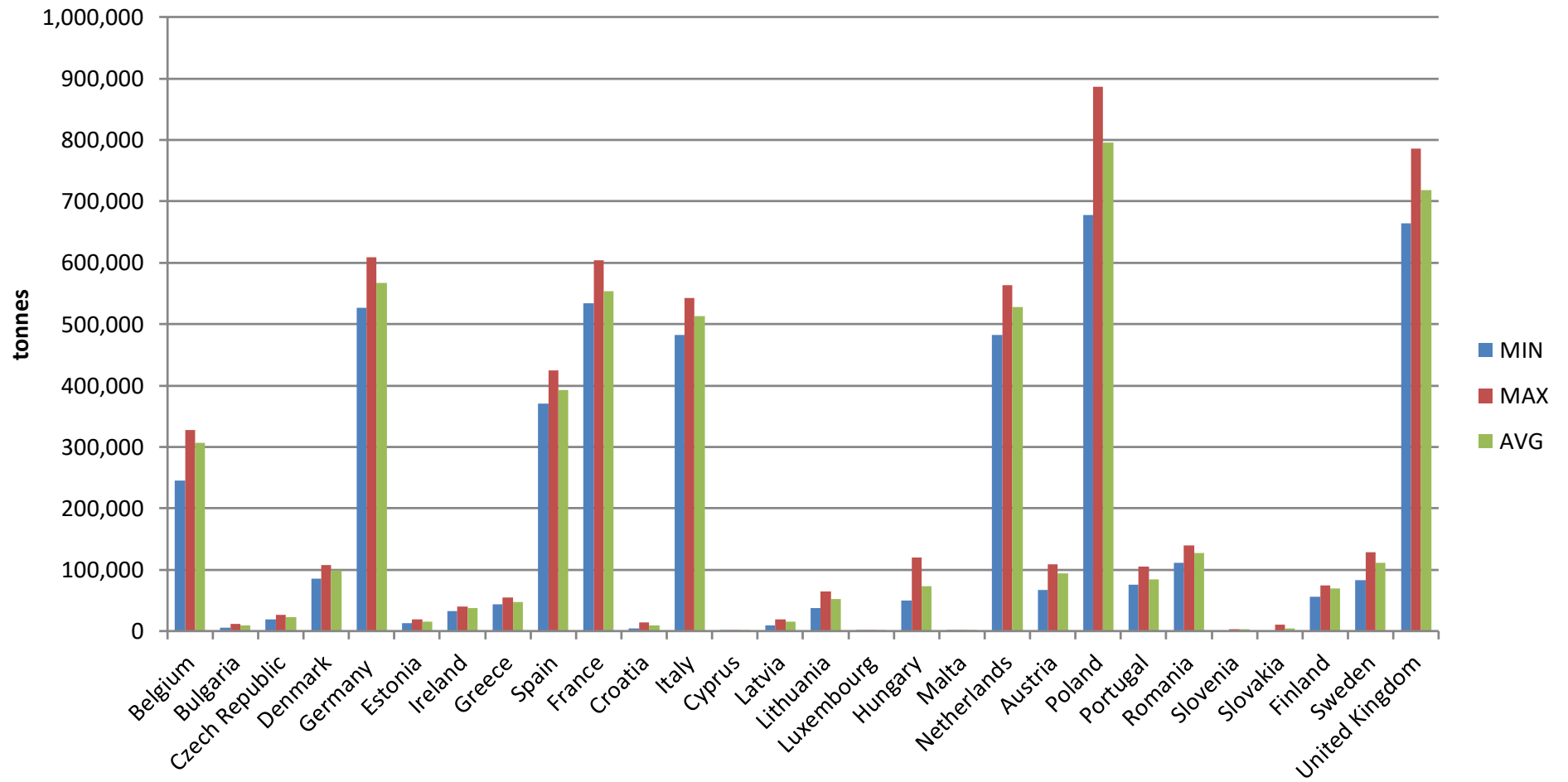


Figure 45 Tonnes of harvested carrots per country, 2010-2015

Table 34 Tonnes of damaged carrots per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	62,820	63,480	63,480	63,480	65,600	49,080	49,080	65,600	61,323
Bulgaria	2,114	2,400	1,920	1,080	1,924	1,582	1,080	2,400	1,837
Czech Republic	3,766	4,878	4,152	4,624	5,212	4,690	3,766	5,212	4,554
Denmark	20,966	21,448	16,972	19,324	21,462	17,842	16,972	21,462	19,669
Germany	110,794	106,744	118,552	116,718	121,870	105,372	105,372	121,870	113,342
Estonia	3,540	3,780	2,460	3,020	2,560	3,620	2,460	3,780	3,163
Ireland	6,506	7,806	6,674	7,416	8,034	8,034	6,506	8,034	7,412
Greece	8,728	10,954	10,666	8,694	8,780	8,828	8,694	10,954	9,442
Spain	84,862	80,126	74,052	74,542	75,262	82,174	74,052	84,862	78,503
France	108,334	120,836	108,234	106,874	108,640	112,002	106,874	120,836	110,820
Croatia	1,894	1,500	2,706	794	1,440	2,172	794	2,706	1,751
Italy	97,834	108,530	96,460	98,356	107,848	106,590	96,460	108,530	102,603
Cyprus	382	378	372	342	406	456	342	456	389
Latvia	3,440	3,880	2,280	2,780	3,800	1,760	1,760	3,880	2,990
Lithuania	7,540	12,840	12,040	10,220	12,240	7,598	7,540	12,840	10,413
Luxembourg	96	46	100	188	200	200	46	200	138
Hungary	11,706	13,030	14,944	13,486	23,862	10,000	10,000	23,862	14,505
Malta	274	266	196	262	246	252	196	274	249
Netherlands	102,200	96,400	102,200	111,000	109,600	112,688	96,400	112,688	105,681
Austria	17,126	21,808	19,654	19,100	21,388	13,352	13,352	21,808	18,738
Poland	162,986	177,480	166,940	147,020	164,520	135,540	135,540	177,480	159,081
Portugal	15,076	15,076	15,104	15,432	20,908	19,498	15,076	20,908	16,849
Romania	24,194	27,654	22,214	26,158	27,846	24,418	22,214	27,846	25,414
Slovenia	408	594	542	0	704	674	0	704	487
Slovakia	0	0	0	1,304	1,300	2,020	0	2,020	771
Finland	13,502	14,518	11,112	14,182	14,882	14,396	11,112	14,882	13,765
Sweden	16,602	20,972	25,748	22,562	23,804	23,126	16,602	25,748	22,136
United Kingdom	149,600	137,600	132,800	139,200	157,200	146,200	132,800	157,200	143,767

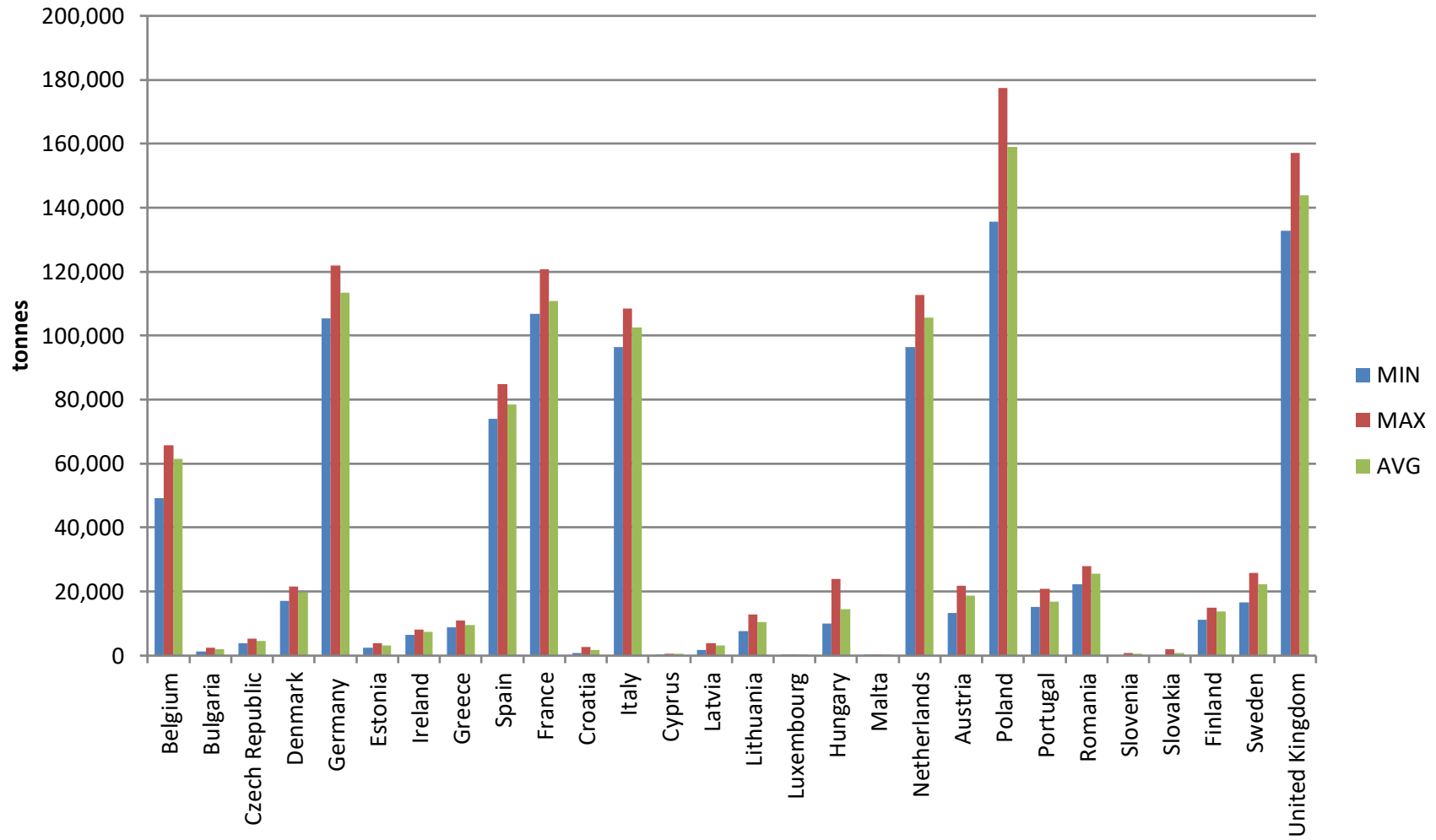


Figure 46 Tonnes of damaged carrots per country, 2010-2015

Table 35 Tonnes of imported and exported carrots per country, 2010-2013 (FAO: Crops and livestock products, n.d.)

GEO/POPULATION	Trade	2010	2011	2012	2013
Belgium	Import	261,789	292,662	279,017	270,661
	Export	151,325	129,439	130,719	150,947
Bulgaria	Import	15,584	15,815	15,289	14,681
	Export	241	6	39	693
Czech Republic	Import	40,175	37,899	37,936	41,773
	Export	9,878	9,930	10,677	8,936
Denmark	Import	10,159	9,802	11,442	9,259
	Export	11,997	17,796	11,397	8,352
Germany	Import	201,533	231,923	253,157	241,798
	Export	22,979	38,871	40,983	35,902
Estonia	Import	1,694	1,316	1,378	1,937
	Export	197	205	107	242
Ireland	Import	19,005	20,385	22,003	26,578
	Export	540	539	516	500
Greece	Import	3,455	4,250	3,089	2,897
	Export	2,435	2,396	4,362	2,646
Spain	Import	24,509	17,986	14,298	18,254
	Export	69,112	94,779	80,496	98,270
France	Import	121,668	118,271	137,908	140,720
	Export	81,638	110,817	92,285	101,555
Croatia	Import	7,397	7,466	7,624	6,854
	Export	28	103	253	35
Italy	Import	9,431	5,869	8,040	14,221
	Export	94,612	81,171	82,829	71,262
Cyprus	Import	1,909	2,747	2,698	2,384
	Export	0	35	0	9
Latvia	Import	4,094	4,579	6,013	7,284
	Export	495	955	829	2,023
Lithuania	Import	13,167	11,775	8,576	14,105

	Export	16,058	13,003	15,430	19,271
Luxembourg	Import	3,947	4,136	3,910	3,844
	Export	329	392	384	390
Hungary	Import	12,453	11,570	7,787	7,107
	Export	1,518	2,397	2,180	1,217
Malta	Import	555	807	926	667
	Export	0	0	0	0
Netherlands	Import	43,523	53,977	73,007	56,503
	Export	405,434	368,330	404,260	366,534
Austria	Import	22,860	20,629	16,642	14,771
	Export	13,179	20,687	19,412	17,290
Poland	Import	36,582	41,070	27,555	31,018
	Export	37,947	28,252	25,984	32,216
Portugal	Import	32,910	29,644	30,917	41,445
	Export	12,515	8,838	22,837	23,419
Romania	Import	30,069	30,095	22,494	17,917
	Export	1,084	636	508	1,512
Slovenia	Import	7,419	8,700	11,651	8,629
	Export	3,170	4,518	6,842	2,934
Slovakia	Import	16,973	20,608	18,539	20,764
	Export	2,086	886	981	1,211
Finland	Import	5,159	4,791	5,449	9,442
	Export	186	272	54	19
Sweden	Import	8,056	6,643	13,600	8,644
	Export	515	1,095	458	793
United Kingdom	Import	40,057	39,468	50,046	55,672
	Export	24,678	28,046	19,492	22,208

Table 36 Tonnes of processed carrots per country, 2010-2013

GEO/TIME	2010	2011	2012	2013	MIN	MAX	AVG
Belgium	329,173	383,817	368,063	338,892	329,173	383,817	354,986
Bulgaria	12,554	14,544	11,661	6,276	6,276	14,544	11,259
Czech Republic	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Denmark	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Germany	20,844	28,840	106,081	88,929	20,844	106,081	61,174
Estonia	17,997	18,814	12,378	15,607	12,378	18,814	16,199
Ireland	41,896	49,734	45,692	53,976	41,896	53,976	47,824
Greece	3,519	15,467	11,037	3,008	3,008	15,467	8,258
Spain	n/a	n/a	n/a	n/a	n/a	n/a	n/a
France	290,735	319,230	293,047	278,333	278,333	319,230	295,336
Croatia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Italy	256,014	318,936	259,025	285,526	256,014	318,936	279,875
Cyprus	3,246	4,014	3,955	3,479	3,246	4,014	3,673
Latvia	18,891	21,157	14,744	17,340	14,744	21,157	18,033
Lithuania	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Luxembourg	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hungary	36,418	41,370	47,552	40,621	36,418	47,552	41,490
Malta	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Netherlands	99,364	117,680	129,556	194,630	99,364	194,630	135,307
Austria	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Poland	555,009	641,392	577,437	475,077	475,077	641,392	562,229
Portugal	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Romania	36,305	54,614	20,518	35,083	20,518	54,614	36,630
Slovenia	2,400	3,257	3,614	1,783	1,783	3,614	2,763
Slovakia	4,106	8,937	6,749	15,251	4,106	15,251	8,761
Finland	46,261	50,770	34,489	53,742	34,489	53,742	46,316
Sweden	57,859	77,454	108,692	87,215	57,859	108,692	82,805
United Kingdom	n/a	n/a	n/a	n/a	n/a	n/a	n/a



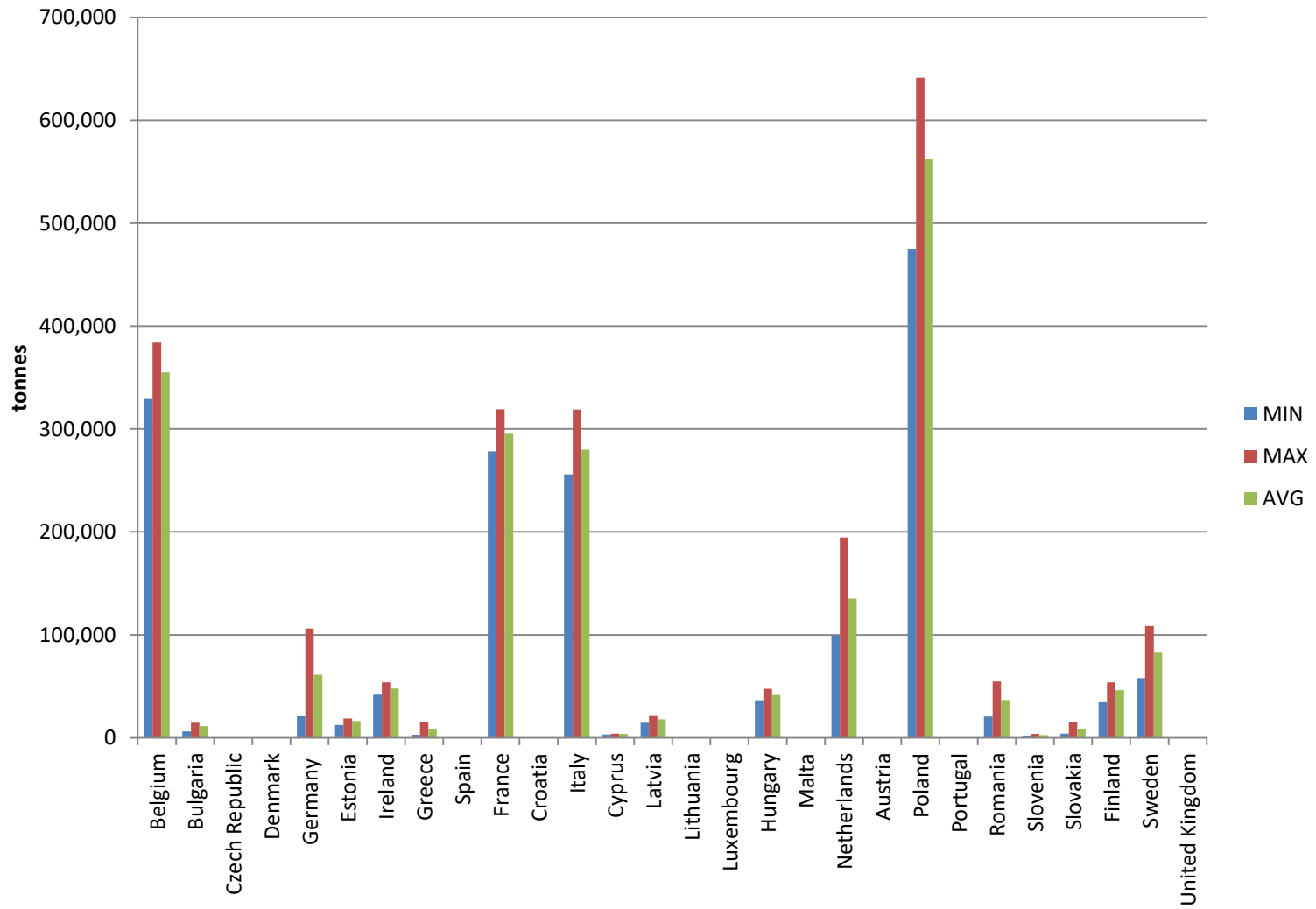


Figure 47 Tonnes of processed carrots per country, 2010-2013

Table 37 Tonnes of carrot pomace and peel per country, 2010-2013

GEO/TIME	2010	2011	2012	2013	MIN	MAX	AVG
Belgium	39,501	46,058	44,168	40,667	39,501	46,058	42,598
Bulgaria	1,506	1,745	1,399	753	753	1,745	1,351
Czech Republic	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Denmark	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Germany	2,501	3,461	12,730	10,672	2,501	12,730	7,341
Estonia	2,160	2,258	1,485	1,873	1,485	2,258	1,944
Ireland	5,028	5,968	5,483	6,477	5,028	6,477	5,739
Greece	422	1,856	1,324	361	361	1,856	991
Spain	n/a	n/a	n/a	n/a	n/a	n/a	n/a
France	34,888	38,308	35,166	33,400	33,400	38,308	35,440
Croatia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Italy	30,722	38,272	31,083	34,263	30,722	38,272	33,585
Cyprus	389	482	475	417	389	482	441
Latvia	2,267	2,539	1,769	2,081	1,769	2,539	2,164
Lithuania	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Luxembourg	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hungary	4,370	4,964	5,706	4,875	4,370	5,706	4,979
Malta	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Netherlands	11,924	14,122	15,547	23,356	11,924	23,356	16,237
Austria	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Poland	66,601	76,967	69,292	57,009	57,009	76,967	67,467
Portugal	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Romania	4,357	6,554	2,462	4,210	2,462	6,554	4,396
Slovenia	288	391	434	214	214	434	332
Slovakia	493	1,072	810	1,830	493	1,830	1,051
Finland	5,551	6,092	4,139	6,449	4,139	6,449	5,558
Sweden	6,943	9,294	13,043	10,466	6,943	13,043	9,937
United Kingdom	n/a	n/a	n/a	n/a	n/a	n/a	n/a

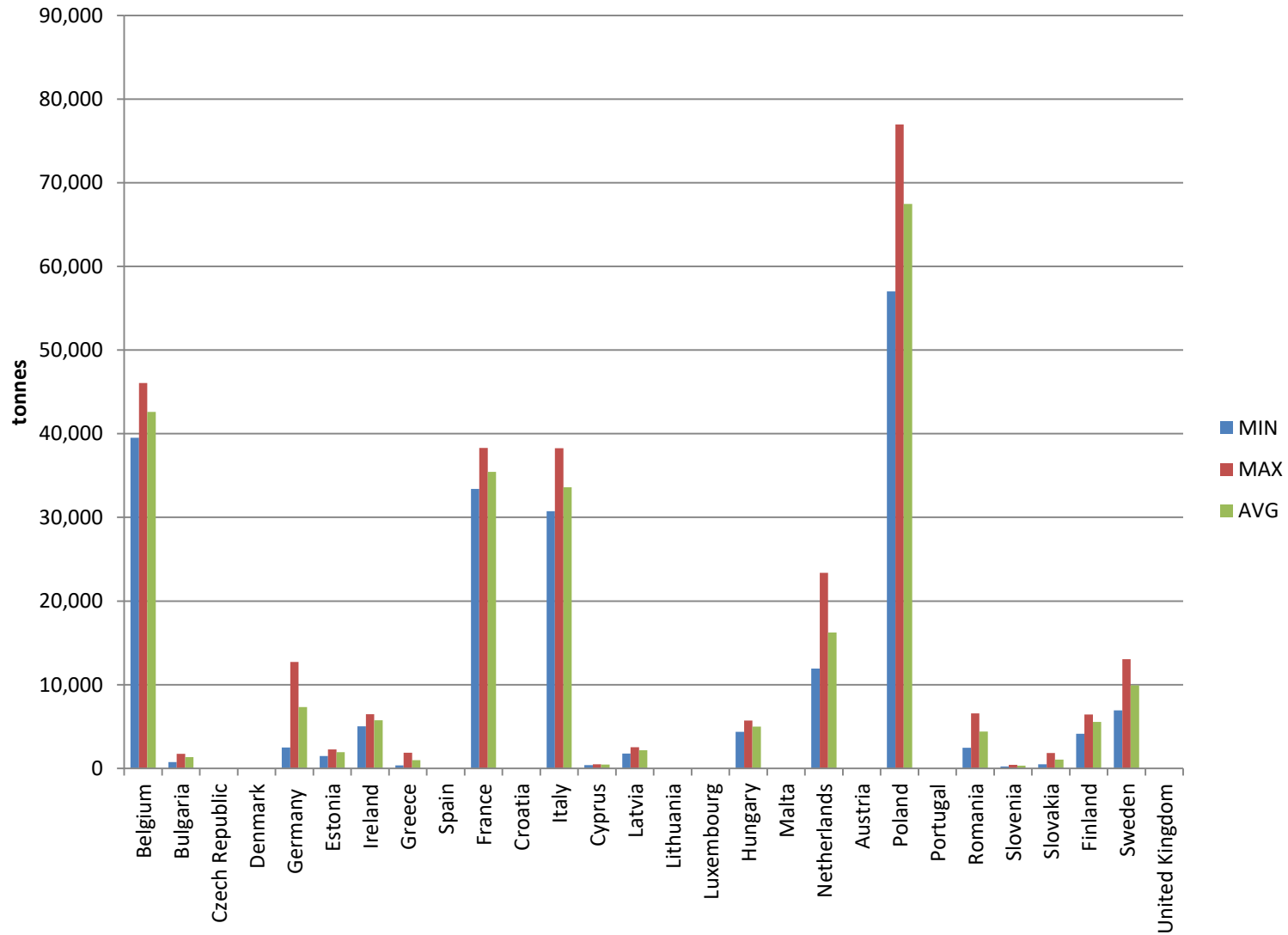


Figure 48 Tonnes of carrot pomace and peel per country, 2010-2013

Table 38 Volume of wastewater from carrot processing in m<sup>3</sup> per country, 2010-2013

GEO/TIME	2010	2011	2012	2013	MIN	MAX	AVG
Belgium	3,686,736	4,298,755	4,122,309	3,795,585	3,686,736	4,298,755	3,975,846
Bulgaria	140,603	162,893	130,603	70,289	70,289	162,893	126,097
Czech Republic	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Denmark	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Germany	233,457	323,008	1,188,110	996,009	233,457	1,188,110	685,146
Estonia	201,567	210,720	138,637	174,797	138,637	210,720	181,430
Ireland	469,237	557,023	511,746	604,529	469,237	604,529	535,634
Greece	39,409	173,235	123,618	33,685	33,685	173,235	92,487
Spain	n/a	n/a	n/a	n/a	n/a	n/a	n/a
France	3,256,234	3,575,373	3,282,122	3,117,334	3,117,334	3,575,373	3,307,766
Croatia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Italy	2,867,353	3,572,086	2,901,085	3,197,890	2,867,353	3,572,086	3,134,604
Cyprus	36,351	44,959	44,291	38,964	36,351	44,959	41,141
Latvia	211,574	236,957	165,129	194,203	165,129	236,957	201,966
Lithuania	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Luxembourg	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hungary	407,879	463,345	532,578	454,955	407,879	532,578	464,689
Malta	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Netherlands	1,112,877	1,318,012	1,451,027	2,179,859	1,112,877	2,179,859	1,515,444
Austria	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Poland	6,216,106	7,183,585	6,467,297	5,320,860	5,320,860	7,183,585	6,296,962
Portugal	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Romania	406,613	611,680	229,806	392,925	229,806	611,680	410,256
Slovenia	26,877	36,474	40,472	19,972	19,972	40,472	30,949
Slovakia	45,989	100,096	75,593	170,815	45,989	170,815	98,123
Finland	518,123	568,626	386,274	601,914	386,274	601,914	518,734
Sweden	648,016	867,479	1,217,350	976,812	648,016	1,217,350	927,415
United Kingdom	n/a	n/a	n/a	n/a	n/a	n/a	n/a

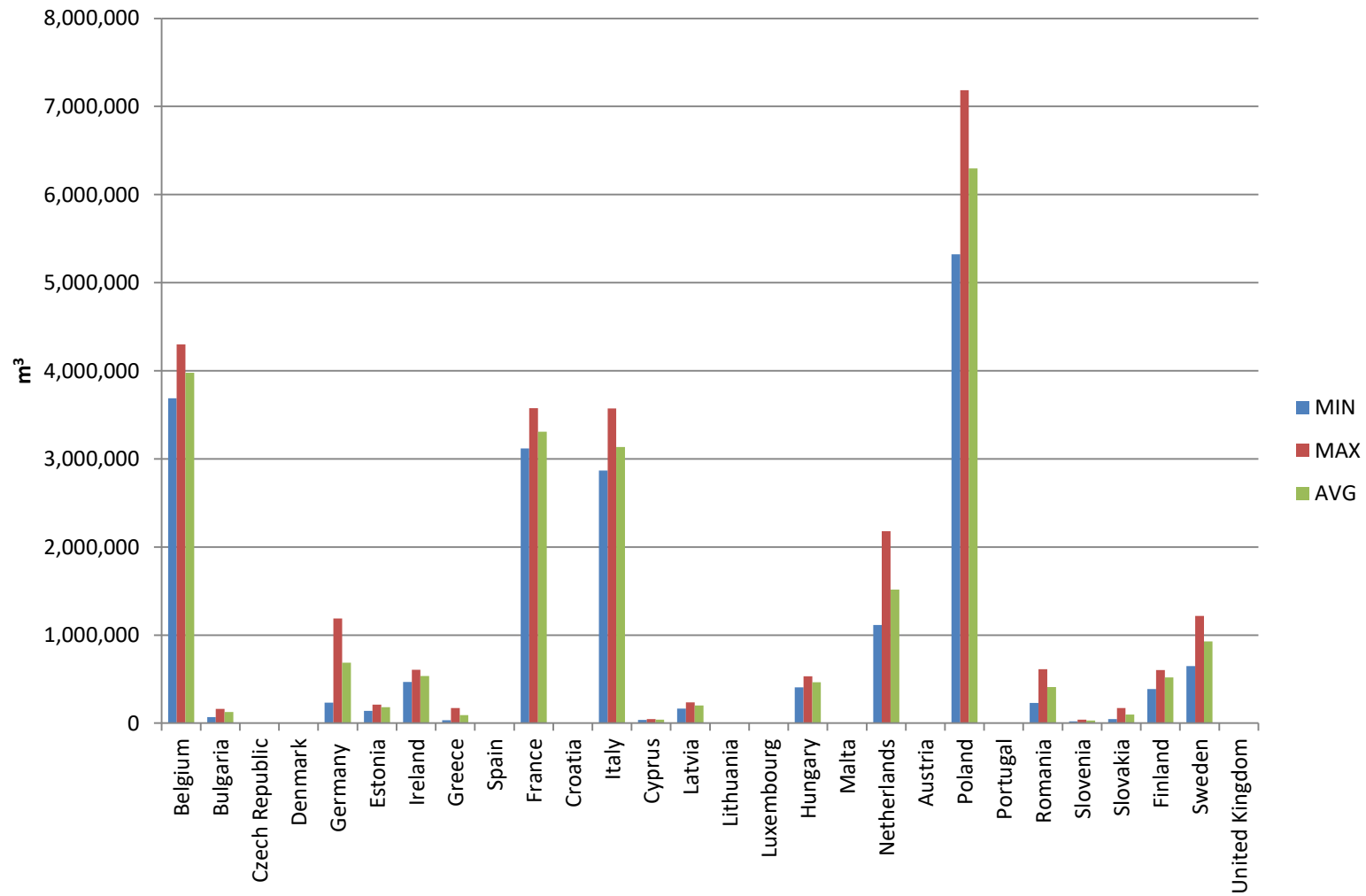


Figure 49 Volume of wastewater from carrot processing in m<sup>3</sup> per country, 2010-2013

Table 39 Consumption of fresh carrots (tonnes) per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	95,391	96,806	97,635	98,222	98,391	98,888	95,391	98,888	97,556
Bulgaria	13,359	13,265	13,189	13,112	13,042	12,964	12,964	13,359	13,155
Czech Republic	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Denmark	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Germany	711,680	697,932	698,853	700,557	702,677	706,419	697,932	711,680	703,019
Estonia	1,200	1,197	1,193	1,188	1,184	1,183	1,183	1,200	1,191
Ireland	9,099	9,142	9,165	9,182	9,211	9,258	9,099	9,258	9,176
Greece	41,141	41,157	41,020	40,713	40,429	40,175	40,175	41,157	40,772
Spain	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
France	290,965	292,404	293,746	295,202	296,739	299,197	290,965	299,197	294,709
Croatia	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Italy	147,975	148,412	148,486	149,213	151,957	151,989	147,975	151,989	149,672
Cyprus	573	588	603	606	601	593	573	606	594
Latvia	1,908	1,867	1,840	1,821	1,801	1,787	1,787	1,908	1,838
Lithuania	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Luxembourg	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hungary	33,047	32,953	32,775	32,699	32,595	32,523	32,523	33,047	32,766
Malta	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Netherlands	49,725	49,967	50,191	50,339	50,488	50,702	49,725	50,702	50,235
Austria	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Poland	258,556	258,826	258,834	258,825	258,521	258,438	258,438	258,834	258,667
Portugal	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Romania	113,650	113,115	112,538	112,112	111,705	111,276	111,276	113,650	112,399
Slovenia	3,889	3,895	3,905	3,912	3,916	3,919	3,889	3,919	3,906
Slovakia	10,781	10,785	10,809	10,822	10,832	10,843	10,781	10,843	10,812
Finland	26,222	26,339	26,466	26,591	26,711	26,812	26,222	26,812	26,523
Sweden	32,692	32,954	33,190	33,446	33,757	34,116	32,692	34,116	33,359
United Kingdom	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

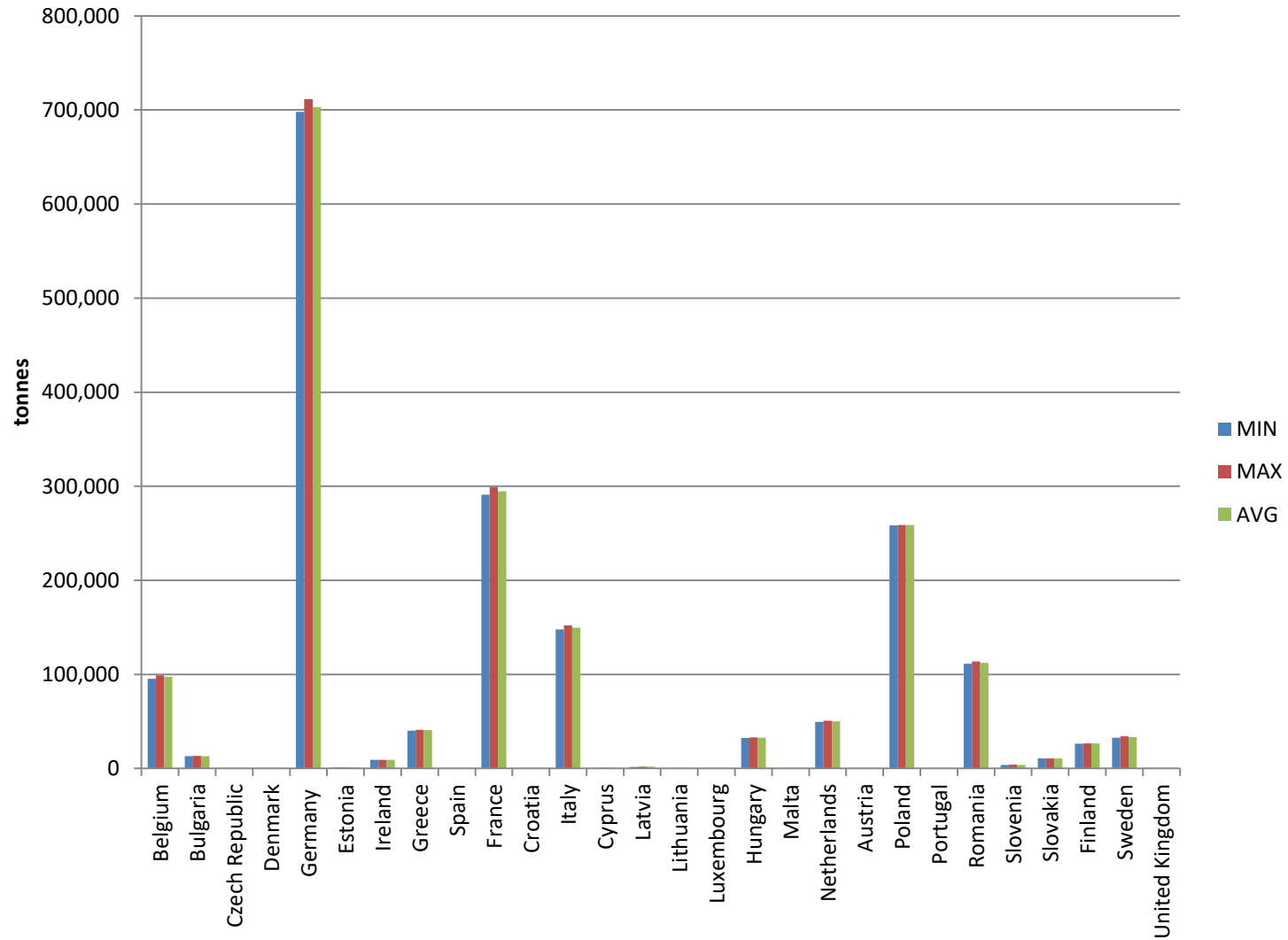


Figure 50 Consumption of fresh carrots (tonnes) per country, 2010-2015

Table 40 Tonnes of rotten carrots per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	18,124	18,393	18,551	18,662	18,694	18,789	18,124	18,789	18,536
Bulgaria	2,538	2,520	2,506	2,491	2,478	2,463	2,463	2,538	2,499
Czech Republic	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Denmark	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Germany	135,219	132,607	132,782	133,106	133,509	134,220	132,607	135,219	133,574
Estonia	228	227	227	226	225	225	225	228	226
Ireland	1,729	1,737	1,741	1,745	1,750	1,759	1,729	1,759	1,743
Greece	7,817	7,820	7,794	7,736	7,682	7,633	7,633	7,820	7,747
Spain	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
France	55,283	55,557	55,812	56,088	56,380	56,847	55,283	56,847	55,995
Croatia	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Italy	28,115	28,198	28,212	28,350	28,872	28,878	28,115	28,878	28,438
Cyprus	109	112	115	115	114	113	109	115	113
Latvia	363	355	350	346	342	340	340	363	349
Lithuania	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Luxembourg	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hungary	6,279	6,261	6,227	6,213	6,193	6,179	6,179	6,279	6,225
Malta	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Netherlands	9,448	9,494	9,536	9,564	9,593	9,633	9,448	9,633	9,545
Austria	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Poland	49,126	49,177	49,178	49,177	49,119	49,103	49,103	49,178	49,147
Portugal	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Romania	21,594	21,492	21,382	21,301	21,224	21,142	21,142	21,594	21,356
Slovenia	739	740	742	743	744	745	739	745	742
Slovakia	2,048	2,049	2,054	2,056	2,058	2,060	2,048	2,060	2,054
Finland	4,982	5,004	5,029	5,052	5,075	5,094	4,982	5,094	5,039
Sweden	6,212	6,261	6,306	6,355	6,414	6,482	6,212	6,482	6,338
United Kingdom	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a



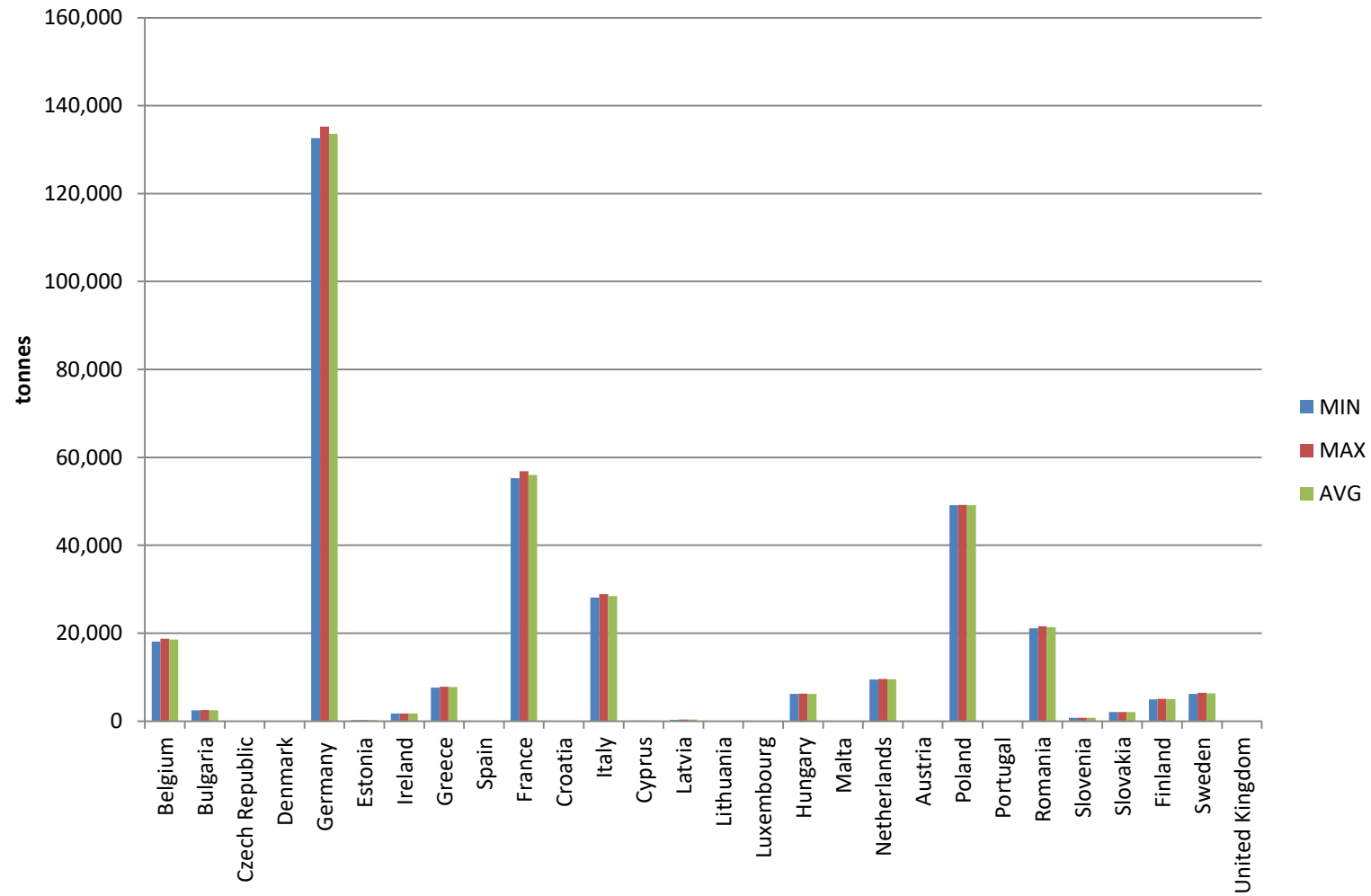


Figure 51 Tonnes of rotten carrots per country, 2010-2015

## 2.6 Potato

The potato is a tuberous crop that is one of the world's most consumed foods (FAO: Statistical Pocketbook , 2015). Europe, China and India are the largest producers of potato. There are more than 5,000 varieties of potato worldwide. The potato is known for its chemical properties, due to high starch content, Figure 52 (Naturawiki: Potato Starch, n.d.).



Figure 52 Potato starch (Naturawiki: Potato Starch, n.d.)

Potato is a crop with a high glycaemic Index, and therefore should be consumed less in the regular diet (NutritionData: Glycemic Index, n.d.). Processed potatoes have several different applications, for example: potato chips, french fries, dehydrated potatoes, alcohol, etc (NIIR PROJECT CONSULTANCY SERVICE: Potato Processing, Potato Processing, Potato Based Products, Potato Chips & Wafers, Potato Granules, Potato Wine, Alcohol, Vodka, Sticks, French Fries, Potato Specialties, Dehydrated, Frozen Potato, Products, Potato, n.d.). Prior to processing, it is necessary to wash the potato and remove the skin. Figure 53 shows part of a potato processing facility (PotatoPRO: Large Russets in Idaho in short supply, n.d.).



Figure 53 A part of a potato processing facility (PotatoPRO: Large Russets in Idaho in short supply, n.d.)

Approximately 19 % of potatoes that are supposed to be consumed end up mouldy, mainly due to inappropriate storage.



Figure 54 Rotten potato (Mid-day: Dog meat, rotten potatoes! 5 bizarre Indian food items that you didn't know exist, n.d.)

The flowchart (Figure 55) presents the value chain for potatoes and specific waste weight from Table 2.

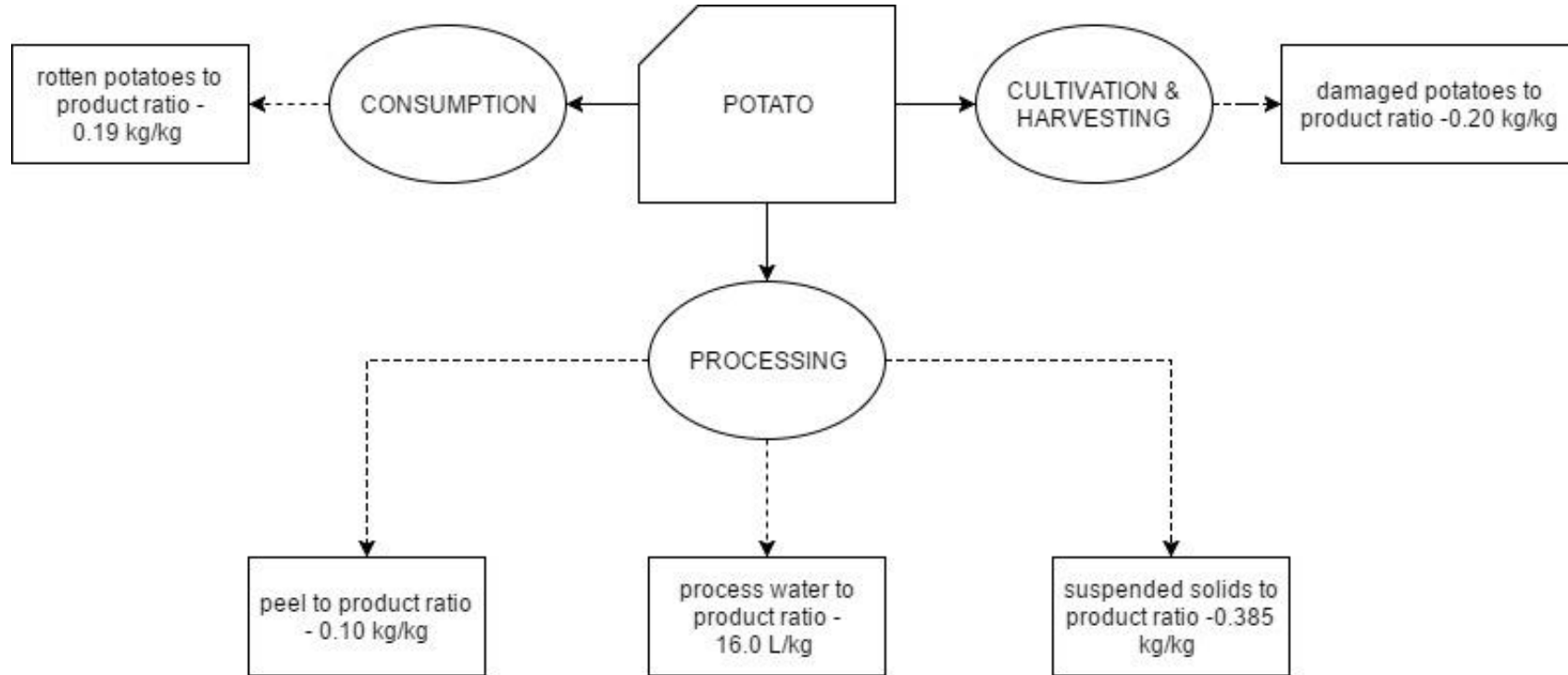


Figure 55 Potato AWCB value chain

Data for cultivated potatoes is taken from EUROSTAT, and data for imported and exported potatoes is taken from FAOSTAT. The methodology used to generate this database requires specific fresh consumption data for the food commodities. Consumption data for potatoes exist in some form, notably in the food balance sheets of FAOSTAT (<http://www.fao.org/faostat/en/#data/FBS>). These data however represent both fresh and processed consumption. Reliable and consistent data for fresh European potato consumption was not available at the time of writing are therefore the AWCB arising from consumption and processing steps is not included in this report. The template for their inclusion is available in the accompanying spreadsheets, which may can be updated when more reliable data becomes available.

Table 41 Tonnes of harvested potatoes per country, 2010-2015 (Eurostat: Agricultural production - crops, n.d.)

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	3,455,800	4,128,670	2,811,500	3,428,000	4,121,450	3,663,170	2,811,500	4,128,670	3,601,432
Bulgaria	251,200	232,310	151,300	186,530	132,650	164,670	132,650	251,200	186,443
Czech Republic	665,180	805,330	661,800	536,450	697,540	504,960	504,960	805,330	645,210
Denmark	1,357,800	1,620,200	1,664,200	1,646,300	964,500	1,748,000	964,500	1,748,000	1,500,167
Germany	10,143,090	11,837,200	10,665,600	9,669,700	11,607,300	10,370,200	9,669,700	11,837,200	10,715,515
Estonia	110,200	110,600	102,000	92,600	82,300	80,700	80,700	110,600	96,400
Ireland	419,610	356,070	232,020	410,150	383,010	360,090	232,020	419,610	360,158
Greece	791,540	757,820	578,820	666,820	582,370	586,750	578,820	791,540	660,687
Spain	2,297,600	2,455,080	2,192,280	2,167,610	2,543,930	2,245,410	2,167,610	2,543,930	2,316,985
France	6,622,040	7,440,220	6,297,130	6,953,280	8,054,520	7,114,490	6,297,130	8,054,520	7,080,280
Croatia	178,610	167,520	151,280	162,500	160,850	171,620	151,280	178,610	165,397
Italy	1,558,030	1,536,850	1,491,250	1,272,210	1,365,440	1,355,410	1,272,210	1,558,030	1,429,865
Cyprus	82,000	126,080	82,200	105,480	117,500	95,920	82,000	126,080	101,530
Latvia	293,300	246,800	238,800	236,800	209,900	203,600	203,600	293,300	238,200
Lithuania	471,100	581,000	542,400	420,700	460,900	391,640	391,640	581,000	477,957
Luxembourg	19,530	19,680	20,610	17,540	18,980	12,970	12,970	20,610	18,218
Hungary	488,410	600,120	547,710	487,360	567,430	412,190	412,190	600,120	517,203
Malta	15,540	18,920	12,690	12,640	10,810	8,020	8,020	18,920	13,103
Netherlands	6,843,530	7,333,000	6,766,000	6,577,000	7,100,000	6,651,690	6,577,000	7,333,000	6,878,537
Austria	671,720	816,070	665,420	604,050	750,640	536,470	536,470	816,070	674,062
Poland	8,187,700	9,111,000	9,041,300	7,110,900	7,424,700	6,151,800	6,151,800	9,111,000	7,837,900
Portugal	383,840	389,800	445,650	487,650	539,870	486,790	383,840	539,870	455,600
Romania	3,283,870	4,076,570	2,465,150	3,289,720	3,519,330	2,625,020	2,465,150	4,076,570	3,209,943
Slovenia	101,210	96,180	79,250	62,160	97,160	91,040	62,160	101,210	87,833
Slovakia	125,920	217,300	165,670	164,460	178,820	144,630	125,920	217,300	166,133
Finland	659,100	673,300	489,600	621,700	600,300	532,100	489,600	673,300	596,017
Sweden	816,300	882,000	805,300	806,100	822,100	802,500	802,500	882,000	822,383
United Kingdom	6,046,000	6,016,000	4,553,000	5,685,000	5,921,000	5,170,000	4,553,000	6,046,000	5,565,167



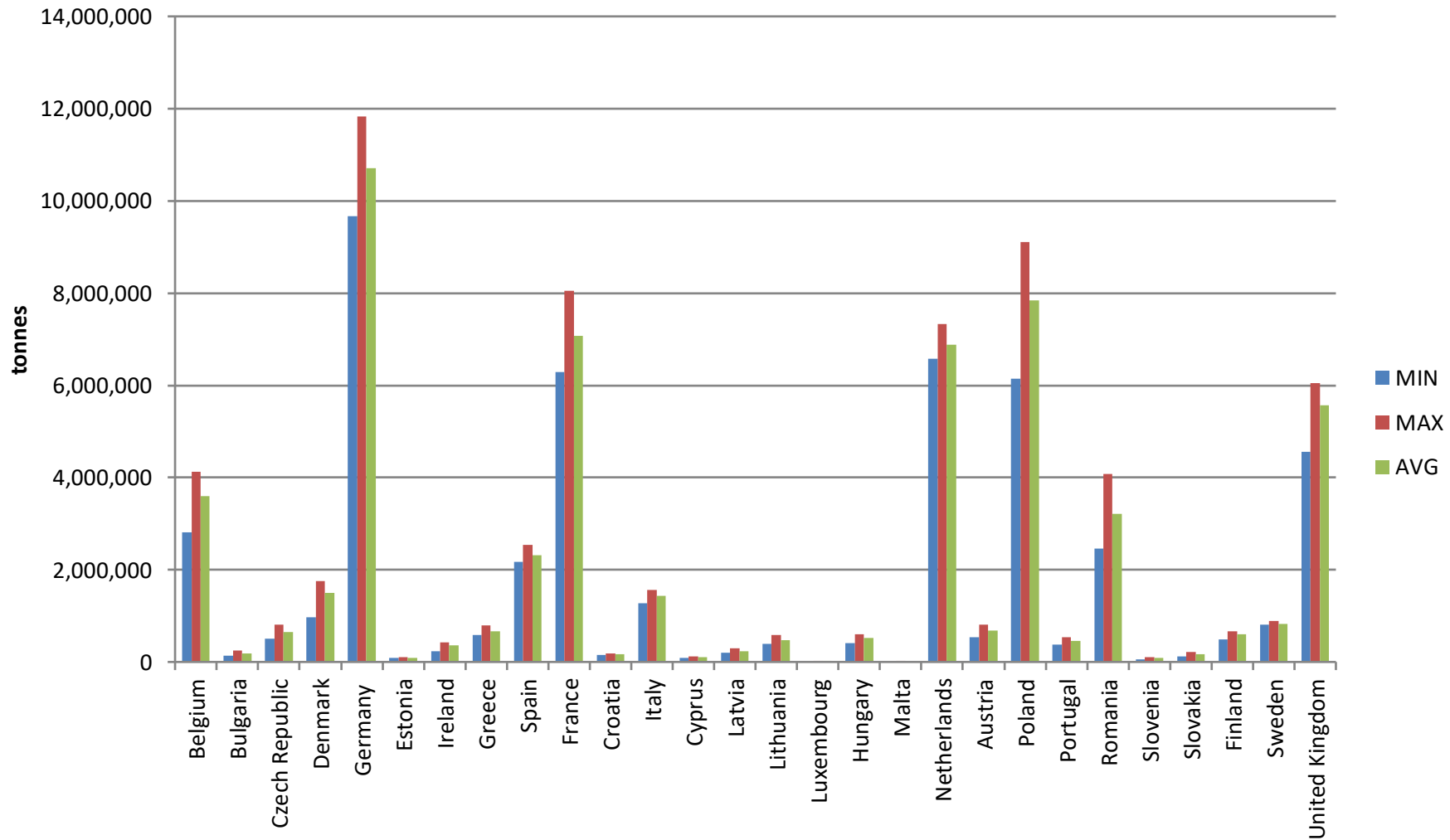


Figure 56 Tonnes of harvested potatoes per country, 2010-2015

Table 42 Tonnes of damaged potatoes per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	691,160	825,734	562,300	685,600	824,290	732,634	562,300	825,734	720,286
Bulgaria	50,240	46,462	30,260	37,306	26,530	32,934	26,530	50,240	37,289
Czech Republic	133,036	161,066	132,360	107,290	139,508	100,992	100,992	161,066	129,042
Denmark	271,560	324,040	332,840	329,260	192,900	349,600	192,900	349,600	300,033
Germany	2,028,618	2,367,440	2,133,120	1,933,940	2,321,460	2,074,040	1,933,940	2,367,440	2,143,103
Estonia	22,040	22,120	20,400	18,520	16,460	16,140	16,140	22,120	19,280
Ireland	83,922	71,214	46,404	82,030	76,602	72,018	46,404	83,922	72,032
Greece	158,308	151,564	115,764	133,364	116,474	117,350	115,764	158,308	132,137
Spain	459,520	491,016	438,456	433,522	508,786	449,082	433,522	508,786	463,397
France	1,324,408	1,488,044	1,259,426	1,390,656	1,610,904	1,422,898	1,259,426	1,610,904	1,416,056
Croatia	35,722	33,504	30,256	32,500	32,170	34,324	30,256	35,722	33,079
Italy	311,606	307,370	298,250	254,442	273,088	271,082	254,442	311,606	285,973
Cyprus	16,400	25,216	16,440	21,096	23,500	19,184	16,400	25,216	20,306
Latvia	58,660	49,360	47,760	47,360	41,980	40,720	40,720	58,660	47,640
Lithuania	94,220	116,200	108,480	84,140	92,180	78,328	78,328	116,200	95,591
Luxembourg	3,906	3,936	4,122	3,508	3,796	2,594	2,594	4,122	3,644
Hungary	97,682	120,024	109,542	97,472	113,486	82,438	82,438	120,024	103,441
Malta	3,108	3,784	2,538	2,528	2,162	1,604	1,604	3,784	2,621
Netherlands	1,368,706	1,466,600	1,353,200	1,315,400	1,420,000	1,330,338	1,315,400	1,466,600	1,375,707
Austria	134,344	163,214	133,084	120,810	150,128	107,294	107,294	163,214	134,812
Poland	1,637,540	1,822,200	1,808,260	1,422,180	1,484,940	1,230,360	1,230,360	1,822,200	1,567,580
Portugal	76,768	77,960	89,130	97,530	107,974	97,358	76,768	107,974	91,120
Romania	656,774	815,314	493,030	657,944	703,866	525,004	493,030	815,314	641,989
Slovenia	20,242	19,236	15,850	12,432	19,432	18,208	12,432	20,242	17,567
Slovakia	25,184	43,460	33,134	32,892	35,764	28,926	25,184	43,460	33,227
Finland	131,820	134,660	97,920	124,340	120,060	106,420	97,920	134,660	119,203
Sweden	163,260	176,400	161,060	161,220	164,420	160,500	160,500	176,400	164,477
United Kingdom	1,209,200	1,203,200	910,600	1,137,000	1,184,200	1,034,000	910,600	1,209,200	1,113,033



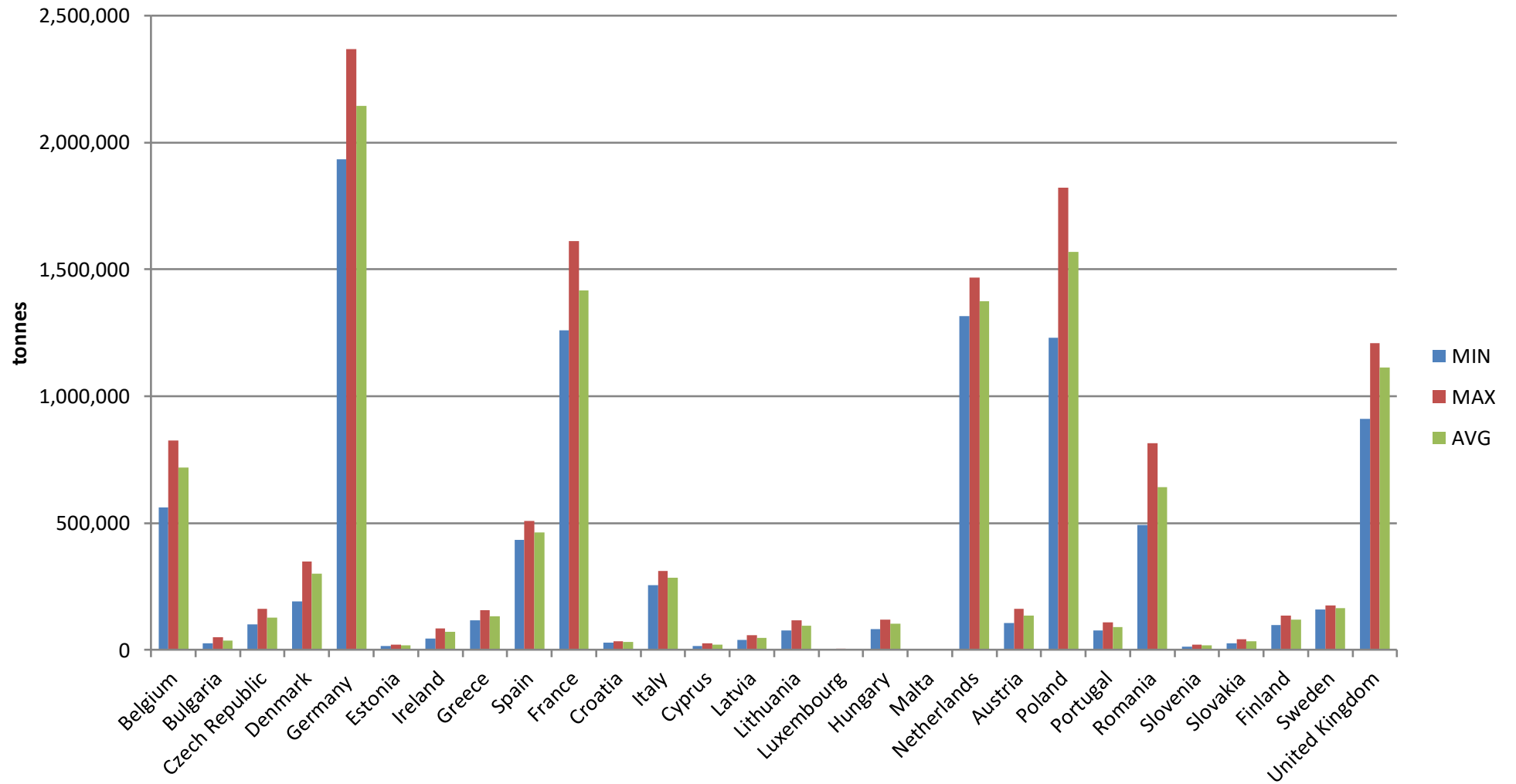


Figure 57 Tonnes of damaged potatoes per country, 2010-2015

Table 43 Tonnes of imported and exported potatoes per country, 2010-2013 (FAO: Crops and livestock products, n.d.)

GEO/POPULATION	Trade	2010	2011	2012	2013
Belgium	Import	1,382,592	1,403,488	1,685,853	1,563,382
	Export	784,858	897,155	911,044	914,582
Bulgaria	Import	18,440	15,637	27,446	41,680
	Export	617	402	3,316	6,740
Czech Republic	Import	151,626	148,549	95,398	157,656
	Export	48,934	38,158	53,743	37,144
Denmark	Import	89,536	101,944	120,859	98,128
	Export	171,480	186,347	175,783	177,995
Germany	Import	573,769	662,001	855,277	1,061,201
	Export	1,592,520	1,596,295	1,972,914	2,195,131
Estonia	Import	4,338	5,030	1,815	2,804
	Export	4,095	6,594	1,125	2,865
Ireland	Import	65,502	61,019	73,580	70,631
	Export	9,137	21,929	3,493	4,663
Greece	Import	132,643	174,361	129,485	147,735
	Export	24,351	22,933	19,094	18,699
Spain	Import	777,942	662,454	715,008	668,263
	Export	240,527	242,402	252,816	240,617
France	Import	414,729	407,234	405,048	469,398
	Export	2,318,680	1,987,500	1,984,730	1,909,669
Croatia	Import	26,011	22,871	23,009	29,384
	Export	1,268	6,375	6,840	3,402
Italy	Import	706,995	606,362	667,020	693,630
	Export	168,099	144,982	121,807	145,861
Cyprus	Import	11,927	8,144	9,434	8,354
	Export	58,188	111,481	67,742	95,317
Latvia	Import	7,048	17,958	8,178	5,014
	Export	8,036	11,239	2,719	4,487
Lithuania	Import	14,547	23,723	17,089	11,879

	Export	18,309	28,123	20,559	37,723
Luxembourg	Import	11,142	11,070	10,214	10,745
	Export	3,019	2,353	1,612	2,562
Hungary	Import	37,751	38,217	26,869	20,540
	Export	4,494	4,845	6,667	3,142
Malta	Import	5,446	5,130	6,690	6,312
	Export	919	5,849	2,860	4,238
Netherlands	Import	1,220,236	1,460,418	1,659,816	1,414,961
	Export	1,883,601	1,942,352	1,693,892	1,778,061
Austria	Import	104,841	108,819	112,796	135,175
	Export	84,069	77,292	92,988	65,832
Poland	Import	235,438	247,100	126,497	103,068
	Export	43,238	73,943	50,557	44,490
Portugal	Import	308,856	281,123	414,599	412,396
	Export	33,188	33,856	57,758	54,646
Romania	Import	64,706	89,597	86,546	137,127
	Export	20,257	11,526	6,197	11,956
Slovenia	Import	26,169	37,909	28,322	31,886
	Export	11,204	22,371	13,443	9,863
Slovakia	Import	83,969	71,267	39,070	41,782
	Export	16,526	8,388	7,251	1,007
Finland	Import	14,299	20,766	17,466	20,757
	Export	55,952	38,147	27,214	8,499
Sweden	Import	65,750	68,752	53,576	50,745
	Export	4,120	6,895	11,804	9,218
United Kingdom	Import	248,841	267,081	465,206	636,302
	Export	336,699	384,622	287,623	288,459

## 2.7 Sunflower seed

The sunflower seed is a product of the sunflower plant. The term ‘sunflower seed’ refers to the seed in its hull (Black, Bewley, & Halmer, 2006). Sunflower seeds are mostly used for oil production; the world’s largest production of sunflower seeds occurs in Russia and Ukraine. Application of sunflower seed as a snack is not taken into account in this review. Sunflower fields are exposed to the elements, with birds being the greatest threat, resulting in a decreased yield of the product during cultivation and harvesting. Figure 58 shows the bird influence on the sunflower plant (Western Region IR-4 Program, Bird Damage sunflower, n.d.).



Figure 58 A bird damaged sunflower (Western Region IR-4 Program, Bird Damage sunflower, n.d.)

Oil is extracted from sunflower seed by pressing the seeds, in a seed oil expeller, shown in Figure 59 (Agico Group: Seed Oil Expeller, n.d.).



Figure 59 Seed oil expeller (Agico Group: Seed Oil Expeller, n.d.)

In modern organic farming, sunflower cake that results from pressing is usually used as fodder for animals (The Organic Farmer: Sunflower is a good source of animal feed, n.d.). It contains a high concentration of proteins, as fibres and oil. Sunflower meal cake pellets are shown in Figure 60 (SunOpta Foods Bulgaria: Organic Sunflower Cakes, n.d.).



Figure 60 Sunflower cake meal (SunOpta Foods Bulgaria: Organic Sunflower Cakes, n.d.)

Slurry (ugido) occurs in a much lower quantity than sunflower cake meal.

The flowchart (Figure 61) presents the value chain for sunflower seed and specific AWCB weight factors from Table 2.

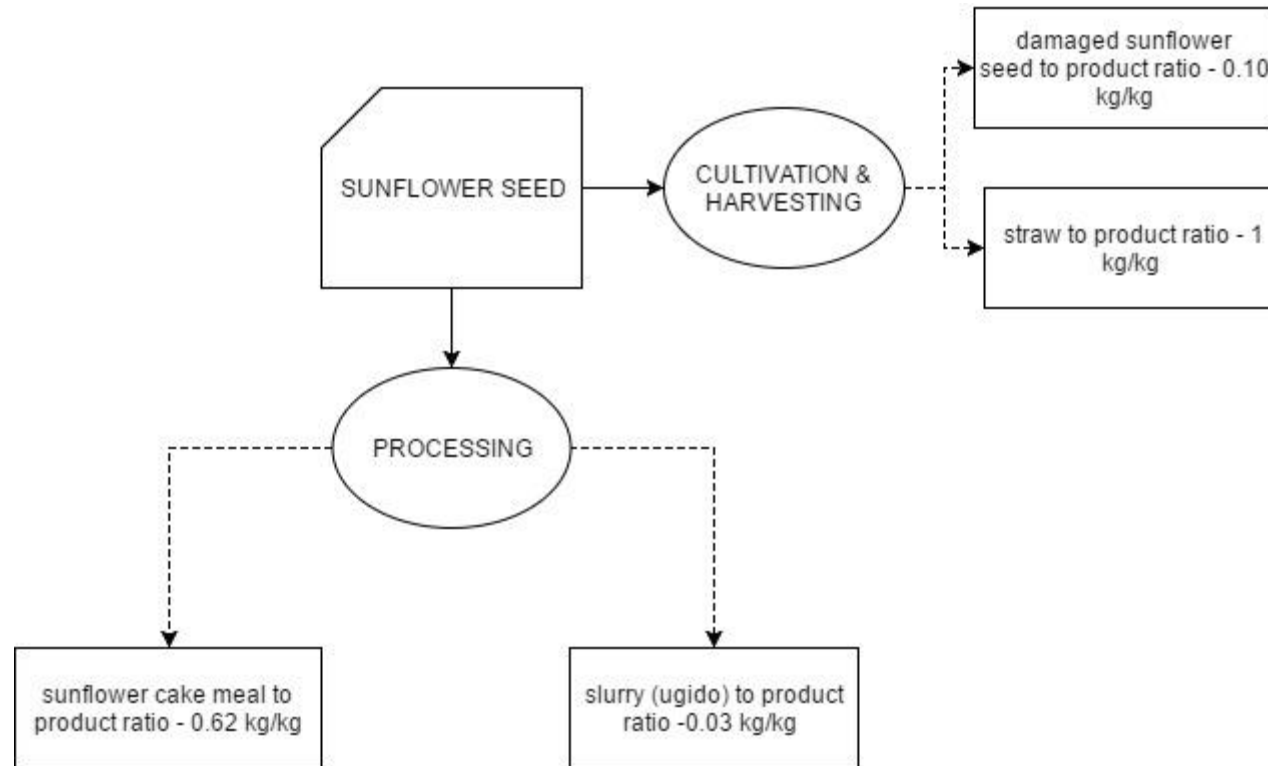


Figure 61 Sunflower seed AWCB value chain

Data for cultivated sunflower seed is taken from EUROSTAT, and data for imported and exported sunflower seed is taken from FAOSTAT. By using relations (I-VIII), the quantity of processed sunflower seed is estimated for each country in each given year. An example of the calculation for Slovakia in 2010 is presented below:

PRD = 150,330 tonnes

IMP = 4,879 tonnes

EXP = 98,480 tonnes

PRC =  $(834,960 + 621,502) - 98,480 = 56,729$  tonnes

The quantity of damaged sunflower seeds is 0.10 kg per kg of harvested seeds; for Slovakia, this was 15,033 tonnes in 2010. Sunflower cake meal that occurs in processing appears in 0.62 kg per of sunflower seeds mass. Sunflower seed straw that appeared in Slovakia was 150,330 tonnes in 2010. For Slovakia in 2010, the quantity of sunflower cake was 35,172 tonnes. The quantity of slurry (ugido) in 2010 for Slovakia was 1,702 tonnes. Results for other countries and years are presented in the tables and figures below.

Table 44 Tonnes of harvested sunflower seed per country, 2010-2015 (Eurostat: Agricultural production - crops, n.d.)

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	0	0	0	0	0	0	0	0	0
Bulgaria	1,536,320	1,439,700	1,387,800	1,974,430	2,010,670	1,708,550	1,387,800	2,010,670	1,676,245
Czech Republic	57,360	70,900	56,940	46,800	42,310	31,620	31,620	70,900	50,988
Denmark	0	0	0	0	0	0	0	0	0
Germany	47,240	53,200	62,800	46,100	46,000	35,300	35,300	62,800	48,440
Estonia	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0
Greece	204,130	300,600	220,170	510,950	218,010	253,070	204,130	510,950	284,488
Spain	846,650	1,090,170	642,020	1,038,070	952,990	691,560	642,020	1,090,170	876,910
France	1,635,590	1,880,700	1,575,130	1,582,450	1,559,140	1,185,770	1,185,770	1,880,700	1,569,797
Croatia	61,790	84,960	90,020	130,580	99,490	94,080	61,790	130,580	93,487
Italy	212,900	274,420	185,490	285,230	250,380	248,010	185,490	285,230	242,738
Cyprus	0	0	0	0	0	0	0	0	0
Latvia	0	0	0	0	0	0	0	0	0
Lithuania	0	0	0	0	0	0	0	0	0
Luxembourg	0	0	0	0	0	0	0	0	0
Hungary	969,720	1,374,780	1,316,550	1,484,370	1,597,250	1,542,470	969,720	1,597,250	1,380,857
Malta	0	0	0	0	0	0	0	0	0
Netherlands	0	0	0	0	0	0	0	0	0
Austria	66,500	73,710	53,050	51,290	57,750	38,060	38,060	73,710	56,727
Poland	4,500	5,200	5,700	4,600	2,300	2,200	2,200	5,700	4,083
Portugal	7,610	12,570	9,620	11,570	16,430	24,740	7,610	24,740	13,757
Romania	1,262,930	1,789,330	1,398,200	2,142,090	2,189,310	1,785,760	1,262,930	2,189,310	1,761,270
Slovenia	480	980	870	510	530	580	480	980	658
Slovakia	150,330	201,000	197,230	195,740	200,700	174,290	150,330	201,000	186,548
Finland	0	0	0	0	0	0	0	0	0
Sweden	0	0	0	0	0	0	0	0	0
United Kingdom	0	0	0	0	0	0	0	0	0



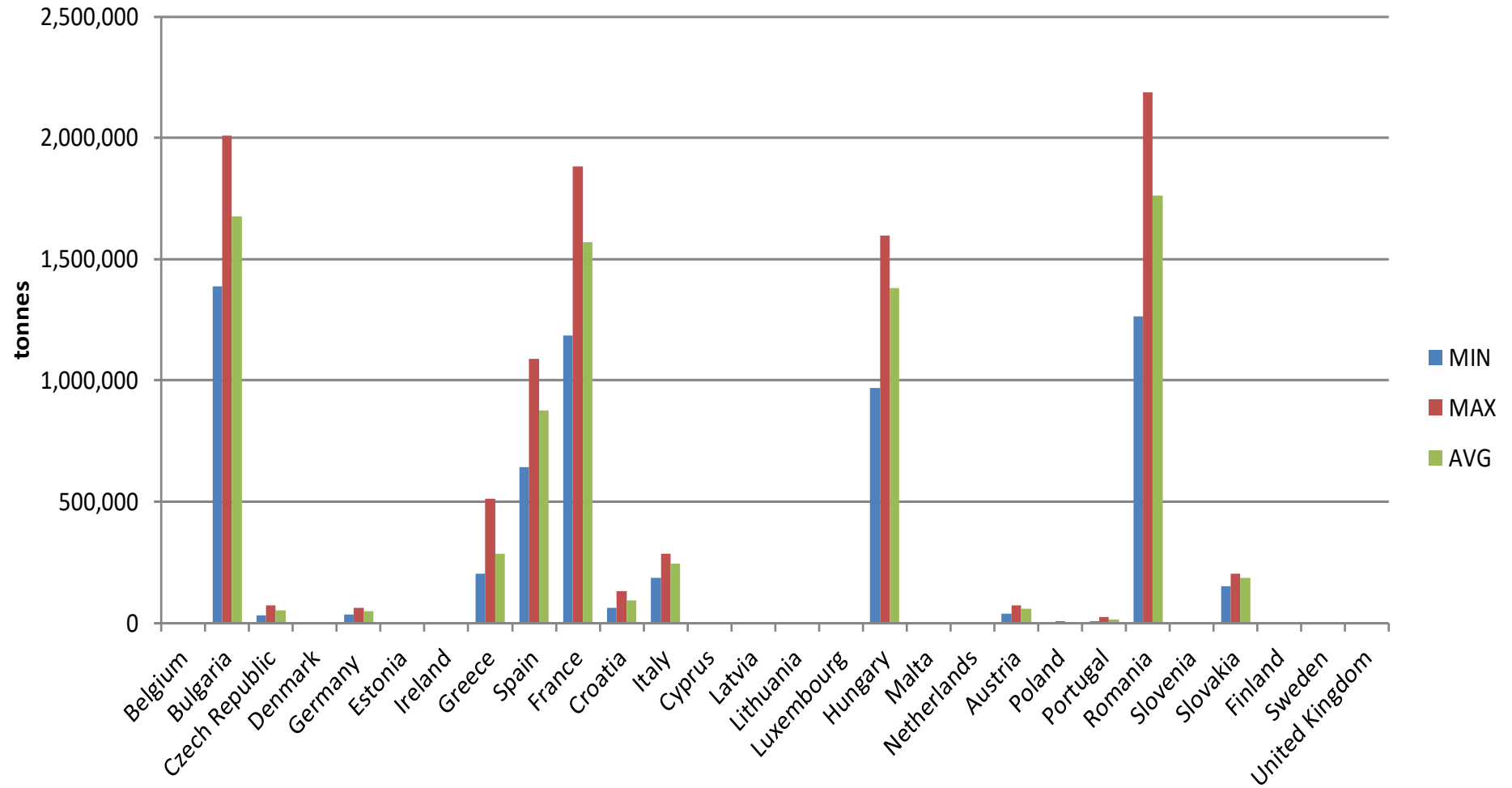


Figure 62 Tonnes of harvested sunflower seed per country, 2010-2015

Table 45 Tonnes of sunflower straw per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	0	0	0	0	0	0	0	0	0
Bulgaria	1,536,320	1,439,700	1,387,800	1,974,430	2,010,670	1,708,550	1,387,800	2,010,670	1,676,245
Czech Republic	57,360	70,900	56,940	46,800	42,310	31,620	31,620	70,900	50,988
Denmark	0	0	0	0	0	0	0	0	0
Germany	47,240	53,200	62,800	46,100	46,000	35,300	35,300	62,800	48,440
Estonia	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0
Greece	204,130	300,600	220,170	510,950	218,010	253,070	204,130	510,950	284,488
Spain	846,650	1,090,170	642,020	1,038,070	952,990	691,560	642,020	1,090,170	876,910
France	1,635,590	1,880,700	1,575,130	1,582,450	1,559,140	1,185,770	1,185,770	1,880,700	1,569,797
Croatia	61,790	84,960	90,020	130,580	99,490	94,080	61,790	130,580	93,487
Italy	212,900	274,420	185,490	285,230	250,380	248,010	185,490	285,230	242,738
Cyprus	0	0	0	0	0	0	0	0	0
Latvia	0	0	0	0	0	0	0	0	0
Lithuania	0	0	0	0	0	0	0	0	0
Luxembourg	0	0	0	0	0	0	0	0	0
Hungary	969,720	1,374,780	1,316,550	1,484,370	1,597,250	1,542,470	969,720	1,597,250	1,380,857
Malta	0	0	0	0	0	0	0	0	0
Netherlands	0	0	0	0	0	0	0	0	0
Austria	66,500	73,710	53,050	51,290	57,750	38,060	38,060	73,710	56,727
Poland	4,500	5,200	5,700	4,600	2,300	2,200	2,200	5,700	4,083
Portugal	7,610	12,570	9,620	11,570	16,430	24,740	7,610	24,740	13,757
Romania	1,262,930	1,789,330	1,398,200	2,142,090	2,189,310	1,785,760	1,262,930	2,189,310	1,761,270
Slovenia	480	980	870	510	530	580	480	980	658
Slovakia	150,330	201,000	197,230	195,740	200,700	174,290	150,330	201,000	186,548
Finland	0	0	0	0	0	0	0	0	0
Sweden	0	0	0	0	0	0	0	0	0
United Kingdom	0	0	0	0	0	0	0	0	0

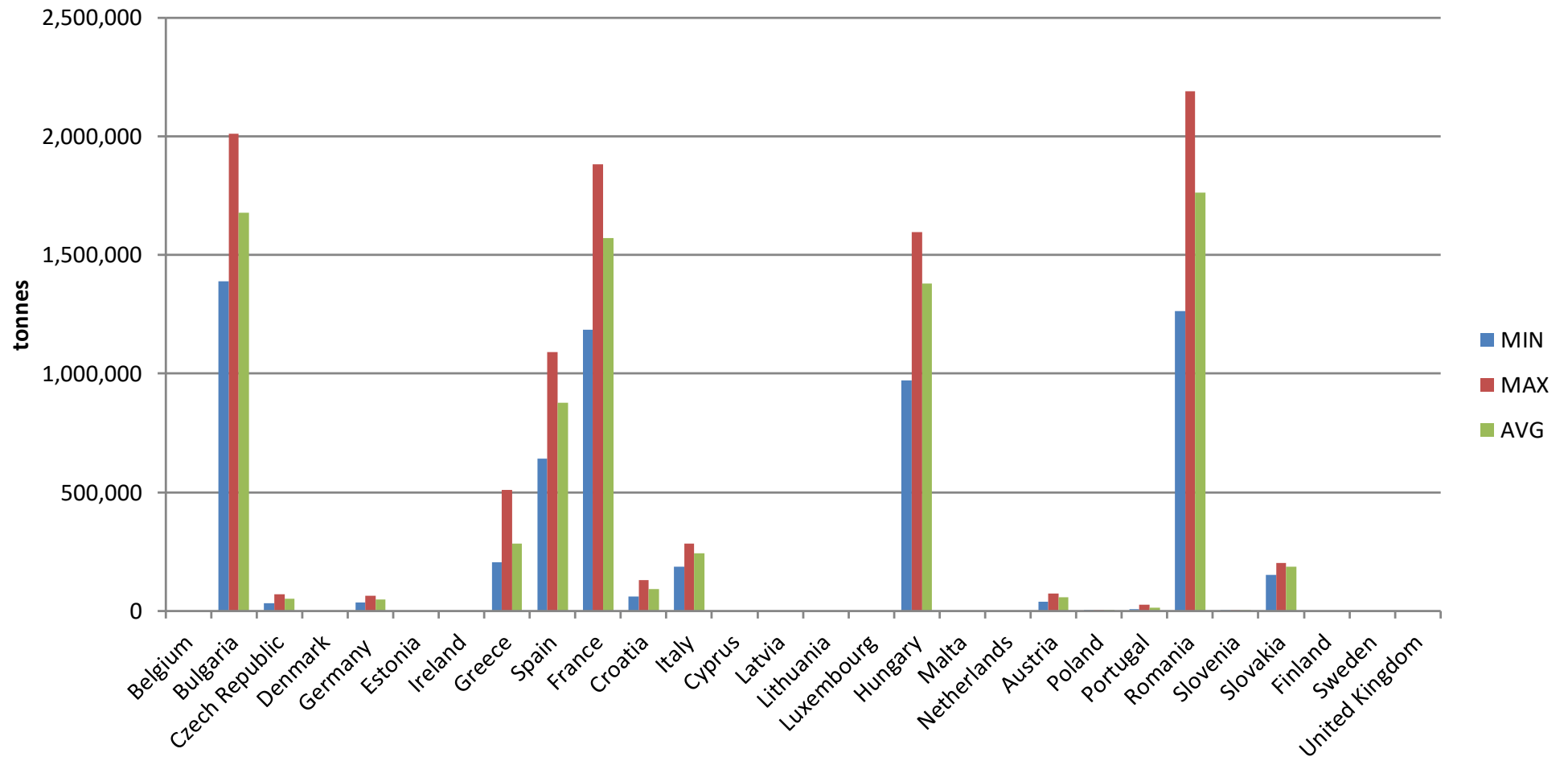


Figure 63 Tonnes of sunflower straw per country, 2010-2015

Table 46 Tonnes of damaged sunflower seed during harvesting per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	0	0	0	0	0	0	0	0	0
Bulgaria	153,632	143,970	138,780	197,443	201,067	170,855	138,780	201,067	167,625
Czech Republic	5,736	7,090	5,694	4,680	4,231	3,162	3,162	7,090	5,099
Denmark	0	0	0	0	0	0	0	0	0
Germany	4,724	5,320	6,280	4,610	4,600	3,530	3,530	6,280	4,844
Estonia	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0
Greece	20,413	30,060	22,017	51,095	21,801	25,307	20,413	51,095	28,449
Spain	84,665	109,017	64,202	103,807	95,299	69,156	64,202	109,017	87,691
France	163,559	188,070	157,513	158,245	155,914	118,577	118,577	188,070	156,980
Croatia	6,179	8,496	9,002	13,058	9,949	9,408	6,179	13,058	9,349
Italy	21,290	27,442	18,549	28,523	25,038	24,801	18,549	28,523	24,274
Cyprus	0	0	0	0	0	0	0	0	0
Latvia	0	0	0	0	0	0	0	0	0
Lithuania	0	0	0	0	0	0	0	0	0
Luxembourg	0	0	0	0	0	0	0	0	0
Hungary	96,972	137,478	131,655	148,437	159,725	154,247	96,972	159,725	138,086
Malta	0	0	0	0	0	0	0	0	0
Netherlands	0	0	0	0	0	0	0	0	0
Austria	6,650	7,371	5,305	5,129	5,775	3,806	3,806	7,371	5,673
Poland	450	520	570	460	230	220	220	570	408
Portugal	761	1,257	962	1,157	1,643	2,474	761	2,474	1,376
Romania	126,293	178,933	139,820	214,209	218,931	178,576	126,293	218,931	176,127
Slovenia	48	98	87	51	53	58	48	98	66
Slovakia	15,033	20,100	19,723	19,574	20,070	17,429	15,033	20,100	18,655
Finland	0	0	0	0	0	0	0	0	0
Sweden	0	0	0	0	0	0	0	0	0
United Kingdom	0	0	0	0	0	0	0	0	0

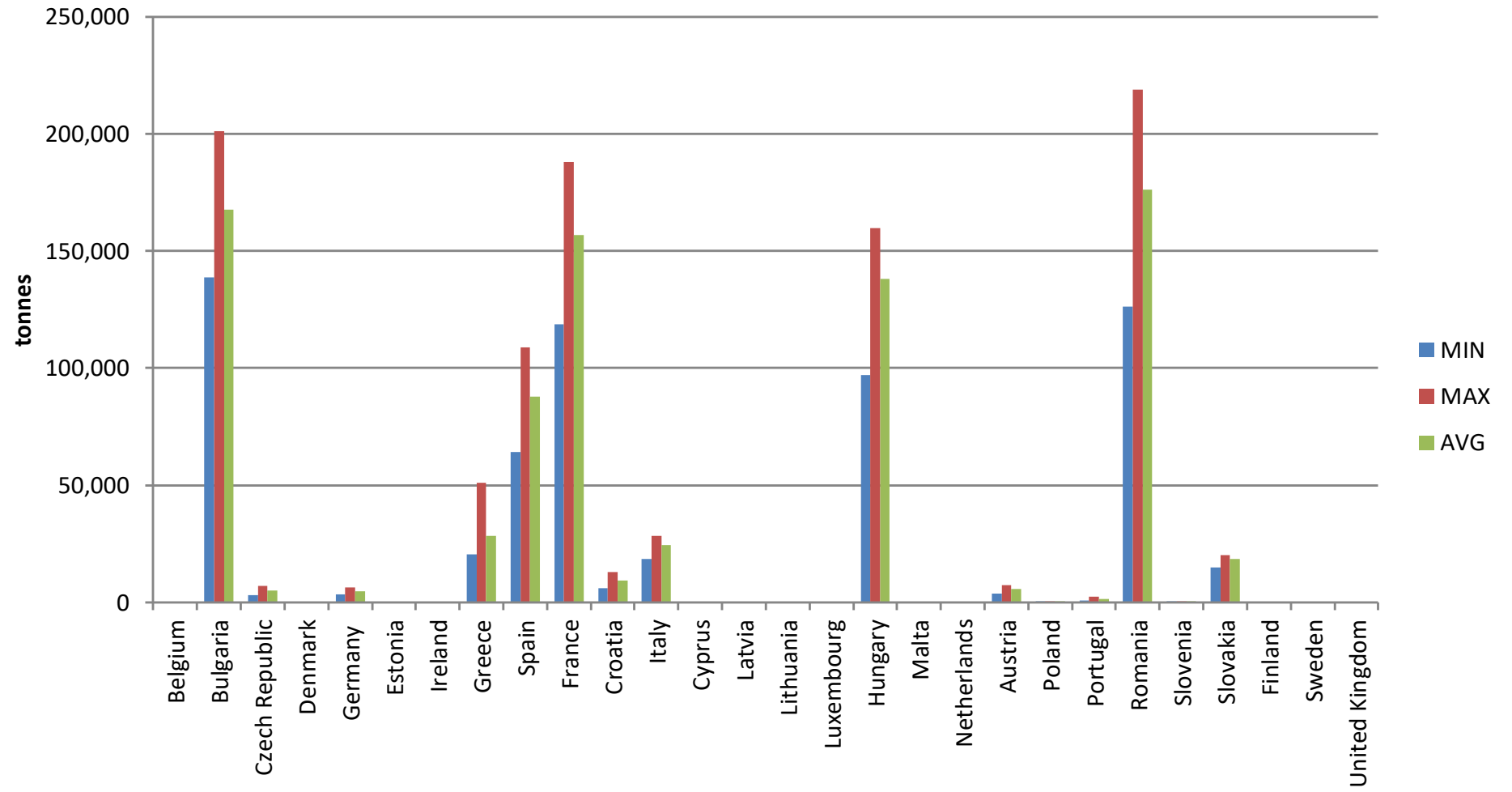


Figure 64 Tonnes of damaged sunflower seed during harvesting per country, 2010-2015

Table 47 Tonnes of imported and exported sunflower seed per country, 2010-2013 (FAO: Crops and livestock products, n.d.)

GEO/POPULATION	Trade	2010	2011	2012	2013
Belgium	Import	32,771	99,940	51,598	130,180
	Export	3,957	12,473	5,837	23,611
Bulgaria	Import	14,894	17,986	12,749	25,509
	Export	579,664	1,040,710	753,935	1,240,206
Czech Republic	Import	5,801	35,958	40,732	52,331
	Export	40,241	36,855	50,074	25,865
Denmark	Import	30,189	28,015	21,229	18,540
	Export	6,476	5,963	7,401	7,447
Germany	Import	478,702	360,770	530,695	501,551
	Export	84,512	61,445	33,733	34,533
Estonia	Import	1,494	1,321	1,626	1,584
	Export	278	22	60	395
Ireland	Import	564	267	323	490
	Export	18	22	45	69
Greece	Import	27,269	25,766	6,019	28,913
	Export	1,308	4,870	1,209	28,892
Spain	Import	241,994	301,510	476,785	320,251
	Export	73,978	80,754	22,256	30,734
France	Import	152,259	426,494	142,828	424,787
	Export	429,270	390,513	445,610	423,881
Croatia	Import	839	763	1,113	1,090
	Export	27,950	55,909	43,929	85,463
Italy	Import	220,715	228,061	214,622	249,223
	Export	17,605	15,472	13,991	5,362
Cyprus	Import	223	136	206	185
	Export	2	0	0	19
Latvia	Import	1,842	3,041	2,650	3,633
	Export	154	176	871	345
Lithuania	Import	3,955	4,916	5,487	5,786
	Export	743	852	755	707
Luxembourg	Import	356	407	391	421
	Export	3	6	4	25

Hungary	Import	66,330	63,283	70,646	224,252
	Export	662,392	397,661	600,305	362,574
Malta	Import	92	170	58	143
	Export	0	1	1	0
Netherlands	Import	555,952	651,881	462,741	635,582
	Export	78,341	31,948	34,646	61,378
Austria	Import	96,948	107,753	98,453	142,359
	Export	49,829	39,260	45,141	54,451
Poland	Import	33,504	37,355	46,370	50,714
	Export	3,534	3,558	5,722	4,280
Portugal	Import	147,189	244,866	285,825	311,536
	Export	17,227	18,565	18,182	12,991
Romania	Import	208,286	237,377	131,294	93,357
	Export	557,409	1,182,870	653,317	1,420,170
Slovenia	Import	1,734	2,044	13,405	14,371
	Export	42	248	11,547	13,092
Slovakia	Import	4,879	15,160	14,448	8,678
	Export	98,480	113,342	228,559	268,923
Finland	Import	9,913	16,453	12,861	15,094
	Export	1,098	870	1,371	872
Sweden	Import	20,973	18,553	18,076	19,870
	Export	2,787	1,909	1,847	2,901
United Kingdom	Import	55,692	66,236	44,085	39,957
	Export	1,068	1,038	2,060	2,506

Table 48 Tonnes of processed sunflower seed per country, 2010-2013

GEO/TIME	2010	2011	2012	2013	MIN	MAX	AVG
Belgium	28,814	87,467	45,761	106,569	28,814	106,569	67,153
Bulgaria	971,550	416,976	646,614	759,733	416,976	971,550	698,718
Czech Republic	22,920	70,003	47,598	73,266	22,920	73,266	53,447
Denmark	23,713	22,052	13,828	11,093	11,093	23,713	17,672
Germany	441,430	352,525	559,762	513,118	352,525	559,762	466,709
Estonia	1,216	1,299	1,566	1,189	1,189	1,566	1,318
Ireland	546	245	278	421	245	546	373
Greece	230,091	321,496	224,980	510,971	224,980	510,971	321,885
Spain	1,014,666	1,310,926	1,096,549	1,327,587	1,014,666	1,327,587	1,187,432
France	1,358,579	1,916,681	1,272,348	1,583,356	1,272,348	1,916,681	1,532,741
Croatia	34,679	29,814	47,204	46,207	29,814	47,204	39,476
Italy	416,010	487,009	386,121	529,091	386,121	529,091	454,558
Cyprus	221	136	206	166	136	221	182
Latvia	1,688	2,865	1,779	3,288	1,688	3,288	2,405
Lithuania	3,212	4,064	4,732	5,079	3,212	5,079	4,272
Luxembourg	353	401	387	396	353	401	384
Hungary	373,658	1,040,402	786,891	1,346,048	373,658	1,346,048	886,750
Malta	92	169	57	143	57	169	115
Netherlands	477,611	619,933	428,095	574,204	428,095	619,933	524,961
Austria	113,619	142,203	106,362	139,198	106,362	142,203	125,346
Poland	34,470	38,997	46,348	51,034	34,470	51,034	42,712
Portugal	137,572	238,871	277,263	310,115	137,572	310,115	240,955
Romania	913,807	843,837	876,177	815,277	815,277	913,807	862,275
Slovenia	2,172	2,776	2,728	1,789	1,789	2,776	2,366
Slovakia	56,729	102,818	NA	NA	56,729	102,818	79,774
Finland	8,815	15,583	11,490	14,222	8,815	15,583	12,528
Sweden	18,186	16,644	16,229	16,969	16,229	18,186	17,007
United Kingdom	54,624	65,198	42,025	37,451	37,451	65,198	49,825



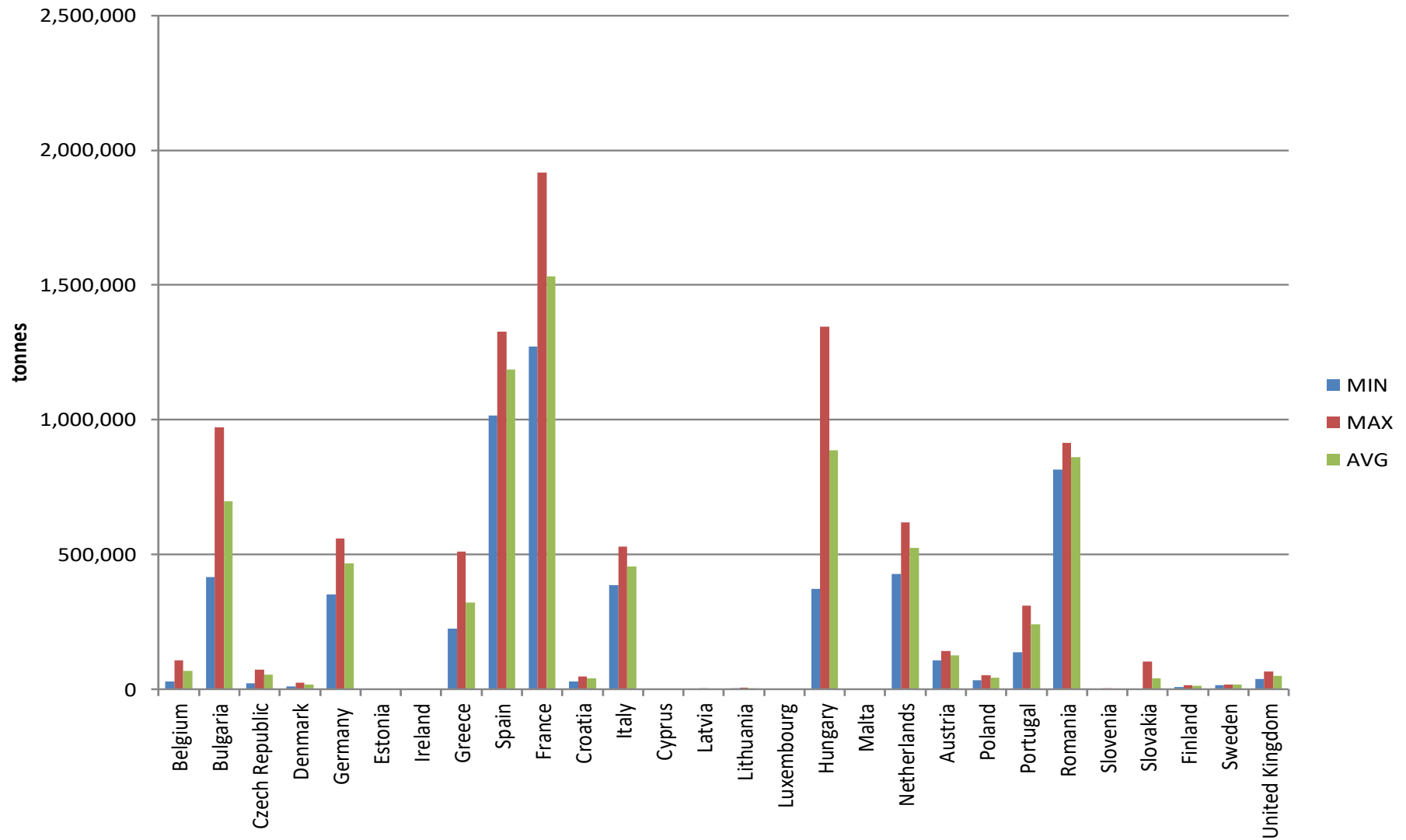


Figure 65 Tonnes of processed sunflower seed per country, 2010-2013

Table 49 Tonnes of sunflower cake per country, 2010-2013

GEO/TIME	2010	2011	2012	2013	MIN	MAX	AVG
Belgium	17,865	54,230	28,372	66,073	17,865	66,073	41,635
Bulgaria	602,361	258,525	400,901	471,034	258,525	602,361	433,205
Czech Republic	14,210	43,402	29,511	45,425	14,210	45,425	33,137
Denmark	14,702	13,672	8,573	6,878	6,878	14,702	10,956
Germany	273,687	218,566	347,052	318,133	218,566	347,052	289,359
Estonia	754	805	971	737	737	971	817
Ireland	339	152	172	261	152	339	231
Greece	142,656	199,328	139,488	316,802	139,488	316,802	199,568
Spain	629,093	812,774	679,860	823,104	629,093	823,104	736,208
France	842,319	1,188,342	788,856	981,681	788,856	1,188,342	950,299
Croatia	21,501	18,485	29,266	28,648	18,485	29,266	24,475
Italy	257,926	301,946	239,395	328,036	239,395	328,036	281,826
Cyprus	137	84	128	103	84	137	113
Latvia	1,047	1,776	1,103	2,039	1,047	2,039	1,491
Lithuania	1,991	2,520	2,934	3,149	1,991	3,149	2,648
Luxembourg	219	249	240	246	219	249	238
Hungary	231,668	645,049	487,872	834,550	231,668	834,550	549,785
Malta	57	105	35	89	35	105	71
Netherlands	296,119	384,358	265,419	356,006	265,419	384,358	325,476
Austria	70,444	88,166	65,944	86,303	65,944	88,166	77,714
Poland	21,371	24,178	28,736	31,641	21,371	31,641	26,482
Portugal	85,295	148,100	171,903	192,271	85,295	192,271	149,392
Romania	566,560	523,179	543,230	505,472	505,472	566,560	534,610
Slovenia	1,347	1,721	1,691	1,109	1,109	1,721	1,467
Slovakia	35,172	63,747	NA	NA	35,172	63,747	49,460
Finland	5,465	9,661	7,124	8,818	5,465	9,661	7,767
Sweden	11,275	10,319	10,062	10,521	10,062	11,275	10,544
United Kingdom	33,867	40,423	26,056	23,220	23,220	40,423	30,891

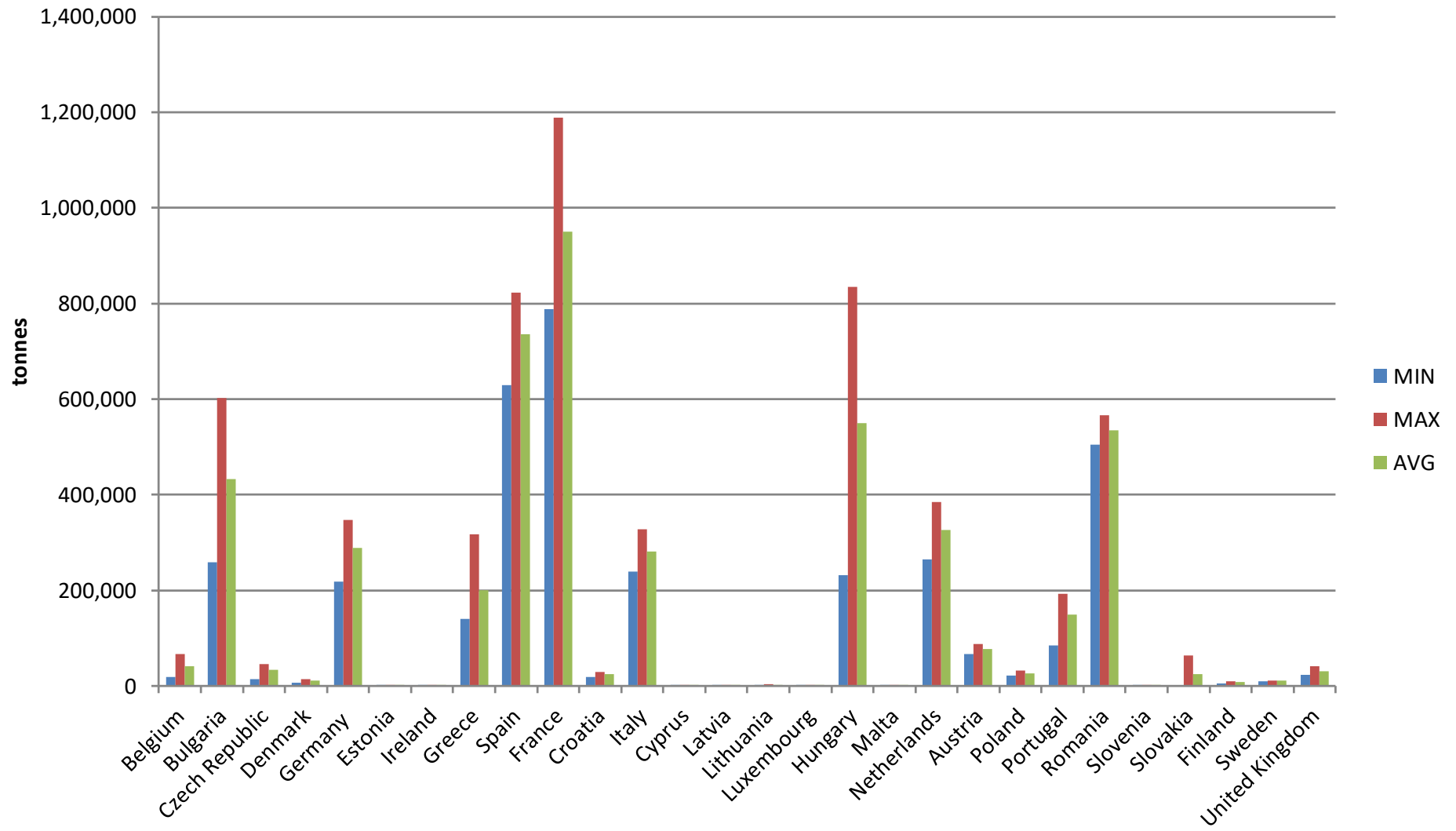


Figure 66 Tonnes of sunflower cake per country, 2010-2013

Table 50 Tonnes of slurry (ugido) from sunflower seed processing per country, 2010-2013

GEO/TIME	2010	2011	2012	2013	MIN	MAX	AVG
Belgium	864	2,624	1,373	3,197	864	3,197	2,015
Bulgaria	29,147	12,509	19,398	22,792	12,509	29,147	20,962
Czech Republic	688	2,100	1,428	2,198	688	2,198	1,603
Denmark	711	662	415	333	333	711	530
Germany	13,243	10,576	16,793	15,394	10,576	16,793	14,001
Estonia	36	39	47	36	36	47	40
Ireland	16	7	8	13	7	16	11
Greece	6,903	9,645	6,749	15,329	6,749	15,329	9,657
Spain	30,440	39,328	32,896	39,828	30,440	39,828	35,623
France	40,757	57,500	38,170	47,501	38,170	57,500	45,982
Croatia	1,040	894	1,416	1,386	894	1,416	1,184
Italy	12,480	14,610	11,584	15,873	11,584	15,873	13,637
Cyprus	7	4	6	5	4	7	5
Latvia	51	86	53	99	51	99	72
Lithuania	96	122	142	152	96	152	128
Luxembourg	11	12	12	12	11	12	12
Hungary	11,210	31,212	23,607	40,381	11,210	40,381	26,602
Malta	3	5	2	4	2	5	3
Netherlands	14,328	18,598	12,843	17,226	12,843	18,598	15,749
Austria	3,409	4,266	3,191	4,176	3,191	4,266	3,760
Poland	1,034	1,170	1,390	1,531	1,034	1,531	1,281
Portugal	4,127	7,166	8,318	9,303	4,127	9,303	7,229
Romania	27,414	25,315	26,285	24,458	24,458	27,414	25,868
Slovenia	65	83	82	54	54	83	71
Slovakia	1,702	3,085	NA	NA	1,702	3,085	2,393
Finland	264	467	345	427	264	467	376
Sweden	546	499	487	509	487	546	510
United Kingdom	1,639	1,956	1,261	1,124	1,124	1,956	1,495

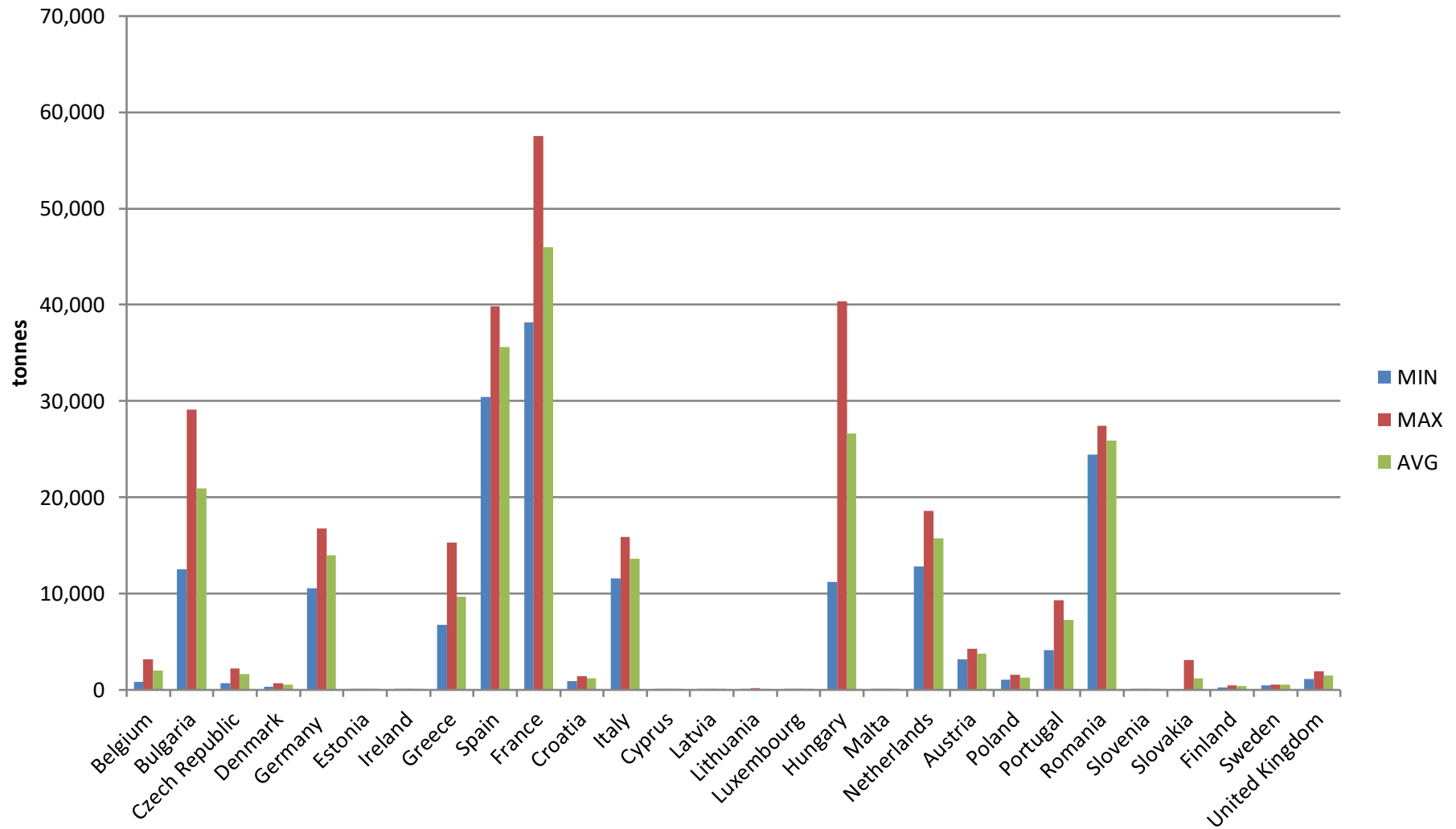


Figure 67 Tonnes of slurry (ugido) from sunflower seed processing per country, 2010-2013

## 2.8 Rapeseed

Rapeseed is a yellow flowering member of the mustard family (Yadava, Vasudev, Singh, Mohapatra, & Prabhu, 2012). Figure 68 shows a rapeseed field (Agrodaily: Decline in UK winter rapeseed area, n.d.).



Figure 68 Rapeseed field (Agrodaily: Decline in UK winter rapeseed area, n.d.)

It is a crop that is mainly used for oil production. In some cases, rapeseed is more profitable than soya beans due to the higher quantity of oil produced. Furthermore, the rapeseed provides good protection to the soil during wintertime and decreases erosion (Agricultural Marketing Resource Center (AgMRC): Rapeseed, n.d.). Another application of rapeseed is in the production of biodiesel. Poor weather conditions and pests cause most of the damaged rapeseed. After rapeseed is harvested, large amounts of stalk remain in the field. The chemical composition of rapeseed stalk shows that it can be used for pulping and papermaking (Housseinpour, Latibari, Farnood, Fatehi, & Sepiddehdam, 2010). Rapeseed that is processed goes through two big stages, mechanical pressing and chemical extraction (Soyatech-Growing Opportunities: Rapeseed Facts, n.d.). Mechanical pressing produces cake meal (Figure 69 shows cake meal (Vinay Industries Limited: Indian Rapeseed Extraction Meal (IRSM), n.d.)), which can be used in animal diet, due to the high concentration of proteins, crude fibre and lipids (All About Feed: Rapeseed meal in animal diets, n.d.).



Figure 69 Rapeseed cake meal (Vinay Industries Limited: Indian Rapeseed Extraction Meal (IRSM), n.d.)

The flowchart (Figure 70) presents the value chain for rapeseed and specific AWCB weight factors from Table 2.

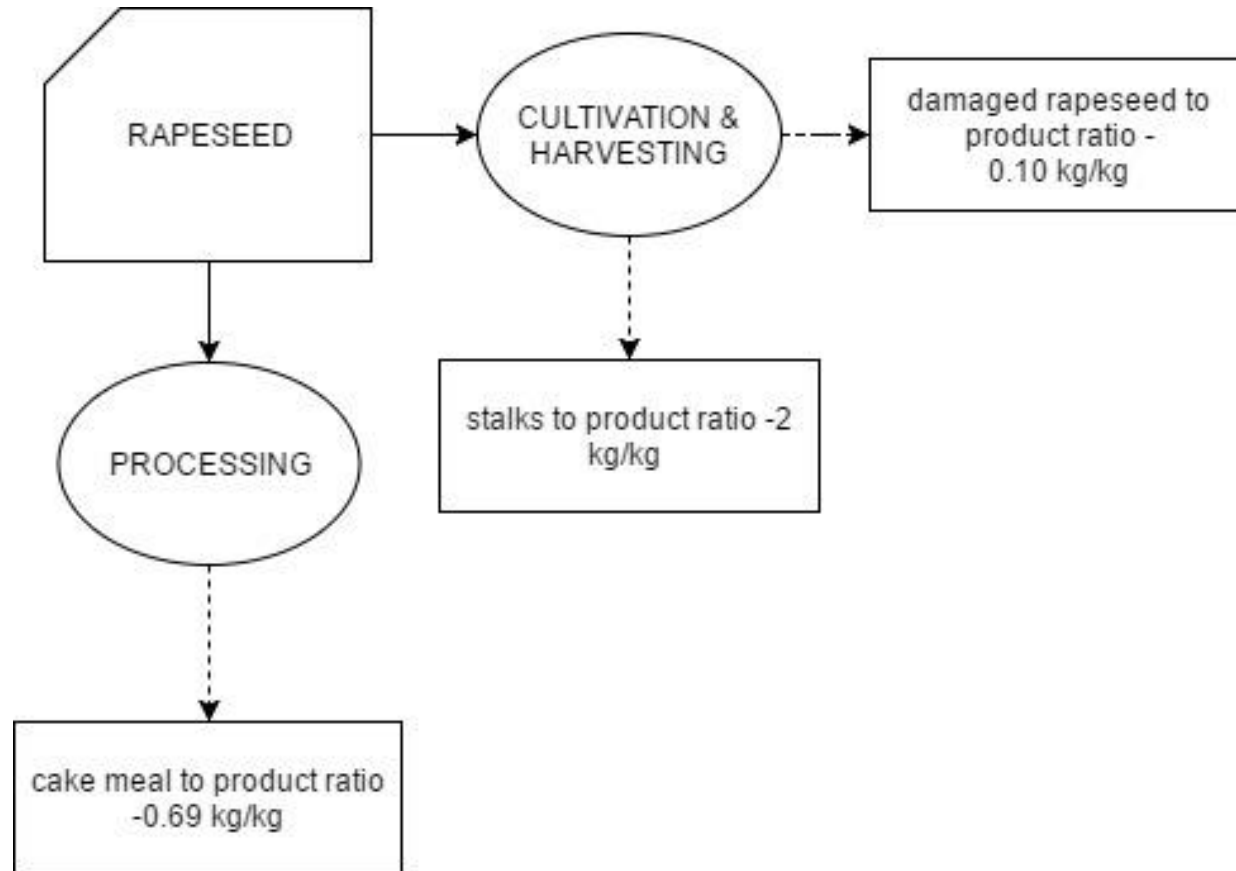


Figure 70 Rapeseed AWCB value chain



Data for cultivated rapeseed and data for imported and exported rapeseed is taken from FAOSTAT. By using relations (I-VIII), the quantity of processed rapeseed is calculated for each country in each given year. Then the quantity of AWCB is estimated for each step and each year. An example of the calculation for Germany in 2010 is now presented:

PRD = 5,697,595 tonnes

IMP = 2,313,571 tonnes

EXP = 278,748 tonnes

PRC = 5,697,595 + 2,313,571 - 278,748 = 7,732,418 tonnes

Damaged rapeseed accounts 0.10 kg per kg of harvested rapeseed and for Germany, in 2010 it was 569,759.5 tonnes. After harvesting the quantity of stalks was 11,395,190. The quantity of cake meal in Germany in that year was 5,335,368 tonnes. Results for other countries and years are presented in the tables and figures below.

Table 51 Tonnes of harvested rapeseed per country, 2010-2015 (FAOSTAT)

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	45665	52211	48431	60900	58500	50744	45,665	60,900	52,742
Bulgaria	544841	519910	271041	336731	527912	422092	271,041	544,841	437,088
Czech Republic	1042418	1046071	1109137	1443210	1537320	1256212	1,042,418	1,537,320	1,239,061
Denmark	579800	508300	484600	687655	708900	826000	484,600	826,000	632,543
Germany	5697595	3869500	4821100	5784300	6247400	5016800	3,869,500	6,247,400	5,239,449
Estonia	131022	144194	157816	174028	166495	196300	131,022	196,300	161,643
Ireland	28100	55900	58700	49200	34200	39900	28,100	58,700	44,333
Greece	25175	21897	14087	12181	8173	6431	6,431	25,175	14,657
Spain	35500	63902	53447	107700	104262	149198	35,500	149,198	85,668
France	4815239	5369011	5463186	4366200	5524094	5334404	4,366,200	5,524,094	5,145,356
Croatia	33047	49483	26406	47827	71228	56783	26,406	71,228	47,462
Italy	50300	44033	25192	40242	41633	28073	25,192	50,300	38,246
Cyprus	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Latvia	226300	219100	303500	296600	185500	293200	185,500	303,500	254,033
Lithuania	416700	484300	632900	550600	501500	512162	416,700	632,900	516,360
Luxembourg	15895	15574	15338	15259	15705	13834	13,834	15,895	15,268
Hungary	530619	526712	414640	532510	699750	590444	414,640	699,750	549,113
Malta	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Netherlands	11521	6757	7475	10275	10221	8852	6,757	11,521	9,184
Austria	170584	179669	148869	196828	198286	111745	111,745	198,286	167,664
Poland	2228676	1861807	1865598	2677665	3275806	2700776	1,861,807	3,275,806	2,435,055
Portugal	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Romania	943033	738971	157511	666097	1059121	919473	157,511	1,059,121	747,368
Slovenia	15522	13948	16692	15113	19883	3643	3,643	19,883	14,134
Slovakia	322452	332155	212632	373960	448858	320626	212,632	448,858	335,114
Finland	178500	115100	73200	80200	62100	85300	62,100	178,500	99,067
Sweden	276200	247500	317800	327500	322700	359000	247,500	359,000	308,450
United Kingdom	2230148	2758302	2556643	2128142	2459576	2542000	2,128,142	2,758,302	2,445,802

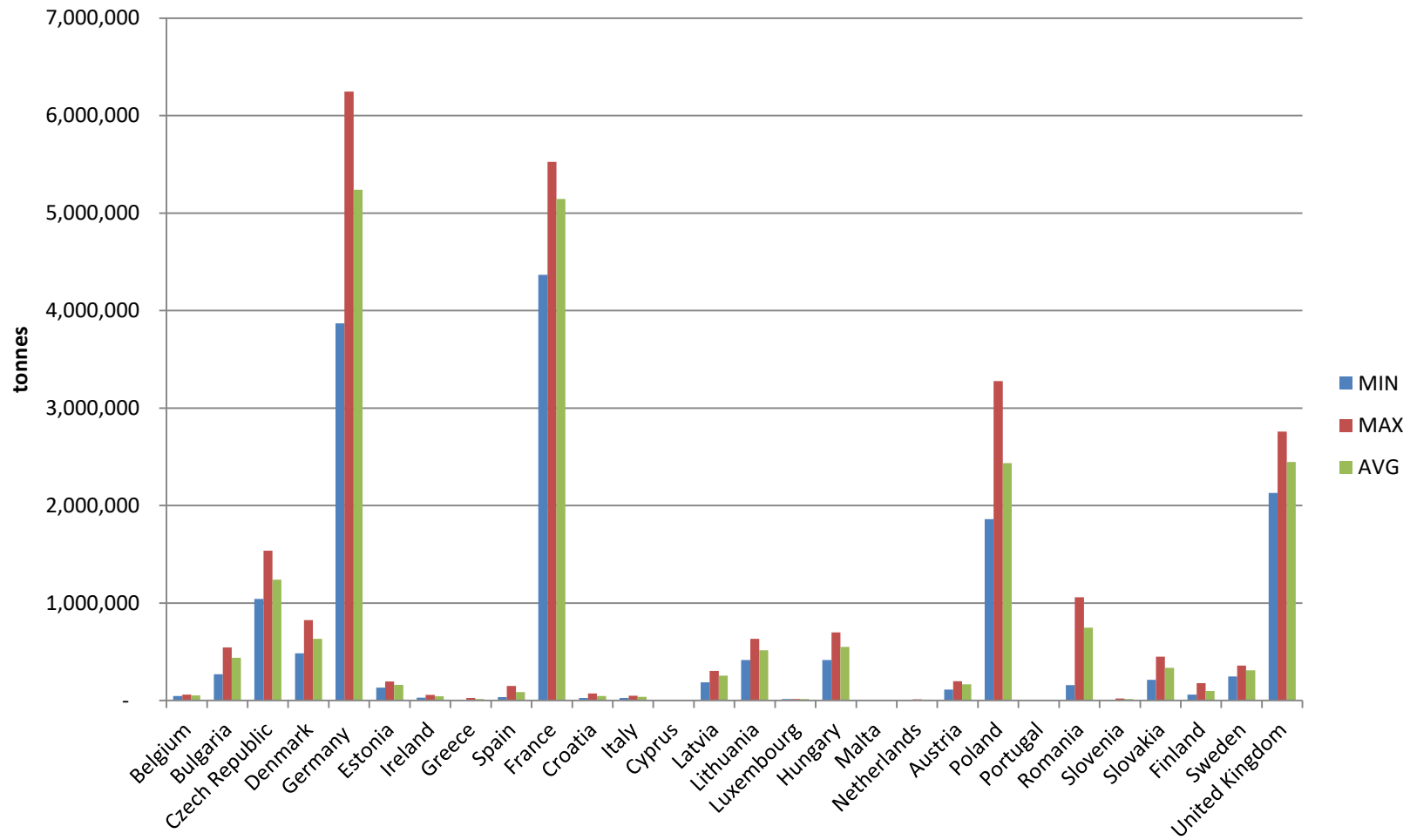


Figure 71 Tonnes of harvested rapeseed per country, 2010-2015

Table 52 Tonnes of damaged rapeseed per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	4,567	5,221	4,843	6,090	5,850	5,074	4,567	6,090	5,274
Bulgaria	54,484	51,991	27,104	33,673	52,791	42,209	27,104	54,484	43,709
Czech Republic	104,242	104,607	110,914	144,321	153,732	125,621	104,242	153,732	123,906
Denmark	57,980	50,830	48,460	68,766	70,890	82,600	48,460	82,600	63,254
Germany	569,760	386,950	482,110	578,430	624,740	501,680	386,950	624,740	523,945
Estonia	13,102	14,419	15,782	17,403	16,650	19,630	13,102	19,630	16,164
Ireland	2,810	5,590	5,870	4,920	3,420	3,990	2,810	5,870	4,433
Greece	2,518	2,190	1,409	1,218	817	643	643	2,518	1,466
Spain	3,550	6,390	5,345	10,770	10,426	14,920	3,550	14,920	8,567
France	481,524	536,901	546,319	436,620	552,409	533,440	436,620	552,409	514,536
Croatia	3,305	4,948	2,641	4,783	7,123	5,678	2,641	7,123	4,746
Italy	5,030	4,403	2,519	4,024	4,163	2,807	2,519	5,030	3,825
Cyprus	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Latvia	22,630	21,910	30,350	29,660	18,550	29,320	18,550	30,350	25,403
Lithuania	41,670	48,430	63,290	55,060	50,150	51,216	41,670	63,290	51,636
Luxembourg	1,590	1,557	1,534	1,526	1,571	1,383	1,383	1,590	1,527
Hungary	53,062	52,671	41,464	53,251	69,975	59,044	41,464	69,975	54,911
Malta	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Netherlands	1,152	676	748	1,028	1,022	885	676	1,152	918
Austria	17,058	17,967	14,887	19,683	19,829	11,175	11,175	19,829	16,766
Poland	222,868	186,181	186,560	267,767	327,581	270,078	186,181	327,581	243,505
Portugal	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Romania	94,303	73,897	15,751	66,610	105,912	91,947	15,751	105,912	74,737
Slovenia	1,552	1,395	1,669	1,511	1,988	364	364	1,988	1,413
Slovakia	32,245	33,216	21,263	37,396	44,886	32,063	21,263	44,886	33,511
Finland	17,850	11,510	7,320	8,020	6,210	8,530	6,210	17,850	9,907
Sweden	27,620	24,750	31,780	32,750	32,270	35,900	24,750	35,900	30,845
United Kingdom	223,015	275,830	255,664	212,814	245,958	254,200	212,814	275,830	244,580

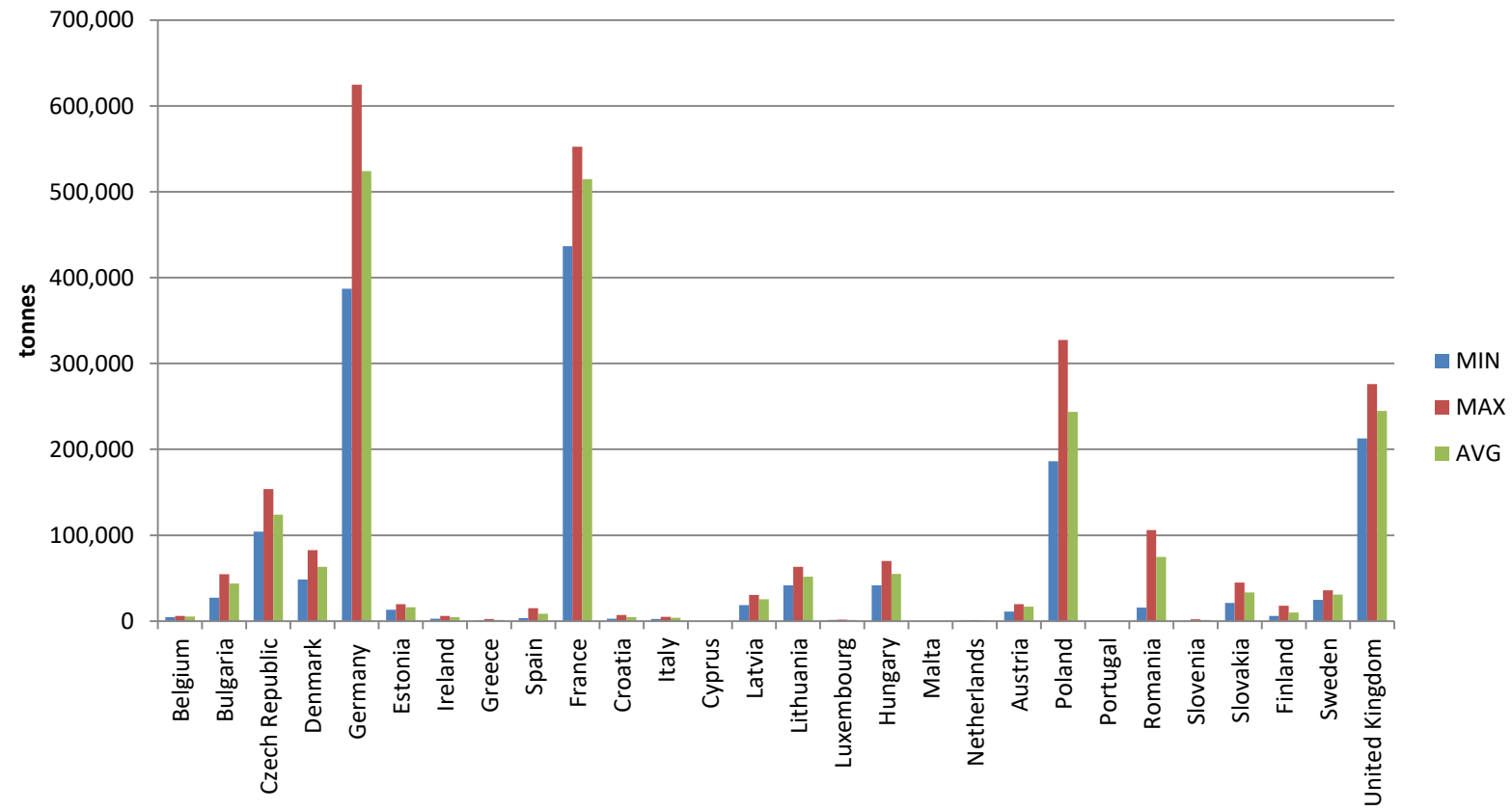


Figure 72 Tonnes of damaged rapeseed per country, 2010-2015

Table 53 Tonnes of rapeseed stalks per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	91,330	104,422	96,862	121,800	117,000	101,488	91,330	121,800	105,484
Bulgaria	1,089,682	1,039,820	542,082	673,462	1,055,824	844,184	542,082	1,089,682	874,176
Czech Republic	2,084,836	2,092,142	2,218,274	2,886,420	3,074,640	2,512,424	2,084,836	3,074,640	2,478,123
Denmark	1,159,600	1,016,600	969,200	1,375,310	1,417,800	1,652,000	969,200	1,652,000	1,265,085
Germany	11,395,190	7,739,000	9,642,200	11,568,600	12,494,800	10,033,600	7,739,000	12,494,800	10,478,898
Estonia	262,044	288,388	315,632	348,056	332,990	392,600	262,044	392,600	323,285
Ireland	56,200	111,800	117,400	98,400	68,400	79,800	56,200	117,400	88,667
Greece	50,350	43,794	28,174	24,362	16,346	12,862	12,862	50,350	29,315
Spain	71,000	127,804	106,894	215,400	208,524	298,396	71,000	298,396	171,336
France	9,630,478	10,738,022	10,926,372	8,732,400	11,048,188	10,668,808	8,732,400	11,048,188	10,290,711
Croatia	66,094	98,966	52,812	95,654	142,456	113,566	52,812	142,456	94,925
Italy	100,600	88,066	50,384	80,484	83,266	56,146	50,384	100,600	76,491
Cyprus	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Latvia	452,600	438,200	607,000	593,200	371,000	586,400	371,000	607,000	508,067
Lithuania	833,400	968,600	1,265,800	1,101,200	1,003,000	1,024,324	833,400	1,265,800	1,032,721
Luxembourg	31,790	31,148	30,676	30,518	31,410	27,668	27,668	31,790	30,535
Hungary	1,061,238	1,053,424	829,280	1,065,020	1,399,500	1,180,888	829,280	1,399,500	1,098,225
Malta	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Netherlands	23,042	13,514	14,950	20,550	20,442	17,704	13,514	23,042	18,367
Austria	341,168	359,338	297,738	393,656	396,572	223,490	223,490	396,572	335,327
Poland	4,457,352	3,723,614	3,731,196	5,355,330	6,551,612	5,401,552	3,723,614	6,551,612	4,870,109
Portugal	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Romania	1,886,066	1,477,942	315,022	1,332,194	2,118,242	1,838,946	315,022	2,118,242	1,494,735
Slovenia	31,044	27,896	33,384	30,226	39,766	7,286	7,286	39,766	28,267
Slovakia	644,904	664,310	425,264	747,920	897,716	641,252	425,264	897,716	670,228
Finland	357,000	230,200	146,400	160,400	124,200	170,600	124,200	357,000	198,133
Sweden	552,400	495,000	635,600	655,000	645,400	718,000	495,000	718,000	616,900
United Kingdom	4,460,296	5,516,604	5,113,286	4,256,284	4,919,152	5,084,000	4,256,284	5,516,604	4,891,604

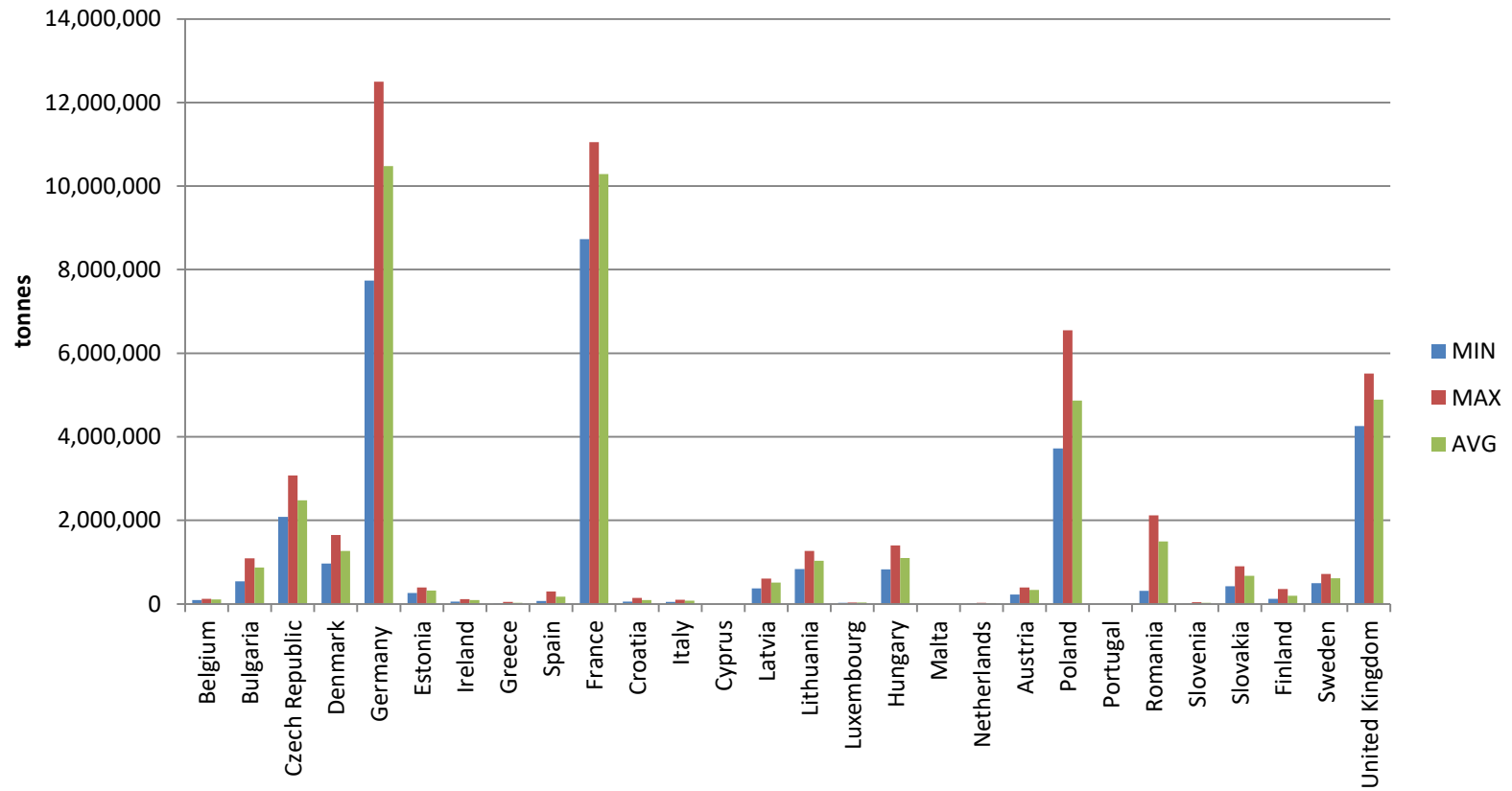


Figure 73 Tonnes of rapeseed stalks per country, 2010-2015

Table 54 Tonnes of imported and exported rapeseed per country, 2010-2013 (FAO: Crops and livestock products, n.d.)

GEO/POPULATION	Trade	2010	2011	2012	2013
Belgium	Import	2,206,326	2,182,582	2,327,684	1,979,537
	Export	282,562	357,410	527,156	738,230
Bulgaria	Import	2,607	2,006	1,708	1,252
	Export	531,680	475,837	213,682	336,862
Czech Republic	Import	115,682	97,940	179,618	140,940
	Export	295,565	170,352	366,077	510,280
Denmark	Import	259,707	158,117	221,890	70,049
	Export	62,809	174,072	97,439	136,537
Germany	Import	2,313,571	3,147,667	4,158,694	4,594,632
	Export	278,748	228,070	149,616	119,003
Estonia	Import	6,601	1,241	4,698	13,555
	Export	76,276	87,130	79,102	60,154
Ireland	Import	4,899	1,116	8,557	2,854
	Export	3,432	18,204	30,118	16,276
Greece	Import	28,000	6,550	8,336	18,605
	Export	44	26	45	20
Spain	Import	91,297	38,670	45,434	28,490
	Export	4,777	4,472	9,164	20,017
France	Import	940,093	610,630	474,403	1,105,211
	Export	1,525,756	1,664,713	1,503,774	1,316,923
Croatia	Import	81	120	1,879	648
	Export	28,446	36,649	14,053	18,947
Italy	Import	111,363	16,962	56,411	44,592
	Export	14,228	9,260	3,049	2,483
Cyprus	Import	0	5	15	3
	Export	0	0	0	0
Latvia	Import	44,509	72,918	80,299	71,547
	Export	185,601	171,108	321,252	236,108
Lithuania	Import	62,221	20,923	4,354	5,273
	Export	278,486	219,121	420,003	369,484
Luxembourg	Import	1,460	2,369	1,795	2,468
	Export	13,718	14,396	13,313	14,057



Hungary	Import	20,177	34,738	93,005	125,513
	Export	613,547	590,149	579,021	422,237
Malta	Import	4	5	35	10
	Export	0	0	0	0
Netherlands	Import	1,468,365	2,250,411	1,734,683	1,659,607
	Export	272,284	179,754	593,647	952,342
Austria	Import	302,678	252,270	217,418	250,532
	Export	75,229	62,717	68,286	82,263
Poland	Import	237,105	408,925	485,294	225,803
	Export	307,183	133,064	256,426	751,326
Portugal	Import	292,827	253,748	188,473	151,751
	Export	2,050	777	0	20
Romania	Import	241,044	70,683	59,499	26,841
	Export	1,052,367	577,208	68,246	471,928
Slovenia	Import	2,525	929	3,169	3,059
	Export	15,476	11,853	14,970	12,882
Slovakia	Import	24,065	93,734	124,929	15,915
	Export	249,376	320,935	579,774	384,120
Finland	Import	112,840	125,609	160,270	119,081
	Export	55	28	1	1
Sweden	Import	41,392	50,415	50,245	16,352
	Export	25,905	12,012	21,694	36,839
United Kingdom	Import	167,234	64,459	20,426	177,380
	Export	263,946	658,474	1,056,733	431,000

Table 55 Tonnes of processed rapeseed per country, 2010-2013

GEO/TIME	2010	2011	2012	2013	MIN	MAX	AVG
Belgium	1,969,429	1,877,383	1,848,959	1,302,207	1,302,207	1,969,429	1,749,495
Bulgaria	0	0	0	0	0	0	0
Czech Republic	862,535	973,659	922,678	1,073,870	862,535	1,073,870	958,186
Denmark	776,698	492,345	609,051	621,167	492,345	776,698	624,815
Germany	7,732,418	6,789,097	8,830,178	10,259,929	6,789,097	10,259,929	8,402,906
Estonia	61,347	58,305	83,412	127,429	58,305	127,429	82,623
Ireland	29,567	38,812	37,139	35,778	29,567	38,812	35,324
Greece	53,131	28,421	22,378	30,766	22,378	53,131	33,674
Spain	122,020	98,100	89,717	116,173	89,717	122,020	106,503
France	4,229,576	4,314,928	4,433,815	4,154,488	4,154,488	4,433,815	4,283,202
Croatia	4,682	12,954	14,232	29,528	4,682	29,528	15,349
Italy	147,435	51,735	78,554	82,351	51,735	147,435	90,019
Cyprus	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Latvia	85,208	120,910	0	132,039	0	132,039	84,539
Lithuania	200,435	286,102	217,251	186,389	186,389	286,102	222,544
Luxembourg	3,637	3,547	3,820	3,670	3,547	3,820	3,669
Hungary	0	-28,699	-71,376	235,786	-71,376	235,786	33,928
Malta	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Netherlands	1,207,602	2,077,414	1,148,511	717,540	717,540	2,077,414	1,287,767
Austria	398,033	369,222	298,001	365,097	298,001	398,033	357,588
Poland	2,158,598	2,137,668	2,094,466	2,152,142	2,094,466	2,158,598	2,135,719
Portugal	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Romania	131,710	232,446	148,764	221,010	131,710	232,446	183,483
Slovenia	2,571	3,024	4,891	5,290	2,571	5,290	3,944
Slovakia	0	0	0	0	0	0	0
Finland	291,285	240,681	233,469	199,280	199,280	291,285	241,179
Sweden	291,687	285,903	346,351	307,013	285,903	346,351	307,739
United Kingdom	2,133,436	2,164,287	1,520,336	1,874,522	1,520,336	2,164,287	1,923,145

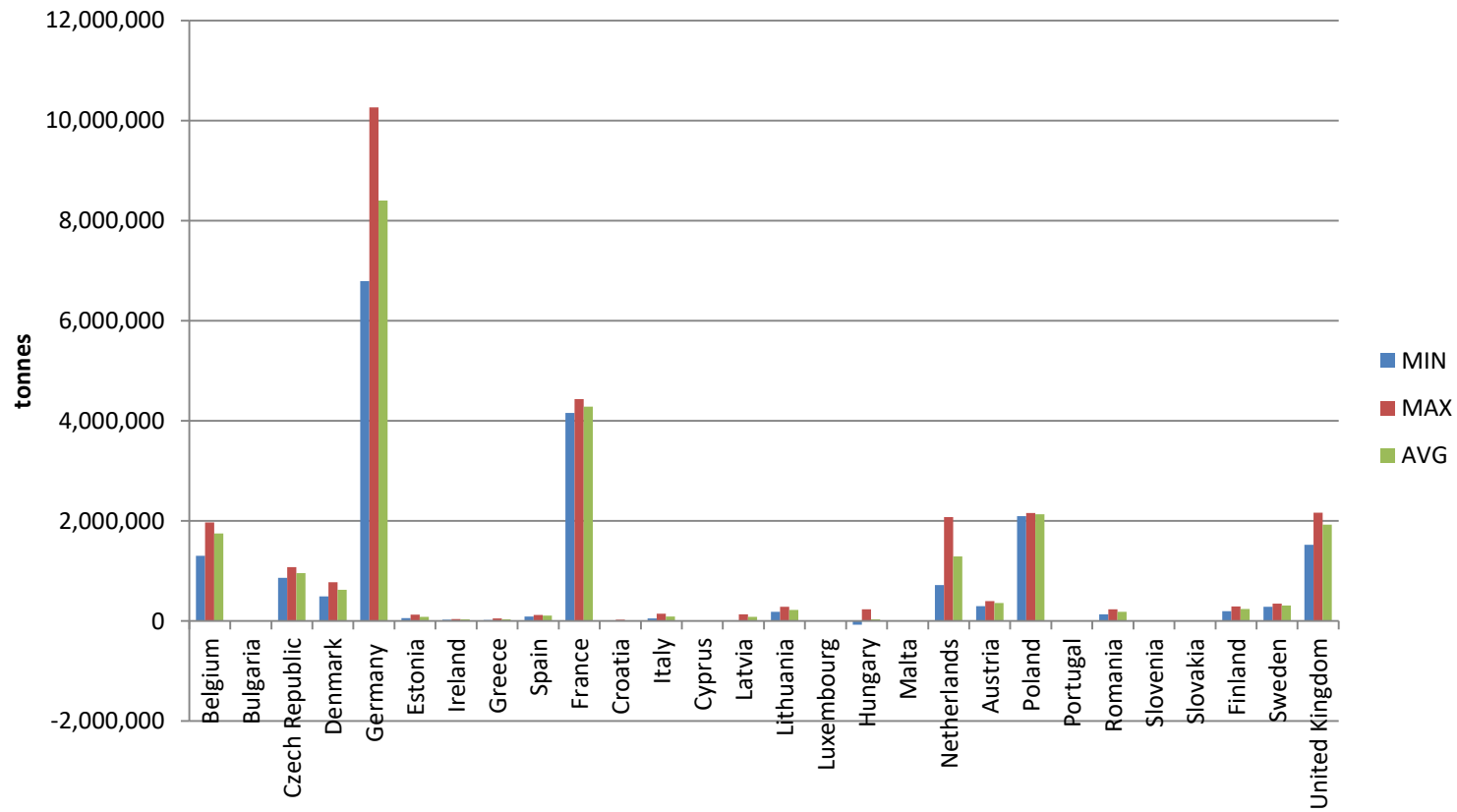


Figure 74 Tonnes of processed rapeseed per country, 2010-2013

Table 56 Tonnes of cake meal from processed rapeseed per country, 2010-2013

GEO/TIME	2010	2011	2012	2013	MIN	MAX	AVG
Belgium	1,358,906	1,295,394	1,275,782	898,523	898,523	1,358,906	1,207,151
Bulgaria	0	0	0	0	0	0	0
Czech Republic	595,149	671,825	636,648	740,970	595,149	740,970	661,148
Denmark	535,922	339,718	420,245	428,605	339,718	535,922	431,123
Germany	5,335,368	4,684,477	6,092,823	7,079,351	4,684,477	7,079,351	5,798,005
Estonia	42,329	40,230	57,554	87,926	40,230	87,926	57,010
Ireland	20,401	26,780	25,626	24,687	20,401	26,780	24,374
Greece	36,660	19,610	15,441	21,229	15,441	36,660	23,235
Spain	84,194	67,689	61,905	80,159	61,905	84,194	73,487
France	2,918,407	2,977,300	3,059,332	2,866,597	2,866,597	3,059,332	2,955,409
Croatia	3,231	8,938	9,820	20,374	3,231	20,374	10,591
Italy	101,730	35,697	54,202	56,822	35,697	101,730	62,113
Cyprus	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Latvia	58,794	83,428	0	91,107	0	91,107	58,332
Lithuania	138,300	197,410	149,903	128,608	128,608	197,410	153,556
Luxembourg	2,510	2,447	2,636	2,532	2,447	2,636	2,531
Hungary	0	-19,802	-49,249	162,692	-49,249	162,692	23,410
Malta	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Netherlands	833,245	1,433,416	792,473	495,103	495,103	1,433,416	888,559
Austria	274,643	254,763	205,621	251,917	205,621	274,643	246,736
Poland	1,489,433	1,474,991	1,445,182	1,484,978	1,445,182	1,489,433	1,473,646
Portugal	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Romania	90,880	160,388	102,647	152,497	90,880	160,388	126,603
Slovenia	1,774	2,087	3,375	3,650	1,774	3,650	2,721
Slovakia	0	0	0	0	0	0	0
Finland	200,987	166,070	161,094	137,503	137,503	200,987	166,413
Sweden	201,264	197,273	238,982	211,839	197,273	238,982	212,340
United Kingdom	1,472,071	1,493,358	1,049,032	1,293,420	1,049,032	1,493,358	1,326,970

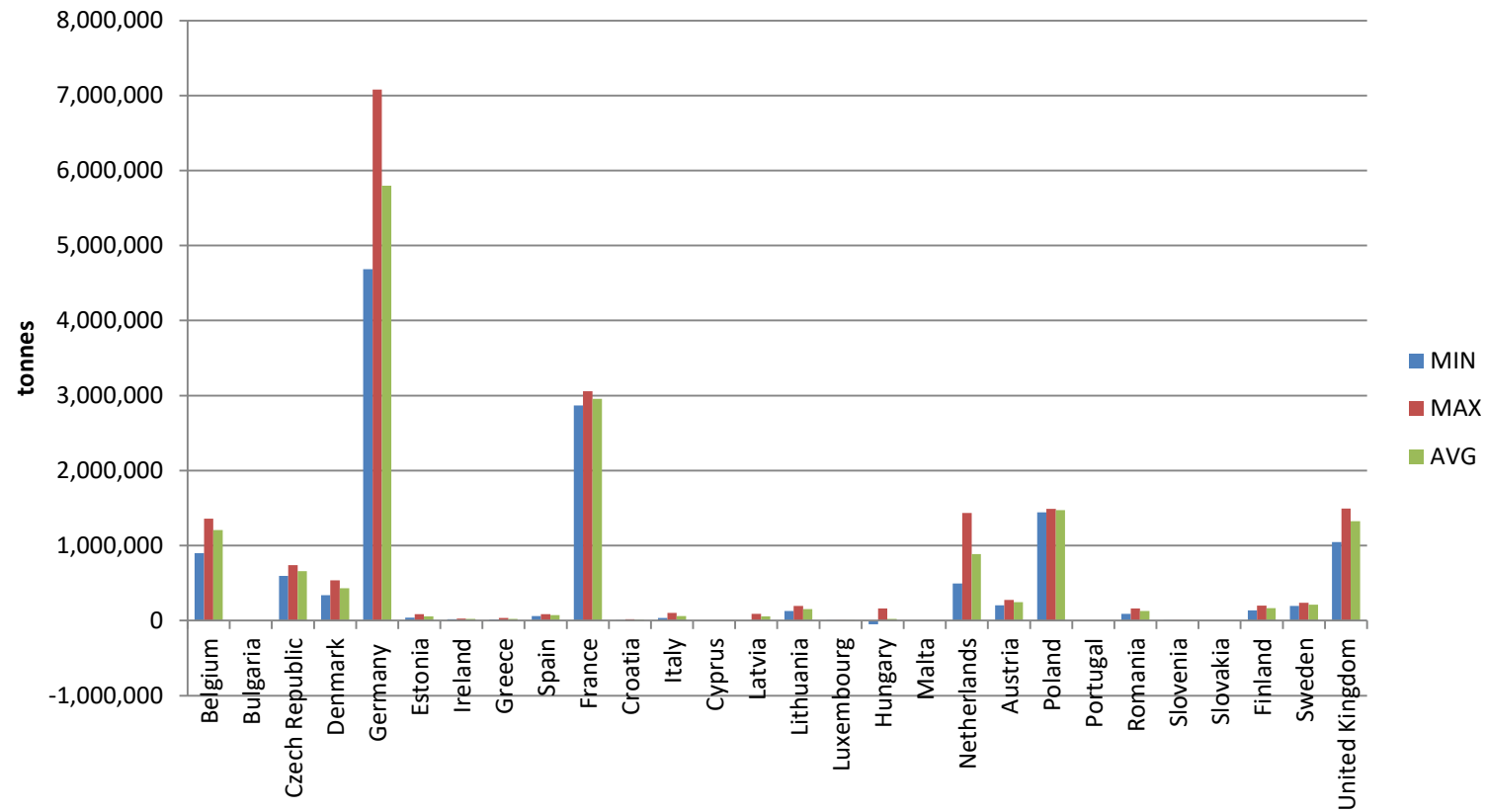


Figure 75 Tonnes of cake meal from processed rapeseed per country, 2010-2013

## 2.9 Sugar beet

Sugar beet is a plant whose root contains high concentrations of sucrose (El, 2010). Sugar beet is cultivated for sugar production, but also for bioethanol and biogas. The sugar beet plants consist of a taproot in the soil and leaves that are above ground, as shown in Figure 76 (Repa: Građa korjena šećerne repe [In Croatian], n.d.).



Figure 76 Sugar beet (58)

During cultivation, the main AWCB is sugar beet leaves, which can be used as fodder for animals or can be left on the field and be reintegrated into the soil. Newer studies show that sugar beet leaves could be used for the production of proteins that would replace protein from meat or soya (Katie Levans: Sugar Beet Leaves Create Vegan Protein Alternative , EcoWatch (2015) , n.d.). After stones are removed from harvested sugar beet, it goes to the beet washer, where it is cleaned from mud and sand, and possible metals (Department of Geography, Environment, and Spatial Sciences, Michigan State University (MSU): The Sugar Beet Industry in Michigan, n.d.). After that, sugar beet is sliced into smaller pieces, like French fries, or cosettes, as shown in Figure 77 (American Crystal Sugar Company: A Tale of Three Seasons, n.d.).



Figure 77 Sugar beet cossettes (American Crystal Sugar Company: A Tale of Three Seasons, n.d.)

The shaped sugar beet cossettes are then sent through an extractor or diffuser, where hot water is mixed with the cossettes to dissolve and remove the sugar through osmosis. The residue left behind after sugar extractions, i.e. de-sugared (aka spent or exhausted) cossettes, is known as fresh pulp, which is either mechanically pressed into pressed pulp or mechanically pressed into dry sugar beet pulp. Both types of pulp, as well as unpressed fresh (or wet) pulp, are mostly used as livestock feed. A more detailed description of the processing of sugar is available in the published literature (60) .

The flowchart (Figure 78) presents the value chain for sugar beet and specific AWCB weight factors from Table 2.



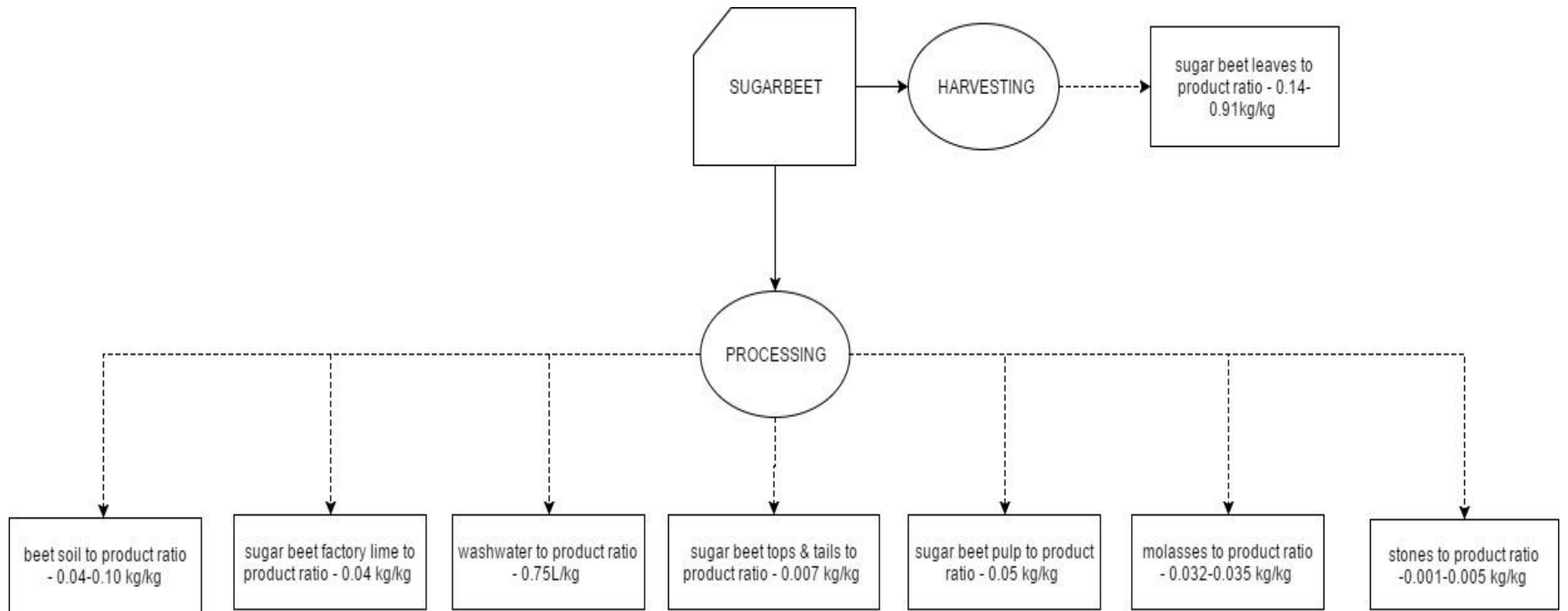


Figure 78 Sugar beet AWCB value chain



Data for cultivated sugar beet is taken from EUROSTAT. The assumption is that only harvested sugar beet is processed. The quantity of AWCB is calculated for each step and each given year. An example of the calculation for Croatia in 2010 is now presented:

PRD= PRC =1,249,150 tonnes

On a fresh weight basis, the quantity of sugar beet leaves corresponds to 0.91 kg per kg of harvested sugar beet. For Croatia, this was 1,124,235 tonnes (0.91 kg/kg) in 2010. Sugar beet pulp resulting from processing represents 0.50 kg per kg of processed sugar beet (on a fresh weight basis); in 2010, this was 624,575 tonnes. Other AWCBs in Croatian beet sugar factories in 2010 were: 39,973 tonnes of molasses (0.032 kg of molasses per kg of processed sugar beet); 93,686m<sup>3</sup> of sugar beet wash water (0.75L of wash water per kg of processed sugar beet); 49,966 tonnes of sugar factory lime (0.040 kg of sugar factory lime per kg of processed sugar beet); 8,744 tonnes of sugar beet tops and tails (0.007 kg of sugar beet tops and tails per kg of processed sugar beet), 1,249 tonnes of stones (0.001 kg of stones per kg of processed sugar beet) and 49,966 tonnes of soil (0.040 kg of soil per kg of processed sugar beet). Results for other countries and years are presented in the tables and figures below.

Table 57 Tonnes of harvested sugar beet per country, 2010-2015 (Eurostat: Agricultural production - crops, n.d.)

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	4,464,800	5,408,980	4,830,400	4,809,300	5,162,110	4,453,630	4,453,630	5,408,980	4,854,870
Czech Republic	3,064,990	3,898,890	3,868,830	3,743,770	4,424,620	3,421,040	3,064,990	4,424,620	3,737,023
Denmark	2,356,400	2,700,400	2,648,900	1,993,600	2,266,100	2,429,000	1,993,600	2,700,400	2,399,067
Germany	23,431,930	29,577,500	27,686,800	22,828,700	29,748,100	22,572,000	22,572,000	29,748,100	25,974,172
Greece	761,460	324,400	434,860	340,400	524,330	259,880	259,880	761,460	440,888
Spain	3,534,520	4,188,540	3,460,230	2,519,480	3,723,310	3,605,110	2,519,480	4,188,540	3,505,198
France	31,874,920	38,106,130	33,739,000	33,749,440	37,931,490	33,503,370	31,874,920	38,106,130	34,817,392
Croatia	1,249,150	1,168,020	919,230	1,050,720	1,392,000	756,510	756,510	1,392,000	1,089,272
Italy	3,550,070	3,547,950	2,501,160	2,159,380	3,784,440	2,183,880	2,159,380	3,784,440	2,954,480
Lithuania	706,700	877,800	1,003,000	967,100	1,014,400	619,480	619,480	1,014,400	864,747
Hungary	818,940	856,370	881,720	990,720	1,066,750	910,920	818,940	1,066,750	920,903
Netherlands	5,280,430	5,858,000	5,735,000	5,727,000	6,822,000	4,868,260	4,868,260	6,822,000	5,715,115
Austria	3,131,670	3,456,230	3,114,430	3,465,790	4,244,220	2,853,280	2,853,280	4,244,220	3,377,603
Poland	9,972,600	11,674,200	12,349,500	11,234,200	13,488,900	9,364,500	9,364,500	13,488,900	11,347,317
Portugal	4,160	7,960	18,890	9,890	13,320	5,760	4,160	18,890	9,997
Romania	837,900	660,500	719,790	1,029,210	1,398,570	1,040,650	660,500	1,398,570	947,770
Slovakia	977,690	1,160,700	894,460	1,144,600	1,550,220	1,205,450	894,460	1,550,220	1,155,520
Finland	542,100	675,700	398,700	459,500	626,300	406,500	398,700	675,700	518,133
Sweden	1,976,200	2,493,200	2,314,200	2,326,200	2,517,800	1,178,300	1,178,300	2,517,800	2,134,317
United Kingdom	6,527,000	8,504,000	7,291,000	8,430,000	9,310,000	6,218,000	6,218,000	9,310,000	7,713,333

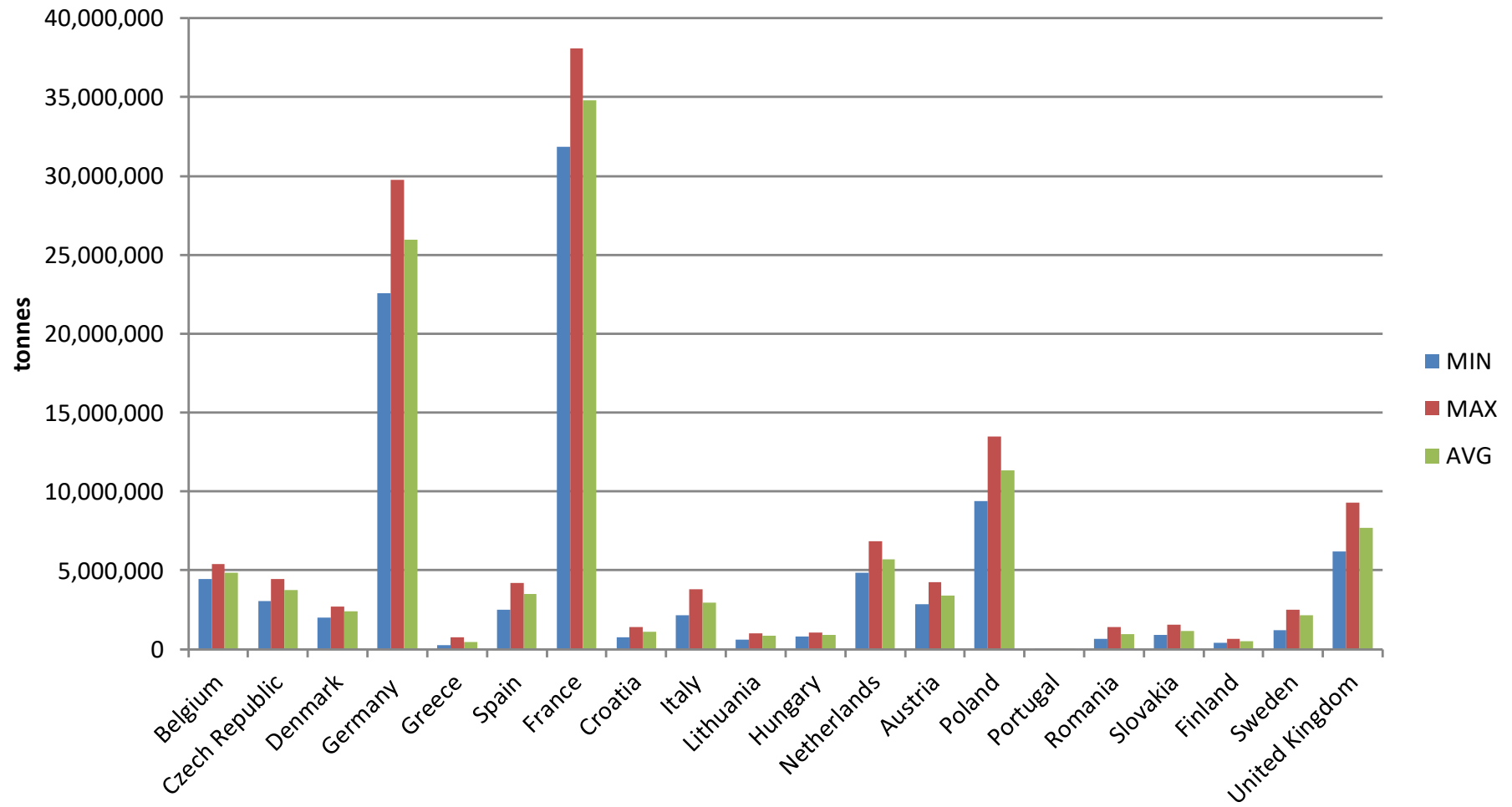


Figure 79 Tonnes of harvested sugar beet per country, 2010-2015

Table 58 Tonnes of sugar beet leaves, fresh weight per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	4,018,320	4,868,082	4,347,360	4,328,370	4,645,899	4,008,267	4,008,267	4,868,082	4,369,383
Czech Republic	2,758,491	3,509,001	3,481,947	3,369,393	3,982,158	3,078,936	2,758,491	3,982,158	3,363,321
Denmark	2,120,760	2,430,360	2,384,010	1,794,240	2,039,490	2,186,100	1,794,240	2,430,360	2,159,160
Germany	21,088,737	26,619,750	24,918,120	20,545,830	26,773,290	20,314,800	20,314,800	26,773,290	23,376,755
Greece	685,314	291,960	391,374	306,360	471,897	233,892	233,892	685,314	396,800
Spain	3,181,068	3,769,686	3,114,207	2,267,532	3,350,979	3,244,599	2,267,532	3,769,686	3,154,679
France	28,687,428	34,295,517	30,365,100	30,374,496	34,138,341	30,153,033	28,687,428	34,295,517	31,335,653
Croatia	1,124,235	1,051,218	827,307	945,648	1,252,800	680,859	680,859	1,252,800	980,345
Italy	3,195,063	3,193,155	2,251,044	1,943,442	3,405,996	1,965,492	1,943,442	3,405,996	2,659,032
Lithuania	636,030	790,020	902,700	870,390	912,960	557,532	557,532	912,960	778,272
Hungary	737,046	770,733	793,548	891,648	960,075	819,828	737,046	960,075	828,813
Netherlands	2,587,411	2,870,420	2,810,150	2,806,230	3,342,780	2,385,447	2,385,447	3,342,780	2,800,406
Austria	2,818,503	3,110,607	2,802,987	3,119,211	3,819,798	2,567,952	2,567,952	3,819,798	3,039,843
Poland	8,975,340	10,506,780	11,114,550	10,110,780	12,140,010	8,428,050	8,428,050	12,140,010	10,212,585
Portugal	3,744	7,164	17,001	8,901	11,988	5,184	3,744	17,001	8,997
Romania	754,110	594,450	647,811	926,289	1,258,713	936,585	594,450	1,258,713	852,993
Slovakia	879,921	1,044,630	805,014	1,030,140	1,395,198	1,084,905	805,014	1,395,198	1,039,968
Finland	487,890	608,130	358,830	413,550	563,670	365,850	358,830	608,130	466,320
Sweden	1,778,580	2,243,880	2,082,780	2,093,580	2,266,020	1,060,470	1,060,470	2,266,020	1,920,885
United Kingdom	5,874,300	7,653,600	6,561,900	7,587,000	8,379,000	5,596,200	5,596,200	8,379,000	6,942,000

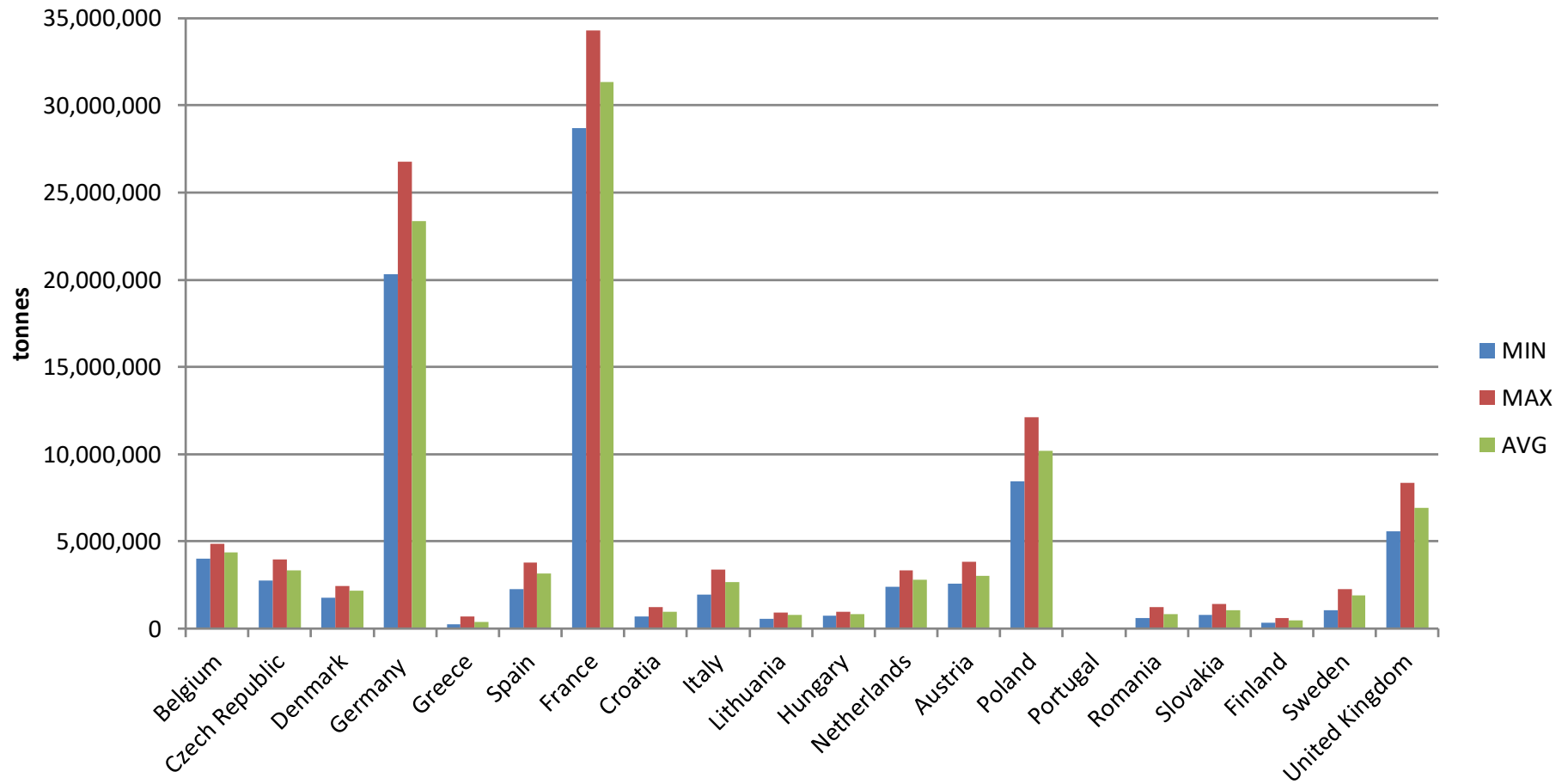


Figure 80 Tonnes of sugar beet leaves, fresh weight per country, 2010-2015

Table 59 Tonnes of processed sugar beet per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	4,464,800	5,408,980	4,830,400	4,809,300	5,162,110	4,453,630	4,453,630	5,408,980	4,854,870
Czech Republic	3,064,990	3,898,890	3,868,830	3,743,770	4,424,620	3,421,040	3,064,990	4,424,620	3,737,023
Denmark	2,356,400	2,700,400	2,648,900	1,993,600	2,266,100	2,429,000	1,993,600	2,700,400	2,399,067
Germany	23,431,930	29,577,500	27,686,800	22,828,700	29,748,100	22,572,000	22,572,000	29,748,100	25,974,172
Greece	761,460	324,400	434,860	340,400	524,330	259,880	259,880	761,460	440,888
Spain	3,534,520	4,188,540	3,460,230	2,519,480	3,723,310	3,605,110	2,519,480	4,188,540	3,505,198
France	31,874,920	38,106,130	33,739,000	33,749,440	37,931,490	33,503,370	31,874,920	38,106,130	34,817,392
Croatia	1,249,150	1,168,020	919,230	1,050,720	1,392,000	756,510	756,510	1,392,000	1,089,272
Italy	3,550,070	3,547,950	2,501,160	2,159,380	3,784,440	2,183,880	2,159,380	3,784,440	2,954,480
Lithuania	706,700	877,800	1,003,000	967,100	1,014,400	619,480	619,480	1,014,400	864,747
Hungary	818,940	856,370	881,720	990,720	1,066,750	910,920	818,940	1,066,750	920,903
Netherlands	5,280,430	5,858,000	5,735,000	5,727,000	6,822,000	4,868,260	4,868,260	6,822,000	5,715,115
Austria	3,131,670	3,456,230	3,114,430	3,465,790	4,244,220	2,853,280	2,853,280	4,244,220	3,377,603
Poland	9,972,600	11,674,200	12,349,500	11,234,200	13,488,900	9,364,500	9,364,500	13,488,900	11,347,317
Portugal	4,160	7,960	18,890	9,890	13,320	5,760	4,160	18,890	9,997
Romania	837,900	660,500	719,790	1,029,210	1,398,570	1,040,650	660,500	1,398,570	947,770
Slovakia	977,690	1,160,700	894,460	1,144,600	1,550,220	1,205,450	894,460	1,550,220	1,155,520
Finland	542,100	675,700	398,700	459,500	626,300	406,500	398,700	675,700	518,133
Sweden	1,976,200	2,493,200	2,314,200	2,326,200	2,517,800	1,178,300	1,178,300	2,517,800	2,134,317
United Kingdom	6,527,000	8,504,000	7,291,000	8,430,000	9,310,000	6,218,000	6,218,000	9,310,000	7,713,333

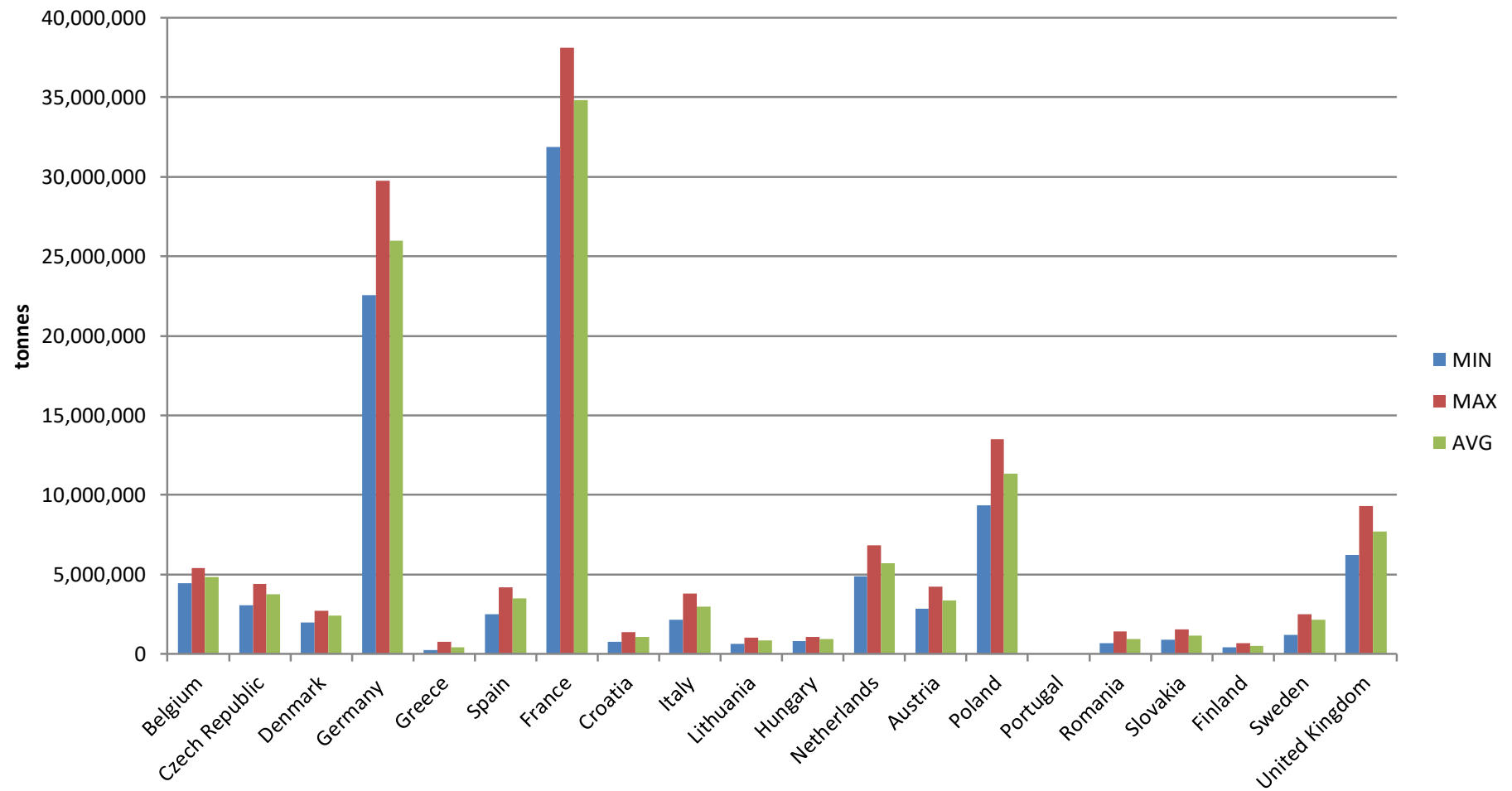


Figure 81 Tonnes of processed sugar beet per country, 2010-2015

Table 60 Tonnes of sugar beet molasses per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	142,874	173,087	154,573	153,898	165,188	142,516	142,516	173,087	155,356
Czech Republic	98,080	124,764	123,803	119,801	141,588	109,473	98,080	141,588	119,585
Denmark	75,405	86,413	84,765	63,795	72,515	77,728	63,795	86,413	76,770
Germany	749,822	946,480	885,978	730,518	951,939	722,304	722,304	951,939	831,173
Greece	24,367	10,381	13,916	10,893	16,779	8,316	8,316	24,367	14,108
Spain	113,105	134,033	110,727	80,623	119,146	115,364	80,623	134,033	112,166
France	1,019,997	1,219,396	1,079,648	1,079,982	1,213,808	1,072,108	1,019,997	1,219,396	1,114,157
Croatia	39,973	37,377	29,415	33,623	44,544	24,208	24,208	44,544	34,857
Italy	113,602	113,534	80,037	69,100	121,102	69,884	69,100	121,102	94,543
Lithuania	22,614	28,090	32,096	30,947	32,461	19,823	19,823	32,461	27,672
Hungary	26,206	27,404	28,215	31,703	34,136	29,149	26,206	34,136	29,469
Netherlands	184,815	205,030	200,725	200,445	238,770	170,389	170,389	238,770	200,029
Austria	100,213	110,599	99,662	110,905	135,815	91,305	91,305	135,815	108,083
Poland	319,123	373,574	395,184	359,494	431,645	299,664	299,664	431,645	363,114
Portugal	133	255	604	316	426	184	133	604	320
Romania	26,813	21,136	23,033	32,935	44,754	33,301	21,136	44,754	30,329
Slovakia	31,286	37,142	28,623	36,627	49,607	38,574	28,623	49,607	36,977
Finland	17,347	21,622	12,758	14,704	20,042	13,008	12,758	21,622	16,580
Sweden	63,238	79,782	74,054	74,438	80,570	37,706	37,706	80,570	68,298
United Kingdom	208,864	272,128	233,312	269,760	297,920	198,976	198,976	297,920	246,827



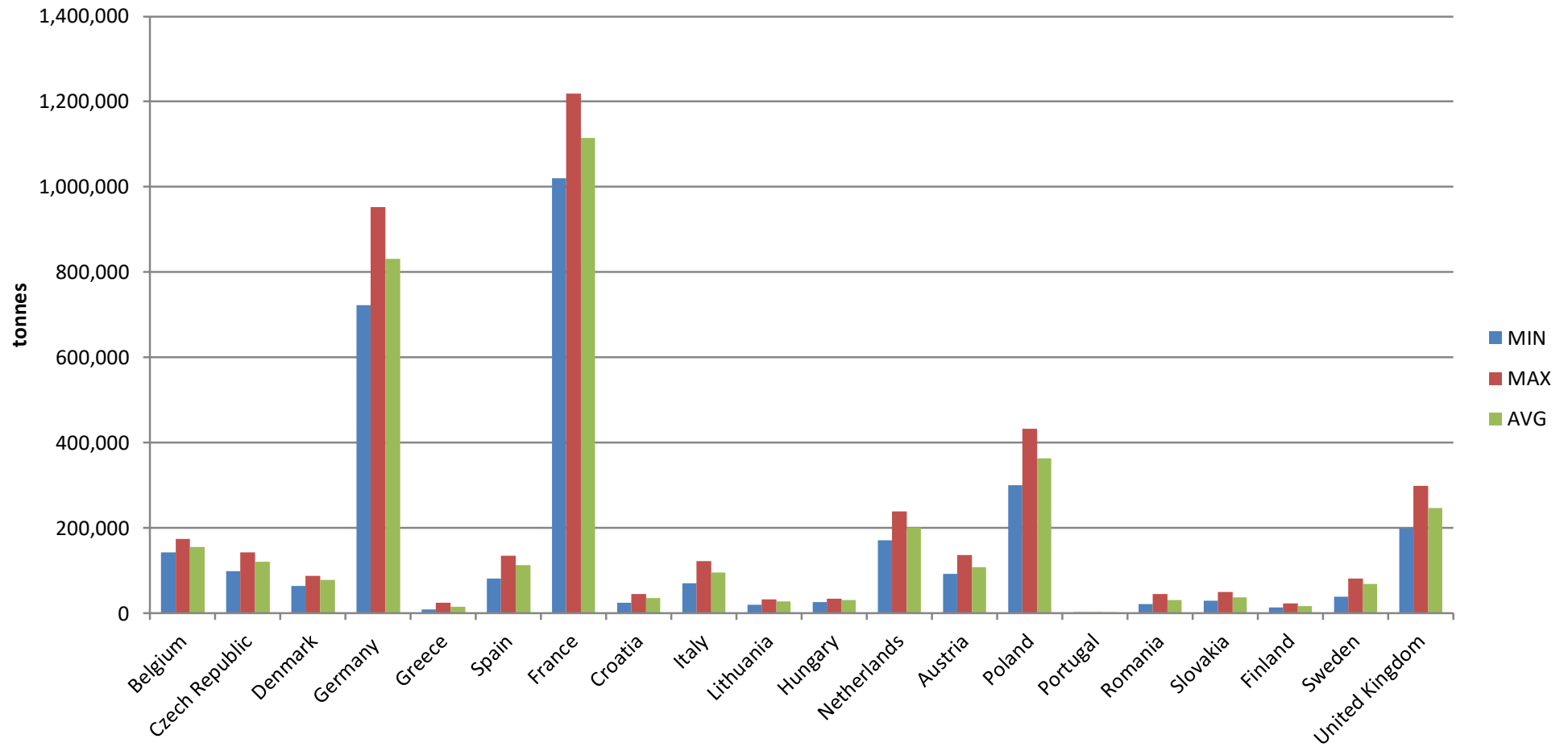


Figure 82 Tonnes of sugar beet molasses per country, 2010-2015

Table 61 Tonnes of fresh sugar beet pulp per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	2,232,400	2,704,490	2,415,200	2,404,650	2,581,055	2,226,815	2,226,815	2,704,490	2,427,435
Czech Republic	1,532,495	1,949,445	1,934,415	1,871,885	2,212,310	1,710,520	1,532,495	2,212,310	1,868,512
Denmark	1,178,200	1,350,200	1,324,450	996,800	1,133,050	1,214,500	996,800	1,350,200	1,199,533
Germany	11,715,965	14,788,750	13,843,400	11,414,350	14,874,050	11,286,000	11,286,000	14,874,050	12,987,086
Greece	380,730	162,200	217,430	170,200	262,165	129,940	129,940	380,730	220,444
Spain	1,767,260	2,094,270	1,730,115	1,259,740	1,861,655	1,802,555	1,259,740	2,094,270	1,752,599
France	15,937,460	19,053,065	16,869,500	16,874,720	18,965,745	16,751,685	15,937,460	19,053,065	17,408,696
Croatia	624,575	584,010	459,615	525,360	696,000	378,255	378,255	696,000	544,636
Italy	1,775,035	1,773,975	1,250,580	1,079,690	1,892,220	1,091,940	1,079,690	1,892,220	1,477,240
Lithuania	353,350	438,900	501,500	483,550	507,200	309,740	309,740	507,200	432,373
Hungary	409,470	428,185	440,860	495,360	533,375	455,460	409,470	533,375	460,452
Netherlands	2,640,215	2,929,000	2,867,500	2,863,500	3,411,000	2,434,130	2,434,130	3,411,000	2,857,558
Austria	1,565,835	1,728,115	1,557,215	1,732,895	2,122,110	1,426,640	1,426,640	2,122,110	1,688,802
Poland	4,986,300	5,837,100	6,174,750	5,617,100	6,744,450	4,682,250	4,682,250	6,744,450	5,673,658
Portugal	2,080	3,980	9,445	4,945	6,660	2,880	2,080	9,445	4,998
Romania	418,950	330,250	359,895	514,605	699,285	520,325	330,250	699,285	473,885
Slovakia	488,845	580,350	447,230	572,300	775,110	602,725	447,230	775,110	577,760
Finland	271,050	337,850	199,350	229,750	313,150	203,250	199,350	337,850	259,067
Sweden	988,100	1,246,600	1,157,100	1,163,100	1,258,900	589,150	589,150	1,258,900	1,067,158
United Kingdom	3,263,500	4,252,000	3,645,500	4,215,000	4,655,000	3,109,000	3,109,000	4,655,000	3,856,667

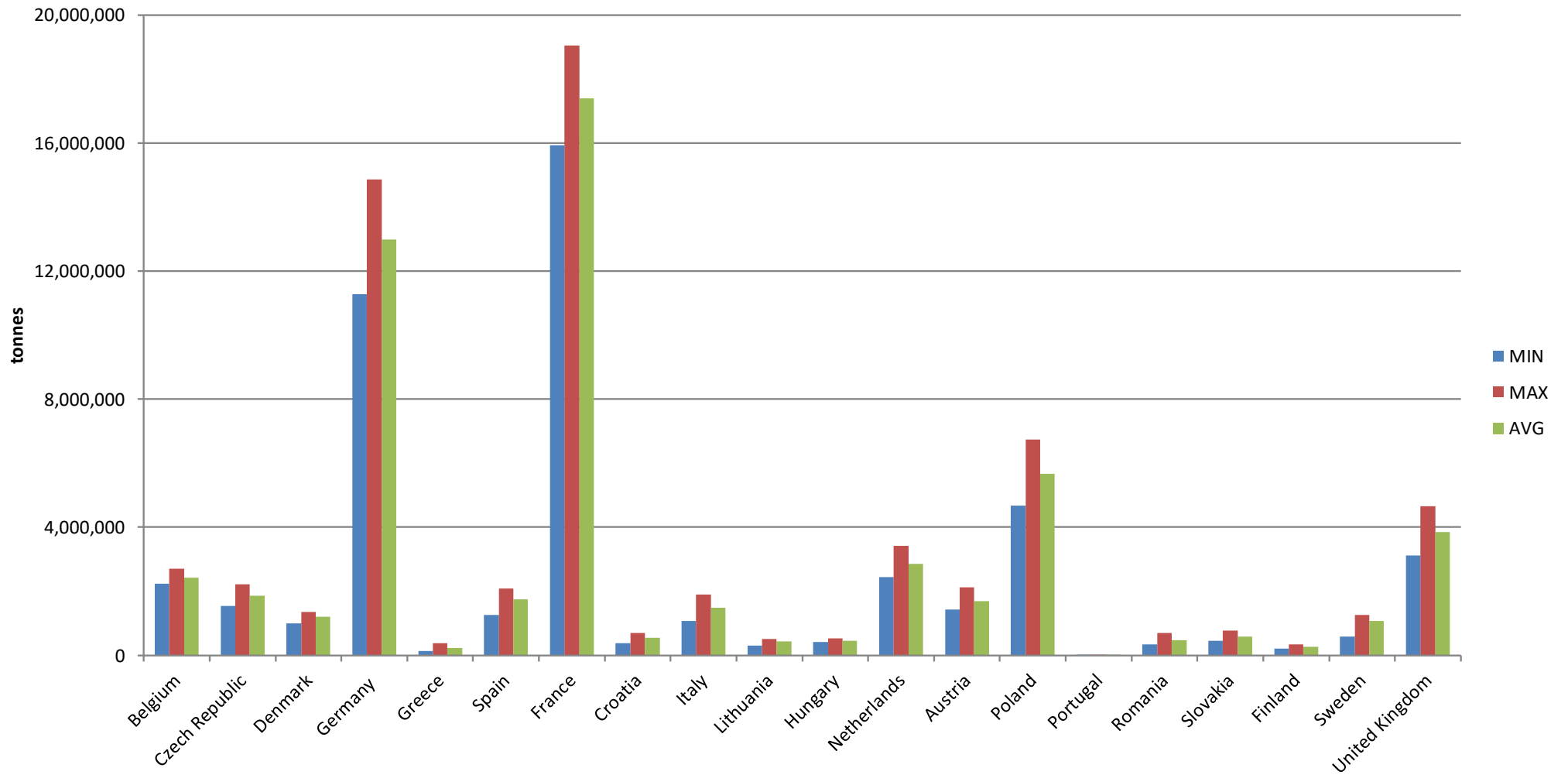


Figure 83 Tonnes of fresh sugar beet pulp per country, 2010-2015

Table 62 Volume of sugar beet wash water in m<sup>3</sup> per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	334,860	405,674	362,280	360,698	387,158	334,022	334,022	405,674	364,115
Czech Republic	229,874	292,417	290,162	280,783	331,847	256,578	229,874	331,847	280,277
Denmark	176,730	202,530	198,668	149,520	169,958	182,175	149,520	202,530	179,930
Germany	1,757,395	2,218,313	2,076,510	1,712,153	2,231,108	1,692,900	1,692,900	2,231,108	1,948,063
Greece	57,110	24,330	32,615	25,530	39,325	19,491	19,491	57,110	33,067
Spain	265,089	314,141	259,517	188,961	279,248	270,383	188,961	314,141	262,890
France	2,390,619	2,857,960	2,530,425	2,531,208	2,844,862	2,512,753	2,390,619	2,857,960	2,611,304
Croatia	93,686	87,602	68,942	78,804	104,400	56,738	56,738	104,400	81,695
Italy	266,255	266,096	187,587	161,954	283,833	163,791	161,954	283,833	221,586
Lithuania	53,003	65,835	75,225	72,533	76,080	46,461	46,461	76,080	64,856
Hungary	61,421	64,228	66,129	74,304	80,006	68,319	61,421	80,006	69,068
Netherlands	396,032	439,350	430,125	429,525	511,650	365,120	365,120	511,650	428,634
Austria	234,875	259,217	233,582	259,934	318,317	213,996	213,996	318,317	253,320
Poland	747,945	875,565	926,213	842,565	1,011,668	702,338	702,338	1,011,668	851,049
Portugal	312	597	1,417	742	999	432	312	1,417	750
Romania	62,843	49,538	53,984	77,191	104,893	78,049	49,538	104,893	71,083
Slovakia	73,327	87,053	67,085	85,845	116,267	90,409	67,085	116,267	86,664
Finland	40,658	50,678	29,903	34,463	46,973	30,488	29,903	50,678	38,860
Sweden	148,215	186,990	173,565	174,465	188,835	88,373	88,373	188,835	160,074
United Kingdom	489,525	637,800	546,825	632,250	698,250	466,350	466,350	698,250	578,500

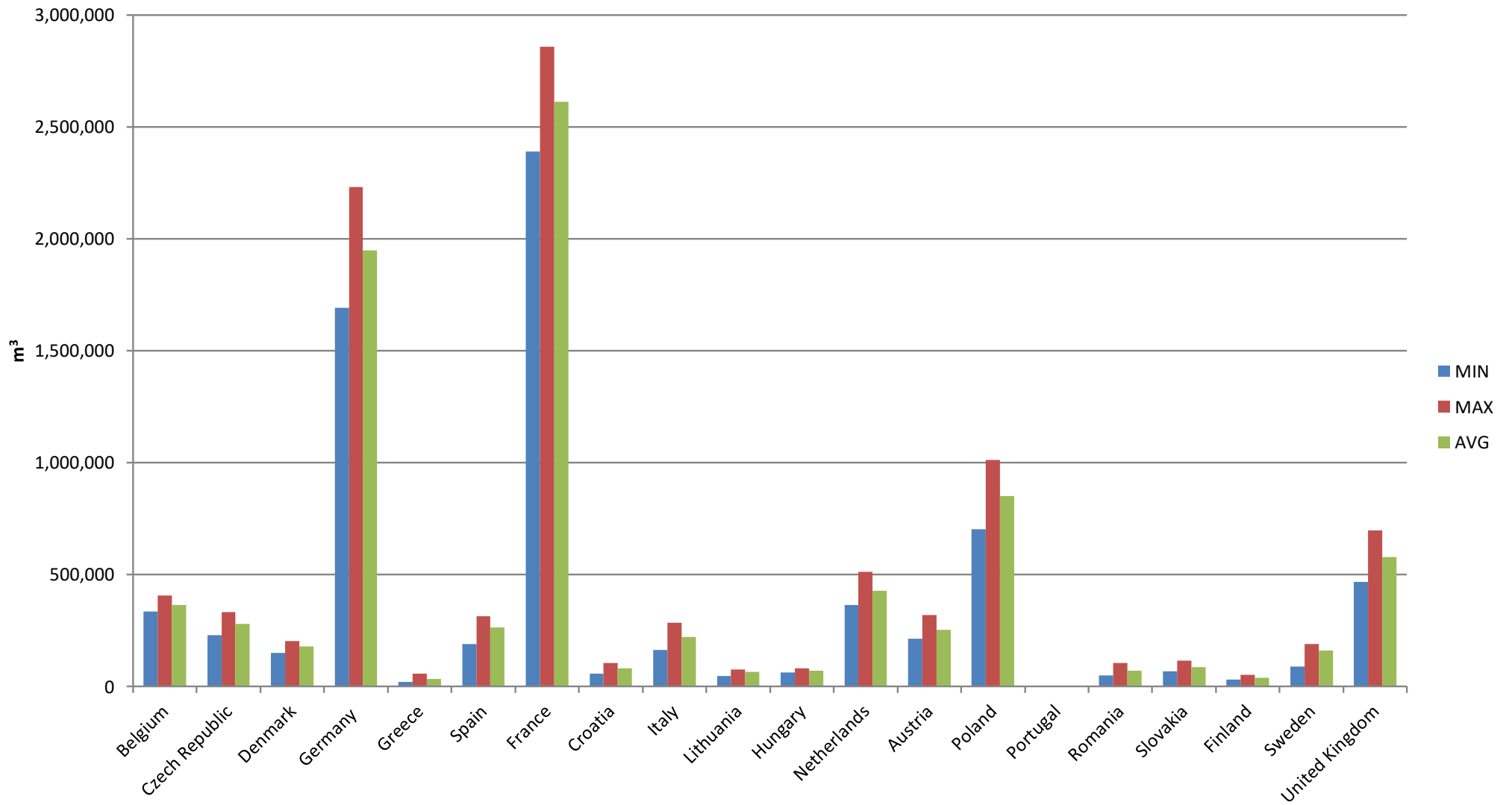


Figure 84 Volume of sugar beet wash water in m<sup>3</sup> per country, 2010-2015

Table 63 Tonnes of sugar factory lime per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	178,592	216,359	193,216	192,372	206,484	178,145	178,145	216,359	194,195
Czech Republic	122,600	155,956	154,753	149,751	176,985	136,842	122,600	176,985	149,481
Denmark	94,256	108,016	105,956	79,744	90,644	97,160	79,744	108,016	95,963
Germany	937,277	1,183,100	1,107,472	913,148	1,189,924	902,880	902,880	1,189,924	1,038,967
Greece	30,458	12,976	17,394	13,616	20,973	10,395	10,395	30,458	17,636
Spain	141,381	167,542	138,409	100,779	148,932	144,204	100,779	167,542	140,208
France	1,274,997	1,524,245	1,349,560	1,349,978	1,517,260	1,340,135	1,274,997	1,524,245	1,392,696
Croatia	49,966	46,721	36,769	42,029	55,680	30,260	30,260	55,680	43,571
Italy	142,003	141,918	100,046	86,375	151,378	87,355	86,375	151,378	118,179
Lithuania	28,268	35,112	40,120	38,684	40,576	24,779	24,779	40,576	34,590
Hungary	32,758	34,255	35,269	39,629	42,670	36,437	32,758	42,670	36,836
Netherlands	211,217	234,320	229,400	229,080	272,880	194,730	194,730	272,880	228,605
Austria	125,267	138,249	124,577	138,632	169,769	114,131	114,131	169,769	135,104
Poland	398,904	466,968	493,980	449,368	539,556	374,580	374,580	539,556	453,893
Portugal	166	318	756	396	533	230	166	756	400
Romania	33,516	26,420	28,792	41,168	55,943	41,626	26,420	55,943	37,911
Slovakia	39,108	46,428	35,778	45,784	62,009	48,218	35,778	62,009	46,221
Finland	21,684	27,028	15,948	18,380	25,052	16,260	15,948	27,028	20,725
Sweden	79,048	99,728	92,568	93,048	100,712	47,132	47,132	100,712	85,373
United Kingdom	261,080	340,160	291,640	337,200	372,400	248,720	248,720	372,400	308,533

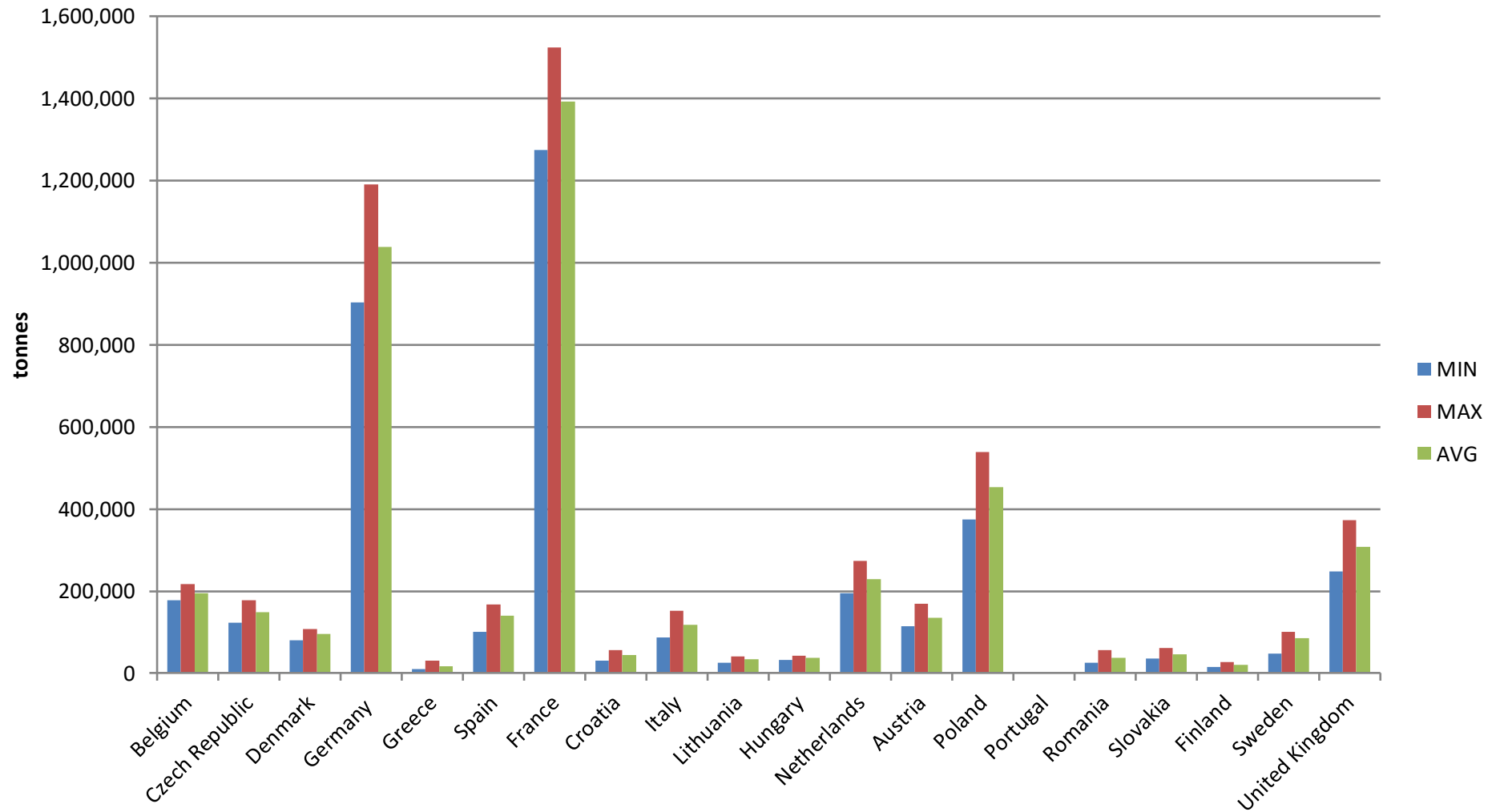


Figure 85 Tonnes of sugar factory lime per country, 2010-2015

Table 64 Tonnes of sugar beet tops &amp; tails per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	31,254	37,863	33,813	33,665	36,135	31,175	31,175	37,863	33,984
Czech Republic	21,455	27,292	27,082	26,206	30,972	23,947	21,455	30,972	26,159
Denmark	16,495	18,903	18,542	13,955	15,863	17,003	13,955	18,903	16,793
Germany	164,024	207,043	193,808	159,801	208,237	158,004	158,004	208,237	181,819
Greece	5,330	2,271	3,044	2,383	3,670	1,819	1,819	5,330	3,086
Spain	24,742	29,320	24,222	17,636	26,063	25,236	17,636	29,320	24,536
France	223,124	266,743	236,173	236,246	265,520	234,524	223,124	266,743	243,722
Croatia	8,744	8,176	6,435	7,355	9,744	5,296	5,296	9,744	7,625
Italy	24,850	24,836	17,508	15,116	26,491	15,287	15,116	26,491	20,681
Lithuania	4,947	6,145	7,021	6,770	7,101	4,336	4,336	7,101	6,053
Hungary	5,733	5,995	6,172	6,935	7,467	6,376	5,733	7,467	6,446
Netherlands	79,206	87,870	86,025	85,905	102,330	73,024	73,024	102,330	85,727
Austria	21,922	24,194	21,801	24,261	29,710	19,973	19,973	29,710	23,643
Poland	69,808	81,719	86,447	78,639	94,422	65,552	65,552	94,422	79,431
Portugal	29	56	132	69	93	40	29	132	70
Romania	5,865	4,624	5,039	7,204	9,790	7,285	4,624	9,790	6,634
Slovakia	6,844	8,125	6,261	8,012	10,852	8,438	6,261	10,852	8,089
Finland	3,795	4,730	2,791	3,217	4,384	2,846	2,791	4,730	3,627
Sweden	13,833	17,452	16,199	16,283	17,625	8,248	8,248	17,625	14,940
United Kingdom	45,689	59,528	51,037	59,010	65,170	43,526	43,526	65,170	53,993



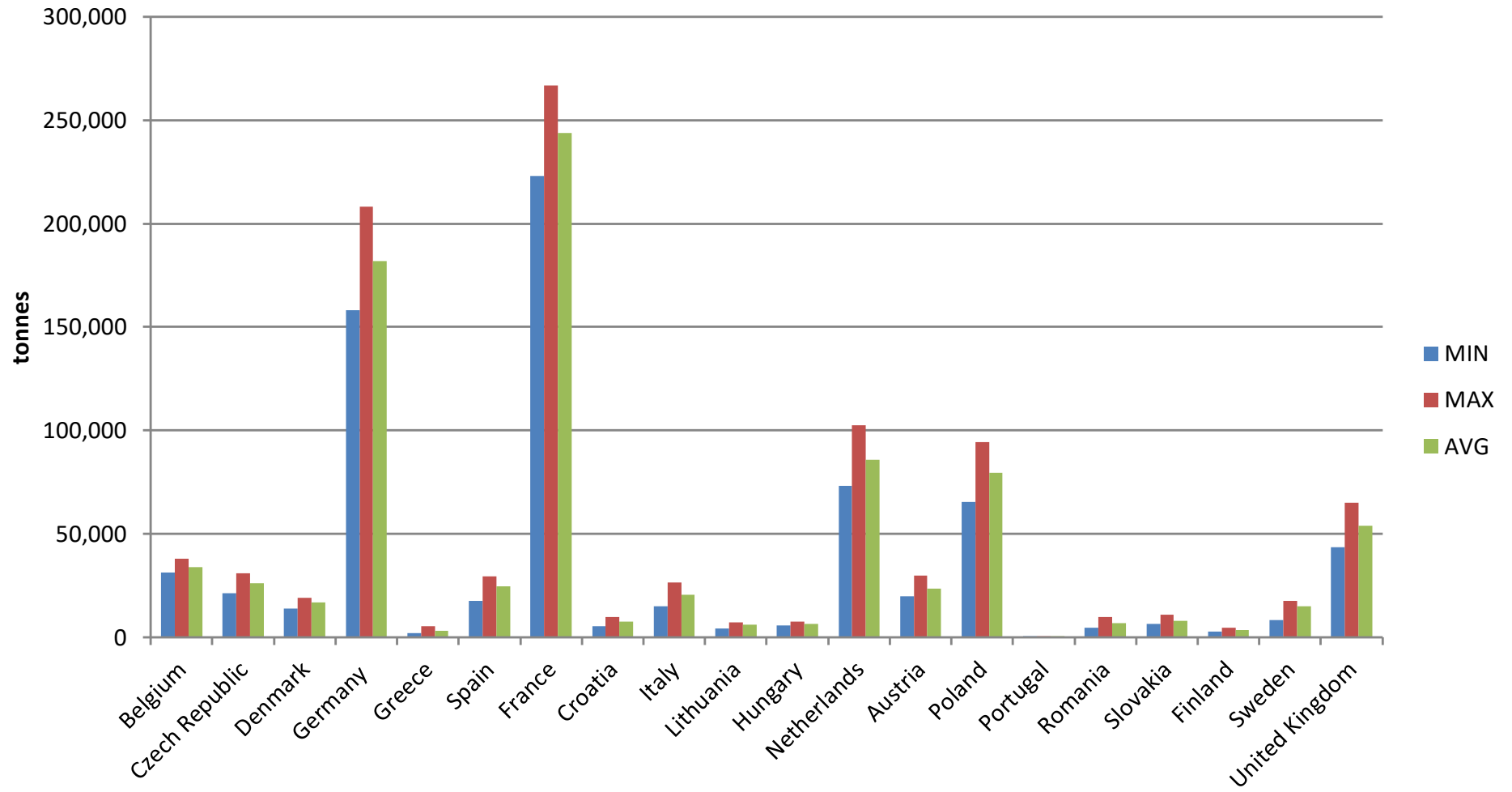


Figure 86 Tonnes of sugar beet tops & tails per country, 2010-2015

Table 65 Tonnes of stones in sugar beet processing per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	4,465	5,409	4,830	4,809	5,162	4,454	4,454	5,409	4,855
Czech Republic	6,130	7,798	7,738	7,488	8,849	6,842	6,130	8,849	7,474
Denmark	2,356	2,700	2,649	1,994	2,266	2,429	1,994	2,700	2,399
Germany	23,432	29,578	27,687	22,829	29,748	22,572	22,572	29,748	25,974
Greece	761	324	435	340	524	260	260	761	441
Spain	3,535	4,189	3,460	2,519	3,723	3,605	2,519	4,189	3,505
France	31,875	38,106	33,739	33,749	37,931	33,503	31,875	38,106	34,817
Croatia	1,249	1,168	919	1,051	1,392	757	757	1,392	1,089
Italy	3,550	3,548	2,501	2,159	3,784	2,184	2,159	3,784	2,954
Lithuania	707	878	1,003	967	1,014	619	619	1,014	865
Hungary	819	856	882	991	1,067	911	819	1,067	921
Netherlands	5,280	5,858	5,735	5,727	6,822	4,868	4,868	6,822	5,715
Austria	3,132	3,456	3,114	3,466	4,244	2,853	2,853	4,244	3,378
Poland	9,973	11,674	12,350	11,234	13,489	9,365	9,365	13,489	11,347
Portugal	4	8	19	10	13	6	4	19	10
Romania	838	661	720	1,029	1,399	1,041	661	1,399	948
Slovakia	978	1,161	894	1,145	1,550	1,205	894	1,550	1,156
Finland	2,711	3,379	1,994	2,298	3,132	2,033	1,994	3,379	2,591
Sweden	1,976	2,493	2,314	2,326	2,518	1,178	1,178	2,518	2,134
United Kingdom	6,527	8,504	7,291	8,430	9,310	6,218	6,218	9,310	7,713

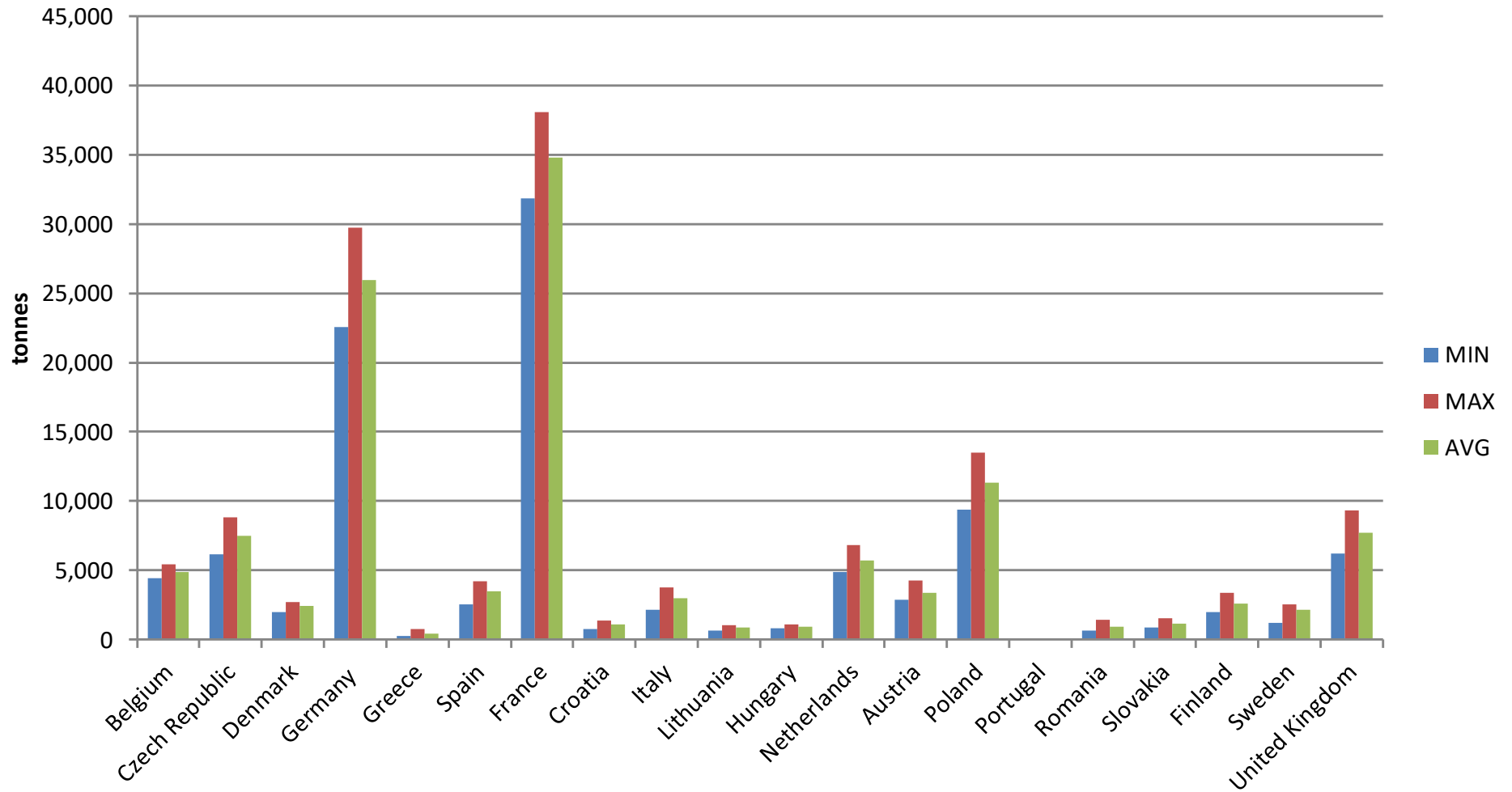


Figure 87 Tonnes of stones in sugar beet processing per country, 2010-2015

Table 66 Tonnes of beet soil per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	178,592	216,359	193,216	192,372	206,484	178,145	178,145	216,359	194,195
Czech Republic	122,600	155,956	154,753	149,751	176,985	136,842	122,600	176,985	149,481
Denmark	94,256	108,016	105,956	79,744	90,644	97,160	79,744	108,016	95,963
Germany	937,277	1,183,100	1,107,472	913,148	1,189,924	902,880	902,880	1,189,924	1,038,967
Greece	30,458	12,976	17,394	13,616	20,973	10,395	10,395	30,458	17,636
Spain	141,381	167,542	138,409	100,779	148,932	144,204	100,779	167,542	140,208
France	1,274,997	1,524,245	1,349,560	1,349,978	1,517,260	1,340,135	1,274,997	1,524,245	1,392,696
Croatia	49,966	46,721	36,769	42,029	55,680	30,260	30,260	55,680	43,571
Italy	142,003	141,918	100,046	86,375	151,378	87,355	86,375	151,378	118,179
Lithuania	28,268	35,112	40,120	38,684	40,576	24,779	24,779	40,576	34,590
Hungary	32,758	34,255	35,269	39,629	42,670	36,437	32,758	42,670	36,836
Netherlands	211,217	234,320	229,400	229,080	272,880	194,730	194,730	272,880	228,605
Austria	125,267	138,249	124,577	138,632	169,769	114,131	114,131	169,769	135,104
Poland	398,904	466,968	493,980	449,368	539,556	374,580	374,580	539,556	453,893
Portugal	166	318	756	396	533	230	166	756	400
Romania	33,516	26,420	28,792	41,168	55,943	41,626	26,420	55,943	37,911
Slovakia	39,108	46,428	35,778	45,784	62,009	48,218	35,778	62,009	46,221
Finland	43,368	54,056	31,896	36,760	50,104	32,520	31,896	54,056	41,451
Sweden	79,048	99,728	92,568	93,048	100,712	47,132	47,132	100,712	85,373
United Kingdom	261,080	340,160	291,640	337,200	372,400	248,720	248,720	372,400	308,533

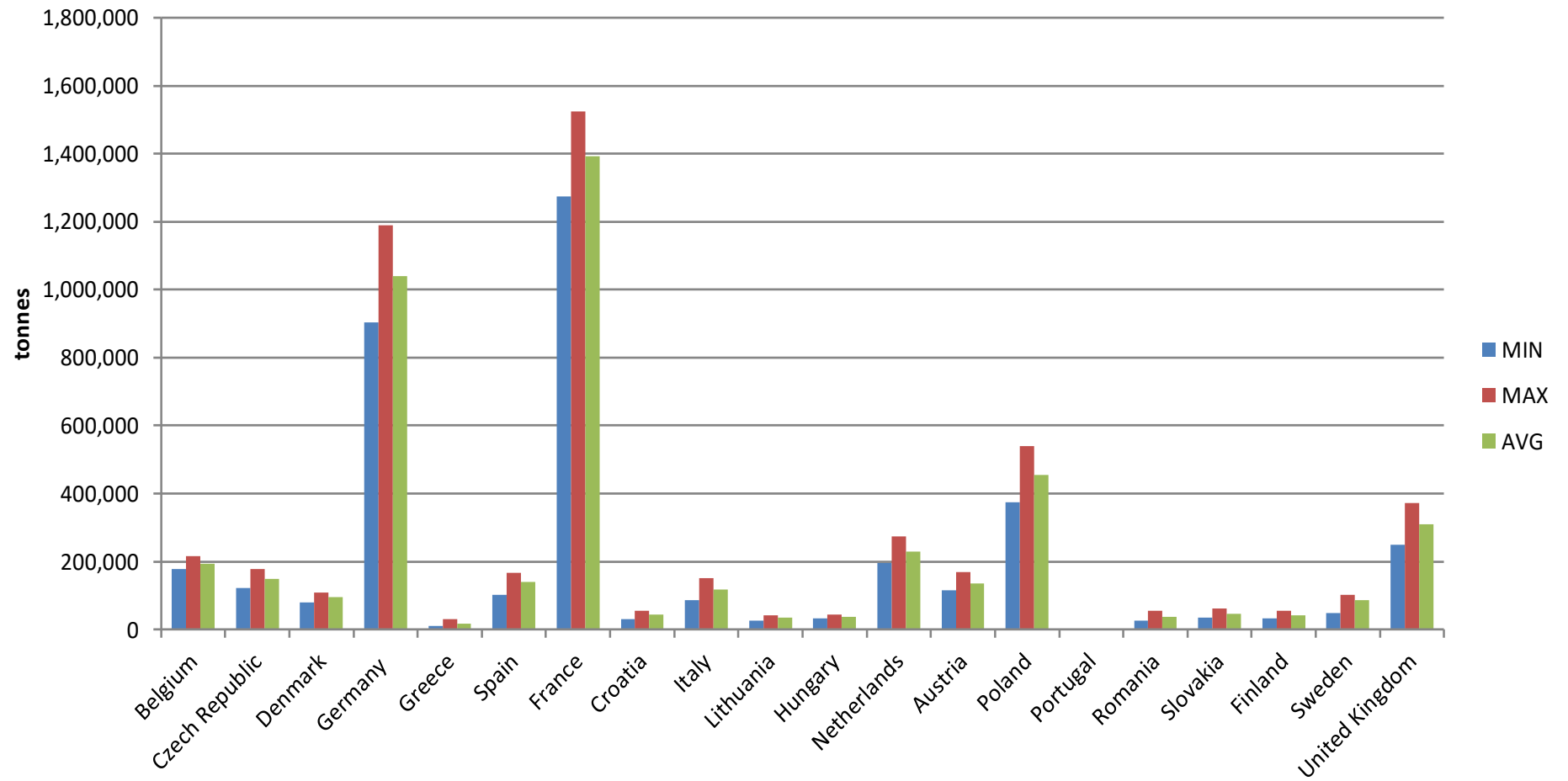


Figure 88 Tonnes of beet soil per country, 2010-2015

## 2.10 Olive

Olives are mostly grown in Mediterranean countries, from Portugal to the Arabian Peninsula. They are also grown in parts of southern Asia and China (Tous & Ferguson, 1996). There are many cultivars of the olive vegetable, which are different in colour, size and shape. Figure 89 shows the cultivar “Hojiblanca”, characteristic for the Spanish provinces Seville, Cordoba and Malaga (Olive Oil Times: Hojiblanca, n.d.).



Figure 89 Hojiblanca olives (Olive Oil Times: Hojiblanca, n.d.)

The main sources of AWCBs that occur during cultivation are wooden branches, twigs and leaves as a result of pruning, shown in Figure 90 (Notes from a Tuscan olive grove: Pruning the olive trees – before and after, n.d.).



Figure 90 Pruning of olive tree (64)

After olives are harvested, they are either consumed fresh or processed (How Products are Made: The Manufacturing Process, n.d.). Olives go through blowers that remove possible leaves and dirt from harvested materials. The cleaned olives go to a tank filled with water and salt; in order to start fermentation (curing), active brine is added. When fermentation is over (which is known from the salt concentration) olives are cleaned with water, pitted and canned. Olives produced for oil production is processed in a different way (Olive Oil Source: Extraction Process, n.d.). After the olives are cleaned, they are crushed into a paste in order to release oils from vacuoles in flesh cells, this procedure is accomplished by disc crusher (left) or hammer mill (right), as shown in Figure 91 (California Olive Oil: Calivirgin Down Under...Adelaide Countryside, Olive Oil & Kangaroos, n.d.).



Figure 91 Disc crusher (left) and hammer mill (right) for olive crushing (California Olive Oil: Calivirgin Down Under...Adelaide Countryside, Olive Oil & Kangaroos, n.d.)

The next step is the separation of olive oil from the rest of olive components. There are several types of separation, usually with pressing or in centrifugal separators (Alfa Laval: Separating oil from olives, n.d.). The separated oil goes through a filtration process to increase the purity of the final product. This is the point where olive pomace and olive mill wastewater occur, as shown in Figure 92 (Olive Oil Market: How to Purify Olive Mill Wastewater?, n.d.).





Figure 92 Olive pomace and olive mill wastewater (69)

At the consumption stage, the quantity of rotten olives is much lower compared to other vegetables and fruits, due to preservation measure in olive processing facilities.

The flowchart (Figure 93) presents the value chain for olive and specific AWCB weight factors from Table 2.

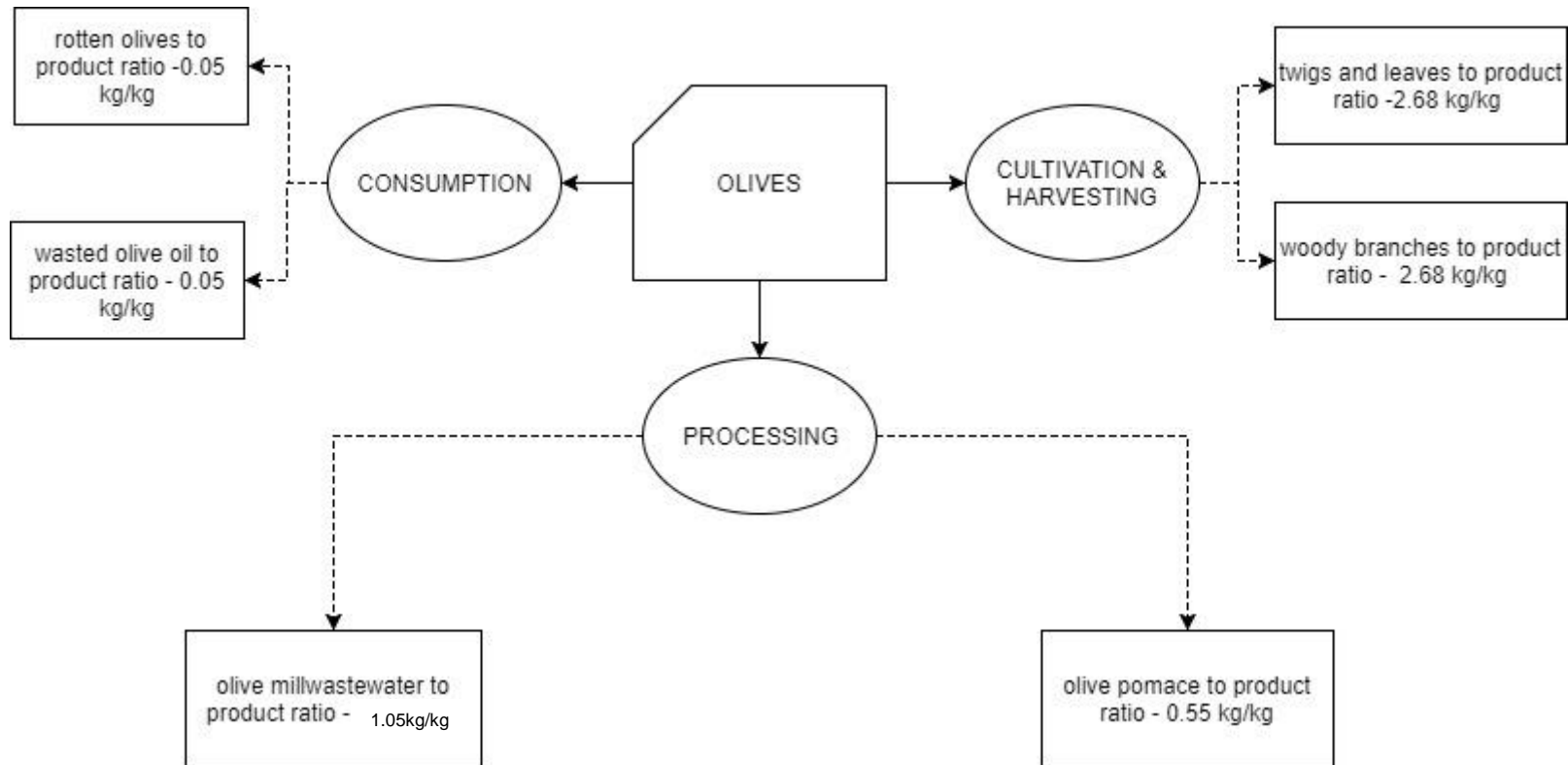


Figure 93 Olive AWCB value chain

Data for cultivated and processed olives are taken from EUROSTAT. Numbers for consumed olives and olive oil were not calculated but taken from the International Olive Council (IOC) for each country (IOC-International Olive Council, n.d.). Then the quantity of AWCB is calculated for each step and each given year. An example of the calculation for Cyprus in 2010 is now presented:

PRD = 14,870 tonnes

PRC = 11,860 tonnes

CON (OLIVES) = 4,400 tonnes

CON (OLIVE OIL) = 5,000 tonnes

The quantity of twigs and leaves was the same as the quantity of wooden branches (2.68 kg per kg of harvested olives) and for Cyprus, in 2010 it was 39,703 tonnes. The quantity of olive pomace arising during processing was 6,523 tonnes (0.55 kg of olive pomace per kg of processed olives). The quantity of olive mill wastewater was 12,453 tonnes (1.05 kg of olive mill wastewater per kg of processed olives). The quantity of olives consumed in Cyprus in 2010 was 4,400 tonnes, of which 5% or 220 tonnes were rotten. The people of Cyprus consumed 5,000 tonnes of olive oil in 2010, where 250 tonnes became spoiled. Results for other countries and years are presented in the tables and figures below.

Table 67 Tonnes of harvested olives per country, 2010-2015 (Eurostat: Agricultural production - crops, n.d.)

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	0	0	0	0	0	0	0	0	0
Bulgaria	0	0	0	0	0	0	0	0	0
Czech Republic	0	0	0	0	0	0	0	0	0
Denmark	0	0	0	0	0	0	0	0	0
Germany	0	0	0	0	0	0	0	0	0
Estonia	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0
Greece	1,809,810	1,873,860	2,080,770	1,296,640	1,781,060.00	1,269,850.00	1,269,850	2,080,770	1,685,332
Spain	n/a	7,820,060.00	n/a	9,250,610	4,577,800.00	7,344,820.00	4,577,800	9,250,610	7,248,323
France	31710	23320	29560	29400	n/a	34400	23,320	34,400	29,678
Croatia	38,000	n/a	n/a	n/a	8,840	28,270	8,840	38,000	25,037
Italy	3,130,800	3,185,960	3,050,160	2,940,550	1,963,680	3,171,010	1,963,680	3,185,960	2,907,027
Cyprus	14,870	10,650	12,640	12,730	17,270	13,420	10,650	17,270	13,597
Latvia	0	0	0	0	0	0	0	0	0
Lithuania	0	0	0	0	0	0	0	0	0
Luxembourg	0	0	0	0	0	0	0	0	0
Hungary	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0
Netherlands	0	0	0	0	0	0	0	0	0
Austria	0	0	0	0	0	0	0	0	0
Poland	0	0	0	0	0	0	0	0	0
Portugal	445,300	519,780	429,920	651,740	455,370	723	723	651,740	417,139
Romania	0	0	0	0	0	0	0	0	0
Slovenia	1,900	1,700	740	n/a	n/a	1,580	740	1,900	1,480
Slovakia	0	0	0	0	0	0	0	0	0
Finland	0	0	0	0	0	0	0	0	0
Sweden	0	0	0	0	0	0	0	0	0
United Kingdom	0	0	0	0	0	0	0	0	0

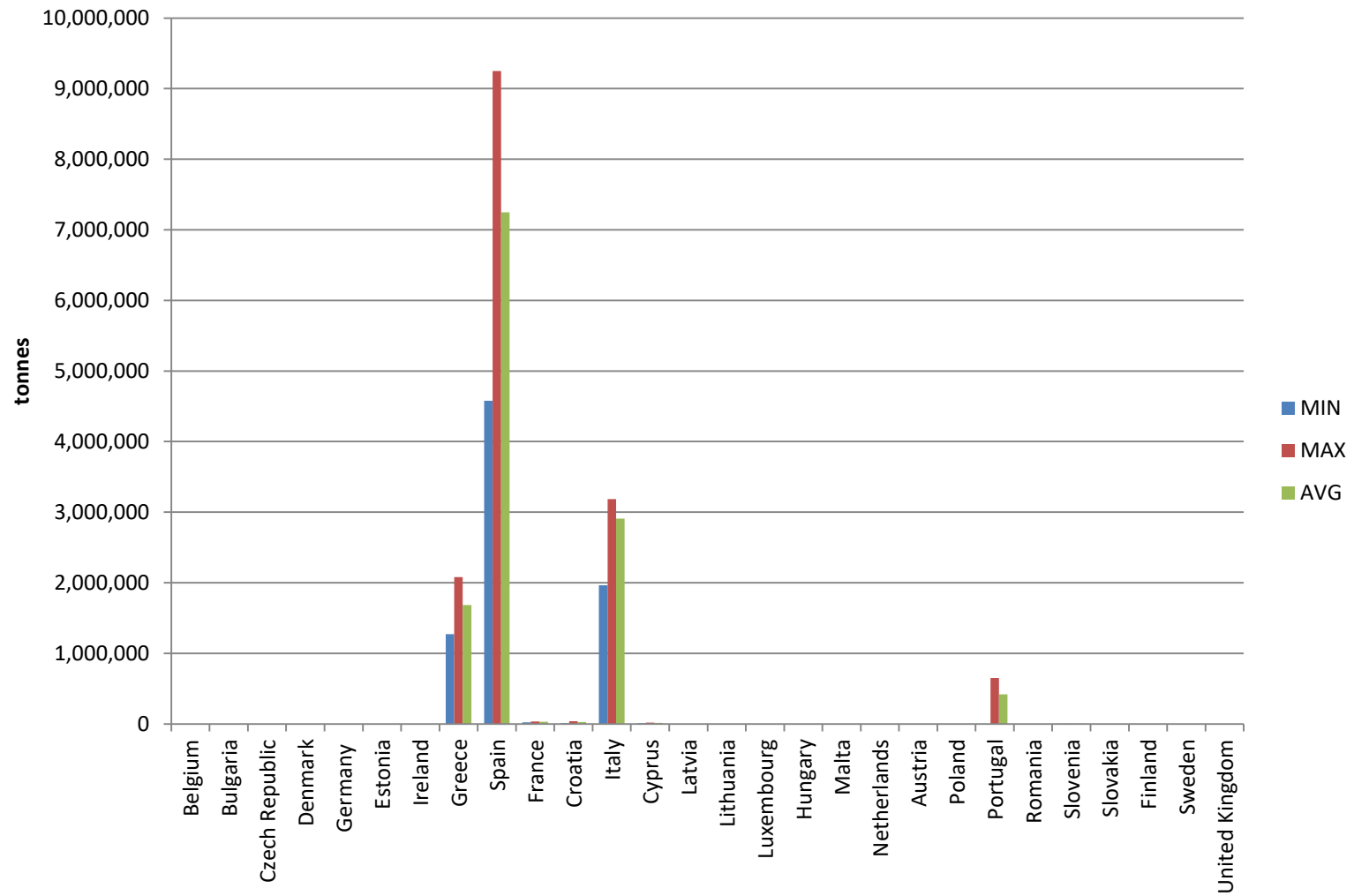


Figure 94 Tonnes of harvested olives per country, 2010-2015

Table 68 Tonnes of olive twigs and leaves per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	0	0	0	0	0	0	0	0	0
Bulgaria	0	0	0	0	0	0	0	0	0
Czech Republic	0	0	0	0	0	0	0	0	0
Denmark	0	0	0	0	0	0	0	0	0
Germany	0	0	0	0	0	0	0	0	0
Estonia	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0
Greece	4,832,193	5,003,206	5,555,656	3,462,029	4,755,430	3,390,500	3,390,500	5,555,656	4,499,836
Spain	n/a	20,879,560	n/a	24,699,129	12,222,726	19,610,669	12,222,726	24,699,129	19,353,021
France	84,666	62,264	78,925	78,498	n/a	91,848	62,264	91,848	79,240
Croatia	101,460	n/a	n/a	n/a	23,603	75,481	23,603	101,460	66,848
Italy	8,359,236	8,506,513	8,143,927	7,851,269	5,243,026	8,466,597	5,243,026	8,506,513	7,761,761
Cyprus	39,703	28,436	33,749	33,989	46,111	35,831	28,436	46,111	36,303
Latvia	0	0	0	0	0	0	0	0	0
Lithuania	0	0	0	0	0	0	0	0	0
Luxembourg	0	0	0	0	0	0	0	0	0
Hungary	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0
Netherlands	0	0	0	0	0	0	0	0	0
Austria	0	0	0	0	0	0	0	0	0
Poland	0	0	0	0	0	0	0	0	0
Portugal	1,188,951	1,387,813	1,147,886	1,740,146	1,215,838	1,930	1,930	1,740,146	1,113,761
Romania	0	0	0	0	0	0	0	0	0
Slovenia	5,073	4,539	1,976	n/a	n/a	4,219	1,976	5,073	3,952
Slovakia	0	0	0	0	0	0	0	0	0
Finland	0	0	0	0	0	0	0	0	0
Sweden	0	0	0	0	0	0	0	0	0
United Kingdom	0	0	0	0	0	0	0	0	0

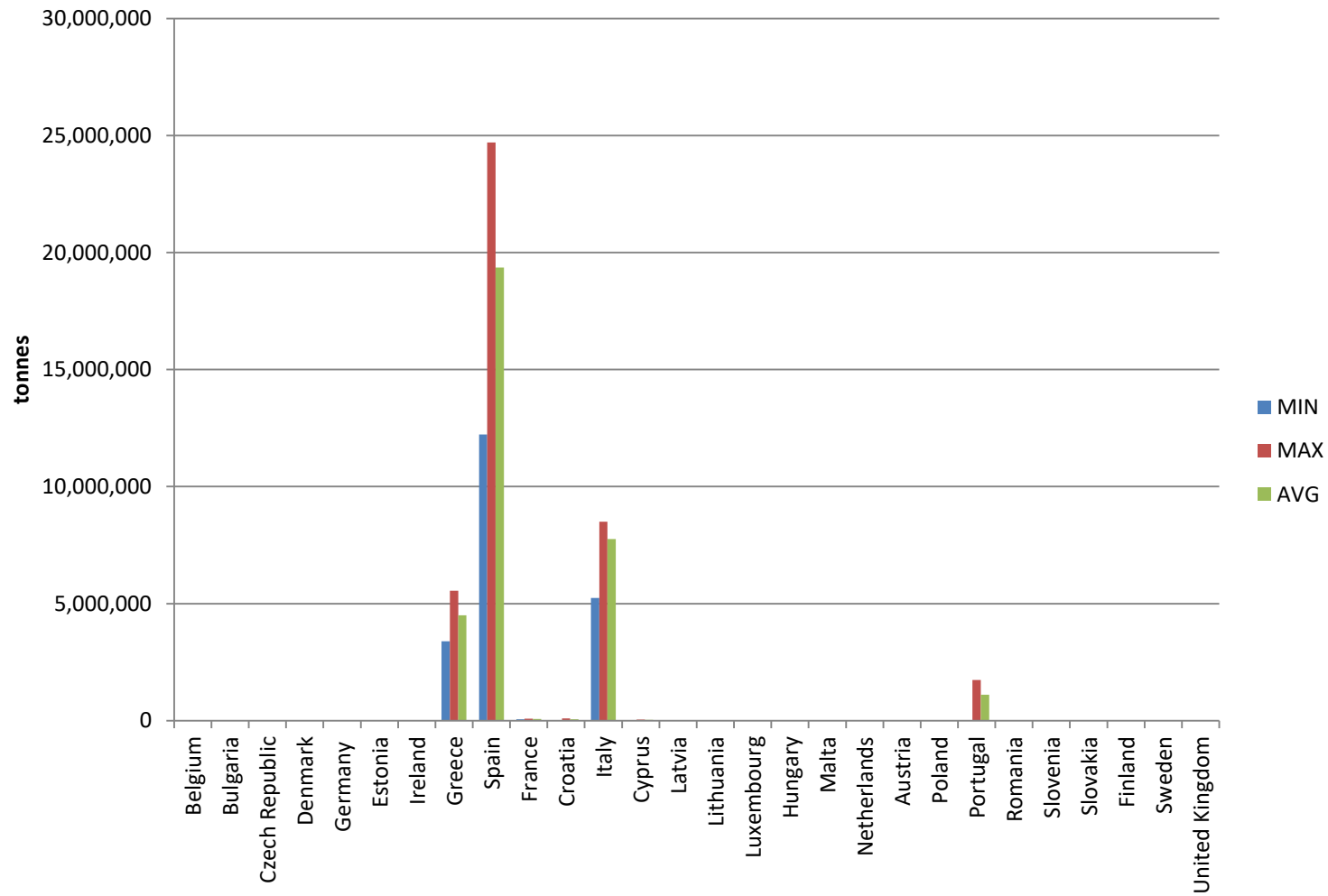


Figure 95 Tonnes of olive twigs and leaves per country, 2010-2015

Table 69 Tonnes of wooden olive branches per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	0	0	0	0	0	0	0	0	0
Bulgaria	0	0	0	0	0	0	0	0	0
Czech Republic	0	0	0	0	0	0	0	0	0
Denmark	0	0	0	0	0	0	0	0	0
Germany	0	0	0	0	0	0	0	0	0
Estonia	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0
Greece	4,832,193	5,003,206	5,555,656	3,462,029	4,755,430	3,390,500	3,390,500	5,555,656	4,499,836
Spain	n/a	20,879,560	n/a	24,699,129	12,222,726	19,610,669	12,222,726	24,699,129	19,353,021
France	84,666	62,264	78,925	78,498	n/a	91,848	62,264	91,848	79,240
Croatia	101,460	n/a	n/a	n/a	23,603	75,481	23,603	101,460	66,848
Italy	8,359,236	8,506,513	8,143,927	7,851,269	5,243,026	8,466,597	5,243,026	8,506,513	7,761,761
Cyprus	39,703	28,436	33,749	33,989	46,111	35,831	28,436	46,111	36,303
Latvia	0	0	0	0	0	0	0	0	0
Lithuania	0	0	0	0	0	0	0	0	0
Luxembourg	0	0	0	0	0	0	0	0	0
Hungary	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0
Netherlands	0	0	0	0	0	0	0	0	0
Austria	0	0	0	0	0	0	0	0	0
Poland	0	0	0	0	0	0	0	0	0
Portugal	1,188,951	1,387,813	1,147,886	1,740,146	1,215,838	1,930	1,930	1,740,146	1,113,761
Romania	0	0	0	0	0	0	0	0	0
Slovenia	5,073	4,539	1,976	n/a	n/a	4,219	1,976	5,073	3,952
Slovakia	0	0	0	0	0	0	0	0	0
Finland	0	0	0	0	0	0	0	0	0
Sweden	0	0	0	0	0	0	0	0	0
United Kingdom	0	0	0	0	0	0	0	0	0



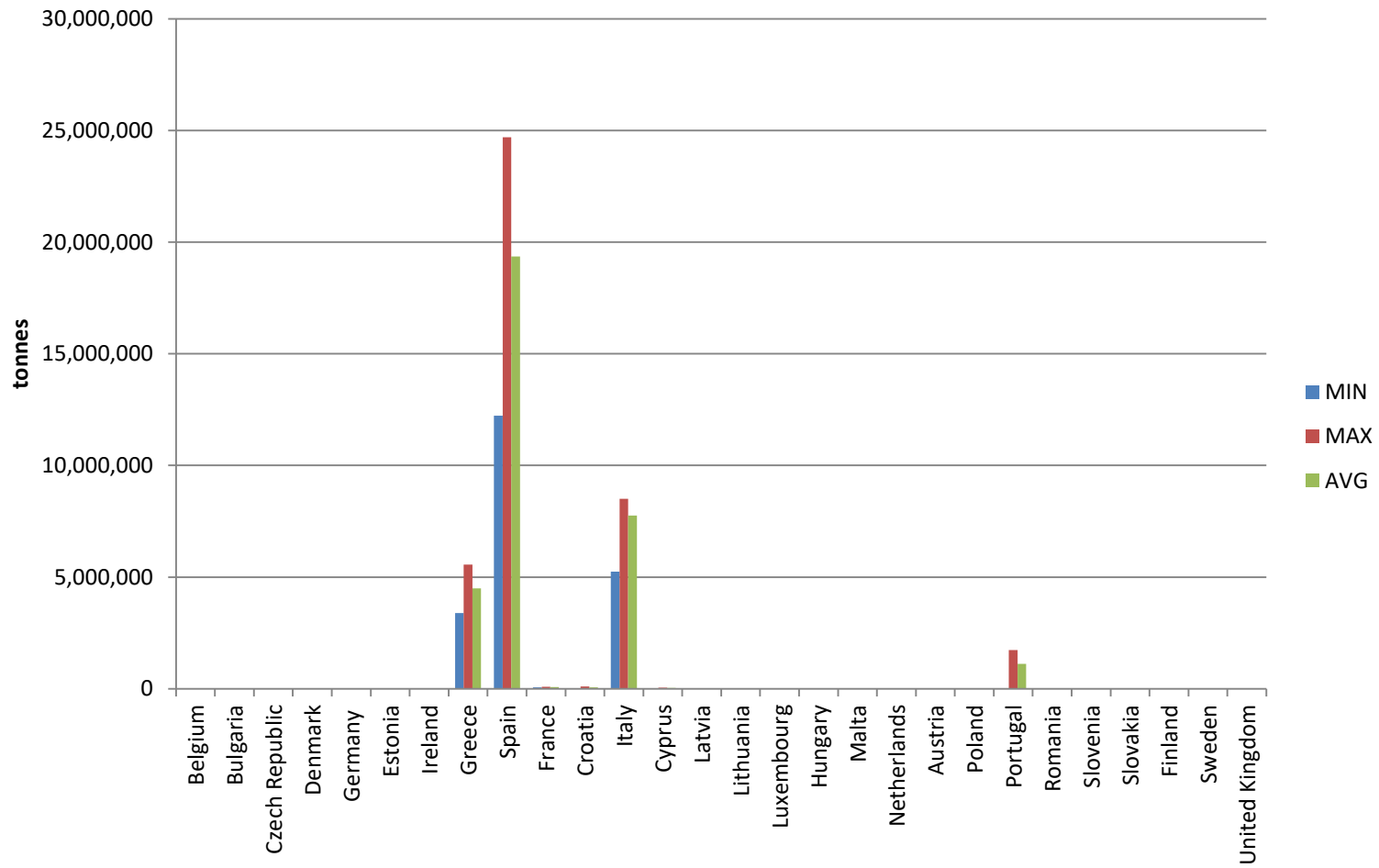


Figure 96 Tonnes of wooden olive branches per country, 2010-2015

Table 70 Tonnes of processed olives for oil per country, 2010-2015 (Eurostat: Agricultural production - crops, n.d.)

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	0	0	0	0	0	0	0	0	0
Bulgaria	0	0	0	0	0	0	0	0	0
Czech Republic	0	0	0	0	0	0	0	0	0
Denmark	0	0	0	0	0	0	0	0	0
Germany	0	0	0	0	0	0	0	0	0
Estonia	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0
Greece	1,662,350	1,699,910	1,793,520	638,000	1,570,930	889,010	638,000	1,793,520	1,375,620
Spain	6,682,010	7,352,700	3,448,610	8,766,900	4,142,980	6,804,340	3,448,610	8,766,900	6,199,590
France	31,310	23,030	29,220	28,870	12,740	33,900	12,740	33,900	26,512
Croatia	38,000	31,420	50,950	34,200	8,840	28,270	8,840	50,950	31,947
Italy	3,060,390	3,133,730	2,967,290	2,852,700	1,903,430	0	0	3,133,730	2,319,590
Cyprus	11,860	7,640	9,620	9,760	13,760	11,320	7,640	13,760	10,660
Latvia	0	0	0	0	0	0	0	0	0
Lithuania	0	0	0	0	0	0	0	0	0
Luxembourg	0	0	0	0	0	0	0	0	0
Hungary	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0
Netherlands	0	0	0	0	0	0	0	0	0
Austria	0	0	0	0	0	0	0	0	0
Poland	0	0	0	0	0	0	0	0	0
Portugal	435,010	510,730	417,950	634,210	437,970	702,140	417,950	702,140	523,002
Romania	0	0	0	0	0	0	0	0	0
Slovenia	1,900	1,700	740	1,480	810	1,580	740	1,900	1,368
Slovakia	0	0	0	0	0	0	0	0	0
Finland	0	0	0	0	0	0	0	0	0
Sweden	0	0	0	0	0	0	0	0	0
United Kingdom	0	0	0	0	0	0	0	0	0

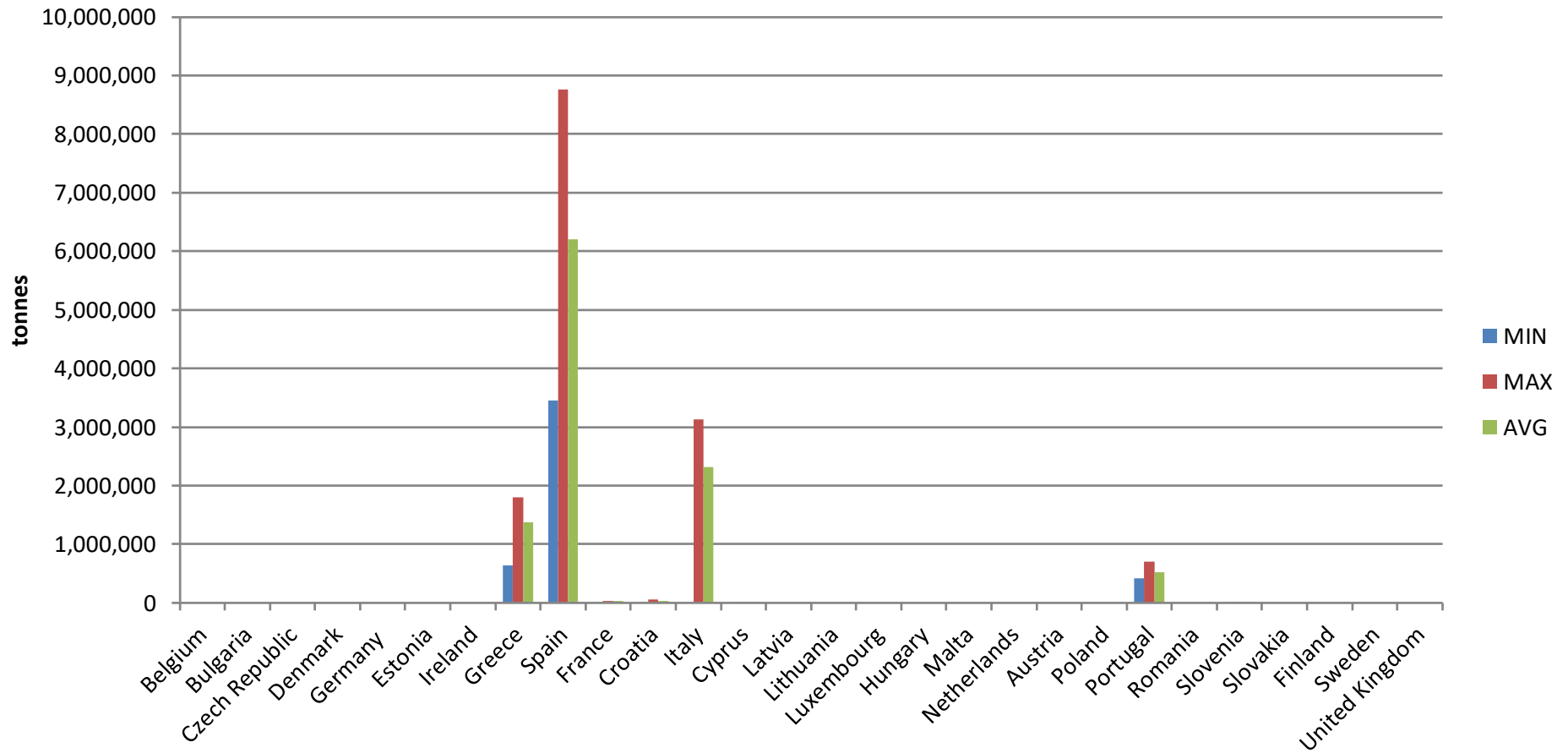


Figure 97 Tonnes of processed olives for oil per country, 2010-2015

Table 71 Volume of olive mill wastewater in m<sup>3</sup> per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	0	0	0	0	0	0	0	0	0
Bulgaria	0	0	0	0	0	0	0	0	0
Czech Republic	0	0	0	0	0	0	0	0	0
Denmark	0	0	0	0	0	0	0	0	0
Germany	0	0	0	0	0	0	0	0	0
Estonia	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0
Greece	1,745,468	1,784,906	1,883,196	669,900	1,649,477	933,461	669,900	1,883,196	1,444,401
Spain	7,016,111	7,720,335	3,621,041	9,205,245	4,350,129	7,144,557	3,621,041	9,205,245	6,509,570
France	32,876	24,182	30,681	30,314	13,377	35,595	13,377	35,595	27,837
Croatia	39,900	32,991	53,498	35,910	9,282	29,684	9,282	53,498	33,544
Italy	3,213,410	3,290,417	3,115,655	2,995,335	1,998,602	0	0	3,290,417	2,435,570
Cyprus	12,453	8,022	10,101	10,248	14,448	11,886	8,022	14,448	11,193
Latvia	0	0	0	0	0	0	0	0	0
Lithuania	0	0	0	0	0	0	0	0	0
Luxembourg	0	0	0	0	0	0	0	0	0
Hungary	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0
Netherlands	0	0	0	0	0	0	0	0	0
Austria	0	0	0	0	0	0	0	0	0
Poland	0	0	0	0	0	0	0	0	0
Portugal	456,761	536,267	438,848	665,921	459,869	737,247	438,848	737,247	549,152
Romania	0	0	0	0	0	0	0	0	0
Slovenia	1,995	1,785	777	1,554	851	1,659	777	1,995	1,437
Slovakia	0	0	0	0	0	0	0	0	0
Finland	0	0	0	0	0	0	0	0	0
Sweden	0	0	0	0	0	0	0	0	0
United Kingdom	0	0	0	0	0	0	0	0	0

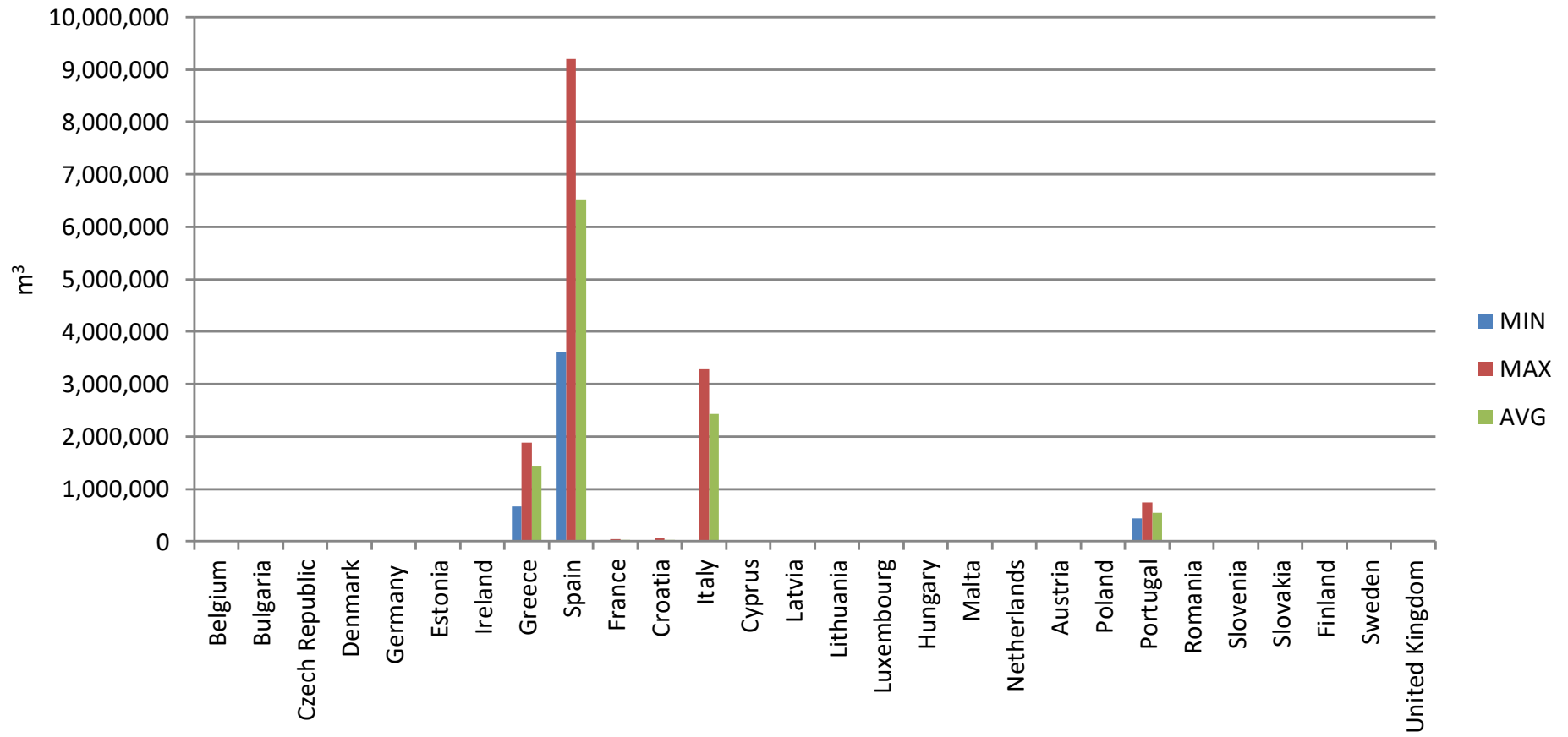


Figure 98 Volume of olive mill wastewater per country, 2010-2015

Table 72 Tonnes of olive pomace per country, 2010-2015

GEO/TIME	2010	2011	2012	2013	2014	2015	MIN	MAX	AVG
Belgium	0	0	0	0	0	0	0	0	0
Bulgaria	0	0	0	0	0	0	0	0	0
Czech Republic	0	0	0	0	0	0	0	0	0
Denmark	0	0	0	0	0	0	0	0	0
Germany	0	0	0	0	0	0	0	0	0
Estonia	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0
Greece	914,293	934,951	986,436	350,900	864,012	488,956	350,900	986,436	756,591
Spain	3,675,106	4,043,985	1,896,736	4,821,795	2,278,639	3,742,387	1,896,736	4,821,795	3,409,775
France	17,221	12,667	16,071	15,879	7,007	18,645	7,007	18,645	14,581
Croatia	20,900	17,281	28,023	18,810	4,862	15,549	4,862	28,023	17,571
Italy	1,683,215	1,723,552	1,632,010	1,568,985	1,046,887	0	0	1,723,552	1,275,775
Cyprus	6,523	4,202	5,291	5,368	7,568	6,226	4,202	7,568	5,863
Latvia	0	0	0	0	0	0	0	0	0
Lithuania	0	0	0	0	0	0	0	0	0
Luxembourg	0	0	0	0	0	0	0	0	0
Hungary	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0
Netherlands	0	0	0	0	0	0	0	0	0
Austria	0	0	0	0	0	0	0	0	0
Poland	0	0	0	0	0	0	0	0	0
Portugal	239,256	280,902	229,873	348,816	240,884	386,177	229,873	386,177	287,651
Romania	0	0	0	0	0	0	0	0	0
Slovenia	1,045	935	407	814	446	869	407	1,045	753
Slovakia	0	0	0	0	0	0	0	0	0
Finland	0	0	0	0	0	0	0	0	0
Sweden	0	0	0	0	0	0	0	0	0
United Kingdom	0	0	0	0	0	0	0	0	0

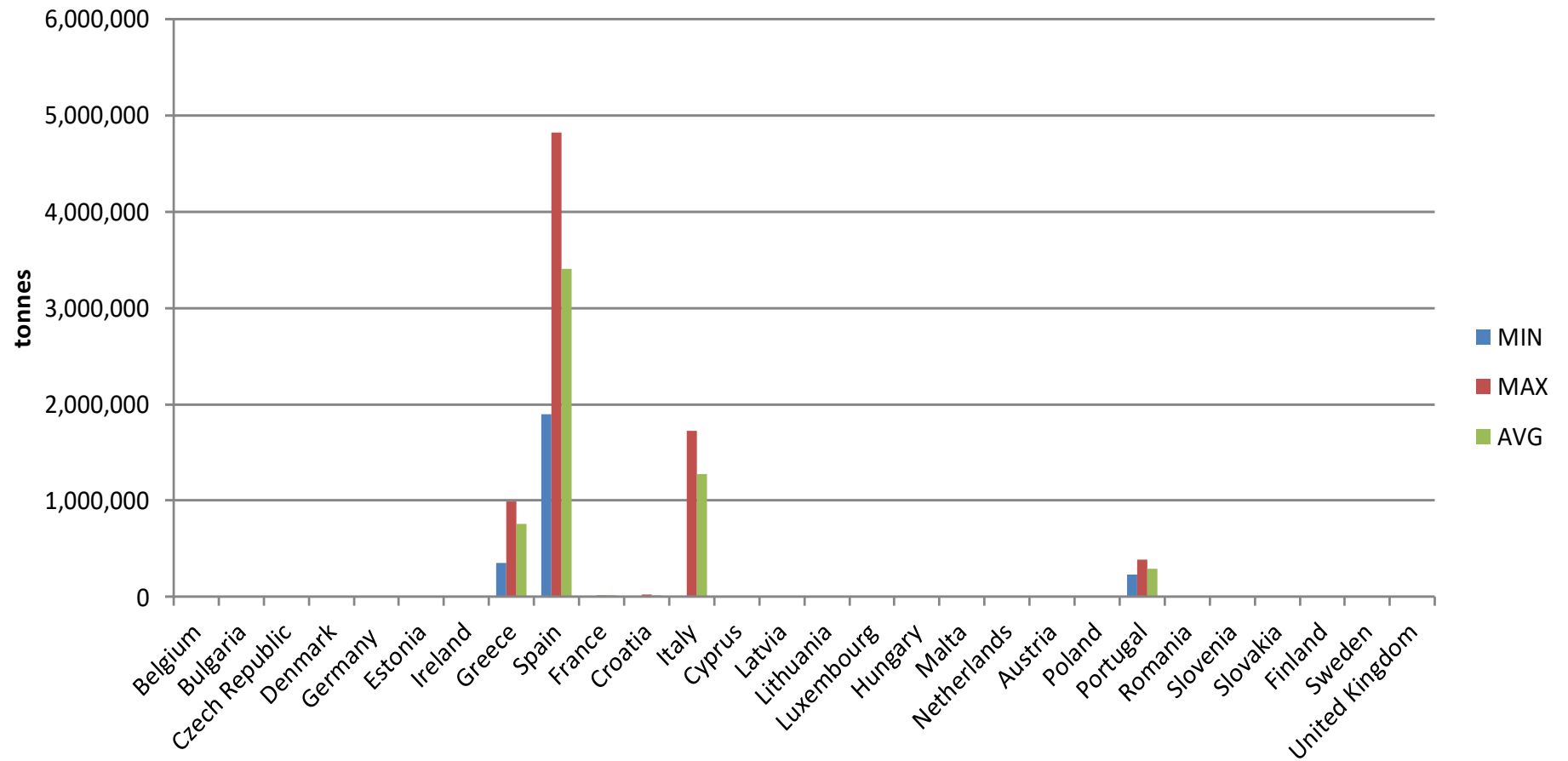


Figure 99 Tonnes of olive pomace per country, 2010-2015

Table 73 Consumption of table olives (tonnes) per country, 2010-2014 (IOC-International Olive Council, n.d.)

GEO/TIME	2010	2011	2012	2013	2014	MIN	MAX	AVG
Belgium	8,200	7,500	13,100	9,100	8,800	7,500	13,100	9,340
Bulgaria	13,200	14,000	28,100	13,200	11,900	11,900	28,100	16,080
Czech Republic	9,000	5,000	5,000	9,200	2,200	2,200	9,200	6,080
Denmark	3,800	4,600	3,700	2,300	2,600	2,300	4,600	3,400
Germany	57,800	62,900	65,100	40,800	36,700	36,700	65,100	52,660
Estonia	200	600	400	500	300	200	600	400
Ireland	300	300	900	1,100	1,300	300	1,300	780
Greece	20,000	16,000	15,000	20,000	14,000	14,000	20,000	17,000
Spain	107,900	150,000	217,900	188,600	175,400	107,900	217,900	167,960
France	56,800	58,000	56,200	67,300	60,000	56,200	67,300	59,660
Croatia	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300
Italy	122,400	148,000	139,800	145,200	119,700	119,700	148,000	135,020
Cyprus	4,400	4,300	4,400	3,400	3,600	3,400	4,400	4,020
Latvia	4,000	4,000	900	500	500	500	4,000	1,980
Lithuania	1,200	1,400	1,500	800	1,200	800	1,500	1,220
Luxembourg	600	600	600	900	900	600	900	720
Hungary	900	1,200	1,500	1,200	1,700	900	1,700	1,300
Malta	1,200	1,400	1,200	1,600	1,300	1,200	1,600	1,340
Netherlands	14,600	6,500	7,400	2,400	2,700	2,400	14,600	6,720
Austria	3,800	6,100	6,500	4,100	4,400	3,800	6,500	4,980
Poland	8,300	9,800	8,500	7,600	9,000	7,600	9,800	8,640
Portugal	7,000	10,000	7,000	6,000	6,000	6,000	10,000	7,200
Romania	22,900	23,500	22,000	17,500	19,200	17,500	23,500	21,020
Slovenia	1,000	1,000	1,000	600	700	600	1,000	860
Slovakia	1,600	2,000	1,700	1,700	1,400	1,400	2,000	1,680
Finland	3,100	3,700	3,300	1,900	2,000	1,900	3,700	2,800
Sweden	10,300	10,400	10,300	7,100	7,600	7,100	10,400	9,140
United Kingdom	33,700	39,600	41,600	34,600	34,100	33,700	41,600	36,720



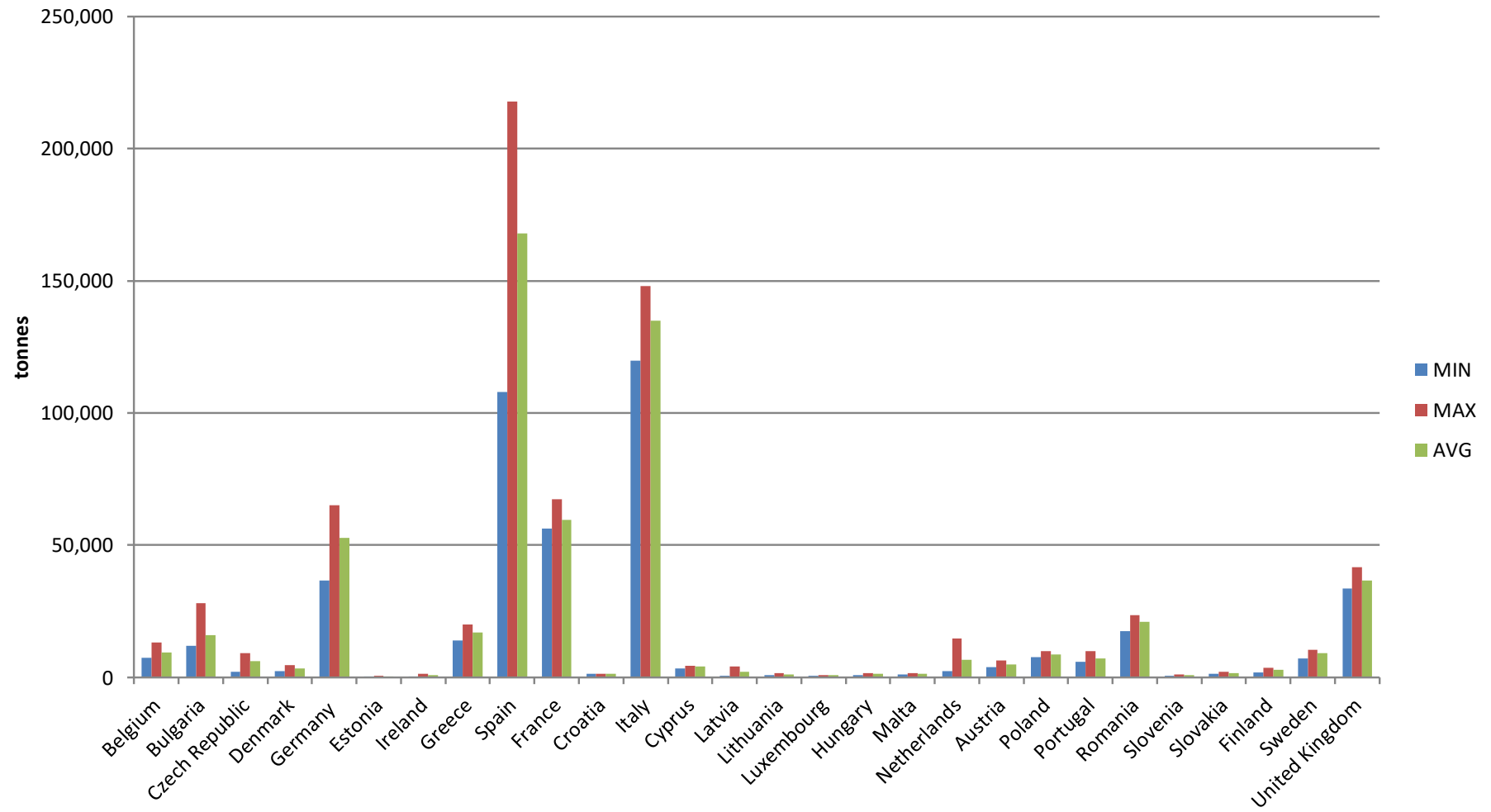


Figure 100 Consumption of table olives (tonnes) per country, 2010-2014

Table 74 Tonnes of rotten table olives per country, 2010-2014

GEO/TIME	2010	2011	2012	2013	2014	MIN	MAX	AVG
Belgium	410	375	655	455	440	375	655	467
Bulgaria	660	700	1,405	660	595	595	1,405	804
Czech Republic	450	250	250	460	110	110	460	304
Denmark	190	230	185	115	130	115	230	170
Germany	2,890	3,145	3,255	2,040	1,835	1,835	3,255	2,633
Estonia	10	30	20	25	15	10	30	20
Ireland	15	15	45	55	65	15	65	39
Greece	1,000	800	750	1,000	700	700	1,000	850
Spain	5,395	7,500	10,895	9,430	8,770	5,395	10,895	8,398
France	2,840	2,900	2,810	3,365	3,000	2,810	3,365	2,983
Croatia	65	65	65	65	65	65	65	65
Italy	6,120	7,400	6,990	7,260	5,985	5,985	7,400	6,751
Cyprus	220	215	220	170	180	170	220	201
Latvia	200	200	45	25	25	25	200	99
Lithuania	60	70	75	40	60	40	75	61
Luxembourg	30	30	30	45	45	30	45	36
Hungary	45	60	75	60	85	45	85	65
Malta	60	70	60	80	65	60	80	67
Netherlands	730	325	370	120	135	120	730	336
Austria	190	305	325	205	220	190	325	249
Poland	415	490	425	380	450	380	490	432
Portugal	350	500	350	300	300	300	500	360
Romania	1,145	1,175	1,100	875	960	875	1,175	1,051
Slovenia	50	50	50	30	35	30	50	43
Slovakia	80	100	85	85	70	70	100	84
Finland	155	185	165	95	100	95	185	140
Sweden	515	520	515	355	380	355	520	457
United Kingdom	1,685	1,980	2,080	1,730	1,705	1,685	2,080	1,836

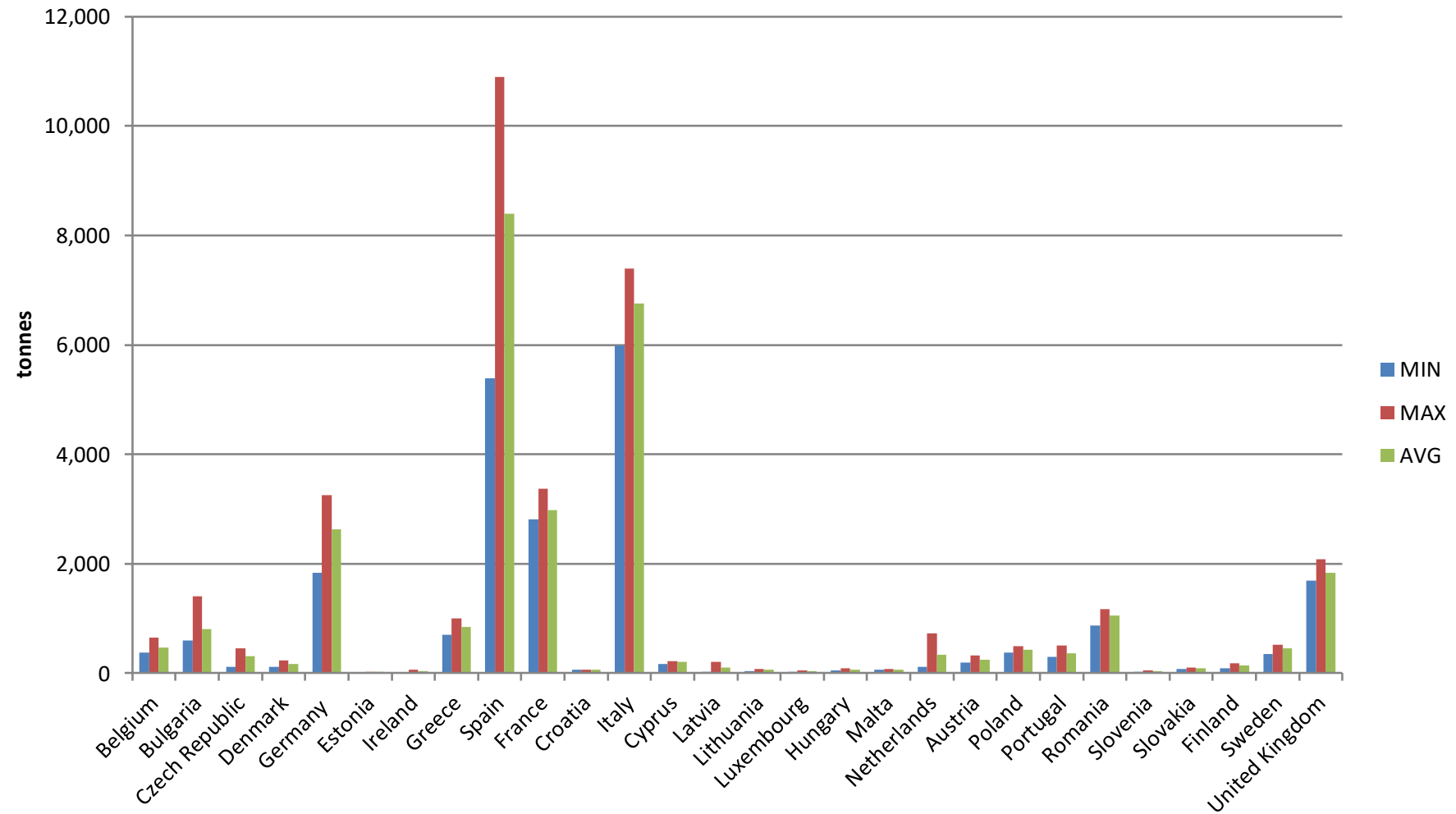


Figure 101 Tonnes of rotten table olives per country, 2010-2014

Table 75 Consumption of olive oil (tonnes) per country, 2010-2014 (IOC-International Olive Council, n.d.)

GEO/TIME	2010	2011	2012	2013	2014	MIN	MAX	AVG
Belgium	12,300	13,700	13,400	13,800	15,400	12,300	15,400	13,720
Bulgaria	1,300	1,300	1,900	2,000	2,800	1,300	2,800	1,860
Czech Republic	4,400	6,100	5,000	4,000	6,300	4,000	6,300	5,160
Denmark	4,300	5,900	4,800	5,800	6,700	4,300	6,700	5,500
Germany	50,100	58,800	61,000	60,500	66,000	50,100	66,000	59,280
Estonia	300	400	600	500	700	300	700	500
Ireland	5,700	6,300	4,800	5,800	6,400	4,800	6,400	5,800
Greece	228,500	227,500	200,000	180,000	140,000	140,000	228,500	195,200
Spain	539,400	554,200	574,000	486,900	524,800	486,900	574,000	535,860
France	114,800	112,800	112,000	113,100	110,600	110,600	114,800	112,660
Croatia	7,100	7,100	7,100	7,100	7,100	7,100	7,100	7,100
Italy	675,700	660,000	610,000	550,000	641,100	550,000	675,700	627,360
Cyprus	5,000	6,500	6,300	6,000	6,300	5,000	6,500	6,020
Latvia	1,200	1,500	1,600	1,500	1,200	1,200	1,600	1,400
Lithuania	700	1,000	800	1,100	1,200	700	1,200	960
Luxembourg	1,100	1,200	1,400	3,000	1,800	1,100	3,000	1,700
Hungary	2,300	2,500	2,100	2,200	2,700	2,100	2,700	2,360
Malta	700	600	700	700	1,300	600	1,300	800
Netherlands	27,200	16,300	14,600	14,400	13,900	13,900	27,200	17,280
Austria	8,900	8,700	9,200	8,000	8,700	8,000	9,200	8,700
Poland	3,500	9,600	10,400	7,900	8,000	3,500	10,400	7,880
Portugal	87,800	82,000	78,000	74,000	75,000	74,000	87,800	79,360
Romania	3,200	5,700	3,700	3,500	3,600	3,200	5,700	3,940
Slovenia	2,000	2,100	1,900	1,900	2,300	1,900	2,300	2,040
Slovakia	1,200	1,800	1,800	1,600	1,700	1,200	1,800	1,620
Finland	1,700	2,400	2,700	2,900	4,000	1,700	4,000	2,740
Sweden	7,400	8,100	8,400	8,300	10,000	7,400	10,000	8,440
United Kingdom	55,300	69,500	59,200	62,000	61,300	55,300	69,500	61,460

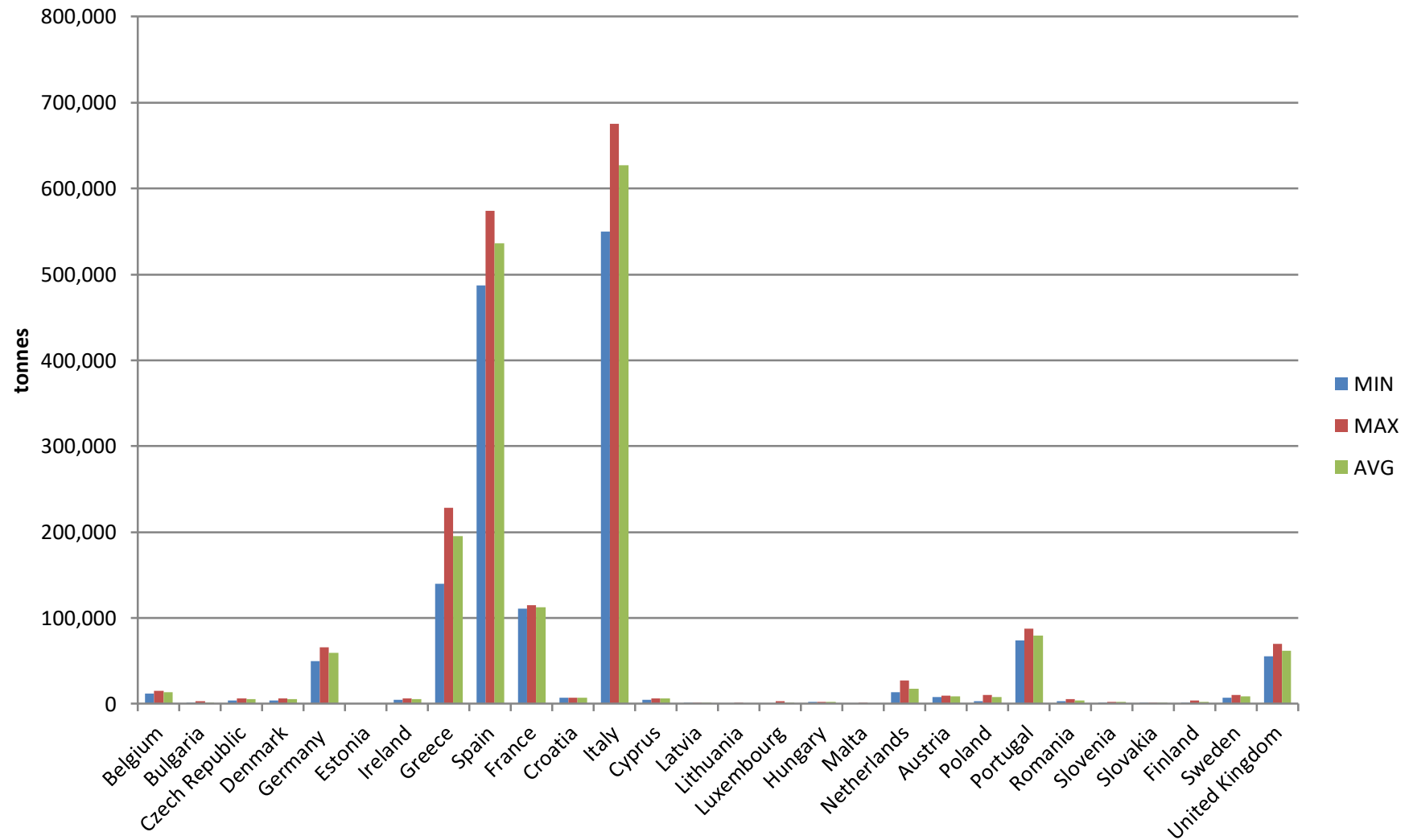


Figure 102 Consumption of olive oil (tonnes) per country, 2010-2014

Table 76 Tonnes of spoiled olive oil per country, 2010-2014

GEO/TIME	2010	2011	2012	2013	2014	MIN	MAX	AVG
Belgium	2,337	2,603	2,546	2,622	2,926	2,337	2,926	2,607
Bulgaria	247	247	361	380	532	247	532	353
Czech Republic	836	1,159	950	760	1,197	760	1,197	980
Denmark	817	1,121	912	1,102	1,273	817	1,273	1,045
Germany	9,519	11,172	11,590	11,495	12,540	9,519	12,540	11,263
Estonia	57	76	114	95	133	57	133	95
Ireland	1,083	1,197	912	1,102	1,216	912	1,216	1,102
Greece	43,415	43,225	38,000	34,200	26,600	26,600	43,415	37,088
Spain	102,486	105,298	109,060	92,511	99,712	92,511	109,060	101,813
France	21,812	21,432	21,280	21,489	21,014	21,014	21,812	21,405
Croatia	1,349	1,349	1,349	1,349	1,349	1,349	1,349	1,349
Italy	128,383	125,400	115,900	104,500	121,809	104,500	128,383	119,198
Cyprus	950	1,235	1,197	1,140	1,197	950	1,235	1,144
Latvia	228	285	304	285	228	228	304	266
Lithuania	133	190	152	209	228	133	228	182
Luxembourg	209	228	266	570	342	209	570	323
Hungary	437	475	399	418	513	399	513	448
Malta	133	114	133	133	247	114	247	152
Netherlands	5,168	3,097	2,774	2,736	2,641	2,641	5,168	3,283
Austria	1,691	1,653	1,748	1,520	1,653	1,520	1,748	1,653
Poland	665	1,824	1,976	1,501	1,520	665	1,976	1,497
Portugal	16,682	15,580	14,820	14,060	14,250	14,060	16,682	15,078
Romania	608	1,083	703	665	684	608	1,083	749
Slovenia	380	399	361	361	437	361	437	388
Slovakia	228	342	342	304	323	228	342	308
Finland	323	456	513	551	760	323	760	521
Sweden	1,406	1,539	1,596	1,577	1,900	1,406	1,900	1,604
United Kingdom	10,507	13,205	11,248	11,780	11,647	10,507	13,205	11,677

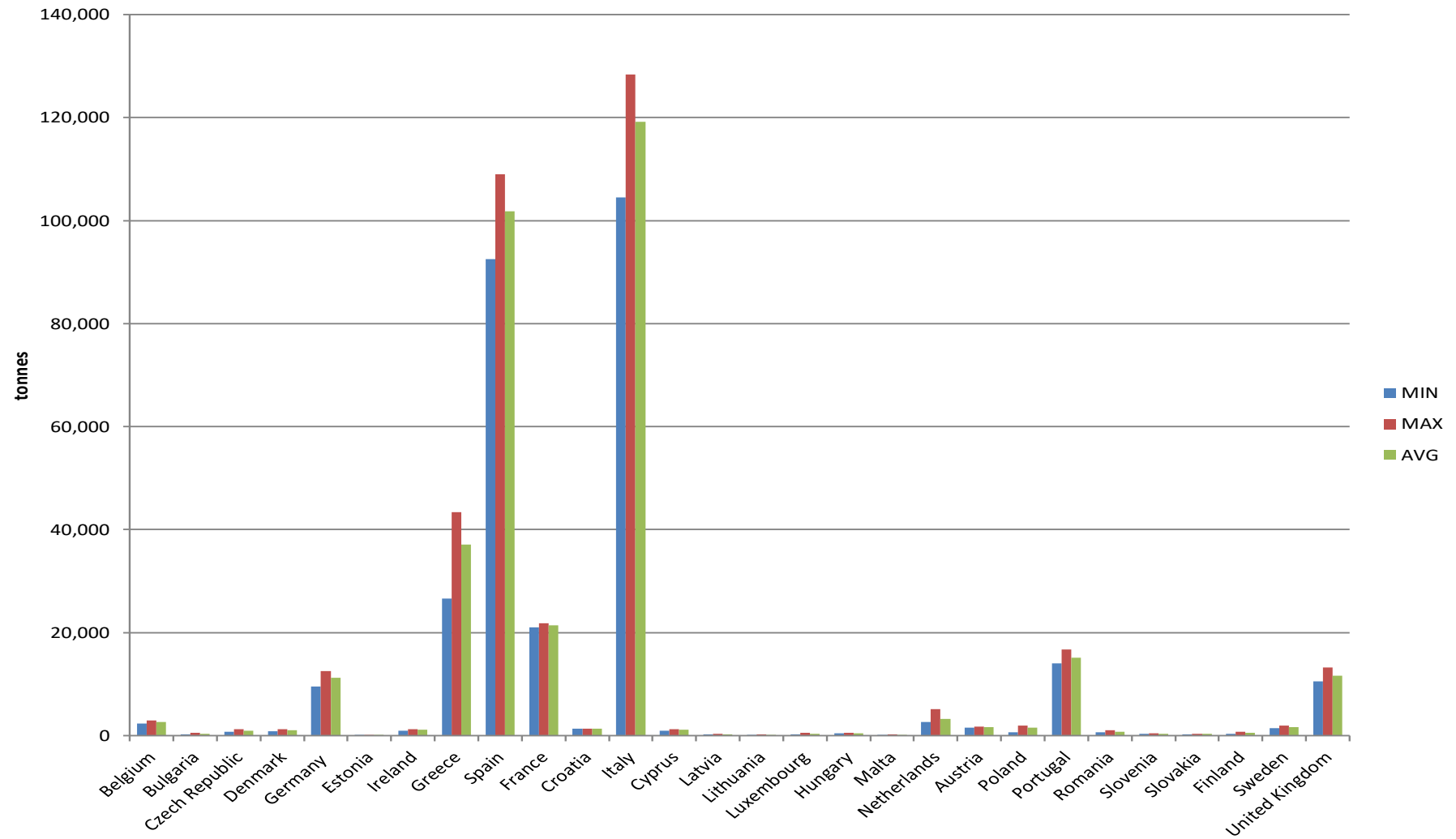


Figure 103 Tonnes of spoiled olive oil per country, 2010-2014

### 3 Current practices of commodity AWCB valorisation

AWCB generated across the vegetable value chain can be employed in many different ways. If any disease does not infect the AWCB, it can be used as animal feed, e.g. the leaves of sugar beet, cauliflower and cabbages are used for feeding cattle and pigs (Wadhwa & Bakshi, 2013). Lycopene, one of the greatest antioxidants used in detoxification of the body can be extracted from AWCBs of tomatoes (Poojary & Passamonti, 2015). By-products of potato processing can have a useful role in biochemical/pharmaceutical and fermentation applications as substrates for production of various bio-molecules (potato pulp), or in tissue engineering applications (potato starch) (Singh & Kaur, 2016). Wastewater sludge from vegetable oils and cooking oil after its use has a potential to be converted into biodiesel in a process with various bio-catalysts (El-Gendy, Deriase, Hamdy, & Abdallah, 2015), (Gunawan, i dr., 2014).

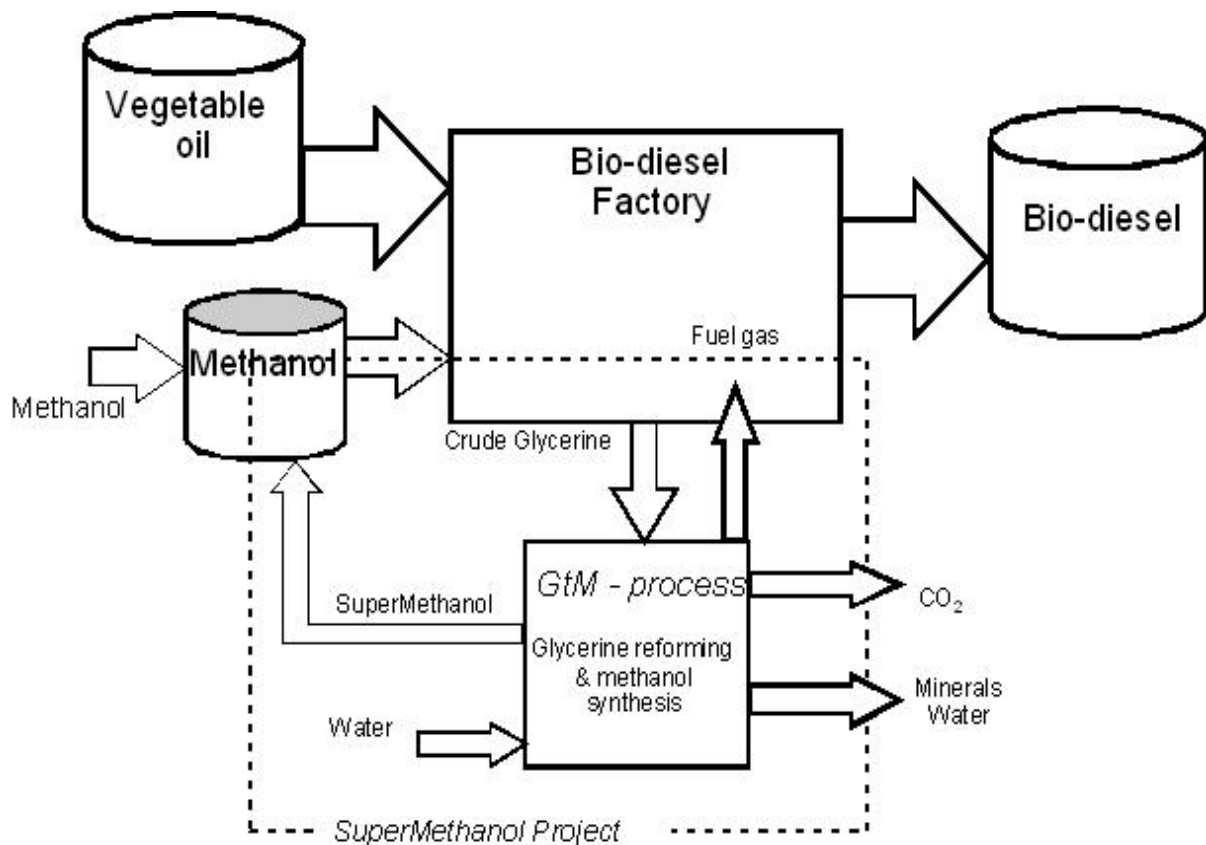


Figure 104 A schematic of bio-diesel production from vegetable oil and methanol (El-Gendy, Deriase, Hamdy, & Abdallah, 2015)



Onion skin produced from processed onions can be valorised to produce bio sugar and quercetin (Choi, Cho, Moon, & Bae, 2015). Sugar beet pulp contains pectin gels that can be valorised as biosorbent for heavy metals (Mata, Blazquez, Ballester, Gonzalez, & Muñoz, 2009).

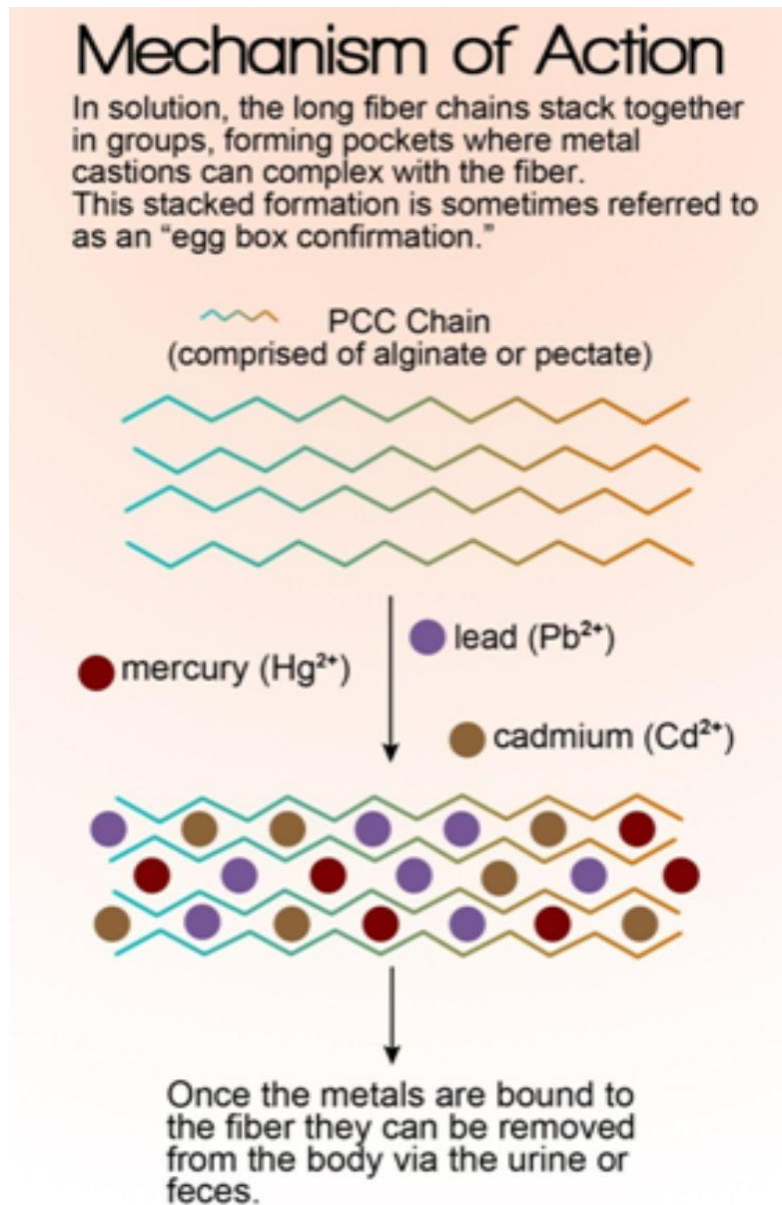


Figure 105 Pectin used as biosorbent for heavy metals (Eliaz, 2013)

Sugar factory lime can be used for immobilization of toxic metals (Cd, Co, Cr, Pb, Zn, etc) under different redox potentials in contaminated floodplain soils (Shaheen & Rinklebe, 2017). Sugar beet tailings can be valorised as a feedstock for anaerobic digestion (Tian, Chauliac, & Pullammanappallil, 2013). Rapeseed cake meal can be used in animal's diet, due

to an optimal concentration of proteins (Kasprzak, i dr., 2016). Furthermore, it can be used as a surface for production of different bacteria (Jajor, Pilakowska-Pietras, Krasowska, & Lukaszewicz, 2016). Rapeseed cake can be valorised in pyrolytic processes with different catalysts in order to produce different chemical compounds (such as nitrites, aromatics and aliphatic hydrocarbons) (Smets, i dr., 2013). Generally, rapeseed biomass can be used for bio-sorption of lead ions from aqueous solutions (Morosanu, Teodosiu, Paduraru, Ibanescu, & Tofan). Sunflower cake can be used for the production of new materials, such as fibreboards, that are biodegradable (Evon, Vinet, Labonne, & Rigal, 2015). Sunflower cake can be used in a process of pyrolysis with several inorganic reagents for biofuels production (Shie, i dr., 2011). Potato skin (peel) can be valorised to develop biopolymer film combined with sweet lime pomace by ultrasound (Borah, Das, & Badwaik, 2017). Potato skin can also be used for sorption of cadmium ions (toxic) from aqueous solutions (Asuquo & Martin, 2016). Carrot pomace from carrot processing facilities can be valorised in bioethanol production (Demiray, Karatay, Donmez, & Donmez, 2014). Sugars and natural antioxidants can be extracted from olive leaves and used in the human diet (Romero-García, i dr., 2016). Olive leaves contain oleuropein that can be extracted by several unit operations (Khemakhem, Gargouri, Dhouib, Ayadi, & Bouaziz, 2017). Figure 106 shows the structure of oleuropein (Omar, 2010). Studies showed that it has pharmacological applications.

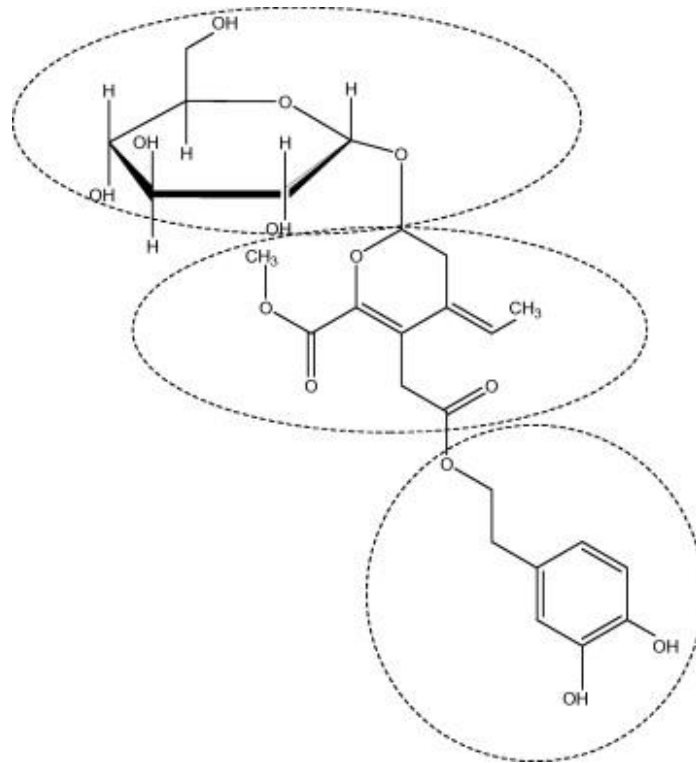


Figure 106 Structure of oleuropein (Omar, 2010)

Polyphenols from olive pomace extract can be used in a process of encapsulation in order to produce nanoparticles (Aliakbarian, Pains, Adami, Perego, & Reverchon, 2017). Another use of olive pomace is in the production of astaxanthin, one of many terpenes. Astaxanthin is used for protection of skin from sunburn, photodermatitis and allergies (Betül Eryılmaz, Dursun, & Coşkun Dalgıç, 2016). Another possible application of olive pomace is in the extraction of the bacteria it harbours (Dashti, i dr., 2015). Those bacteria can be used in bioremediation processes, due to the diversity of their nature. Olive mill wastewater has an application in a treatment of crops, as a biopesticide (El-Abbassi, Saadaoui, Kiai, Raiti, & Hafidi, 2017).

AWCB source	Characteristics	Potential use	Patents
Cultivation	According to Table 2 and variety of analysed vegetables, the chemical composition and physical properties of the AWCB generated in cultivation step is very complex	If the AWCB is affected by any disease its use as animal fodder should be avoided, the leaves of sugar beet, cauliflower and cabbages are used for feeding cattle and pigs (Wadhwa & Bakshi, 2013); extraction of chemicals from pruning residues (Khemakhem, Gargouri, Dhouib, Ayadi, & Bouaziz, 2017), (Omar, 2010);	Method of controlling pests on a crop field (Br. patenta US20150157017 A1, 2015)
Harvesting	According to Table 2 and variety of analysed vegetables, the chemical composition and physical properties of the AWCB generated in harvesting step is very complex, for example the chemical composition of sunflower straw is presented in (Antonopoulou, Dimitrellos, Beobide, Vayenas, & Lyberatos, 2015)	Biogas production from residues (Tian, Chauillac, & Pullammanappallil, 2013); residues could be used as renewable sources of materials (Svärd, Brännvall, & Edlund, 2015)	Reducing of post-harvest losses (Br. patenta US4206242 A, 1980) ; improvement of agricultural products through use of metal nanoparticles during cultivation (Br. patenta WO2017101691 A1, 2017)
Processing	According to Table 2 and variety of analysed vegetables, the chemical composition and physical properties of the AWCB generated in harvesting step is very complex, for example, the chemical composition of rapeseed meal is presented in (Ballester, i dr., 1970)	Solid agro-industrial by-products have potential role in chemical/biochemical/pharmaceutical applications (Singh & Kaur, 2016), (Jajor, Pilakowska-Pietras, Krasowska, & Lukaszewicz, 2016), (Morosanu, Teodosiu, Paduraru, Ibanescu, & Tofan), (Evon, Vinet, Labonne, & Rigal, 2015), (Asuquo & Martin, 2016), (Aliakbarian, Paini, Adami, Perego, & Reverchon, 2017), (Betül Eryilmaz, Dursun, & Coşkun Dalgıç, 2016), (Dashti, i dr., 2015) and (Smolinska, Kowalska, Kowalczyk, & Szczech, 2014); production of biofuels from processing residues (Demiray, Karatay, Donmez, & Donmez, 2014); liquid by-products could be	Vegetable pomace in combination with fruit pomace used in health applications (Br. patenta WO2017075078 A1, 2017); extraction of lycopene and carotenoids from tomato pomace and skin (Br. patenta EP1103579 B1, 2002) and (Br. patenta US7572468 B1, 2009); recovery of olive AWCB (Br. patenta EP2102110 B1, 2012);

		used for the treatment of other crops (El-Abbassi, Saadaoui, Kiai, Raiti, & Hafidi, 2017)	
Consumption	Leftovers from consumption stage approximately are consisted from moisture, fat, proteins and carbohydrates (Nagy, Wopera, & Koos, 2014), the percentage of each component depends on the composition of meal	Organic AWCB from consumption step could be digested and biogas produced (Zhang, Gekas, Zhu, Lord, & Choate) ; also leftovers from consumption can be used for biofuel production (Razaghi, Karthikeyan, Nguyen Hao, & Heimann, 2016)	Device for removal of moisture from AWCB, including meal leftovers (Br. patenta US20170152155 A1, 2017)

Table 77 Characteristics, potential use and developed patents of vegetable AWCB

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## 5 ANNEX - Consumption per capita

Consumption data for tomatoes and potatoes exist in some form, notably in the food balance sheets of FAOSTAT (<http://www.fao.org/faostat/en/#data/FBS>). These data however represent both fresh and processed consumption of Tomatos/potatos. Reliable and consistent data for fresh European tomato/potato consumption was not available at the time of writing.

Table 78 Cabbage consumption per capita in kg/year

Country	Kg/capita/year	Reference 1	Comment
Belgium	1.1	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdaycons%20days.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdaycons days.xlsx</a> (accessed November 30, 2017)	
Bulgaria	7.1	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdaycons%20days.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdaycons days.xlsx</a> (accessed November 30, 2017)	
Czech Republic	n/a		No reliable data available for fresh consumption at a European level
Denmark	n/a		No reliable data available for fresh consumption at a European level
Germany	4.9	<a href="http://www.gtai.de/GTAI/Content/EN/Invest/_SharedDocs/Downloads/GTAI/Industry-overviews/industry-overview-food-beverage-industry-en.pdf">http://www.gtai.de/GTAI/Content/EN/Invest/_SharedDocs/Downloads/GTAI/Industry-overviews/industry-overview-food-beverage-industry-en.pdf</a> (accessed October 31, 2016)	
Estonia	2.2	<a href="https://www.researchgate.net/publication/233096133_Nitrate_in_leafy_vegetables_culi0ry_herbs_and_cucumber_grown_under_cover_in_Estonia_Content_and_intake">https://www.researchgate.net/publication/233096133_Nitrate_in_leafy_vegetables_culi0ry_herbs_and_cucumber_grown_under_cover_in_Estonia_Content_and_intake</a> (accessed October 31, 2016)	
Ireland	4	<a href="http://www.efsa.europa.eu/sites/default/files/scientific_output/files/main_documents/689.pdf">http://www.efsa.europa.eu/sites/default/files/scientific_output/files/main_documents/689.pdf</a> (accessed October 31, 2016)	
Greece	n/a		No reliable data available for fresh consumption at a European level
Spain	0.7	<a href="http://www.efsa.europa.eu/sites/default/files/scientific_output/files/main_documents/689.pdf">http://www.efsa.europa.eu/sites/default/files/scientific_output/files/main_documents/689.pdf</a> (accessed October 31, 2016)	
France	1.4	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdaycons%20days.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdaycons days.xlsx</a> (accessed November 30, 2017)	
Croatia	n/a		No reliable data available for fresh consumption at a European level
Italy	0.4	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdaycons%20days.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdaycons days.xlsx</a> (accessed November 30, 2017)	
Cyprus	1.3	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdaycons%20days.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdaycons</a>	



		days.xlsx (accessed November 30, 2017)	
Latvia	0.8	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdaycons%20days.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdaycons days.xlsx</a> (accessed November 30, 2017)	
Lithuania	n/a		No reliable data available for fresh consumption at a European level
Luxembourg	n/a		No reliable data available for fresh consumption at a European level
Hungary	5.5	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdaycons%20days.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdaycons days.xlsx</a> (accessed November 30, 2017)	
Malta	n/a		No reliable data available for fresh consumption at a European level
Netherlands	n/a		No reliable data available for fresh consumption at a European level
Austria	n/a		No reliable data available for fresh consumption at a European level
Poland	7.4	<a href="http://maciejczak.pl/download/jelgava.pdf">http://maciejczak.pl/download/jelgava.pdf</a> (accessed October 31, 2016)	
Portugal			
Romania	8	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdaycons%20days.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdaycons days.xlsx</a> (accessed November 30, 2017)	
Slovenia	1.8	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdaycons%20days.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdaycons days.xlsx</a> (accessed November 30, 2017)	
Slovakia	1.3	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdaycons%20days.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdaycons days.xlsx</a> (accessed November 30, 2017)	
Finland	2.3	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdaycons%20days.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdaycons days.xlsx</a> (accessed November 30, 2017)	
Sweden	1.8	<a href="http://www.efsa.europa.eu/sites/default/files/scientific_output/files/main_documents/689.pdf">http://www.efsa.europa.eu/sites/default/files/scientific_output/files/main_documents/689.pdf</a> (accessed October 31, 2016)	
United Kingdom	n/a		No reliable data available for fresh consumption at a European level

Table 79 Cauliflower and broccoli consumption per capita in kg/year

Country	Value 1	Reference 1	Comment
Belgium	1.6	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx</a> (accessed November 30, 2017)	
Bulgaria	n/a		No reliable data available for fresh consumption at a European level
Czech Republic	1.6	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx</a> (accessed November 30, 2017)	
Denmark	n/a		No reliable data available for fresh consumption at a European level
Germany	0.3	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx</a> (accessed November 30, 2017)	
Estonia	0.8	<a href="http://ec.europa.eu/food/fvo/act_getProfile.cfm?pdf_id=25">ec.europa.eu/food/fvo/act_getProfile.cfm?pdf_id=25</a> (accessed October 31, 2016)	
Ireland	3.2	<a href="http://ec.europa.eu/agriculture/statistics/agricultural/2011/pdf/full-report_en.pdf">http://ec.europa.eu/agriculture/statistics/agricultural/2011/pdf/full-report_en.pdf</a> (accessed October 31, 2016)	
Greece	n/a		No reliable data available for fresh consumption at a European level
Spain	n/a		No reliable data available for fresh consumption at a European level
France	n/a		No reliable data available for fresh consumption at a European level
Croatia	n/a		No reliable data available for fresh consumption at a European level
Italy	4.4	<a href="http://ec.europa.eu/agriculture/statistics/agricultural/2013/pdf/c8-1-38_en.pdf">http://ec.europa.eu/agriculture/statistics/agricultural/2013/pdf/c8-1-38_en.pdf</a> (accessed October 31, 2016)	
Cyprus	0.4	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx</a> (accessed November 30, 2017)	

Latvia	0.4	<a href="http://ec.europa.eu/agriculture/statistics/agricultural/2011/pdf/full-report_en.pdf">http://ec.europa.eu/agriculture/statistics/agricultural/2011/pdf/full-report_en.pdf</a> (accessed October 31, 2016)	
Lithuania	0.5	<a href="http://ec.europa.eu/agriculture/statistics/agricultural/2011/pdf/full-report_en.pdf">http://ec.europa.eu/agriculture/statistics/agricultural/2011/pdf/full-report_en.pdf</a> (accessed October 31, 2016)	
Luxembourg	n/a		No reliable data available for fresh consumption at a European level
Hungary	n/a		No reliable data available for fresh consumption at a European level
Malta	3.8	<a href="http://ec.europa.eu/agriculture/statistics/agricultural/2011/pdf/full-report_en.pdf">http://ec.europa.eu/agriculture/statistics/agricultural/2011/pdf/full-report_en.pdf</a> (accessed October 31, 2016)	
Netherlands	2.5	<a href="http://ec.europa.eu/agriculture/statistics/agricultural/2013/pdf/c8-1-38_en.pdf">http://ec.europa.eu/agriculture/statistics/agricultural/2013/pdf/c8-1-38_en.pdf</a> (accessed October 31, 2016)	<a href="http://www.carib-export.com/obic/documents/Fresh_fruit_and_vegetables_vol2.pdf">http://www.carib-export.com/obic/documents/Fresh_fruit_and_vegetables_vol2.pdf</a> (accessed October 31, 2016)
Austria	1.2	<a href="http://ec.europa.eu/agriculture/statistics/agricultural/2013/pdf/c8-1-38_en.pdf">http://ec.europa.eu/agriculture/statistics/agricultural/2013/pdf/c8-1-38_en.pdf</a> (accessed October 31, 2016)	
Poland	5.2	<a href="http://ec.europa.eu/agriculture/statistics/agricultural/2013/pdf/c8-1-38_en.pdf">http://ec.europa.eu/agriculture/statistics/agricultural/2013/pdf/c8-1-38_en.pdf</a> (accessed October 31, 2016)	<a href="http://maciejczak.pl/download/jelgava.pdf">http://maciejczak.pl/download/jelgava.pdf</a> (accessed October 31, 2016)
Portugal	0.5	<a href="http://ec.europa.eu/agriculture/statistics/agricultural/2011/pdf/full-report_en.pdf">http://ec.europa.eu/agriculture/statistics/agricultural/2011/pdf/full-report_en.pdf</a> (accessed October 31, 2016)	
Romania	1.4	<a href="http://ec.europa.eu/agriculture/statistics/agricultural/2013/pdf/c8-1-38_en.pdf">http://ec.europa.eu/agriculture/statistics/agricultural/2013/pdf/c8-1-38_en.pdf</a> (accessed October 31, 2016)	
Slovenia			
Slovakia	0.9	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx</a> (accessed November 30, 2017)	
Finland	n/a		No reliable data available for fresh consumption at a European level
Sweden	1.2	<a href="http://ec.europa.eu/agriculture/statistics/agricultural/2013/pdf/c8-1-38_en.pdf">http://ec.europa.eu/agriculture/statistics/agricultural/2013/pdf/c8-1-38_en.pdf</a> (accessed October 31, 2016)	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx</a> (accessed November 30, 2017)
United Kingdom	n/a		No reliable data available for fresh consumption at a European level

Table 80 Carrot consumption per capita in kg/year

Country	Value	Reference	Comment
Belgium	8.8	<a href="http://apeda.in/agriexchange/Market%20Profile/Vollume_III/BELGIUM.aspx">http://apeda.in/agriexchange/Market%20Profile/Vollume_III/BELGIUM.aspx</a> (accessed October 31, 2016)	
Bulgaria	1.8	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx</a> (accessed November 30, 2017)	
Czech Republic	n/a		No reliable data available for fresh consumption at a European level
Denmark	n/a		No reliable data available for fresh consumption at a European level
Germany	8.7	<a href="http://www.gtai.de/GTAI/Content/EN/Invest/_SharedDocs/Downloads/GTAI/Industry-overviews/industry-overview-food-beverage-industry-en.pdf">http://www.gtai.de/GTAI/Content/EN/Invest/_SharedDocs/Downloads/GTAI/Industry-overviews/industry-overview-food-beverage-industry-en.pdf</a> (accessed October 31, 2016)	
Estonia	0.9	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx</a> (accessed November 30, 2017)	
Ireland	2	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx</a> (accessed November 30, 2017)	
Greece	3.7	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx</a> (accessed November 30, 2017)	
Spain	n/a		No reliable data available for fresh consumption at a European level
France	4.5	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx</a> (accessed November 30, 2017)	
Croatia	n/a		No reliable data available for fresh consumption at a European level
Italy	2.5	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx</a> (accessed November 30, 2017)	
Cyprus	0.7	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx</a> (accessed November 30, 2017)	
Latvia	0.9	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx</a>	

		days.xlsx (accessed November 30, 2017)	
Lithuania	n/a		No reliable data available for fresh consumption at a European level
Luxembourg	n/a		No reliable data available for fresh consumption at a European level
Hungary	3.3	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx</a> (accessed November 30, 2017)	
Malta	n/a		No reliable data available for fresh consumption at a European level
Netherlands	2.4	<a href="http://www.carib-export.com/obic/documents/Fresh_fruit_and_vegetables_vol2.pdf">http://www.carib-export.com/obic/documents/Fresh_fruit_and_vegetables_vol2.pdf</a> (accessed October 31, 2016)	
Austria	n/a		No reliable data available for fresh consumption at a European level
Poland	6.8	<a href="http://maciejczak.pl/download/jelgava.pdf">http://maciejczak.pl/download/jelgava.pdf</a> (accessed October 31, 2016)	
Portugal	n/a		No reliable data available for fresh consumption at a European level
Romania	5.6	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx</a> (accessed November 30, 2017)	
Slovenia	1.9	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx</a> (accessed November 30, 2017)	
Slovakia	2	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx</a> (accessed November 30, 2017)	
Finland	4.9	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx</a> (accessed November 30, 2017)	

Sweden	3.5	<a href="https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx">https://www.efsa.europa.eu/sites/default/files/acutegdayconsdays.xlsx</a> (accessed November 30, 2017)	
United Kingdom	n/a		No reliable data available for fresh consumption at a European level

Table 81 Onion consumption per capita in kg/year

FAOSTAT's Food Balance Sheet data was employed to estimate consumption figures for Onions. While this data may include some processing consumption, we assume it reasonably reflects fresh onion consumption

Country	2010	2011	2012	2013	Reference
Belgium	0.5	1.1	1.48	3.18	FAOSTAT - Food Balance - Food Balance Sheets: <a href="http://www.fao.org/faostat/en/#data/FBS">http://www.fao.org/faostat/en/#data/FBS</a>
Bulgaria	n/a	n/a	n/a	n/a	No reliable data available for fresh consumption at a European level
Czech Republic	7.96	8.67	7.08	8.36	FAOSTAT - Food Balance - Food Balance Sheets: <a href="http://www.fao.org/faostat/en/#data/FBS">http://www.fao.org/faostat/en/#data/FBS</a>
Denmark	8.69	10.13	8.2	8.28	FAOSTAT - Food Balance - Food Balance Sheets: <a href="http://www.fao.org/faostat/en/#data/FBS">http://www.fao.org/faostat/en/#data/FBS</a>
Germany	5.78	7.5	6.87	6.06	FAOSTAT - Food Balance - Food Balance Sheets: <a href="http://www.fao.org/faostat/en/#data/FBS">http://www.fao.org/faostat/en/#data/FBS</a>
Estonia	7.25	5.83	6.56	5.09	FAOSTAT - Food Balance - Food Balance Sheets: <a href="http://www.fao.org/faostat/en/#data/FBS">http://www.fao.org/faostat/en/#data/FBS</a>
Ireland	n/a	n/a	n/a	n/a	No reliable data available for fresh consumption at a European level
Greece	16.67	21.63	21.3	21.38	FAOSTAT - Food Balance - Food Balance Sheets: <a href="http://www.fao.org/faostat/en/#data/FBS">http://www.fao.org/faostat/en/#data/FBS</a>
Spain	17.82	20.91	18.04	18.39	FAOSTAT - Food Balance - Food Balance Sheets:

					<a href="http://www.fao.org/faostat/en/#data/FBS">http://www.fao.org/faostat/en/#data/FBS</a>
France	4.42	2.03	2.08	3.12	FAOSTAT - Food Balance - Food Balance Sheets: <a href="http://www.fao.org/faostat/en/#data/FBS">http://www.fao.org/faostat/en/#data/FBS</a>
Croatia	8.47	9.69	8.69	8.28	FAOSTAT - Food Balance - Food Balance Sheets: <a href="http://www.fao.org/faostat/en/#data/FBS">http://www.fao.org/faostat/en/#data/FBS</a>
Italy	5.92	6.34	5.12	5.73	FAOSTAT - Food Balance - Food Balance Sheets: <a href="http://www.fao.org/faostat/en/#data/FBS">http://www.fao.org/faostat/en/#data/FBS</a>
Cyprus	n/a	n/a	n/a	n/a	No reliable data available for fresh consumption at a European level
Latvia	10.52	10.9	10.68	7.8	FAOSTAT - Food Balance - Food Balance Sheets: <a href="http://www.fao.org/faostat/en/#data/FBS">http://www.fao.org/faostat/en/#data/FBS</a>
Lithuania	n/a	n/a	n/a	n/a	No reliable data available for fresh consumption at a European level
Luxembourg	5.76	5.54	5.18	4.94	FAOSTAT - Food Balance - Food Balance Sheets: <a href="http://www.fao.org/faostat/en/#data/FBS">http://www.fao.org/faostat/en/#data/FBS</a>
Hungary	n/a	n/a	n/a	n/a	No reliable data available for fresh consumption at a European level
Malta	16.59	15.94	13.43	14.52	FAOSTAT - Food Balance - Food Balance Sheets: <a href="http://www.fao.org/faostat/en/#data/FBS">http://www.fao.org/faostat/en/#data/FBS</a>
Netherlands	0.61	4.9	3.05	1.4	FAOSTAT - Food Balance - Food Balance Sheets: <a href="http://www.fao.org/faostat/en/#data/FBS">http://www.fao.org/faostat/en/#data/FBS</a>



<b>Austria</b>	14.5	16.9	7.9	10.02	FAOSTAT - Food Balance - Food Balance Sheets: <a href="http://www.fao.org/faostat/en/#data/FBS">http://www.fao.org/faostat/en/#data/FBS</a>
<b>Poland</b>	12.81	15.05	13.39	11.45	FAOSTAT - Food Balance - Food Balance Sheets: <a href="http://www.fao.org/faostat/en/#data/FBS">http://www.fao.org/faostat/en/#data/FBS</a>
<b>Portugal</b>	n/a	n/a	n/a	n/a	No reliable data available for fresh consumption at a European level
<b>Romania</b>	n/a	n/a	n/a	n/a	No reliable data available for fresh consumption at a European level
<b>Slovenia</b>	n/a	n/a	n/a	n/a	No reliable data available for fresh consumption at a European level
<b>Slovakia</b>	8.38	8.88	5.08	5.79	FAOSTAT - Food Balance - Food Balance Sheets: <a href="http://www.fao.org/faostat/en/#data/FBS">http://www.fao.org/faostat/en/#data/FBS</a>
<b>Finland</b>	4.58	5.96	5.76	6.23	FAOSTAT - Food Balance - Food Balance Sheets: <a href="http://www.fao.org/faostat/en/#data/FBS">http://www.fao.org/faostat/en/#data/FBS</a>
<b>Sweden</b>	6.86	7.43	8.36	7.53	FAOSTAT - Food Balance - Food Balance Sheets: <a href="http://www.fao.org/faostat/en/#data/FBS">http://www.fao.org/faostat/en/#data/FBS</a>
<b>United Kingdom</b>	10.34	9.68	10.01	11.13	FAOSTAT - Food Balance - Food Balance Sheets: <a href="http://www.fao.org/faostat/en/#data/FBS">http://www.fao.org/faostat/en/#data/FBS</a>