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Executive Summary

PhasmaFOOD aims to provide a miniaturized, multi-parameter and programmable sensing node for detection of food spoilage, adulteration and aflatoxins. The system will integrate heterogeneous visible and near infrared spectroscopy technologies with a control electronic board which will ensure efficient cooperation between the sensing and the processing part. This report describes the work undertaken in the PhasmaFOOD Business analysis (Task 1.3) and consists of a market scoping exercise and a high-level business model for the PhasmaFOOD solution.

PhasmaFOOD consortium will control the software research and development activity while manufacturing of the design will be outsourced to a manufacturing company within the network. As far as suppliers is concerned, non-essential parts of PhasmaFOOD technology, such as plastic cases and generic microelectronics can be found by many suppliers without noticeable differences and with very low switching costs. The UV-VIS spectrometer will be supplied by Hamamatsu and the camera by Ximea. For the other essential parts of PhasmaFOOD technology (e.g. sensing components, electronic board and algorithms) the suppliers will be the project's partners. PhasmaFOOD's revenue streams will come from device sales as well as subscriptions from consumers who will pay-per-scan. PhasmaFOOD's ultra-portability gives a competitive advantage mainly for players in the food service sector and retailers as well as consumers. The value proposition of PhasmaFOOD to consumers, food scientists or business actors in the food supply chain comes from preventing consumption of contaminated and spoiled food, protection of lawsuits, bad reputation or medical costs, reduction of dependence on the trustworthiness of food providers, avoiding money losses from food wasted in facilities or households and introducing the fascinating world of spectroscopy. The main distribution channel will be PhasmaFOOD's e-shop while multiple distributors in each country should be identified and approached with the purpose of handling the distribution of PhasmaFOOD device in their region.

PhasmaFOOD comes in a time of food market globalization with a rising global food demand due to population growth but also due to the booming demand coming from the Asia-Pacific region. The digital health market size that is expected to reach \$379 billion by 2024 and the number of smartphone users is projected to amount to nearly 2.7 billion by 2019 with China being the leader in the smartphone market. Changing customer preferences, increasing urbanization, busy life schedules, high social costs of food waste, growing food security concerns and declining trust in the food and drink industry declined and Increased waste management challenges are other trends who are bound to affect the operation of PhasmaFOOD. Overall, the combined revenues of the farm-to-fork actors that PhasmaFOOD is targeting can be measured in the trillion-euro scale, while the business actors are characterized by low profit margins. Also, although PhasmaFOOD is not expected to meet the standards of accuracy and scientific soundness of the methods employed by monitoring authorities, it could act as a complementary ser-

vice, by allowing for mass measurements and instant results, guiding the regular sampling-based measurements.

PhasmaFOOD product portfolio will include various product packages that are expected to serve the needs of the identified segments, considering the competition. Overall, 3 product versions will be offered: Consumer edition, Enterprise edition and Science edition; each targeting a different segment in the market. PhasmaFOOD's direct competitions comes from SCiO by Consumer Physics and Tellspec. Both devices use similar technology, though only Tellspec is focused on food products as PhasmaFOOD. More rugged devices are also available but due to size and price considerations, they are more targeted towards the supply chain than to final consumers. In addition, Distell's Torrymeter, BFD-100 by Freshdetect and FOODSniffer seem to be the most important in relation to the PhasmaFOOD solution, although using a completely different technological approach. In general, PhasmaFOOD is well-placed among competitors and has several competitive advantages, the main being the combination of UV/VIS and NIR spectrometers with imaging techniques, the focusing on the specific use cases and the expertise of the consortium. In terms of market forces, the power of suppliers can very high if proper actions are not taken in the direction of designing robust or calibratable algorithms. Same for competitive rivalry and thread from substitutes which are also very high. Buyers' and new entrants' power on the other hand are considered mild. PhasmaFOOD should employ strategies that use its product's strengths to avoid threats such as targeted campaigns to highlight its unique and proven technology, product differentiation using the strong R&D skills of the partners, differentiation focus concentrating on informed buyers and cost focus in the B2B market. Also, it is suggested that value-chain alliances or licensing arrangements with overseas partners are formed, recruitment of scientists from companies that are already active in the handheld spectrometry sector and focusing on the specific use-cases are strategies that minimize weaknesses and avoid threats while value-chain partnerships with importers serving niche markets in the wider Asia-Pacific and differentiation focus on the organic market is another way to overcome weaknesses by taking advantage of the opportunities. Finally, Cost-focus on the large number of local manufacturing SMEs, effective information campaigns and product differentiation based on the unique characteristics of the PhasmaFOOD with respect to competitors (i.e. Firmware updates on the fly, small size of the device, relatively low cost, state of the art algorithms, easy to use) are possible strategies that take advantage of opportunities using its strengths.

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Definitions, Acronyms and Abbreviations

Acronym	Title
F&B	Food and Beverage
F&V	Fruits and Vegetables
EU	European Union
WP	Work Package

1 Introduction

The main objective of the project is to design and implement an autonomous, highly multifunctional, multi-parameter and programmable optical sensing node integrated with spectroscopy technologies for food hazard, microbial activity detection and shelf-life estimation. The system's multifunctionality and adaptability will enable a single device architecture to support highly differentiated applicative goals, through the food industry chain (from farm to fork). Its cognition will support the configurability of the smart system, while its small size, connectivity and energy efficiency will further enhance the smart system to a highly portable interconnected device.

The sensing node will be closely integrated with end user smart mobile devices (smartphones and tablets) and cloud platform. Dedicated PhasmaFOOD mobile application (Android and iOS) will be used as interface towards end users. The project will also work on definition, develop-

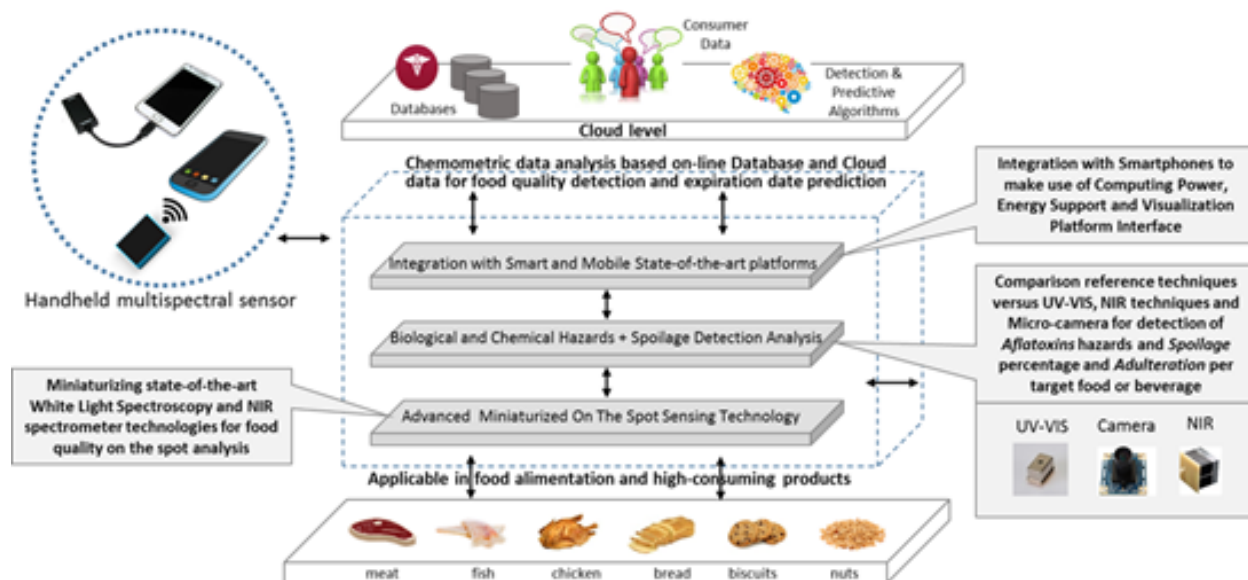


Figure 1 Overall Approach

ment and validation of interfaces through which end users will be engaged and presented with results of food analysis with different level of details. Users will be able to define level of details with which food analysis results should be presented (ranging from a notification if a food is not safe to detailed spectral analysis results which can be interpreted by more informed users).

End user's mobile device will also be integral part of sensory and contextual data analysis. Spectral analysis results conducted on the sensing device itself can be further correlated with contextual data such as temporal and spatial context (from mobile device GPS and calendar), environmental context, sensory data obtained from open food analysis databases and data obtained from databases of food manufacturers. This will help improve accuracy of sensing device's readings and put analysis results into correct context. The mobile application will also be

used for specifying parameters for spectral analysis (e.g. spectral analysis algorithms can be more accurate if user specifies type of food being scanned).

Further on, the project will configure dedicated PhasmaFOOD cloud platform (on one of existing cloud platforms - either commercial one from Google/Amazon/Microsoft or open platform from one of EC projects) for collecting and performing deeper analysis of sensory and contextual data obtained from the project's smart sensor device and end user mobile device. The cloud platform will enable correlation of sensory measurements, spectral analysis results and relevant contextual data from all smart sensing devices, all users and from different open databases. This will provide opportunity for detection of trends, patterns and distribution of food contamination which can help prevent outbreaks and provide recommendation for improving food safety at different stages of farm-to-fork production chain. PhasmaFOOD cloud platform will also host sensory and contextual database which will be used for training data analysis and machine learning models deployed on smart sensory device and as part of PhasmaFOOD mobile application (data analytics calibration). The overall approach is depicted in Figure 2.

The PhasmaFOOD device needs to be closely integrated with smartphones and other mobile devices. These devices are capable of presenting data analysis results to users, providing recommendations/notifications related to these result, provide interfaces with cloud platforms. PhasmaFOOD cloud platform will collect contextual and sensory data from different/distributed sources. Collected data will be correlated and analyzed in order to get more in-depth cause-consequence insight into food production, storage and delivery and its effect on food spoilage and contamination. Sensory data analysis across different systems and measuring points in food production chain (need integration with 3rd party databases) can indicate contamination points and help get more comprehensive insight into sources of food contamination and spoilage hazards.

2 Market Scoping

2.1 A bird's eyes view of the F&B industry and market

The global food and beverage (F&B) supply chain has a complicated structure involving farms, manufacturers, distributors, retailers and a very strong service (catering) sector. The chain's combined revenues of more than €15

trillion and is a major contribution to most of the local economies, while it was one of the few who faced only a mild decline in growth due to the global economic crises. It is indicative that in 2008, the S&P 500 declined 37.6 percent against a fall of 22.9 percent by the Dow

Jones US Food and Beverage Index (IMAP, 2010). The F&B chain is of particular interest to the EU. According to FoodDrinkEurope (2017), the EU food and beverages market is a key pillar of the world market economy, outperforming a large number of other goods. It is the largest manufacturing industry in the EU in terms of turnover, value added and employment. In particular, EU food and beverage chain generated revenues of more than €3,5 trillion in 2016 and employed more than 20 million workers, accounting for the largest share in the global F&B industry followed by China and USA. The entire food chain is characterized by low profit margins so that profitability becomes a great challenge. This is mainly due to the very low margins at which the industry operates, forcing companies to seek for large sales volumes; emerging economies such as China, India, Brazil and other have become extremely important.

The supply chain of food products starts from farmers and ends at consumers. The main middle stages are food producers/manufacturers and brokers², importers/exporters, distributors, retailers and food service companies. The manufacturers, receive raw materials from farmers, perform one or several stages of processing and forward ready-to-eat(drink) products to the distribution channels. The brokers, whether in-house or outsourced, are the middlemen between the manufacturers/importers and

The industry is increasingly feeling the need to be more responsive to food security concerns.

retailers. They are the ones who perform store visits, check and report stock levels, ensure smooth supply and negotiate with retailers on behalf of manufacturers regarding shelf space and promotional

activities. Of course, the chain line depends on the product, the target markets, and the manufacturer. For the majority of food products, the manufacturing sector is highly fragmented with local SMEs, including many family businesses, often having a significant contribution to the in-

² Food brokers act as food manufacturers' representatives at retail and catering stores. For the analysis to follow, they are considered as part of the manufacturing industry. In fact, F&B production companies with high sales volumes have in-house brokers, while others prefer to outsource this service to professional broking companies.

dustry's added value; these SMEs usually outsource food quality and safety controls to external laboratories. Of course, major multinational players such as the Coca-Cola Company, Nestlé, PepsiCo, Kraft Foods, Unilever, Mondelez International and Cargill are rapidly expanding by following growth corporate strategies through geographical expansion, mainly in developing countries in the Asia-Pacific region. For example, according to data provided by the Department of Industrial Policies and Promotion (DIPP) of the country, the food processing sector in India has received more than €7 billion worth of Foreign Direct Investment (FDI) during the period April 2000-December 2016. At the business level (competitive strategy) multinationals prefer focused differentiation by trying to follow closely and meet the latest consumer trends while at the same time continue to produce specific products they have inherent advantages. The industry is also increasingly feeling the need to be more responsive to food security concerns.

Distributors, receive the products from manufacturers, importers or other distributors and deliver them to retail and food service stores or to retailers' warehouses for self-distribution. The number of distributors is usually in accordance with a country's population.

Businesswise PhasmaFOOD's ultra-portability gives a competitive advantage mainly for players in the food service sector and retailers. These actors are also crucial as they serve as mediators, transferring trends upstream to the rest of the actors in the supply chain. The F&B service sector makes an interesting case both as a business actor within the supply chain of each good but also an indicator of food consumption patterns that can be studied alongside with the retail sales for the individual products. Figure 2 maps the most important markets as far as F&B service expenditure is concerned. USA is by far the biggest market for PhasmaFOOD since consumer expenditure on the F&B service sector reached €652 billion in 2015. China was ranked second with more than €360 billion and remarkable growth rates. Other interesting markets

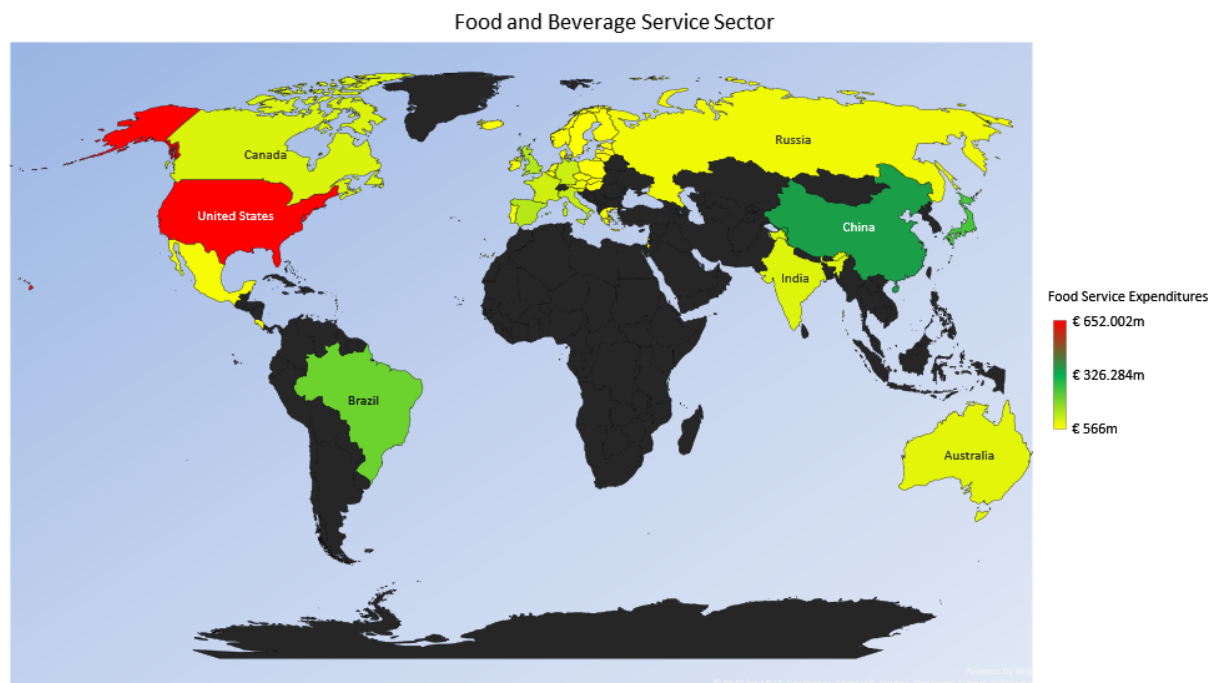


Figure 2. F&B service expenditure

outside the EU are those of Japan and Brazil with their €230 billion and €190 billion food service industries but also India, whose citizens spent about €40 billion per year in food catering, with this figure growing with remarkable rates during the last few years. Indicative of India's potential is the large number of multinational companies (e.g. Cargill Inc., Danone SA, KKR & Co LP, Uber Technologies Inc.) that are currently planning or undergoing large investments in the food service sector of the area. In the EU area, United Kingdom is a €99 billion F&B service market while other key players are Spain (€93 billion), Italy (€75 billion), Germany (€ 68 billion) and France (€ 62 billion).

Retailers place products on shelves, perform in-store marketing activities and place orders to distributors (or directly to manufacturers). The food retail industry has a global turnover of close to €4 trillion, with supermarkets/hypermarkets accounting for the largest share of sales. Also, it is a dynamically progressing industry that contributes to the development of several other industries such as food packaging. The retail industry is one of the most concentrated within the chain with the top 15 global supermarket companies accounting for more than 30 percent of world supermarket sales (USDA, 2016). Due to economies of scale, multinational retailers have some advantages. On the consumers' side, Figure 3 shows that EU28 is leading the food and beverage expenditure with €870 billion and Germany, France and Italy are its top markets. USA follows with €640 billion while China, India and Japan are next, with other remarkable markets being those of Brazil and Russia. A total of more than €500 billion is also spent on the global alcoholic drinks market. Within the total value of alcoholic drinks, spirits are important for PhasmaFOOD and accounted for 43% of the alcoholic drinks market, with beer (38.8%) and wine (17.9%) following closely. China, the United States, and Russia are the top markets. In Europe, the highest values of alcoholic drinks are the UK (more than €20 billion in retail value), Germany (€16 billion in retail value), and France (€15 billion in retail value). These 3 players account for more than 10% of the world's market share. In the wine category, European countries are ranked high with the United Kingdom and France leading based on retail value sales in 2015 in comparison to the other alcoholic drinks categories. The EU and China together make for almost 50%.

In the market potential for each targeted product that follows, all values are estimated using the respective percentage of total food expenditure devoted to the specific category, as available from the WordBank for 144 countries (IMAP, 2010). For countries that there were no available data, their expenditure patterns were approximated by that of the general high-, middle- and low- income groups, depending on their classification based on the World Bank Atlas method. Also, all values are converted from other currencies to Euros using current exchange rates (March 2017). Thus, although valid for the market scoping (ordinally accurate), caution should be taken when comparing among different years and/or products. All data come from FAO, OECD or other sources that are cited in the specific cases.

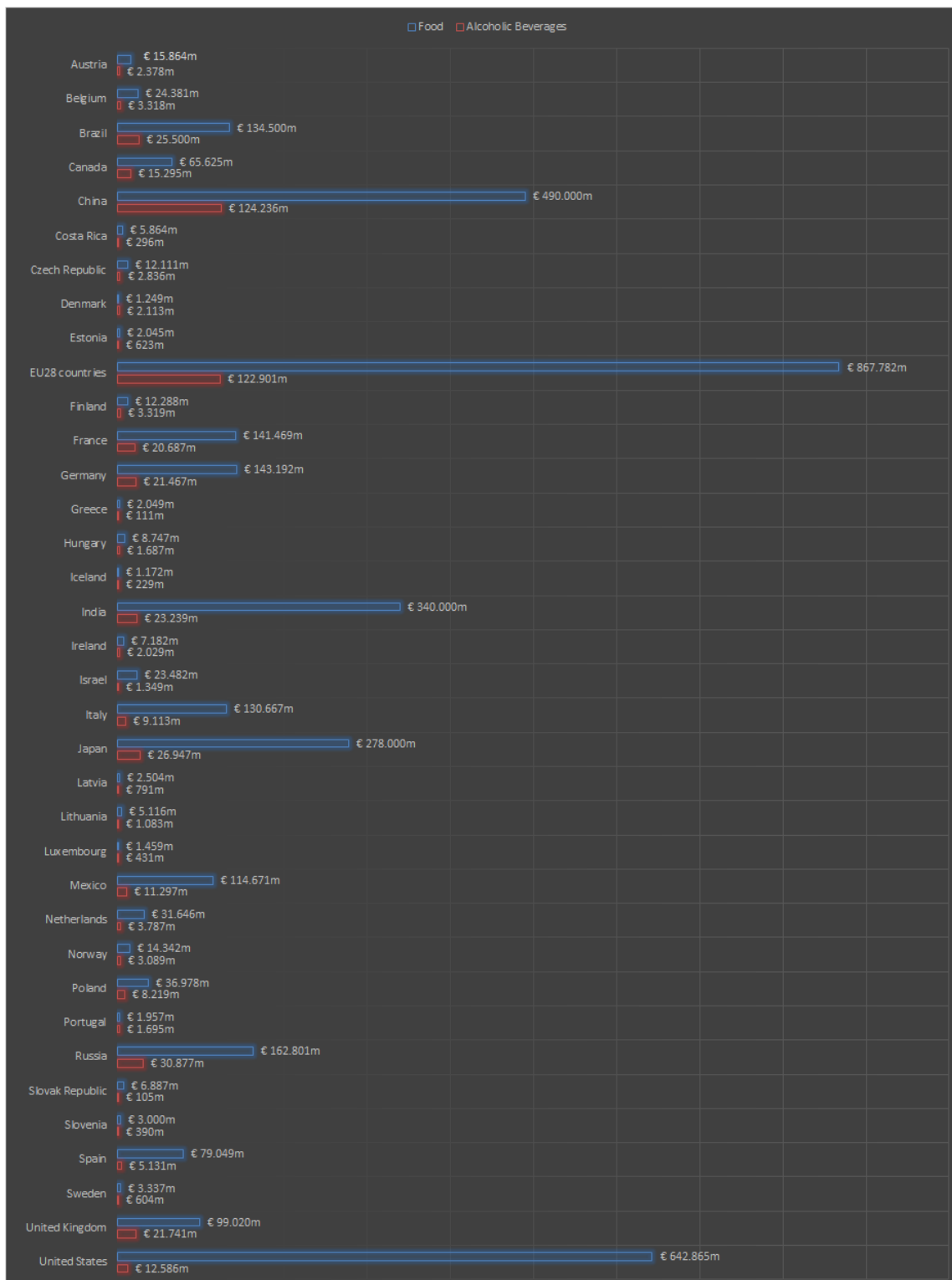


Figure 3. Food and Alcoholic Beverages Consumption (2015)

2.2 Market Segments Identification

Segmentation is the first key step in defining the market potential of the PhasmaFOOD solution. In this chapter, we provide a use-case-specific approach to study the variety of potential end-users so that their specific needs and behavior is considered in the construction of the value proposition. Although the food industry does not represent a unique market, the main issues PhasmaFOOD solution tackles are similar from one food chain to another. However, the various chains (dairy, meat, fruits and vegetable, beverage etc.) are constitutes of different actors and are confronted with different challenges that need to be identified. PhasmaFOOD solution is targeted to both business actors and consumers and in the subsections to follow, we provide a shortlist of several target groups in terms of needs and attractiveness. Of course, the list is non-exhaustive as it is populated based on the general characteristics of the markets that are related to each use-case. In all country-wise comparisons and market values presented below, we omit developing countries although for some use cases, the PhasmaFOOD solution may be more relevant there. This is due to their underdevelopment in technologies that are critical for PhasmaFOOD deployment (e.g. smartphone, broadband, Wi-Fi, etc.) as well as to the lack of resources, food control infrastructure and harmonization of regulations.

Also, a very important segment that was left out of the analysis is that of state or private monitoring authorities that intervene throughout the chain with regular controlling procedures. In terms of food safety, the most commonly used rapid testing methods are PCR-based methods, followed by immunoassay-based methods. The major vendors of these services are constantly developing new products and services, in order to expand their business segments and maintain a prime position in the market. Although PhasmaFOOD is not expected to meet the standards of accuracy and scientific soundness of the methods employed by these vendors, it could act as a complementary service, by allowing for mass measurements and instant results, guiding the regular sampling-based measurements. The global food safety testing market is projected to grow to around €18 billion by 2022 with North America having more than 40% of market share while, as far as products is concerned, meat accounts for more than 30% of the global food safety testing market. Of particular interest to PhasmaFOOD is the mycotoxin testing market which is projected to grow to a value of € 1.5 billion by 2022. The reason of the growth is considered to be the increased consumer awareness due to the several food scandals that has emerged the last few years and that were related to mycotoxin in the food products. Market attention has also led governments to take several measures to ensure that food products are free from mycotoxins and fit for human and animal consumption. Leading companies in this market are SGS S.A. (Switzerland), Bureau Veritas S.A. (France), Intertek Group plc (U.K.), Eurofins Scientific SE (Luxembourg), ALS Limited (Australia), Thermo Fisher Scientific Inc. (U.S.), Mérieux NutriSciences Corporation (U.S.), AsureQuality Ltd. (New Zealand), Microbac Laboratories Inc. (U.S.), and Romer Labs Diagnostic GmbH (Austria). Finally, since governments are currently enforcing stringent regulations regarding food fraud due to increased incidents of mislabeling and other economically motivated adulterations, the food authenticity market is expected to flourish as well. The food authenticity market is projected to reach €7 billion by 2022, at a CAGR of 7.6% from 2016 to 2022 (MarketsandMarkets, 2017). Key players in the food au-

thenticity market include Shimadzu Corporation (Japan) Yokogawa Electric Corporation (Japan), Foss (Denmark), and Agilent Technologies (U.S.) that use process spectroscopy methods and SGS SA (Switzerland), Intertek Group plc (U.K.), Eurofins Scientific (Luxembourg), ALS Limited (Australia), LGC Science Group Ltd (U.K.), Merieux Nutrisciences Corporation (U.S), Microbac Laboratories Inc. (U.S.), EMSL Analytical Inc. (U.S.), Romer Labs Diagnostic GmbH (Austria) and Genetic ID NA, Inc. (U.S.), using a variety of methods with PCR being the most popular one.

Within the chain, all business actors between the production stage and final consumption are potential customers for the PhasmaFOOD solution. In this framework, a market size indicator for PhasmaFOOD is given by the total production, processing and market value for each product included in the use cases. Imports are also indicative of the the potential of its market, especially since imported products usually have to go through more stringent controls and are treated more suspiciously by the industry and the consumers. Finally, the value of exports is a very good proxy of the importance a specific market has to the exporting countries' economies and thus of the interest in ensuring good status. In all maps that follow, countries marked with yellow represent places with low interest to PhasmaFOOD, green countries are of middle-interest and red countries are hotspots, where the examined figures are high and thus they are of paramount importance.

Aside the geographical segmentation based on the size of the market that is presented below, PhasmaFOOD should make also consider the digital attractiveness of the markets that will be targeted. According to Euromonitor (2016), the UK, South Korea, the US and China are the most attractive for future deployment of digital initiatives and thus constitute key markets to explore new food innovations that offer solutions in time management, food waste and experience. Other European countries than score high in digital attractiveness are Denmark, Norway, Switzerland, Sweden, Netherlands, Belgium, France, Germany and Israel.

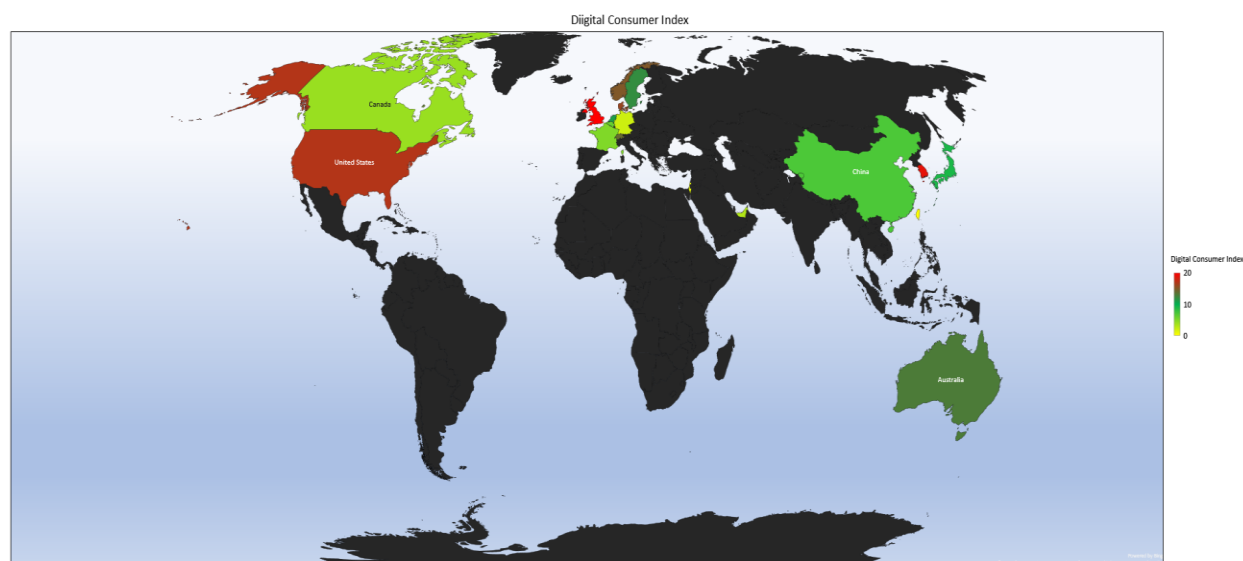


figure 4. Top 20 countries in terms of digital attractiveness

2.2.1 Meat

Compared to other commodities, meat is characterized by high production costs and high output prices. The global gross production value of (indigenous) meat reached almost € 750 billion in 2013 with China (€300 billion), USA (€110 billion), Brazil (€65 billion), Russia (€26 billion), France (€20 billion), Germany (€18 billion) being the major producers globally; Figure 5 shows the countries of interest to PhasmaFOOD solution. Going deeper into the subcategories, USA

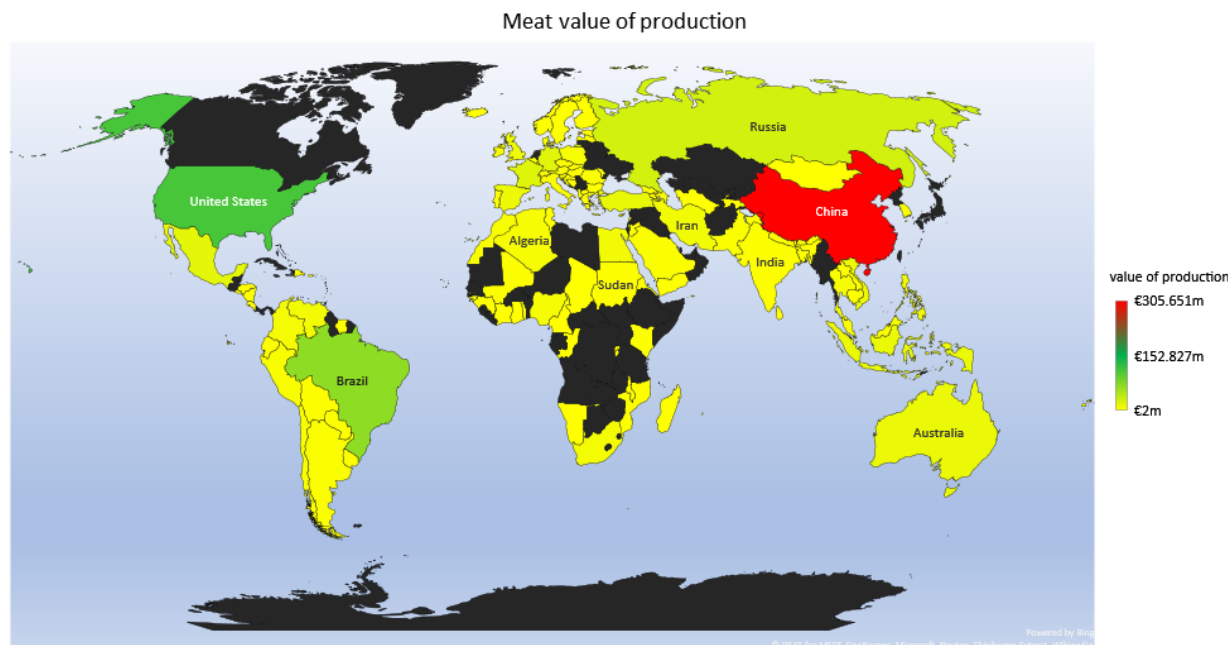


Figure 5. Meat value of production

and China seem to be the top cattle meat producers with over €50 billion, followed by Brazil, France and Russia, producing a value of €30 billion, €9 billion and €8 billion respectively. Other EU bovine meat producers are Germany (€6 billion), Italy (€3 billion) and Ireland (€2.5 billion). Broiler production is again higher in China, USA and Brazil whose production values reached €30 billion in 2013. Within the EU, France, UK, Germany and Spain producers are valued the highest with more than €2 billion worth of chicken meat production. Finally, China is by far the highest value of pork meat, producing roughly half of the global production with more than €150 billion, followed by USA (€20 billion) and Russia (€10 billion). Top European pork producers are Germany (€9 billion), France (€6 billion) and Spain (€4 billion).

In terms of the meat food supply chain as depicted in **Error! Reference source not found.** below, PhasmaFOOD will greatly contribute to reduce food waste through detection of early signs of spoilage and shelf-life estimation as well as to combat incidents of food fraud such as adulteration of pork and beef into raw minced meat and adulteration of horse and beef into raw minced meat samples. Regarding food waste, PhasmaFOOD would be a service/product more easily marketed to the meat processing and retailing industry where long or short- term storage and cooling takes place. The usual First In, First Out (FIFO) practices have been proven inefficient to eliminate spoilage in the premises of such industries in not uncommon and at the mo-

ment, the industry's needs are not properly addressed by any other device/service except BFD-100 by Freshdetect (see Competition section) which is currently only applicable for pork. On the other hand, detecting food fraud, is more critical within the food service industry presents in 2.1 section.

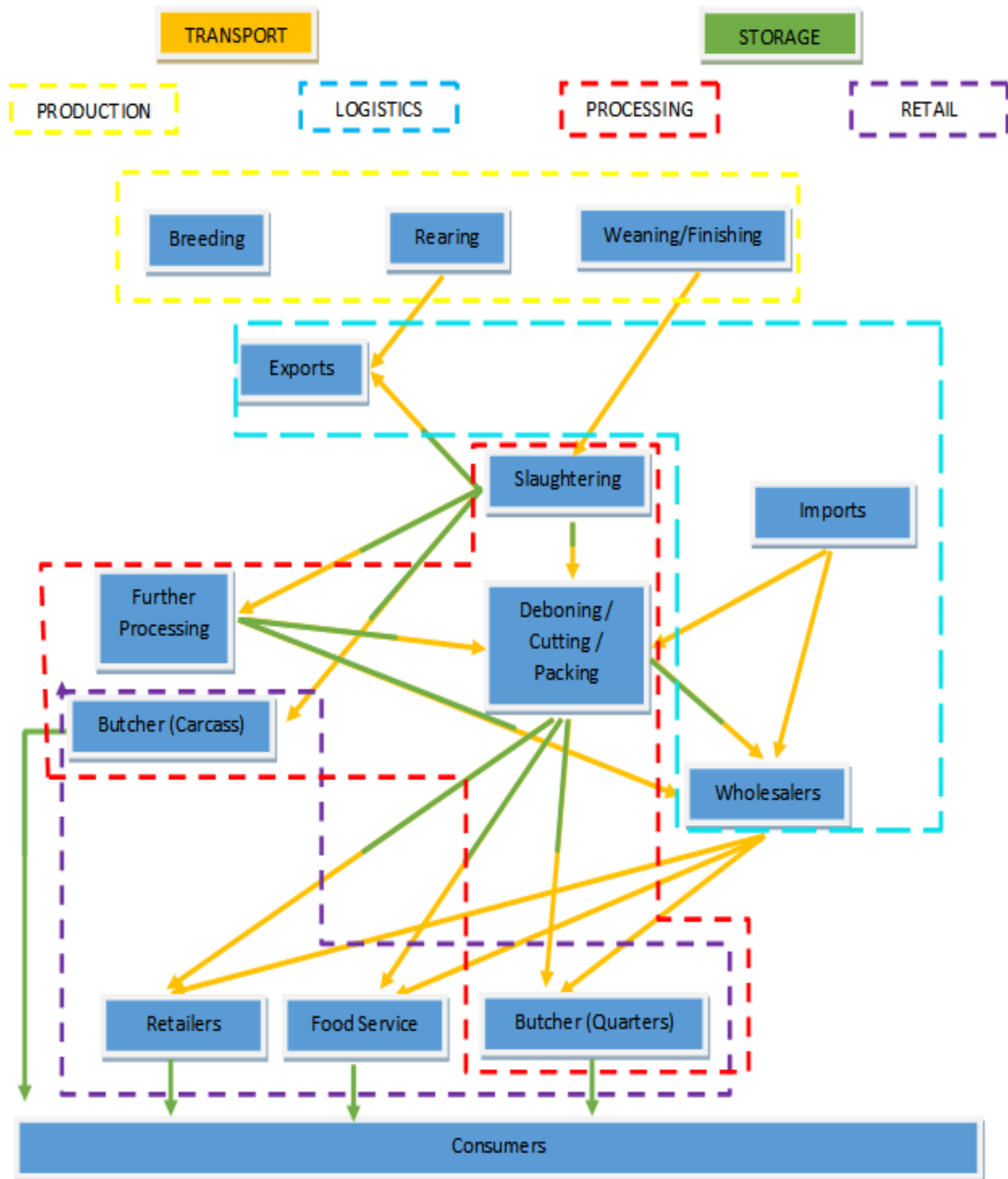


figure 6. Meat food supply chain

Meat Processing is a very promising sector. USA companies are currently global leaders with meat and poultry manufacturing industry sales of more than €180 billion in 2013. China follows

Meat value of Imports

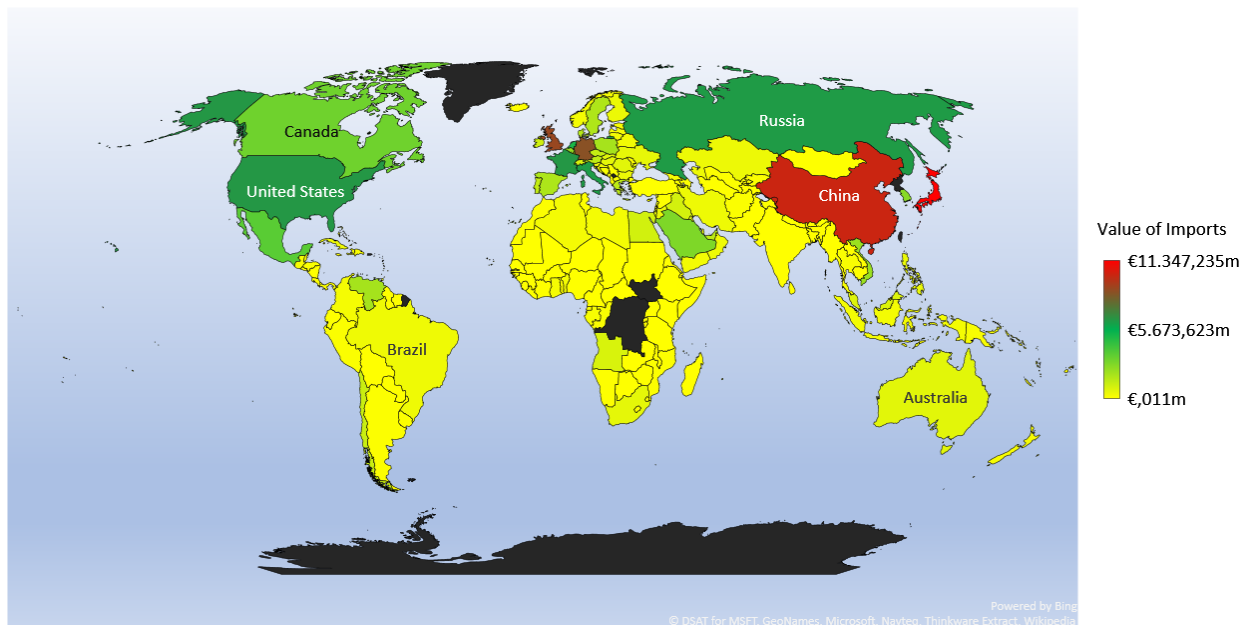


Figure 8. Meat value of Imports

closely with close to €100 billion revenues, same stands for Brazil who exports to more than 150 countries but is very likely to be seriously affected by the recent scandal over allegations

Meat value of Exports

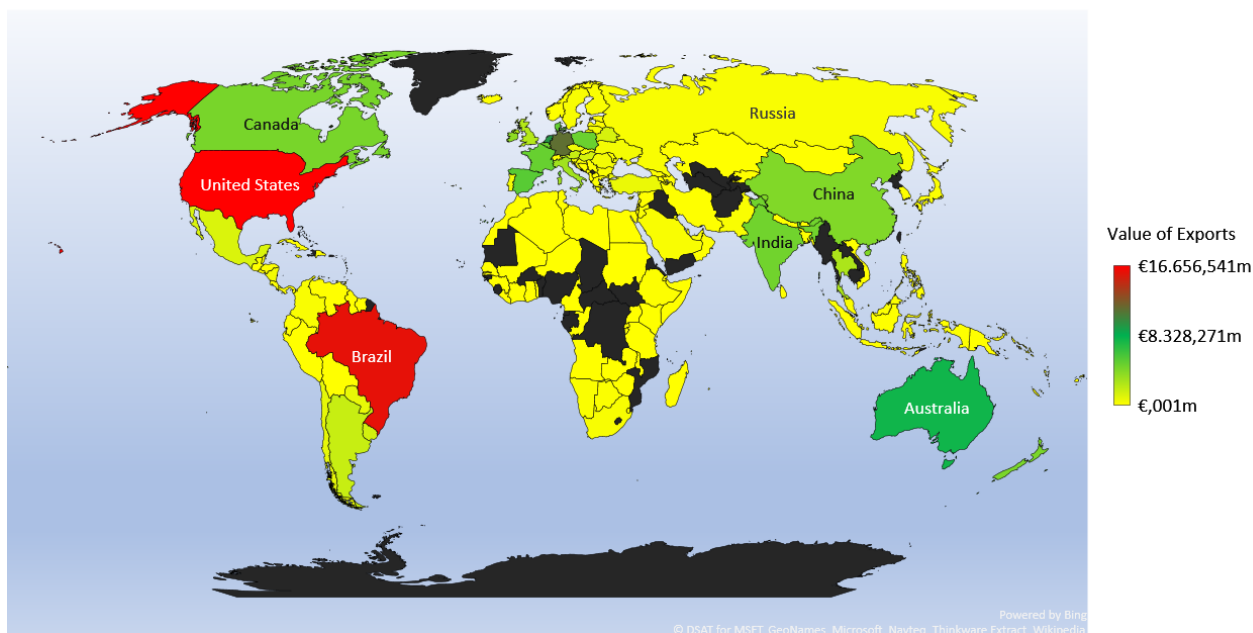


Figure 7. Meat value of Exports

that companies have been selling unsafe produce.³ In the EU, the manufacturing industries with the highest turnover are these of Germany (€44 billion), France (€32.6 billion), Italy (€23 billion), Spain (€21 billion) and the UK (€20 billion). Interesting markets are also the Netherlands, Poland, Belgium, Denmark, Croatia whose meat manufacturing industries are top among the national F&B chain.

Due to longer transportation time and logistics chain, imported food is more susceptible to spoilage. To this end, as also shown in the map of Figure 8, PhasmaFOOD will be mostly relevant to importers in Japan, importing more than €10 billion worth of meat products, China with €10 billion, UK (€9 billion) and Germany (€8 billion), as well as to France, USA, Russia, Italy and Netherlands contributing more than €5 billion each to the total €140 billion global trade value of meat. As depicted in Figure 7, top exporting countries are USA (€16 billion), Brazil (€15 billion), Germany (€10 billion), Netherlands (€9 billion) and Australia (€7 billion), while other important EU countries are Spain, Denmark, France, Poland and Belgium with export values ranging from €4 to €5 billion each. India is among the top exporting countries with around €4 billion export value; given its rapid rate of development, it represents a very interesting case as well.

Of course, the main value of PhasmaFOOD comes from the services it provides to final consumers. Meat consumption is related to living standards, diet, livestock production and consumer prices, as well as macroeconomic uncertainty and shocks to GDP (OECD, 2015). The demand for meat is driven mainly by higher income households with a high-degree of urbanization that is associated to food consumption patterns favoring increased proteins from animal sources. Environmental consciousness and consumer information is also an important factor since the global meat industry has significant environmental and health consequences for the planet. These drivers are in complete accordance with PhasmaFOOD's a solid value proposition to final consumers. Food spoilage recognition and shelf-life estimation will facilitate better management of grocery shopping and cooking plans on the part of the consumers, minimizing economic losses due to food waste at the household level. Also, detection of food adulteration in processed meat would help grocery shoppers reduce their food safety concerns (and probably save by avoiding foodborne illnesses) and promote price competition in a fairer state of the world, where lower prices do not come at the expense of food safety confidence. Fed by health and safety concerns, one of the main reasons driving meat consumption is the increasing role of extrinsic cues in quality perception of meat (Grunert, 2006) while information on meat product's freshness (date of cutting, date of slaughtering) have been found to be easily interpreted for the majority of consumers. Therefore, PhasmaFOOD's services in terms of shelf-life and spoilage will provide quality marks that are expected to create significant value to consumer. Overall, the meat market can be interpreted in €600 billion household expenditure every year for the products related to PhasmaFOOD; Figure 9 above shows the most important markets related to meat. USA is the leader in meat consumption with €125 billion annually, while other non-EU countries like China, India, Japan, Russia and Brazil have shown a considerable market growth during the last few years and are considered highly attractive for PhasmaFOOD.

³<https://www.forbes.com/sites/kenrapoza/2017/03/30/brazil-meat-scandal-losses-could-reach-5-billion/#492da1304657>

In the EU area, Germany, France, Italy and Spain, altogether constituting a meat market of more than €100 billion, are the territories with the highest value for PhasmaFOOD. While mature markets are exhibiting a shift toward natural and organically-sourced food, a demand for processed and ready-to-eat foods is now taking shape in emerging economies. Consumers, on their part, are moving away from partially hydrogenated oils, GMO food, and are looking for natural alternatives to inferior goods which aligns perfectly with PhasmaFOOD.

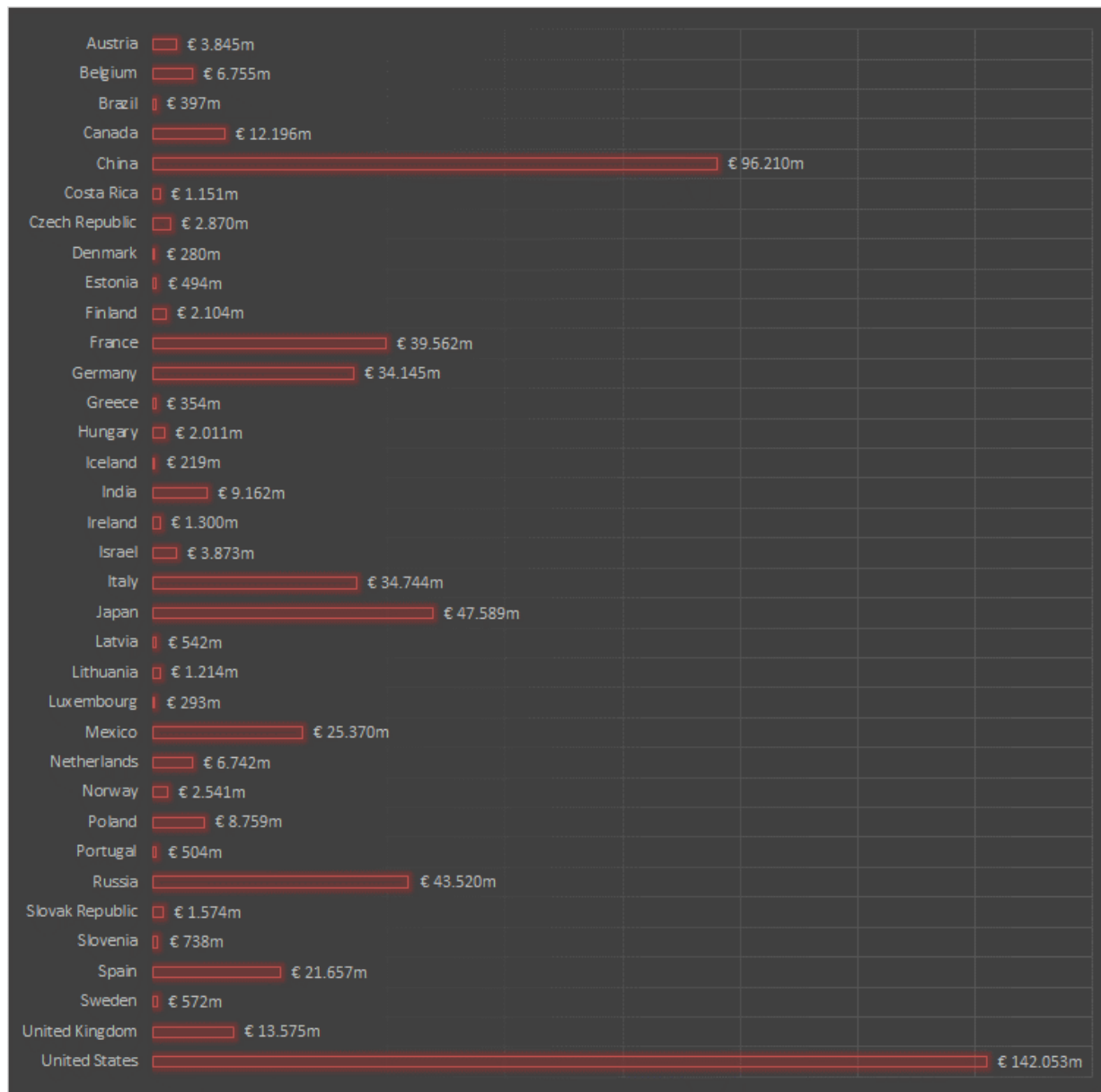


Figure 9. Meat consumption expenditure

Concluding, the specific geographical scope and business market segments for this use case can be meat manufacturers in: USA, China, Brazil, Germany, France; Meat Importers in: Japan, China, UK, Germany, France, Italy, Netherlands; Local logistics, retail and food service enterprises as well as meat consumers in: USA, China, Japan, Russia, Mexico, Italy, Germany and France.

2.2.2 Bread and Cereals

Aflatoxin detection is a major issue in the supply chain of corn (maize) shown in Figure 10 below. Governments and private businesses are spending considerable amounts of money to meet food safety criteria enforced by the law.

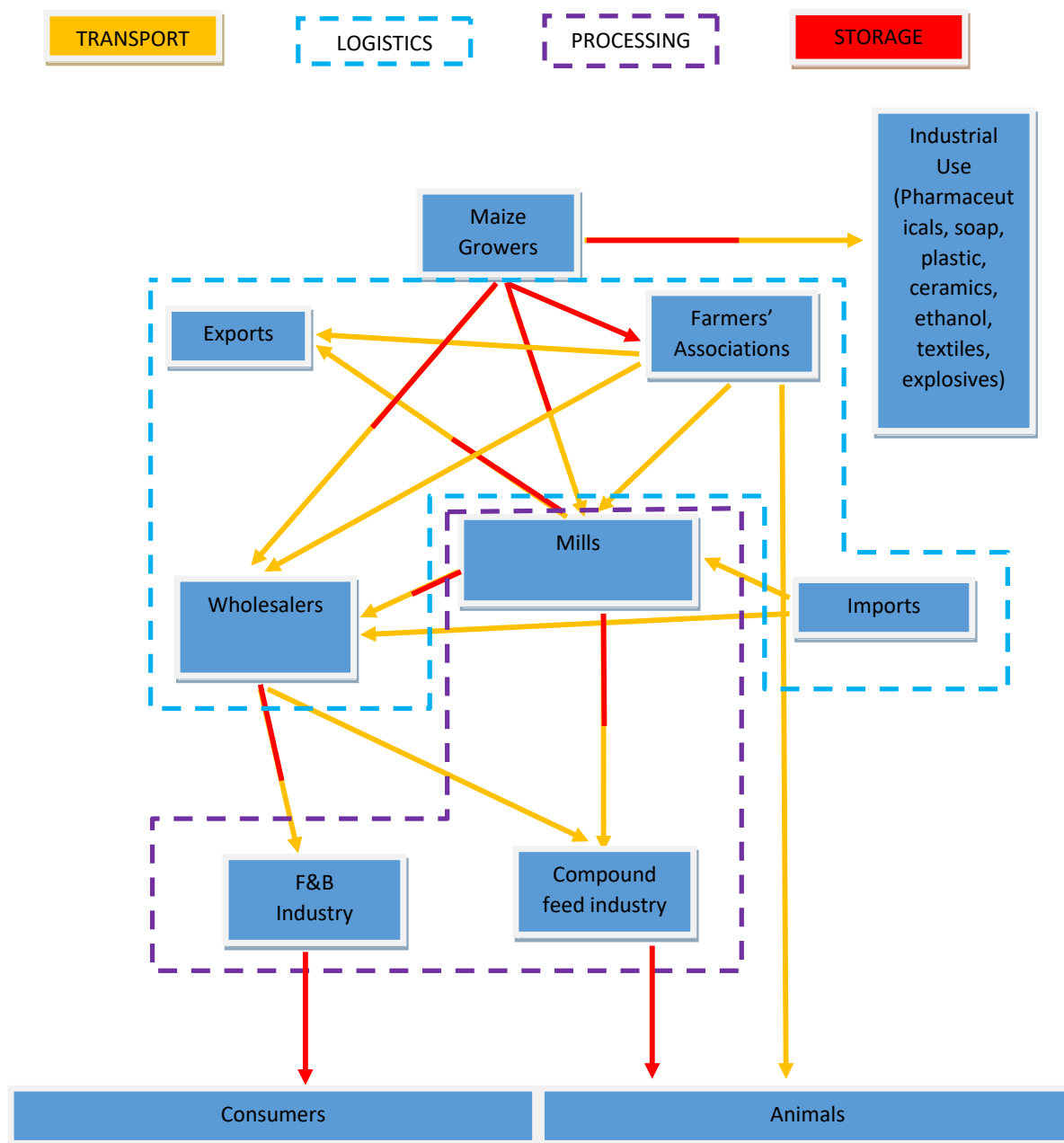


Figure 10. Bread and Cereal food supply chain

Within the supply of corn, the use of PhasmaFOOD would be of value to the logistics and processing industry. In the processing industry, PhasmaFOOD solution is suitable for mills, livestock farmers and the compound feed industry; the latter, according to International Feed Industry Federation, generates an estimated annual turnover of over €400 billion. These segments receive raw material, previously stored at other facilities and/or processed goods that have been found to retain their aflatoxin levels even after processing takes place (e.g. bran or germ after milling). According to the latest FAO data, the total gross value of maize production reached €240 billion, while the value of trade was more than €41 billion. Although USA is currently the greatest corn producer in terms of volume, as seen in Figure 11, China with €90 billion worth of maize production is ranked first in the terms of value; USA is following with €60 billion. This is due to China's agricultural policy that has established floor prices for corn for many years, re-

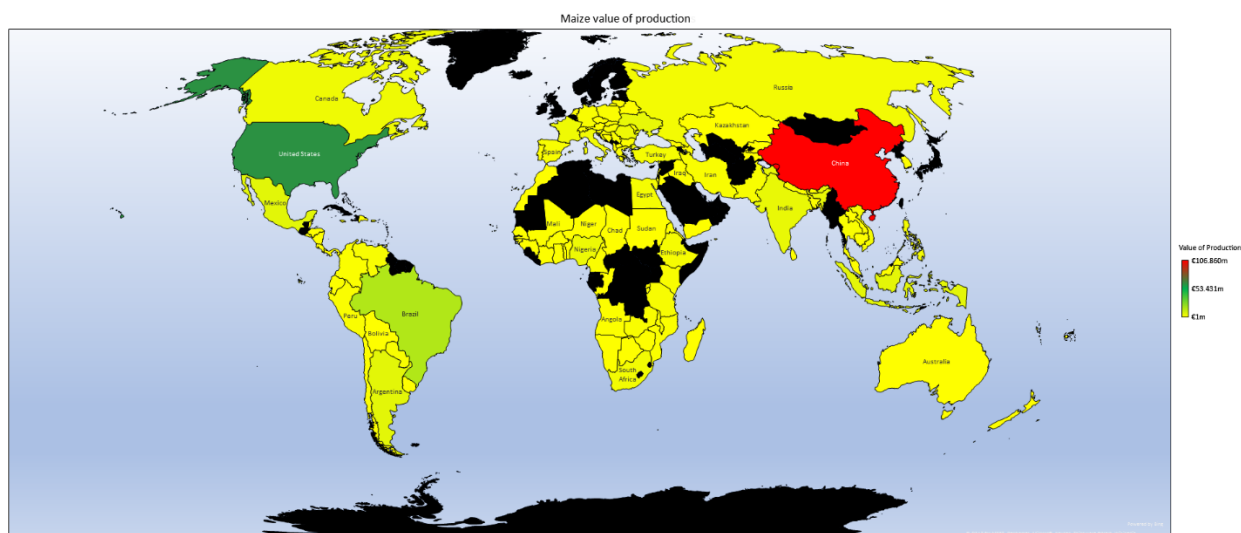


Figure 11. Maize value of production

sulting to Chinese producers facing 40%-60% higher producer prices than the Americans. In turn, this has led to a large amount of maize stock in China. This stock is expected to be out in the market during the following years, since China has made a turn to more sustainable agricultural policies, such as direct payments, that aim to reduce the current stocks. Given that the necessity for Aflatoxin monitoring increases with the time corn remains stored, China and countries importing from China will be of high interest for PhasmaFOOD.

Since food processing (milling, thermal processing and extrusion processing as well as other processes used in the F&B industry) seems to result in considerable reduction but not elimination of aflatoxins in the byproducts aimed for human consumption (Bullerman & Bianchini, 2007), food manufacturing have a high interest in PhasmaFOOD to reduce negative publicity in case random controls reveal high aflatoxin levels in its products⁴. Bread and bakery manufacturing takes place mostly in USA with the value of shipments reaching €40 billion. China has an €18 billion turnover industry while Germany (€22 billion), Italy (€17,9 billion) and the UK are

⁴ Since the effects of aflatoxin consumption are more severe in the long-run and not easily attributable to their cause, we assume that lawsuits and other losses brought about by the consumption of contaminated food are not of great concern to the industry.

leading the EU bakery manufacturing industry in terms of turnover. The U.S. breakfast cereal industry is leading the global turnover with more than €8 billion per year.

As far as trade is concerned, the countries of interest are USA, Brazil and Argentina, each with more than €5 billion worth of corn exports and then Ukraine (€3.5 billion), France (€2.5 billion), India (€1 billion). Other major exporters within the EU are Romania and Hungary.

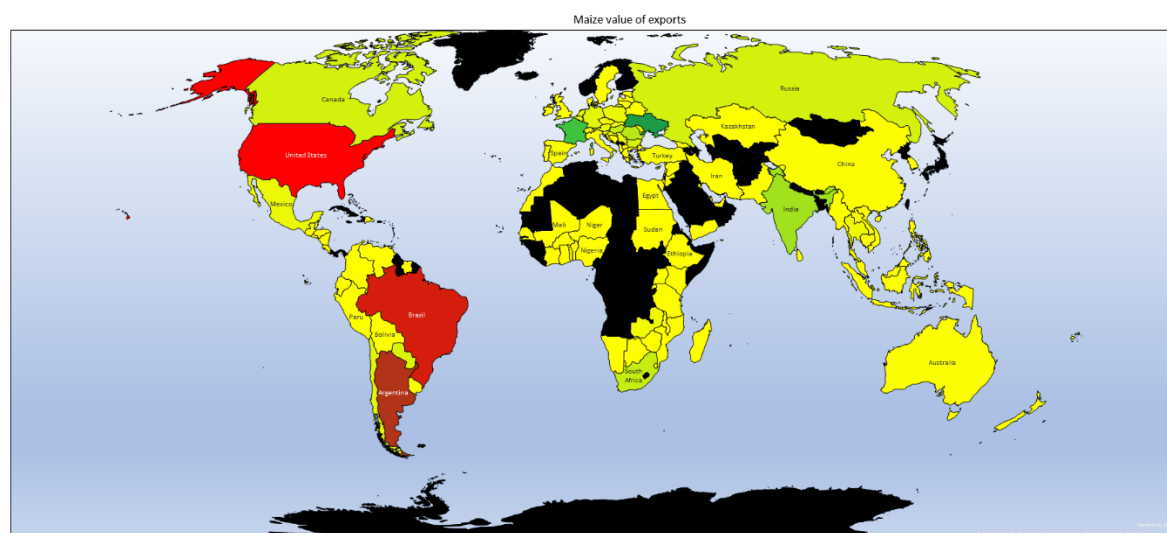


Figure 12. Maize value of exports

Importing is a major source of corn in the supply chain of Japan that is the most important importer with €4.5 billion worth of imports. North Korea is ranked second, importing €2.5 billion of maize, closely followed by China, Mexico and Egypt (with almost €2 billion each). In the EU, Spain, Netherlands and Italy are top importers with more than €1 billion maize imports. USA

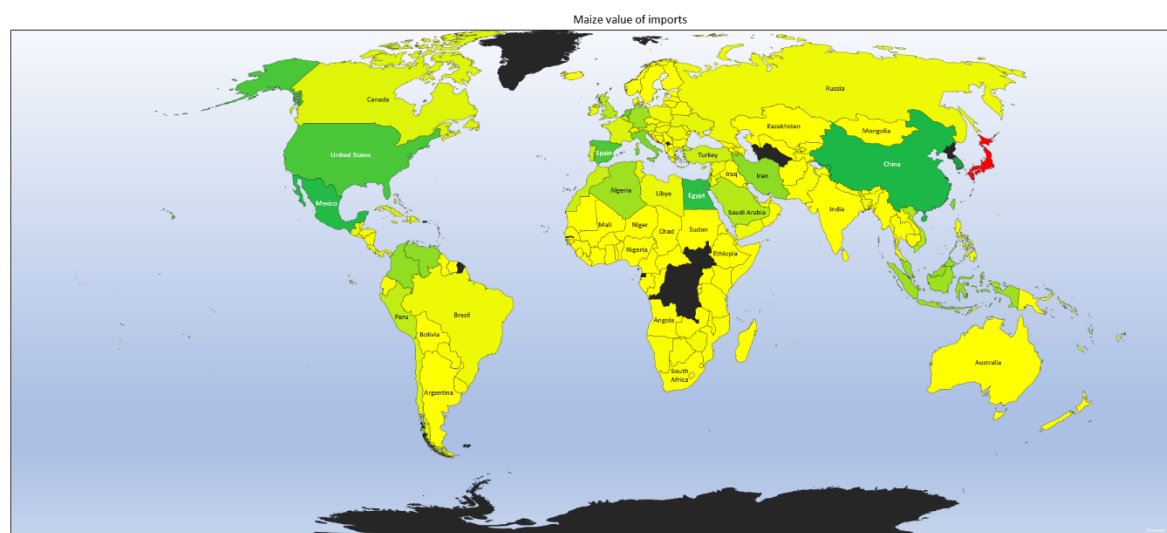


Figure 13. Maize value of Imports

and Latin America are also major players in terms of maize imports as also shown in Figure 13.

At the consumers' end, due to rising health consciousness, the cereals market is driven by the demand for breakfast cereals that contain healthy and nutritious ingredients. The obesity-related health issues that have emerged in the traditional markets for these products along with the greater health awareness among the young generation is creating opportunities for new products that are low in fat and calories or ones that have added health benefits such as high protein concentration or high fibre. The bread and baked food market on the other hand is primarily driven by rising demand for convenience food. These products are usually used to as ingredients of quick snacks or meal substitutes. The prevailing lifestyles that do not allow cook-

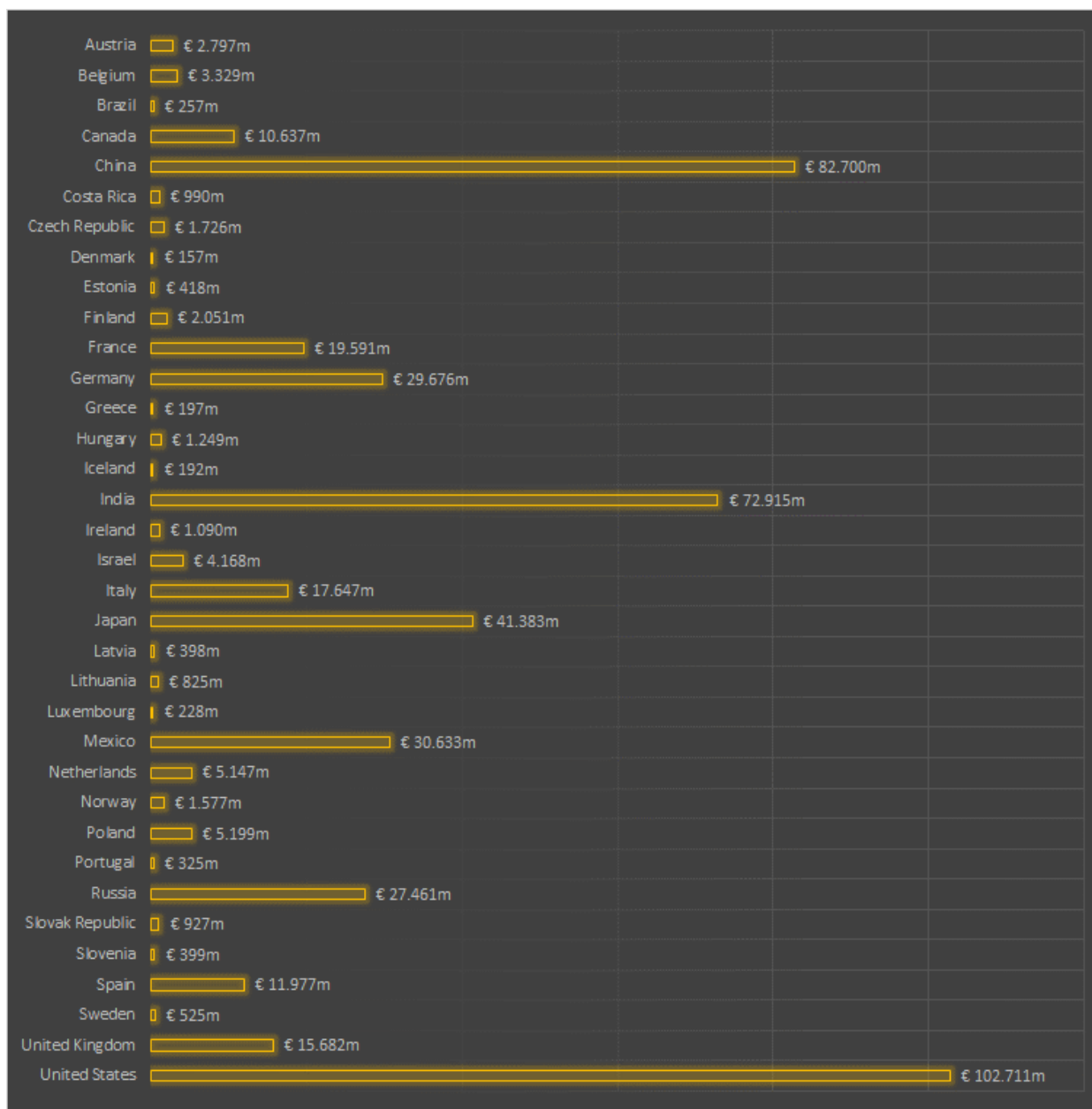


Figure 14. Bread and cereals expenditure

ing and time-consuming meal preparation on daily basis result in high growth of this market. Nevertheless, as in the case of cereals, the introduction of innovative baked products with high nutritional value is likely to open a new era for this market. For this use case, PhasmaFOOD is entering a market with a value of almost €520 billion for the countries of interest (see Figure 14. Bread and cereals expenditure). From these countries, USA, China and India are the most noteworthy, since household spending on bread and cereals is €103 billion, €83 and €73 billion respectively.

Overall, for this use case, key actor-region combinations are bread and bakery manufacturing industry in: USA, China, Germany, Italy; Maize importers in: Japan, North Korea, China, Mexico, Spain, Netherlands, Italy; bread, bakery and cereals consumers in: USA, China, India, Japan, Mexico, Russia, Germany, France, UK.

2.2.3 Milk Powder

The dairy products market is a very attractive market with a gross value of milk produce reaching €250 billion in 2015. Within the supply chain, presented in figure 15 below, PhasmaFOOD is a valuable solution to the groups that receive or forward fresh milk from and to other actors within the chain. These groups include the dairy processing and packaging industries and at a lower degree exporters, importers and wholesalers. Milk adulteration is not an uncommon phenomenon at these stages while aflatoxins that are carried on from animal feed are most likely to be more profound and easily detectable at these early steps in the production.

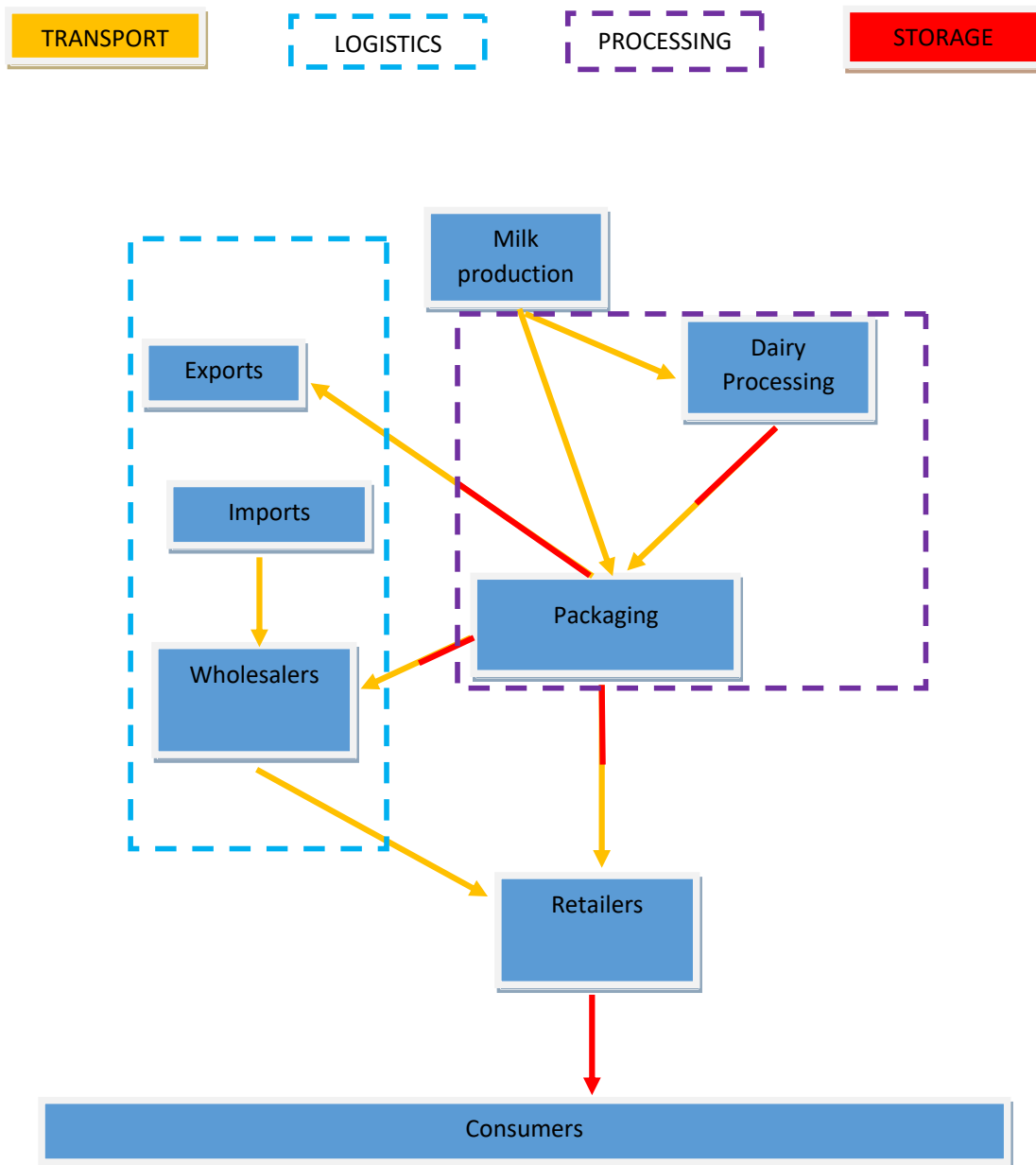


figure 15. Dairy food supply chain

However, the most severe cases of food adulteration in the milk supply chain and thus the focus of PhasmaFOOD is that in milk powder and especially infant formulas. The memories are still vivid since 2008, when melamine was detected in Chinese infant formulas, a fact that caused the death of 6 children and affected 294.000 children who suffered kidney and urinary problems, by consuming contaminated formula. This kind of adulteration takes place mainly during fresh milk production or the manufacturing process which leaves the milk processing,

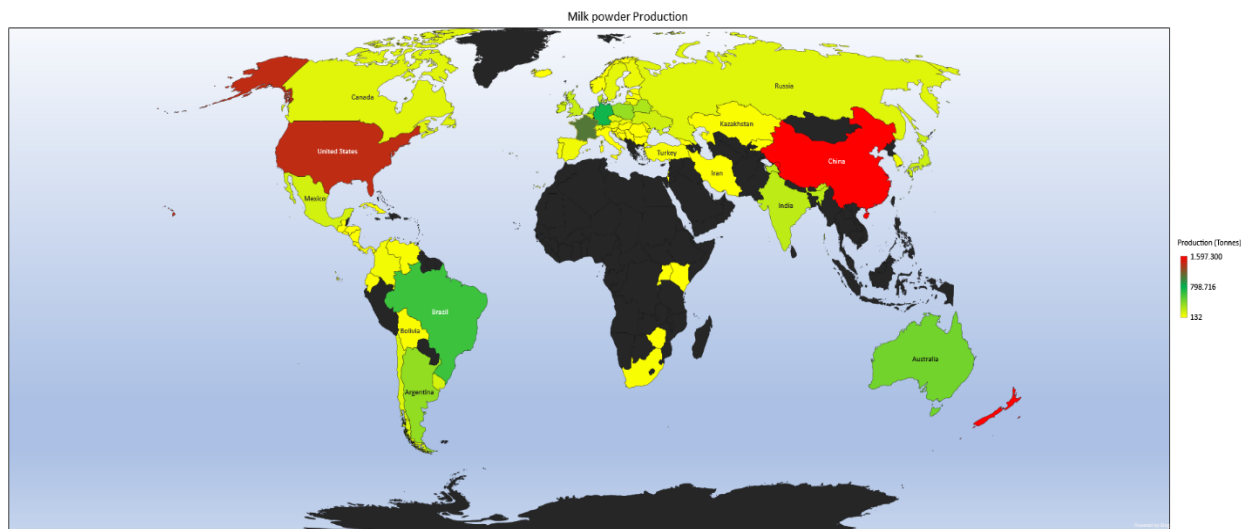


Figure 16. Milk powder production

logistics and retailing business as potential PhasmaFOOD target actors. Nevertheless, because infant formulas reach the logistics and retail stage as packaged products and not in bulk, the non-destructive nature of PhasmaFOOD solution loses its advantage and thus the offered services are not considered competitive.

But which markets are of interest to PhasmaFOOD? Globally, about 11,5 billion tonnes of milk powder are produced every year. More than half of this quantity is made in China (1,6 million tonnes), New Zealand (1,5 million tonnes), USA (1,4 million tonnes), France (1 million tonnes)

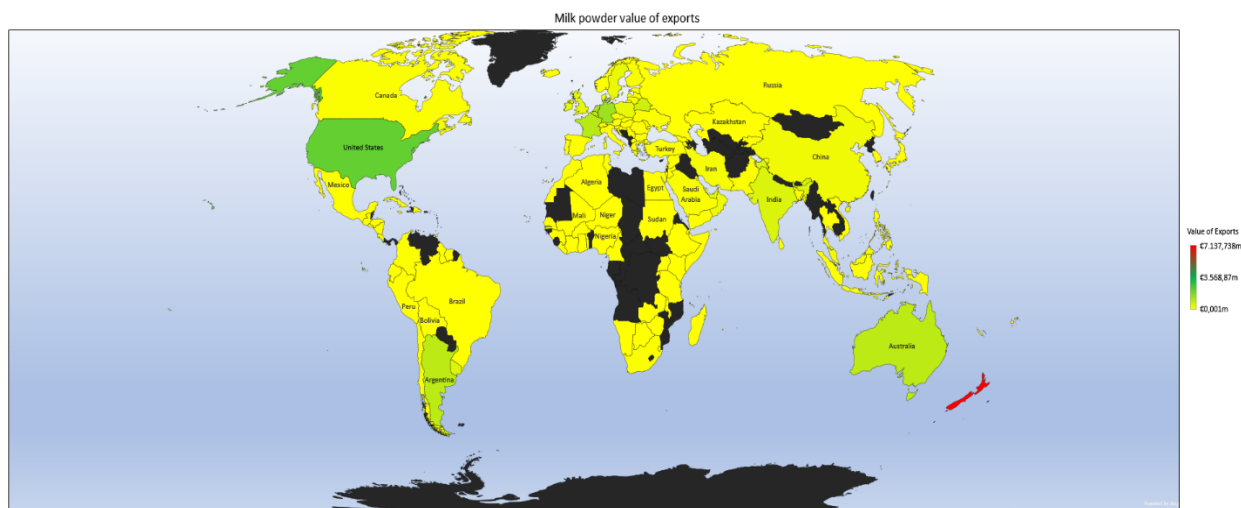


Figure 17. Milk powder value of exports

and Germany (800 thousand tonnes). Figure 16 shows other interesting markets for PhasmaFOOD, such as Brazil, Australia, Argentina and Poland. Regarding cross-border trading, the value of which was estimated at €25 billion in 2015. Almost a third of the global value originates from New Zealand (€7 billion) which makes it a target-market of high potential for PhasmaFOOD. Other major milk powder exporting countries are shown in Figure 17; these are USA (€2 billion), Germany (€1,3 billion), Netherlands (€1 billion), France (€950 million), Argentina (€900 million), Australia (€900 million) and Belgium (€820 million).

Importing countries are even more valuable for PhasmaFOOD, since the food safety issues associated with milk powder adulteration keep the local industries and monitoring authorities alerted. This is due to the severity of impacts as well as to the sensitive groups that these prod-

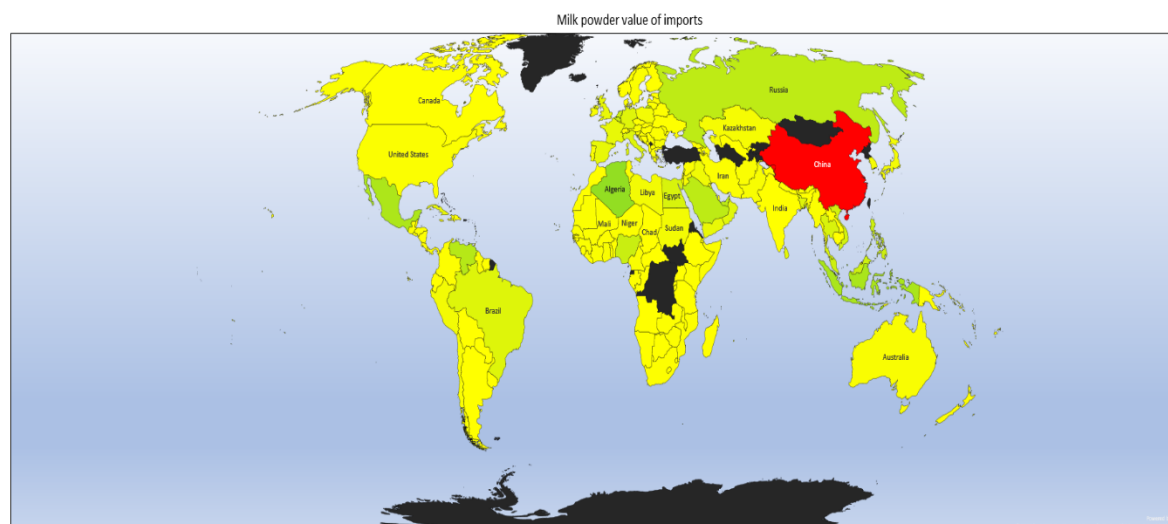


Figure 18. Milk powder value of imports

ucts are addressed (infants and children). However, the greatest importing markets are tricky. In particular, as shown in Figure 18, China is the key importer with €4,5 billion worth of milk powder imports. Nevertheless, other than China and Russia (with value of imports close to €600 million), the rest of the vibrant importing markets are ones that are not very easily accessible or are partially unmapped. These include Algeria, Indonesia, Mexico, Venezuela, Singapore and Nigeria; import values in these countries range between €500 million to €1 billion. This is despite the lower average spending power of consumers in these regions and is attributed to the higher birth rates that are observed there.

In terms of final consumption, the milk powder industry is very attractive for PhasmaFOOD for various reason. As shown above, although milk powder has many other applications, like nutritional foods, baked sweet and savories, confectionaries and more, the infant formulas market seems to be driving the market and this is where PhasmaFOOD has the best value proposition. Since safety and trust are key attributes in parental decisions regarding the infant formula that they will use to feed their child, the contribution of PhasmaFOOD is significant. According to Euromonitor, the retail market of milk formulas reached €40 billion in 2013 while sales of infant formula in China alone are expected to reach €25 billion by 2017 (Jourdan and Tajistsu, 2013).

Demand for milk powder is increasing as the global baby food and formula industry is growing with annual rates of more than 5%. In the Asia-Pacific region (especially China) the growth was even greater as was for Eastern Europe, and in a lesser extent Middle East and Latin America. The emerging middle class, the lower costs of production and the loose legal framework are attracting investments on infant formula manufacturing plants in these areas. In the retail market of developed countries, PhasmaFOOD has probably the clearest target group, which is also the most widely studied by modern marketers, Millennial Moms. This demographic group has a big market power and spends more than €150 billion per year and over \$10 trillion in their life-times. Millennial moms have many characteristics that makes them unique to PhasmaFOOD. First, they are more educated both academically and technologically than the average mother while the majority is in the middle of career building. They are also keen users of social media and smartphones, they often make online purchases and are seeking advices from other peers. Finally, they place food safety as their number one priority when grocery shopping for their kids. Giving them the opportunity to detect foreign substances and aflatoxins in baby food would be a service that this group would value highly.

Concluding, specific target markets for PhasmaFOOD are Milk powder manufacturing industry in: China, New Zealand, USA, France; Milk powder importers in: China, Russia, Algeria, Indonesia, Mexico; Milk powder (infant formula) consumers in: Asia-Pacific region, Eastern Europe.

2.2.4 Pistachios

Scandals related to aflatoxins in pistachios are not uncommon. In September 1997, EU rejected a large pistachio shipment from Iran, due to high levels of aflatoxin contamination. Although this is probably the incidence that was most aggressively advertised, aflatoxin detection in Pistachios is a fact that requires the attention of the supply chain.

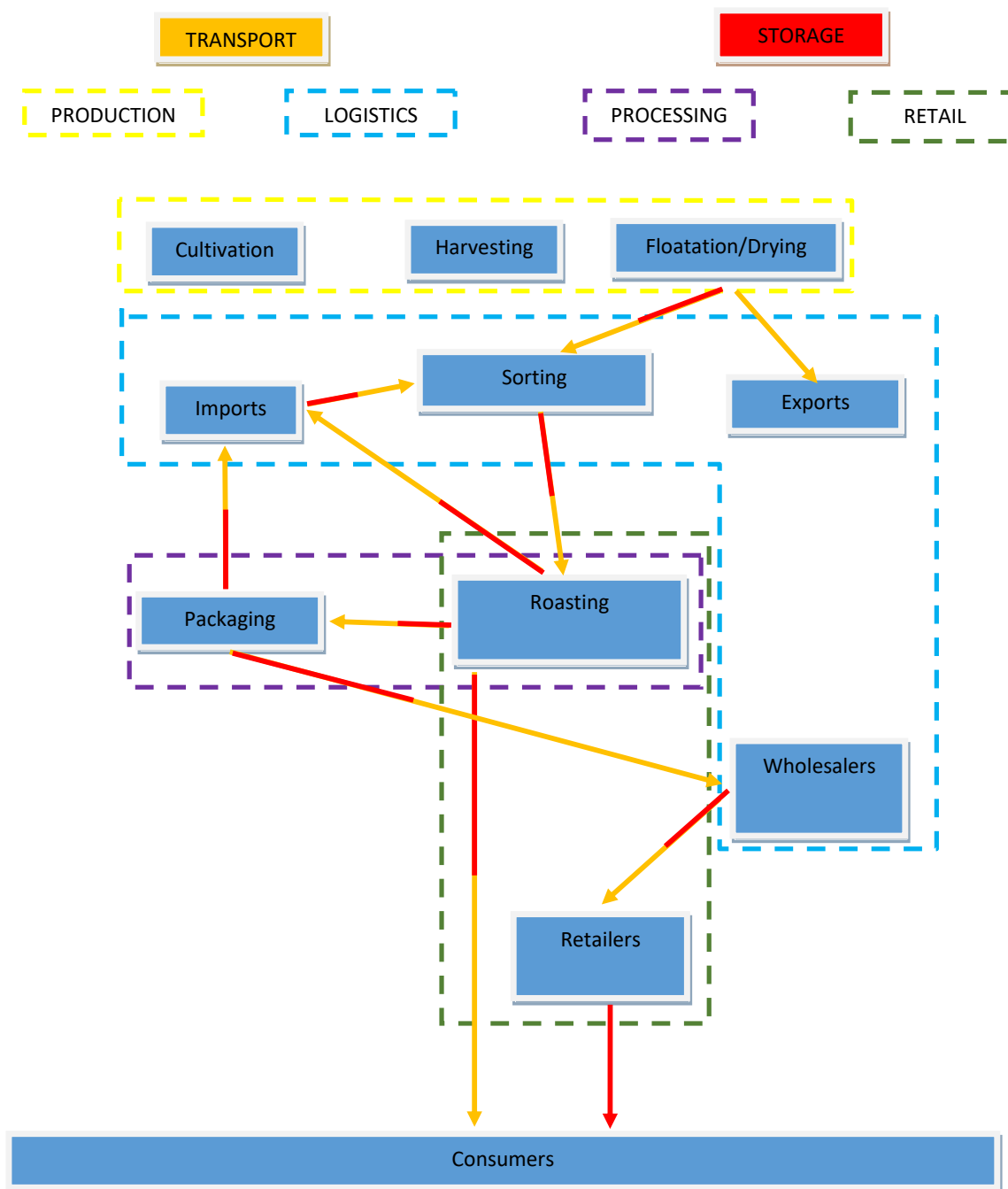


Figure 19. Pistachios supply chain

The RASFF portal alone hosts more than 400 reported cases of aflatoxin detection and other nuts with the latest taking place in Netherlands on April 2017, where pistachios in shell originating from Iran and distributed via Germany were contaminated with high levels of aflatoxins (B1 = 21; Tot. = 59 µg/kg - ppb). As a result, PhasmaFOOD solution is bound to add value within the chain by enabling the detection of aflatoxins before they end up in the hands of consumers. Within the supply chain of pistachios as shown in Figure 19 above, PhasmaFOOD's contribution in aflatoxin detection is more relevant to the retail, processing and logistics chain. Furthermore, imports and exports are of paramount importance for PhasmaFOOD, since very few countries produce pistachios at a large scale and thus most of the global demand for the good is covered by imports/exports that total to over €3 billion annually. Another reason for that is that cross-border food safety checks seem to be the most common reason for uncovering aflatoxin incidents.

Iran and USA are leading global pistachio production with more than €1.5 billion gross value of pistachio production each.⁵ These two countries account for more than 70% of global production value and more than 80% of global trade value. Following Iran and USA are Turkey, Afghanistan, Argentina, Australia, Egypt, Greece, Lebanon, Israel, Italy, Morocco, Spain and Tunisia. The Mediterranean Islands also produce pistachios but most of the quantities are locally consumed, with minor exports to countries within their respective regions.

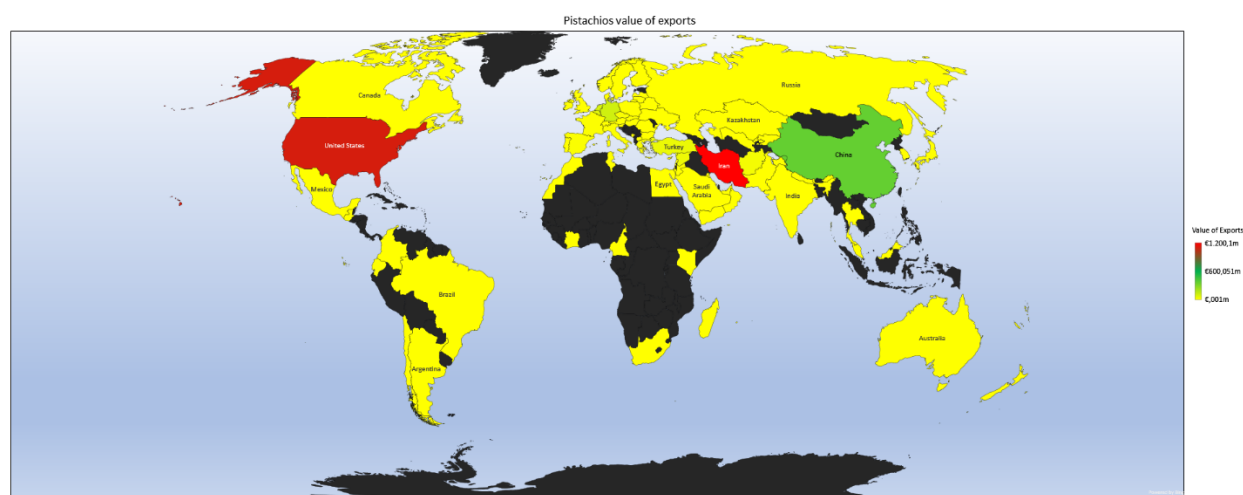


Figure 20. Pistachios value of exports

As expected, major exporters are again USA and Iran, gaining more than €1 billion from pistachio export activities. China derives most of its exporting value from reverse trade with USA, where products are exported from the latter to the former for the purpose of separating the pistachio nut from its shell and then re-imported for sale or further processing. This is due to the lower labour rates in China that the industry seeks to take advantage of. Within the EU,

⁵ The 2015-16 crop year was devastating for US pistachio producers since yield was severely affected by inhospitable climate and drought. In terms of market scoping, we choose to use previous data, because they reflect the long-term opportunities in the global pistachio industry.

Germany (€100 million), Netherlands (€90 million), Belgium (€60 million) and Greece (€10 million) are the most active in pistachio exports.

China and in particular Honk-Kong is the destination of a very big part of total exported pistachios, with almost a third of global imports (€850 million) landing there. Overall, U.S. pistachio exports to Hong Kong have enjoyed very high growth rates since 2008, and increased more than 30% in some of the years thereafter. Aside from China, the EU –with Germany (€300 million), Italy (€115 million), France (€90 million), Netherlands (€85 million), Spain (€80 million), Belgium (€75 million) and Luxembourg (€73 million) as its main markets–, Russia (€100 million pistachio imports) and India (€70 million) are interesting markets for PhasmaFOOD (Figure 21).

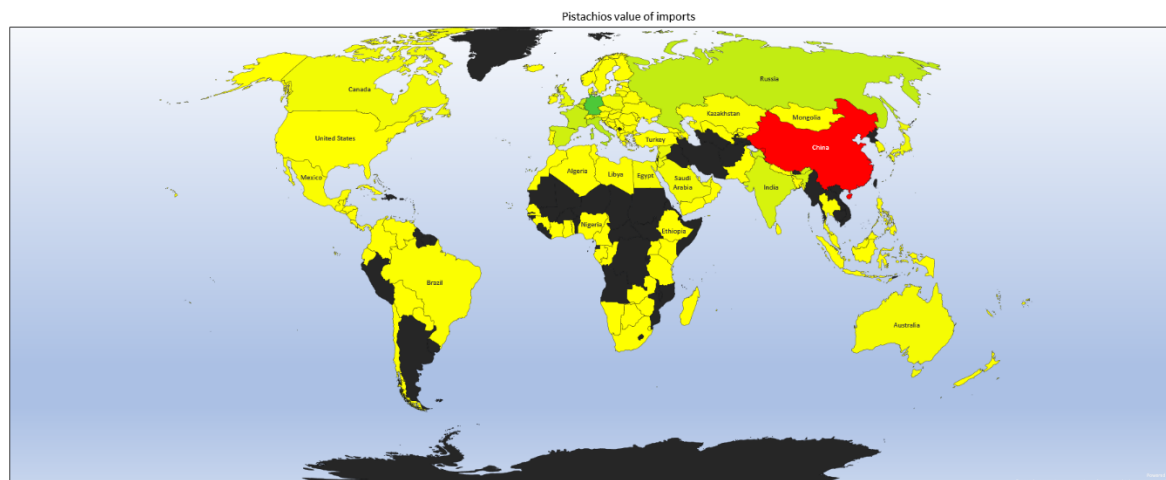


Figure 21. Pistachios value of imports

According to the Global Statistical Review of the International Nut and Dried Fruit (INF) in 2015, tree nuts accounted for a supply value of almost €30 billion, showing an upwards trend during the previous decade. Also, the global nuts market is expected to expand to a valuation of more than €1 billion by 2021 with total consumption of tree nuts growing 53% percent over the last ten years (Transparency Market Research, 2015). In this use case too, the Asia-Pacific region represents the most attractive market. In the region, pistachios are mostly consumed as snacks during leisure and holidays. As a result, the more the living standards are getting higher, the more the demand is expected to grow. Western Europe market is also expected to show favorable growth in terms of volume consumption over the next few years. In terms of value, the Japanese market is expected to account for a major share of the market for edible nuts. As pistachios and other nuts will be entering the daily diet of consumers, health concerns about aflatoxins will emerge and PhasmaFOOD will be there to grasp the anxiety and add value to the consumer.

Based on the above, PhasmaFOOD should target pistachio importers in: China, Germany, Italy, France, Netherlands, Spain, Belgium, Luxembourg and pistachio consumers in: Asia-Pacific region, Western Europe

2.2.5 Edible Oils

Olive oil fraud appears occasionally in different forms, such as olive oil mislabeling, mixing high quality (extra virgin) oils with inferior quality ones (refined olive oil, added dyes, pomace oil, sunflower oil, hazelnut oil).

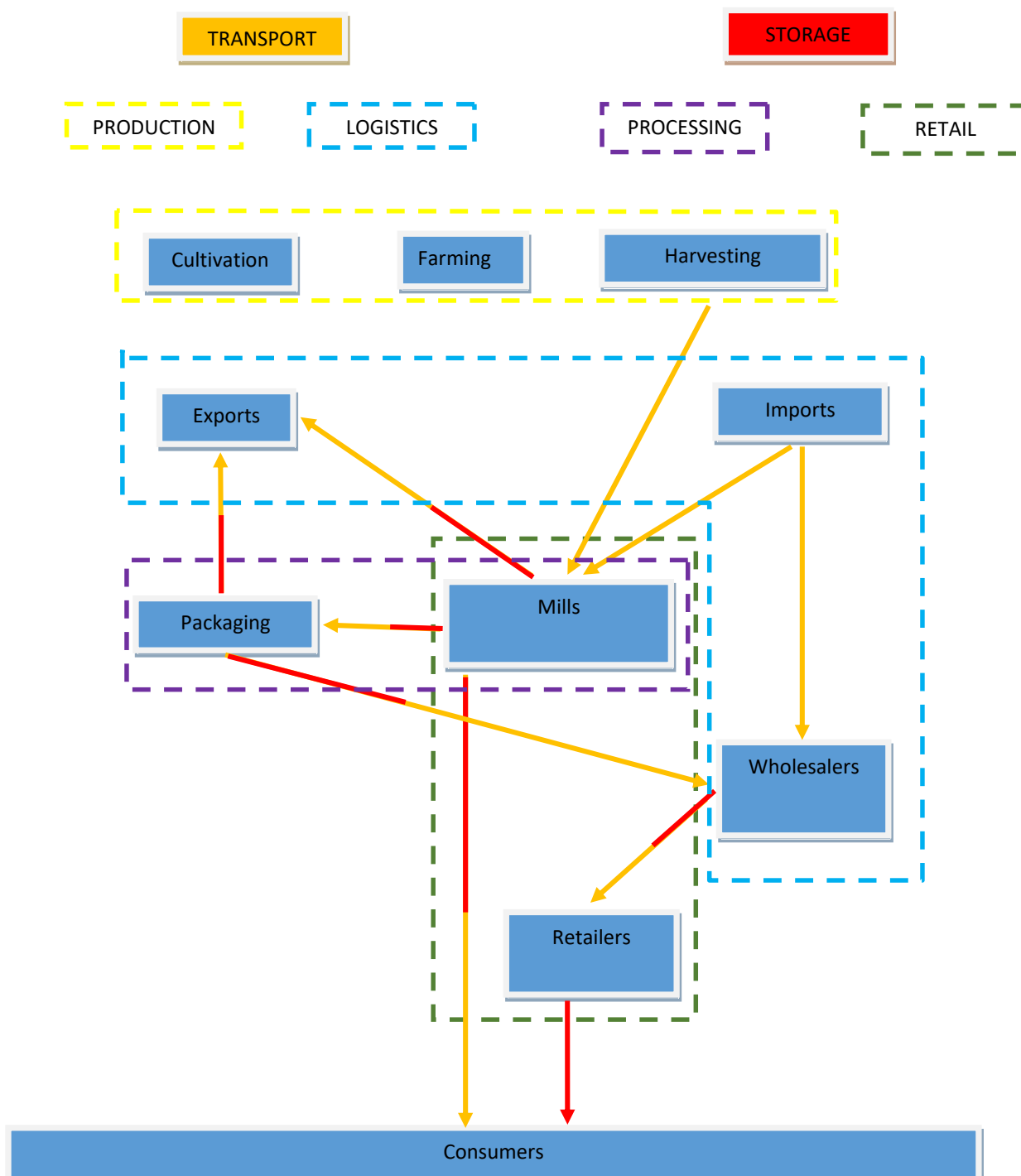


Figure 22. Edible Oils supply chain

But olive oil fraud is not the only nor the most dangerous case of oil adulteration. Incidents of adulteration are also present in sunflower oil where refined chicken fat or other similar additives have been detected. In extreme cases, traces of hazardous material such as mineral oils, diesel motor oils and other pollutants have been detected in sunflower samples. PhasmaFOOD will contribute to the reduction of oil adulteration incidents. It will be of interest to companies in packaging and wholesaling, as well as to importers and exporters of oils in bulk, a current trend in many countries, including USA⁶. This is because, as in the case of milk powder above, after packaging, PhasmaFOOD loses its competitive advantage. Figure 22 shows all actors involved in the food supply chain of edible oils. The value of PhasmaFOOD in this chain is created by the reduction of the economic loss incurred by negative publicity, both from the side of exporting and importing countries as well as of private companies.

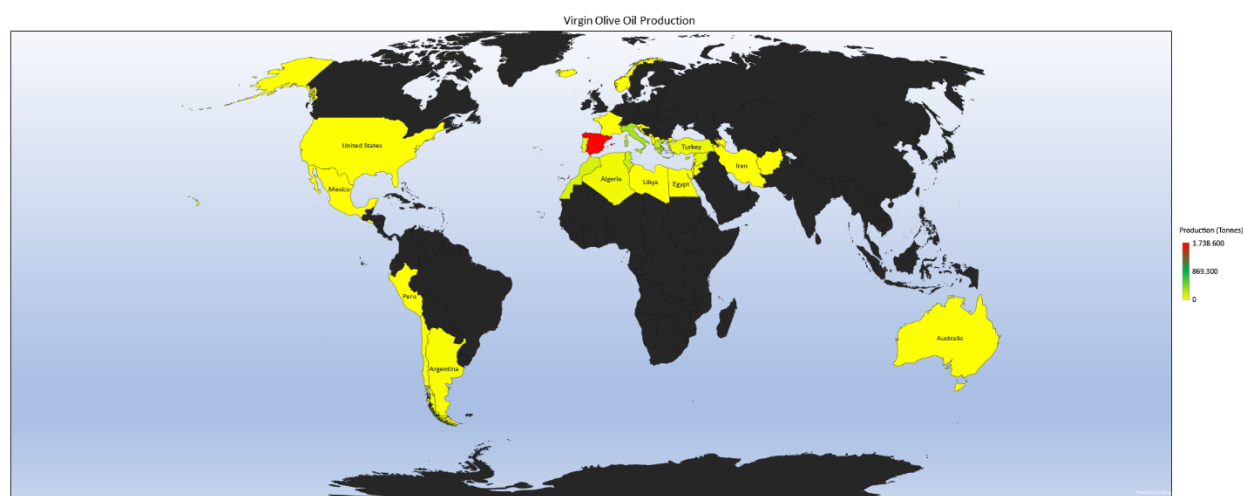


Figure 23. Virgin olive oil production

In targeting top producers, PhasmaFOOD should focus on the Mediterranean and especially on the three most important players in olive oil production, that are Spain, Italy and Greece, collectively producing more than 2 million tonnes of virgin olive oil per year (Figure 23). Among them, Spain is considered the most important producer with 1,7 million tonnes annually.

Total value of olive oil trading reached €6 billion in 2013. No surprise, the Mediterranean countries had the highest value of exports, again with Spain (over €2 billion), Italy (roughly €1.5 billion) and Greece (€600 million) leading the transactions. Top importing countries (figure 24figure 24. Value of virgin olive oil imports) were Italy with olive oil imports of roughly €1.5 billion and USA import over a €1 billion. Within the EU area, France (€400 million), Spain and Portugal (€350 million each) are highlighted while other interesting markets outside the EU are Brazil (€350 million), Canada (€160 million), China (€200 million) and Japan (€250 million).

⁶ <https://www.oliveoiltimes.com/olive-oil-business/u-s-olive-oil-imports-increasingly-bulk/54726>

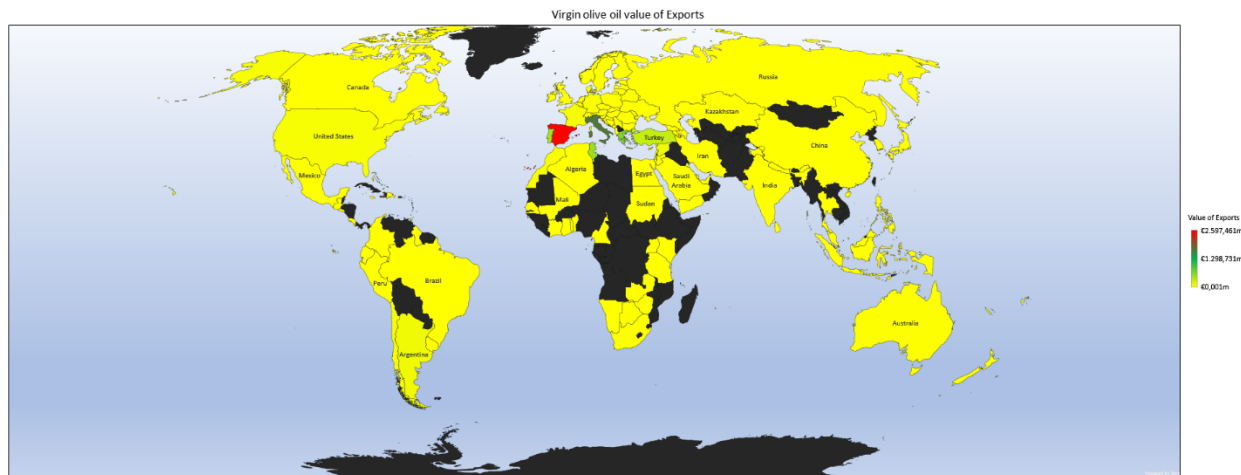


Figure 25. Value of virgin olive oil exports

On the other hand, as shown in Figure 26, sunflower oil production mainly occurs in Ukraine and Russia that produce 4,4 and 4 million tonnes, respectively. Other global producers are Argentina (931 thousand tonnes), Turkey (721 thousand tonnes), France (632 thousand tonnes), Hungary (566 thousand tonnes), Spain (503 thousand tonnes) and Romania (454 thousand tonnes).

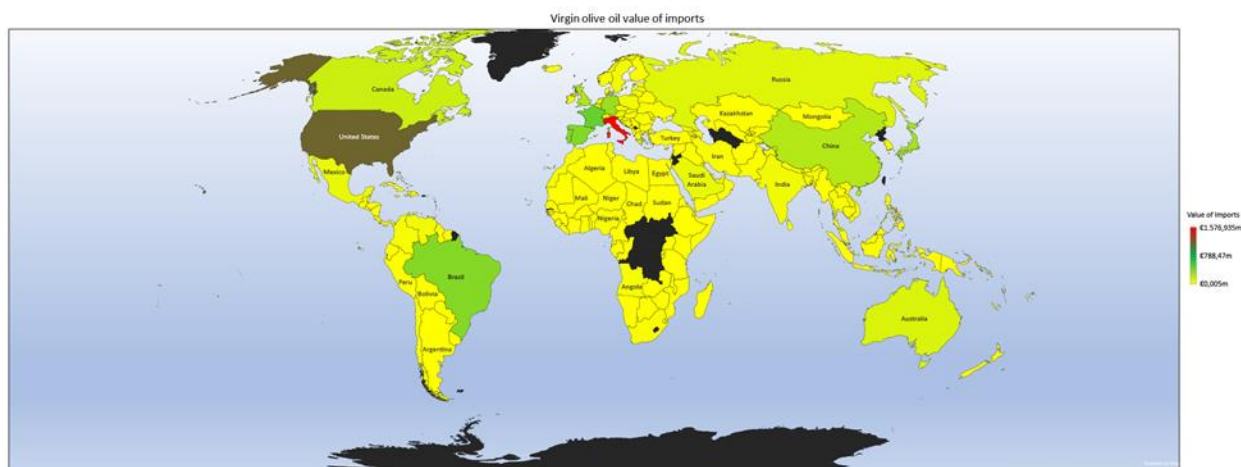


figure 24. Value of virgin olive oil imports

The value of sunflower exports/imports is close to €10 billion annually. Ukraine exports sunflower oil of more than €3 billion. Russia is the second largest exporter with more than €1 billion worth of exports. EU is quite active in export activities regarding sunflower oil since Netherlands (€700 million), Hungary (€600 million), France (€500 million), Argentina (€500 million) and Turkey (€495 million).

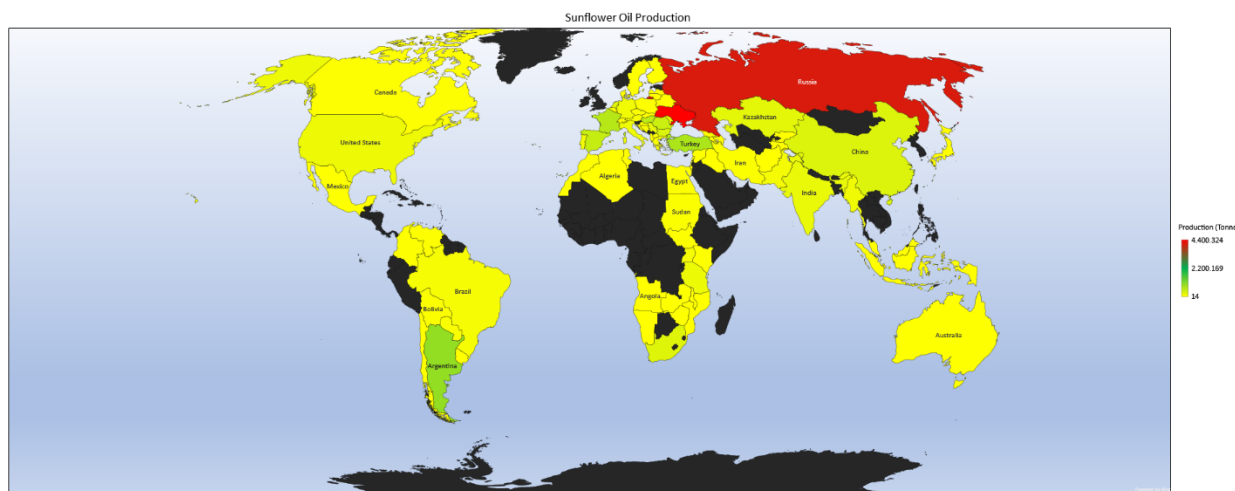


Figure 26. Sunflower oil value of production

PhasmaFOOD needs to target these countries and communicate the benefits of adulteration controls at the border, while showing how costly formal procedures can be facilitated if PhasmaFOOD is used as a screening procedure. Importing countries are very important as well.

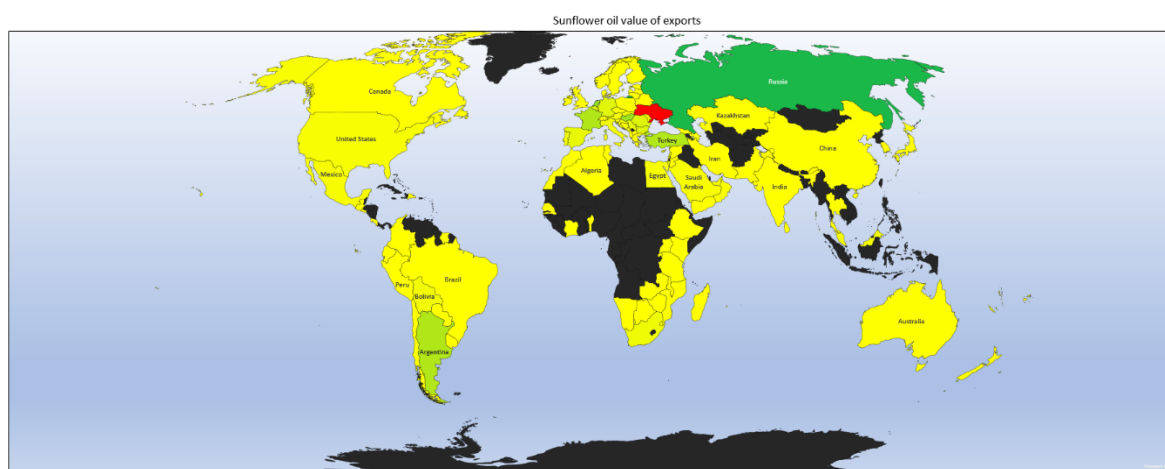


Figure 27. Sunflower oil value of exports

Indian sunflower agriculture faces a high systemic weather risk as about 80% per cent of the area is under rain-fed production. This fact along with the constantly high and rapidly growing demand has made India a primary import market for Ukraine (more than 30% in total Ukrainian export in 2012) as well as the other exporting countries presented above. India's value of sunflower oil imports in a year exceed €1 billion. Other countries with high value of imports (Figure 28) are Turkey (€900 million), Netherlands (€650 million), Egypt (€600 million), China (€520 million), Belgium (€531 million), UK (€350 million), Spain (€380 million), Germany (€350 million), Iraq (€320 million) and Italy (€310 million).

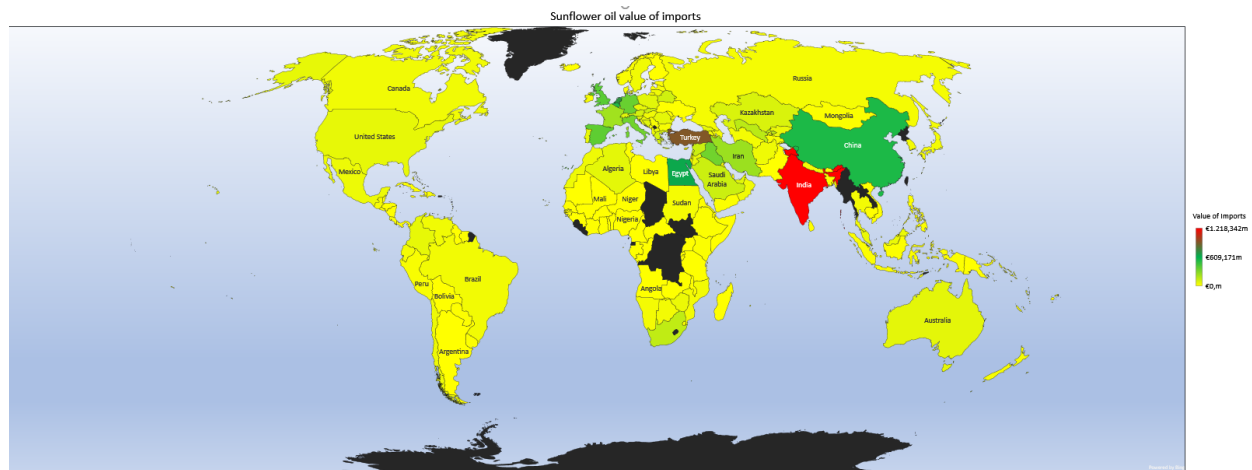


Figure 28. Sunflower oil value of imports

Olive oil is an indispensable part of the Mediterranean diet and is considered a superfood in the

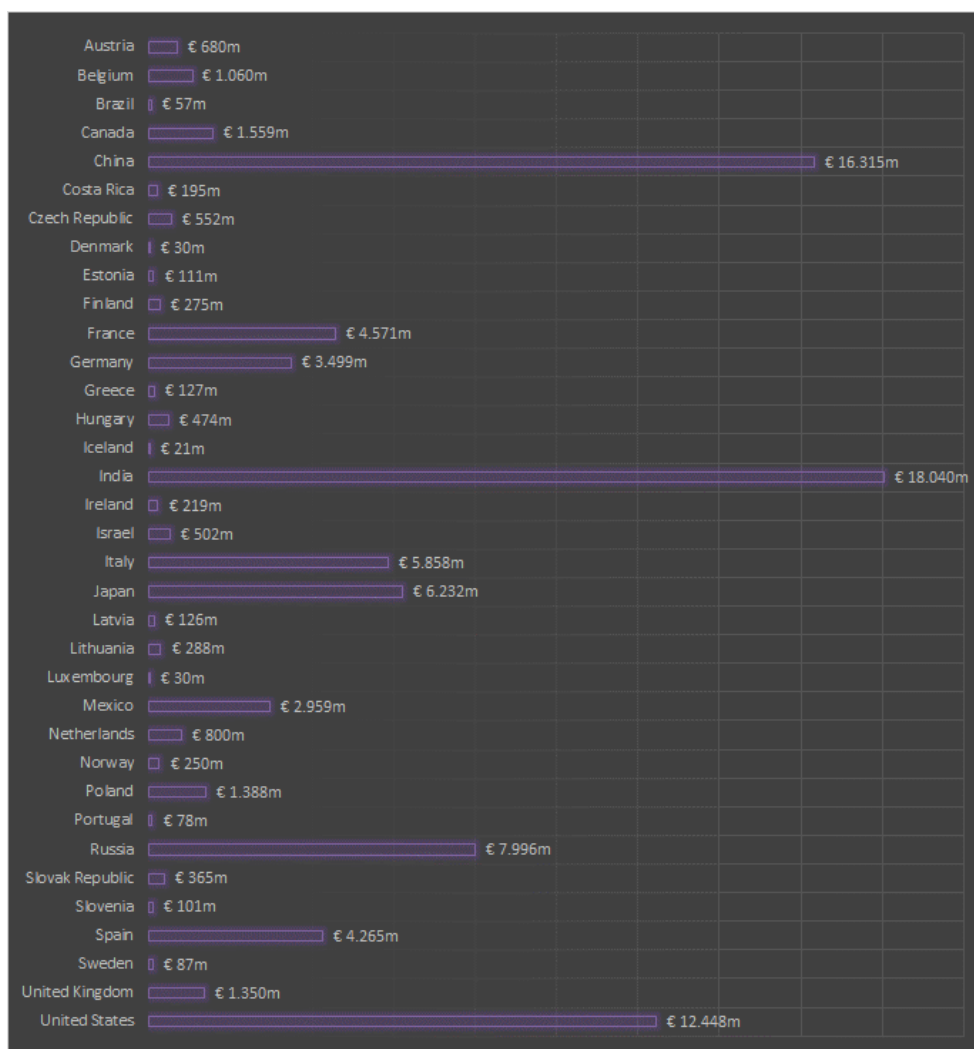


Figure 29. Oils expenditure

diets of other countries. Also, because vegetable oils choices are nowadays more and more driven by risk/benefit balance for diseases prevention and environmental concerns, sunflower oil is attracting the attention of consumers. Sunflower oil comes from a crop that gives health benefits in a sustainable production scheme and this makes it a special case compared to other vegetable oils. The global oils (including fats) expenditure is more than €95 billion. As shown in Figure 29, India, China and USA are markets whose retail value of oils exceeds the €10 billion threshold. Of these, India is the most promising since the per capita consumption of edible oil (at 14.4 Kg/year for 2014-15) is much lower than global averages (24 kg/year). Since demand of edible oil is mainly driven by income, rising income levels and improvement of living standards, a boost in India's market is expected, creating an opportunity for PhasmaFOOD. These expectations are also backed up by the projections for population growth in the area along with the expected increase in per capita expenditures, which in turn will lead to the adoption of western lifestyles, growing urbanization, increasing proportion of middle-class population and steadily rising affluence levels.

A wide range of potential target markets for this use case comprise of olive oil packaging enterprises in: Spain, Italy, Greece; olive oil importers in: USA, Italy, France, Spain, Portugal; olive oil importers in: USA, Italy, France, Spain, Portugal; sunflower oil packaging enterprises in: Ukraine, Russia, Argentina, Turkey, France, Hungary, Spain, Romania; sunflower oil importers in: India, Turkey, Netherlands, Egypt, China, Belgium; Olive and Sunflower oil consumers in: India, China, USA, Japan, Italy, France, Spain

2.2.6 Fruits and Vegetables

Global Fruits and Vegetables production value was higher than €800 billion in 2013. Top producers were China with almost €300 billion and USA with €70 billion, followed by India and Brazil (approximately €55 billions). Within the EU area, France, Spain and Italy were the countries with the highest values with almost €13 billion production value each. The map in Figure 30 shows the production values by country.

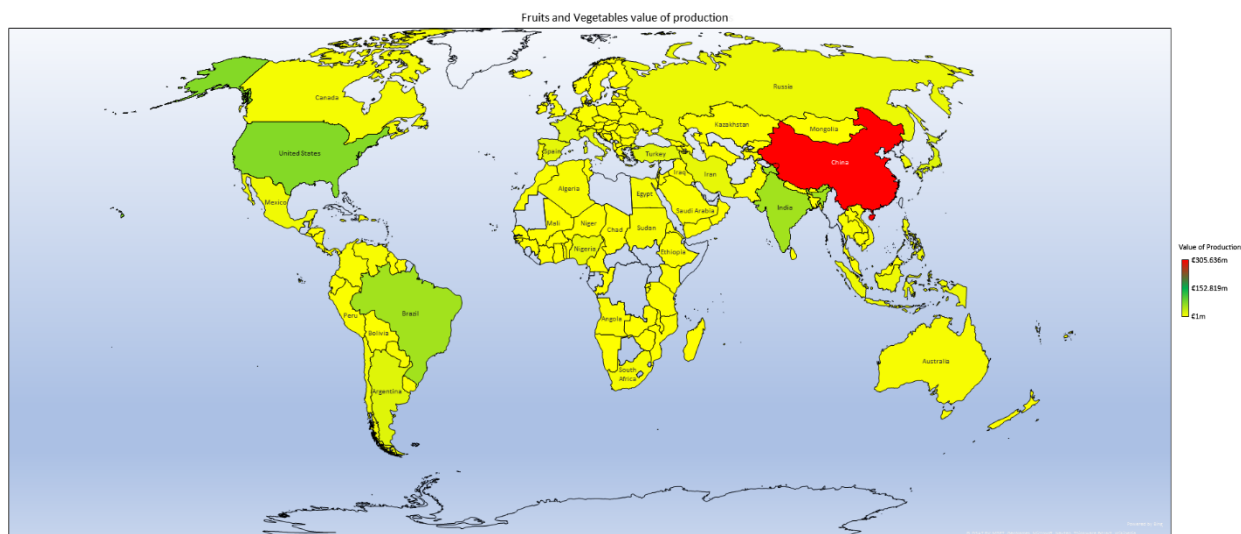


Figure 30. Fruits and Vegetables value of production

Within the supply chain of fruits and vegetables, the logistics and retail segments seem to be the ones with the highest interest for PhasmaFOOD. The use of the PhasmaFOOD device and algorithms for determining shelf-life would greatly benefit the aforementioned segments by reducing food waste within the value chain. From these segments, one probably needs to exclude local markets. This is because, they usually consist of producers which are mostly laypersons with difficulties in adopting new technologies and who live in rural or peri-urban areas with limited access to the infrastructure necessary for the efficient use of PhasmaFOOD. This is also the reason why producers are excluded from PhasmaFOOD's target group, although its technology would be beneficial in terms of logistics management.

For many countries, a very large portion of the supply chain volume comes from imports, while for others, exports are a big part of their total production. As previously discussed, these countries may present opportunities for the PhasmaFOOD solution. In fact, every year the total value of fruits and vegetables exports (imports) reaches €230 billion globally. Figure 32 shows that USA (€22 billion/year), China (€19 billion), Spain (€18 billion) and Netherlands (€16 million) are top exporters. Other important players in the EU are Belgium (€9 billion), Italy(€9 billion), France(€6 billion/year) and Germany(€6 billion/year).

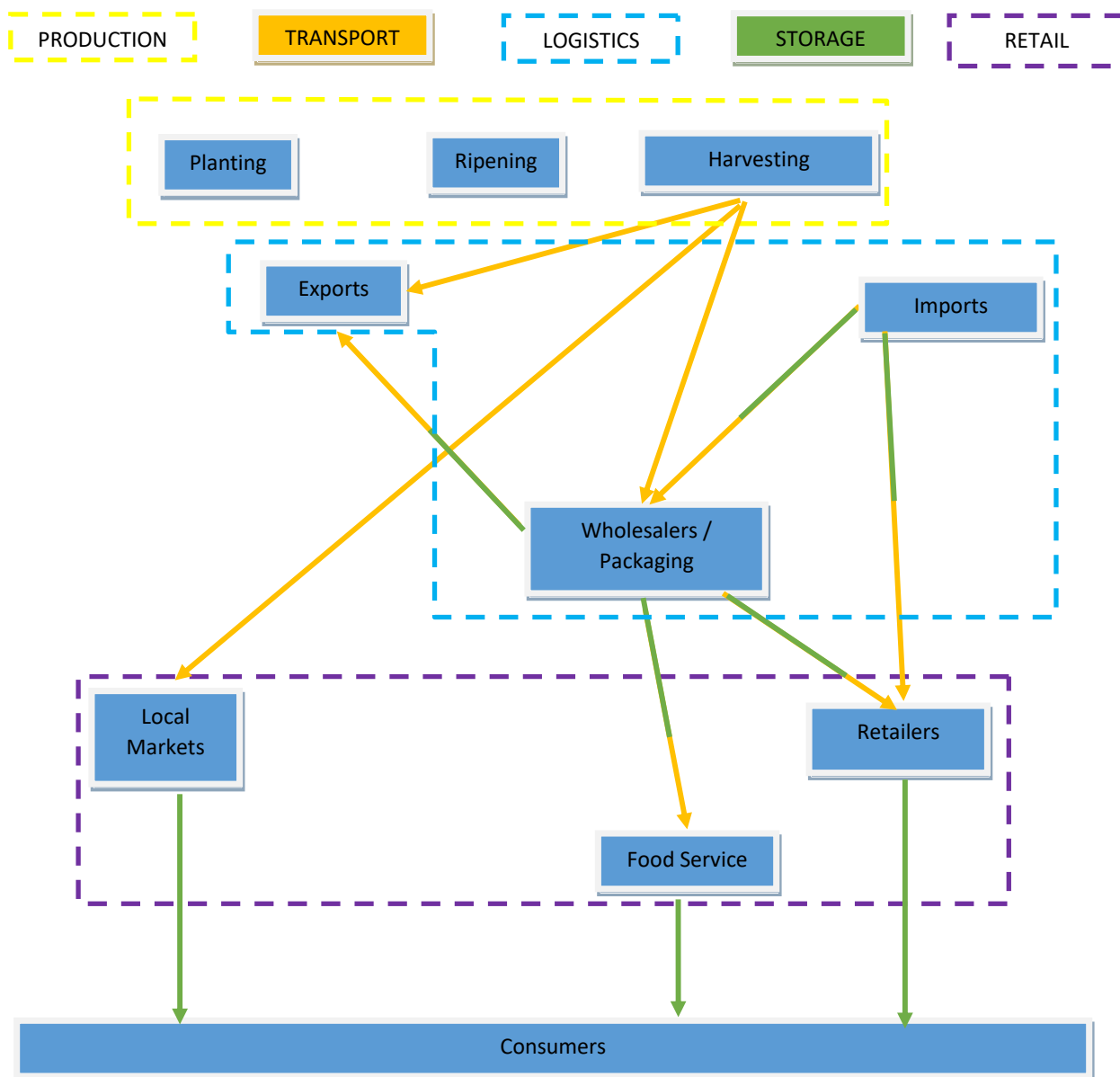


Figure 31. F&V supply chain

In terms of imports, the most important countries for PhasmaFOOD are USA (€27 billion), Germany (€20 billion), UK (€13 billion), China (€12 billion), France (€27 billion). Figure 33, graphs import values around the world.

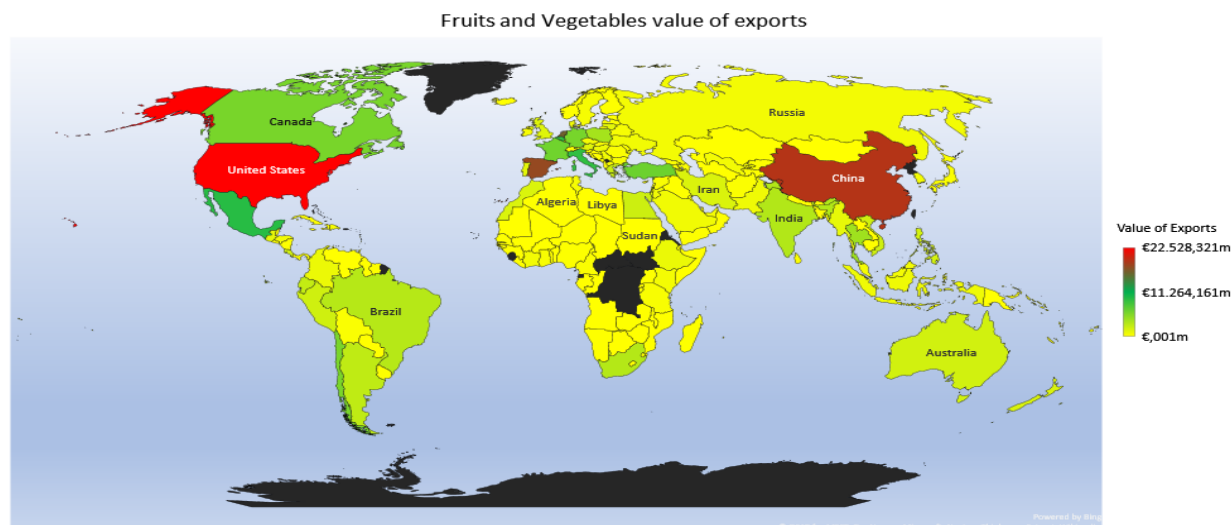


Figure 32. Fruits and Vegetables value of exports

The F&V market value for the countries of interest is presented in Figure 34 below and totals €500 billion; In terms of geography, India is the biggest and fastest growing market. As in the case of cereals, the main driver of the market is the increasing turn into natural foods with beneficial ingredients. Environmental and socioeconomic concerns also factor into purchase decisions. According to a global research contacted by Nielsen (2015), sustainably sourced (35%)

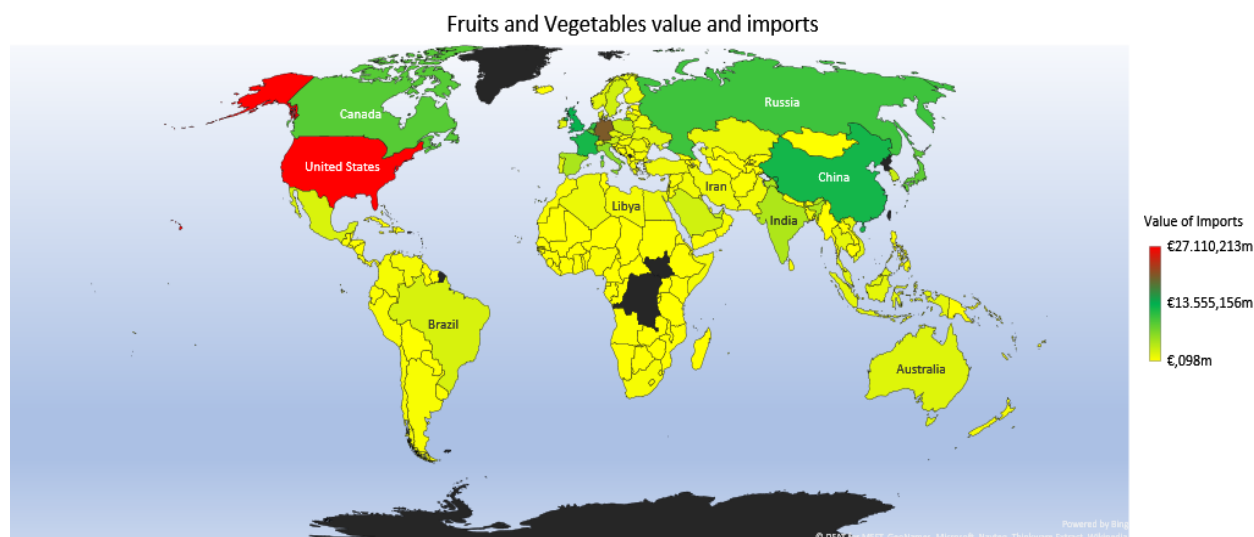


Figure 33. Fruits and Vegetables value of imports

and organic (33%) ingredients are very important in consumer's purchasing decisions while more than 25% of consumers consider local herbs/ingredients to be very desirable. PhasmaFOOD will be largely appealing to this kind of concerned consumers, since freshness will be one of their main choice criteria. Also, since food waste is in complete nonconformity with sustainable development, the growing environmental concern of these consumer segments will urge them to use PhasmaFOOD.

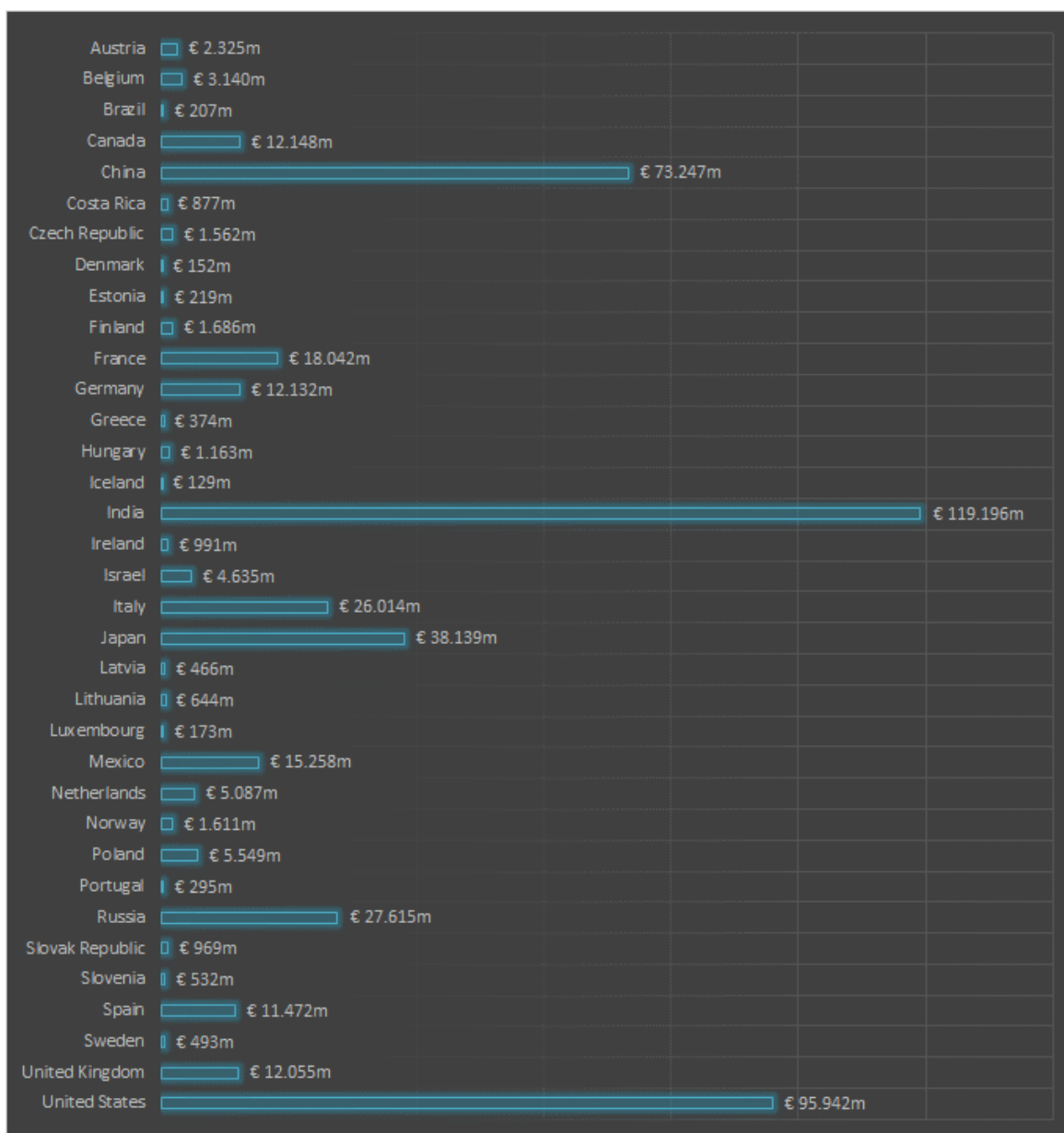


Figure 34. Fruits and Vegetables expenditure

Here, the potential target markets are F&V importers in: India, China, USA, Japan, Russia, Italy, Germany, France and F&V consumers in: India, China, USA, Japan, Russia, Italy, Germany, France

2.2.7 Fish

Fish is regarded a food of exceptionally high nutritional value. However, FAO estimates show that in Oceania, more than 35% of the fish and seafood quantity that enters the supply chain is finally wasted and that more than 20% of total wasting taking place at the household level. In the rest of the world, the total fish and seafood waste is somewhere between 25%-30%. Aside the environmental and ethical issues raised by this fact, economic losses suffered by business actors and consumers are considerable, especially since these products usually enjoy premium

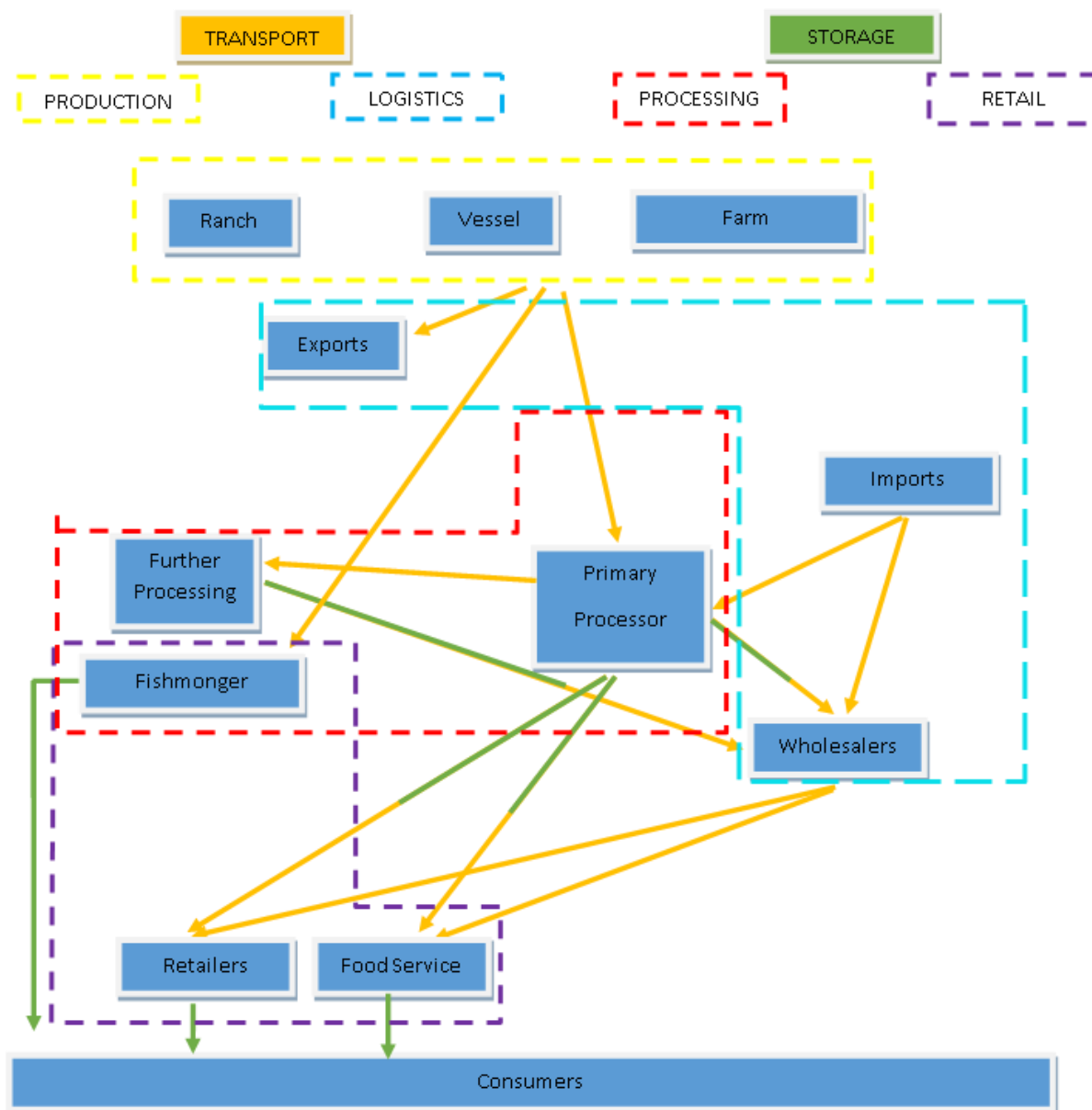


Figure 35. Fish food supply chain

Regarding business actors, the statistics show that most of the waste is produced in the production stage but for reasons that are not related to PhasmaFOOD use cases (quota, undesirable size, undesirable species, etc.). From the rest of the fish supply chain, as shown in Figure 35, the processing, logistics and retail actors are the ones who are suffering the greatest losses and thus PhasmaFOOD should target these industries for the specific use case. At the moment, the methods used by these actors in terms of quality assessment require substantial time, are labour-intensive and are usually destructive. An exemption is the Torrymeter by Distel.com (see section 3.2) that is a direct competitor of PhasmaFOOD in this use case but it is not suitable for fish that are or have been frozen at some previous stage(s) of the supply chain.

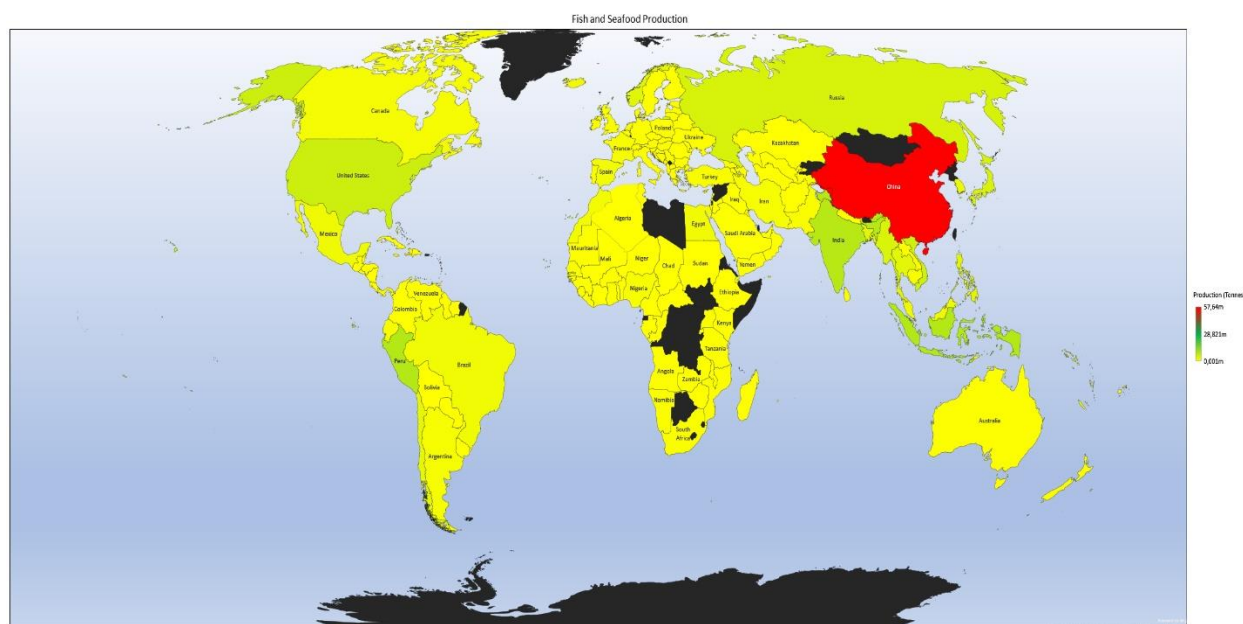


Figure 36. Fish and seafood production

Since waste (and associated economic loss) is a function of total production, PhasmaFOOD will be more easily adopted in areas where the stakes are higher, namely in countries whose supply chain with higher volumes of aquaculture and capture production. Annual global production of fish and fishery products from aquaculture as well as capture fisheries is more than 170 million tonnes. Unfortunately, due to the variability of the food products (species and quality) that are included in this category, a monetary valuation of the gross production value is not feasible for all countries. However, in Figure 36 we present a market scoping based in terms of quantities produced. The ultimate hotspot for PhasmaFOOD is China with 57 million tonnes in 2014, followed by Indonesia (8,4 million tonnes), Peru (8,4 million tonnes), India (8 million tonnes) and USA (5,7 million tonnes). The top producer in Europe is Norway, producing 3,3 million tonnes of fish annually. Great opportunities appear in the fish and seafood processing which is a €18-million industry in the EU (EUMOFA, 2016). Spain, France and UK are the countries with the major processing industries registering more than half (56%) of the total EU processed production (€19 billion). In China, the turnover of the industry reaches €55 billion per year while USA produces a total of more than €10 billion in revenues.

Total value of fish and seafood imports is almost €140 billion per year. Among importers, USA,

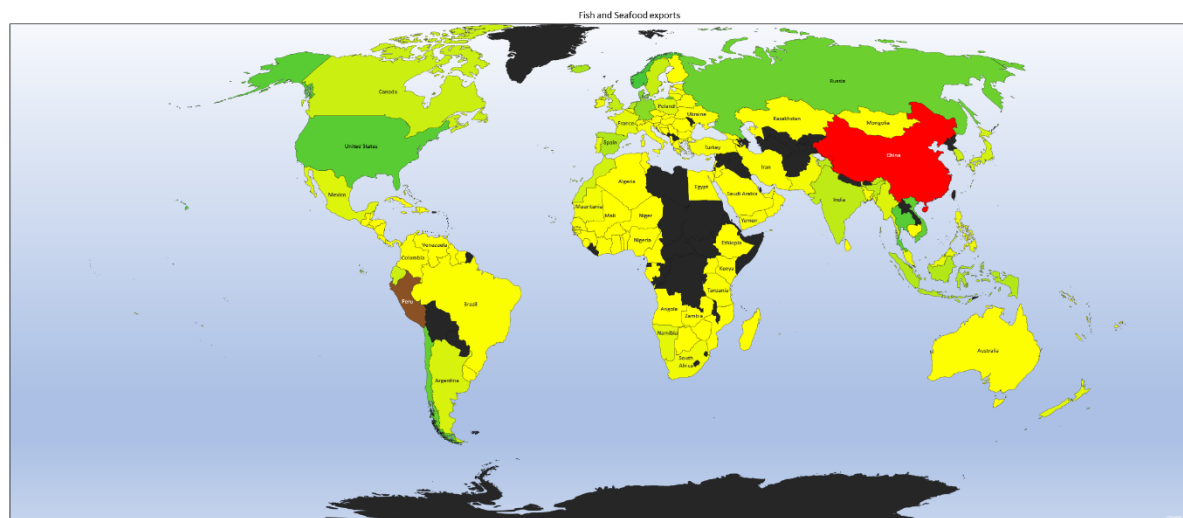


Figure 38. Fish and seafood exports

Japan and China compose the 30% of total imports with fish and seafood import value of roughly €40 billion in 2014. In terms of exports (Figure 38), China's value is close to €20 billion, Norway with €10 billion and Vietnam, Ecuador, Chile and Thailand are following with extensive exporting activity of more than €4 billion per year.

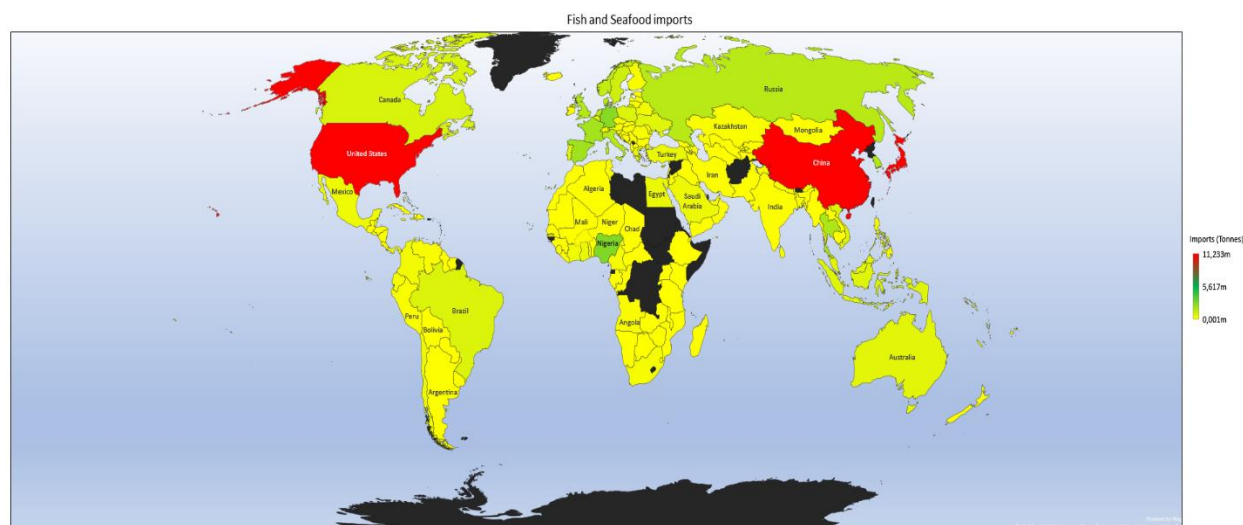


Figure 37. Fish and seafood imports

Overall, EU contributes over €45 billion in total trading of fish; interesting EU markets are those of Germany, Spain, France, UK and Italy. Although these figures are interesting, since more than 90% of internationally traded fish is in processed form, PhasmaFOOD should focus mainly on the local chains.

The global market for fresh fish and seafood is expected to grow over the next few years. As shown in figure 39, USA is the biggest market but China and India are next but showing remarkable growth rates of nearly 6% by 2020 (Research and Markets, 2016). Increase in population of the latter countries, along with the fact that income levels will rise (making fish and seafood more affordable) will help to spur the prospects for market growth. Due to the lack of extrinsic freshness cues, the market is one of asymmetric information and thus fish purchases rely mostly on information given by the sellers. PhasmaFOOD will eliminate transactions and trust costs from the part of consumers since it will provide objective information in a reliable and comprehensible way. Since the determinants of this market are again the growing health consciousness, and rising disposable income, PhasmaFOOD's features are expected to be appealing to fish consumers.

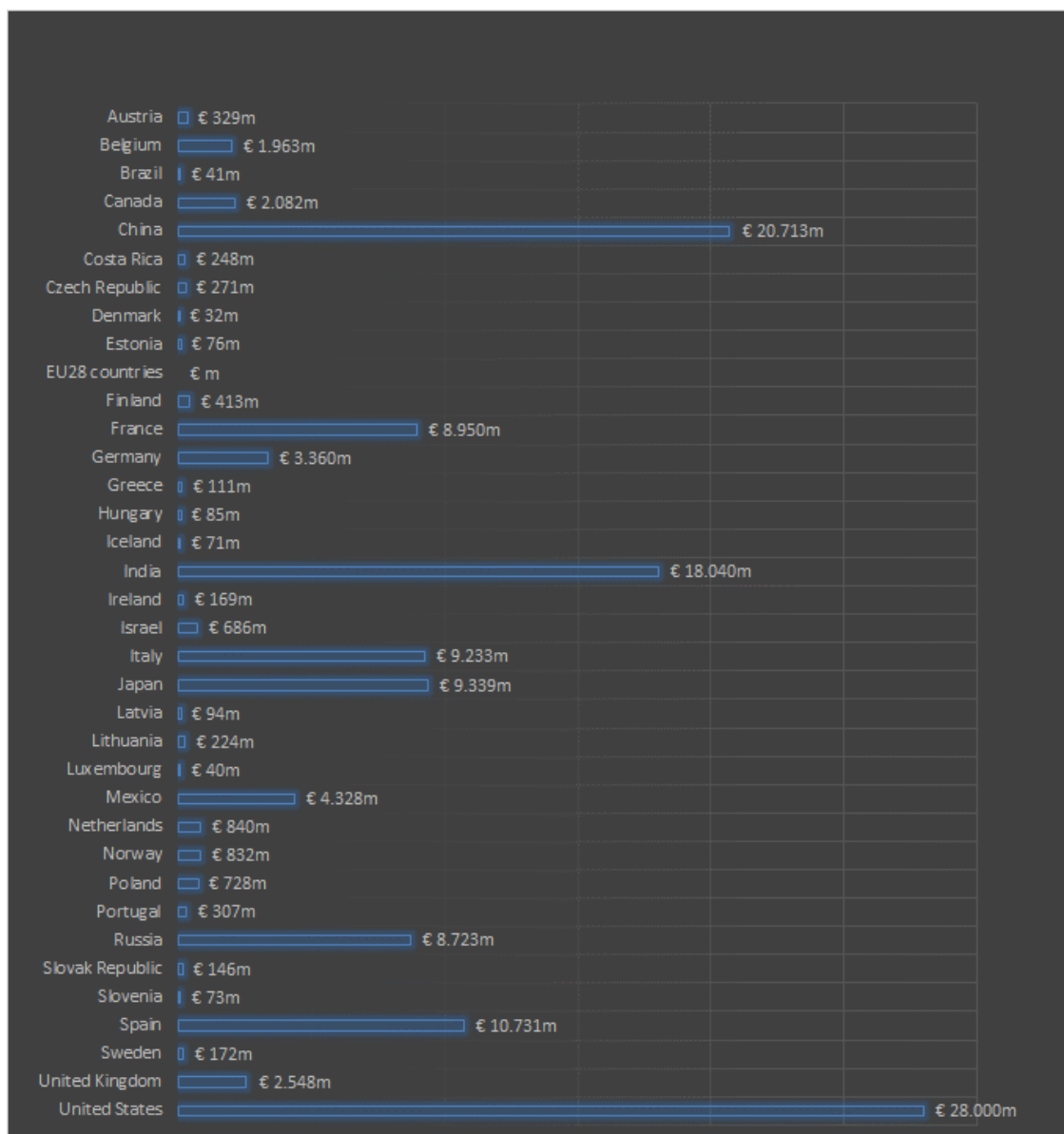


figure 39. Fish expenditure

Based on the above, of particular interest for PhasmaFOOD are the fish and seafood processing industry in: China, USA, Spain, France, UK and fresh fish consumers in: USA, China, India, Spain, Japan, Italy, France

2.2.8 Spirits

Spirits account for 10% of global alcoholic beverage volume, 36% of global sales and 45% of global pure alcohol consumption. They also have the highest tax value and gross margin than the rest of the alcoholic beverages. Thus, the market is constantly susceptible to products that are not compliant with legal processes to avoid taxation and squeeze production costs and increase profits. This type of counterfeit or non-conforming alcohol is part of the unrecorded alcohol chain that is defined as the portion of alcohol consumed but not shown in official figures such as production, trade, and retail sales. More than 25% of the global alcohol consumption is estimated to stem from the unrecorded chain (WHO, 2014).

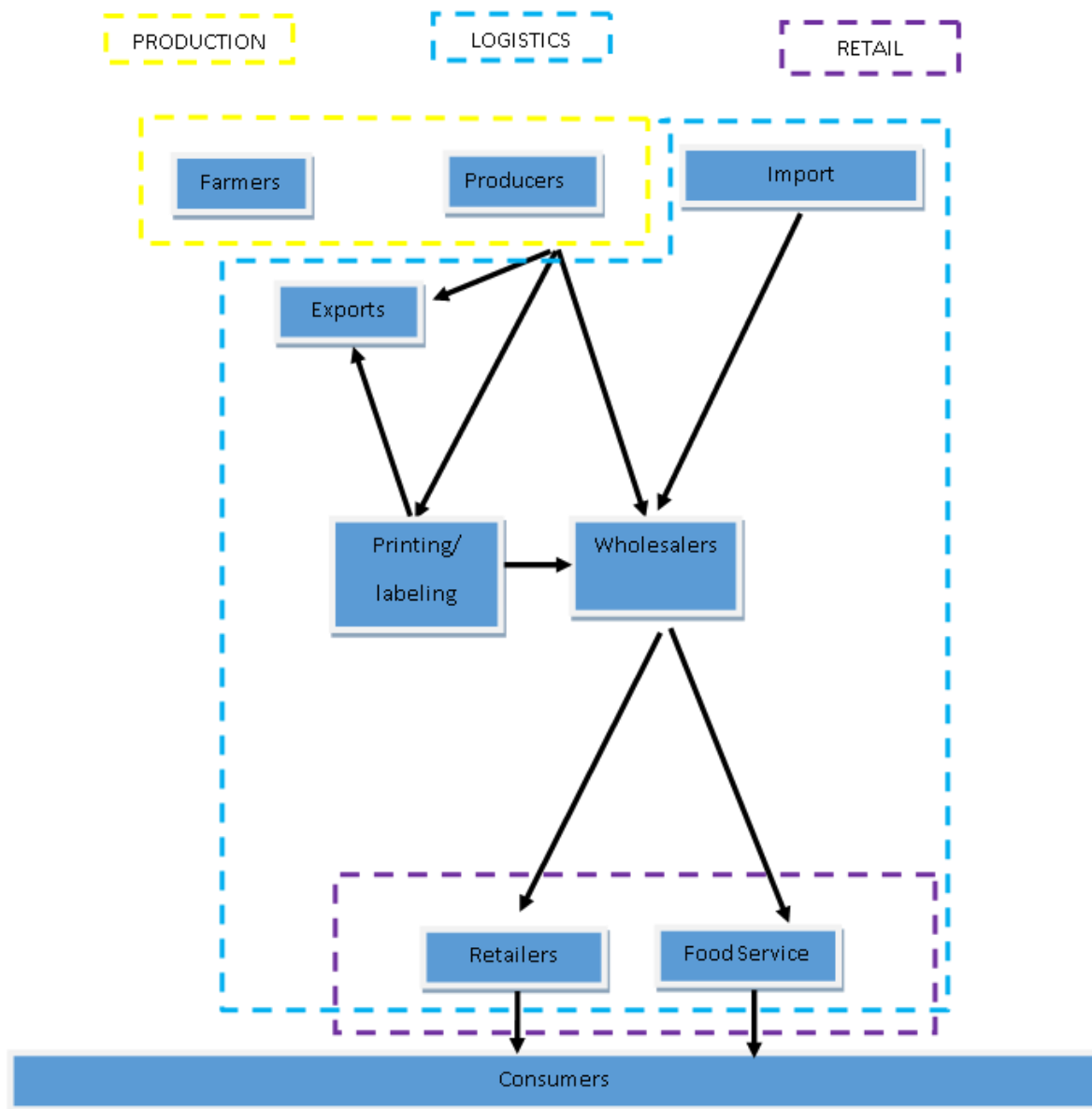


Figure 40. Spirits supply chain

This type of fraud represents fiscal challenges to governments due to losses in revenue from excise and sales taxes. To avoid these costs, governmental authorities around the world are taking measures to detect, regulate and prevent such practices; measures that cost tax-payers' money. But fiscal consequences are not the only challenge that governments face. Counterfeit alcohol consumption poses a threat to public safety and causes externalities due to public welfare costs (e.g. medical costs associated with their consumption). For the food and beverage industry, the economic challenges are obvious, since legitimate actors' sales are competing with those of smugglers. But reputational aspects are also important. Since branding is a very important aspect of the spirits marketing, any trace of evidence that could harm a firm's integrity and reputation is worth avoiding.

Ready-made counterfeit and non-conforming alcoholic beverages may enter the supply chain presented in Figure 40 by illegal producers and then passed by to a set of illegal actors, before they reach consumers. This chain is irrelevant to PhasmaFOOD, since actors involved in such practices cannot be considered legitimate target groups, nor are likely to take precautionary measures against a fraud they are part of. As a result, PhasmaFOOD's business segments for this use case should be retained to logistics and retail actors within the legal chain and especially wholesalers, retailers and food service industries. The most common methods for alcoholic beverage fraud detection are the chromotropic acid colorimetric method, gas chromatography – mass spectrometry (GC-MS), Fourier transform infrared spectrometry (FTIR), high performance liquid chromatography (HPLC), radiocarbon dating and others. All these are costly and time-consuming and require trained personnel. As far as handheld devices are concerned, ID-Raman mini and some others have been successful in detecting counterfeit alcohol. Still, these devices are quite costly and require training to perform. Due to the above, such devices and methods are mostly relevant to monitoring authorities and large enterprises, usually involved wholesalers and retailers. Using this line of reasoning, Food and Beverage service industries, mostly consisting of SMEs, prevail among other business actors in targeting PhasmaFOOD solution. To this end, we refer to Figure 2 for the most attractive markets, i.e. those with the greatest F&B service industry. In all these markets (especially USA and China), although, multinational companies with their high brand awareness as well as standardised product quality are leading, the industry is extremely fragmented.

Finally, the most seriously affected segment is that of consumers that face the probability of serious poisonings by the consumption of such products. The alcoholic drinks retail market worldwide is worth approximately €500 billion and has shown trends of increase between 2010 to 2015. Spirits are a big fraction of this market with more than 43% of sales or €200 billion coming from such products. China and USA the top markets with €80 and €37 billion respectively. As shown in **Error! Reference source not found.**, other potential markets are India and Russia while within the EU, the UK, Germany and France are major players and altogether account for 11.1% of the world's market share. It is noteworthy that each state in Europe has different excise taxes for various categories of wines, beers, and spirits.

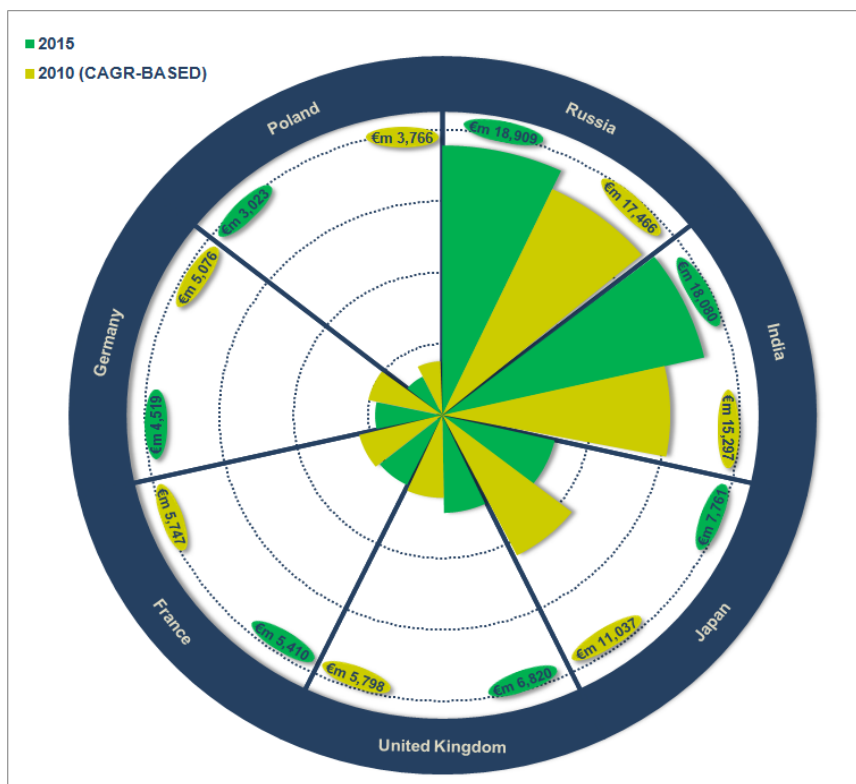


figure 41. Top Spirits Markets after China & USA

The most popular spirit is vodka with global consumption landing to more than 3 billion litres in 2015⁷. Rum is the second most popular with a consumption of a bit less than 1,5 billion litres while whiskey, Tequila and Cognac (in that order) are following. Lately, due to the adoption of healthier lifestyles by consumer's, similar to the other alcoholic drink categories, spirits also experienced a negative performance in growth with a compound annual growth rate (CAGR) of -2.7% (See figure 23). In 2015, the category closed with an estimated retail value of US\$23.9 billion in retail value sales and 1,767.8 in million litres in total volume sales (See figure 24). The country with the best performance was the United Kingdom with a CAGR of 2.4% from 2011 to 2015; while Spain saw the worst performance in this category with a CAGR of -7.6% from 2011 to 2015. In the forecast period, the category is also expected to see positive growth both in retail value and total volume sales with a CAGR of 3.8% and 0.2% (See figure 25 & 26). This is in part due to the premiumisation trend and generation shift towards brown spirits (Euromonitor International, 2016). As a result, Bars, restaurant and spirits (mainly vodka) consumers in: USA, China, Russia, India, Japan, UK, France, Germany and Poland are the main PhasmaFOOD target for this use case.

⁷ <http://www.marketwatch.com/story/the-world-is-drinking-less-alcohol-except-americans-2016-05-19>

3 Business Model

3.1 Product

PhasmaFOOD aims to provide a miniaturized, multi-parameter and programmable sensing node for food spoilage, adulteration and hazard detection through microbial activity. The system will integrate heterogeneous Visible and Near infrared spectroscopy technologies with a control electronic board which will ensure efficient cooperation between the sensing and the processing part. The targeted specifications of the device are given in Table 1 below.

Table 1. PhasmaFOOD specifications

Spectroscopy	Near-infrared, Visible, Imaging (visible range)
Physical Dimensions	<100m ³ (volume)
Weight	
Time	<60 sec
Distance	5cm
Illumination Mode	white LED, UV LED and miniaturized IR Halogen
Spectral Wavelength	400nm to 1900nm
Power	Built-in Li-ion battery
Battery Usage	~3-4 days with normal usage
OS Support	iOS, Android, Windows
Data	Local memory, WiFi, broadband
Colors	TBD

Global spectrometer and spectrophoto/ fluorometer sales are expected to exceed €14 billion by 2020 with a compound annual growth rate (CAGR) of 2.9%. Market sales being driven by several factors, including a shift of research funding from gene sequencing and high-throughput

screening to genetic variation analysis, metabolomics and environmental research (BCC Research, 2016). Together, Japan, Europe and the US represent an 80 percent share of the global spectroscopy market, according to GIA. The expanding research markets in Asia, particularly in India and China, present opportunities for spectrometry.

According to an analysis from Frost & Sullivan (2013), the global sensors market in the food and beverage industry (including flow, level, pressure, temperature, photoelectric, inductive, capacitive, ultrasonic sensors, and biosensors) was estimated this to reach \$4 billion in 2018.

3.1.1 Device (Draft Bill of Materials)

The miniaturized smart integrated system will incorporate multi-parameter and programmable sensing components, a multifunctional chip (data compression and processing, energy and communication management capabilities) and a wireless communication module (Figure 42). The Project's strategy is the design and implementation of state-of-the-art PCB design based on co-integration with micro-photonics sensors. The multi-parameter and programmable sensing component will be comprised by:

- a) a micro UV-VIS spectrometer (400-900) nm
- b) a micro camera and
- c) a MEMS-based near IR (Infrared) spectrometer (950-1900) nm.

Three type of light sources will be implemented in the smart system:

- a) white LED
- b) UV LED and
- c) a miniaturized IR Halogen emitter.

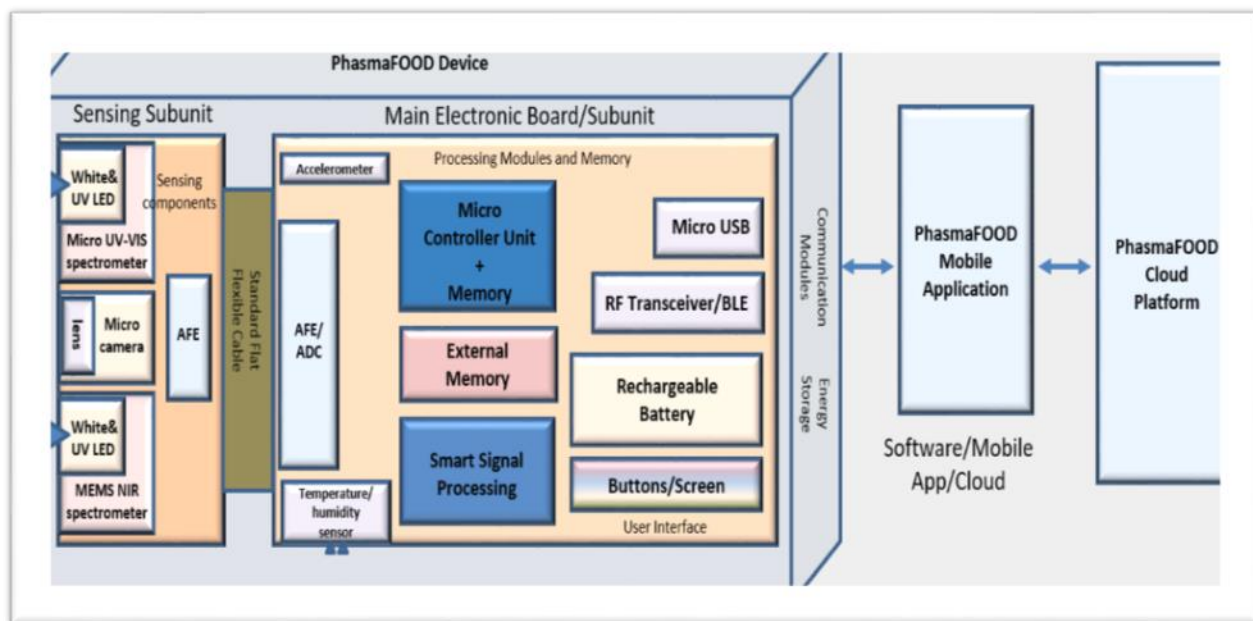


Figure 42. PhasmaFOOD Sensing Device Architecture

Regarding the microscope for detection of early stage spoilage and mycotoxins, the following materials are needed:

1. **High definition (at least 8 megapixel) Micro digital X Webcam (typical power consumption: 5V; 150mA)** powered through a **USB 2.0 high speed** (with a **1/3" 400x objective** or a zoom objective to be controlled by a micromotor)
2. **A microspectrometer ultra-small system (size: 20.1 × 12.5 × 10.1 mm) with spectral resolution of 15 nm, a supply voltage of 5 V and a current consumption of 20 mA.** The spectral response range is **340 nm to 850nm**.

The multifunctional Electronic Board will integrate spectrum/image conditioning of the sensing component, data compression, data processing, energy management and communication. This smart multifunctional Electronic Board will enable the cooperation between the different sensors devices, depending specific food type.

3.1.1.1 Service

To build PhasmaFOOD software architecture which is scalable, modular and extensible, the concept of soft sensors needs to be introduced. Soft sensors are building blocks for data analysis. Every soft sensor combines two or more sensory and/or contextual data streams based on implemented data analysis algorithm to provide actionable results. Soft sensors are considered as the elementary data analytics modules. It is assumed that different production techniques/facilities and different food types require different combination of sensors and other contextual data. PhasmaFOOD's soft sensor approach allows on-fly creation of higher level soft sensors which can combine measurements from sensor primitives, 1st layer soft sensors and other contextual data sources necessary for proper decision making. Figure 5 provides high level insight into PhasmaFOOD's soft sensor logic. First layer soft sensor will be deployed as embedded software on PhasmaFOOD smart sensing device. It will combine and analyze sensory data from built-in spectrometers and report result directly on device (LED signaling) or through PhasmaFOOD mobile application. Second layer soft sensors will be deployed on PhasmaFOOD mobile application and will provide context and deeper analysis of sensory data.

The PhasmaFOOD application will require software agent which bridges soft sensors with other mobile system components (i.e. **GPS module, WiFi module, USB module, clock** etc.), filters and formats data. The software agent will also serve notifications and present results to end users through GUI. The PhasmaFOOD mobile application will host reactive decision making algorithms which can provide end user with actionable insight based on results of sensory and contextual data analysis performed on soft sensors on smart sensing device and within the mobile application. Further on, the PhasmaFOOD mobile application opens its soft sensors to the cloud platform for transferring formatted sensory data and analysis results to the PhasmaFOOD cloud platform and receiving soft sensor calibration inputs from the platform. The cloud platform will enable automatic creation of complex data analysis processes by combining results from different soft sensors and different data streams. Base on this analysis, proactive decision making algorithms and machine learning models will be used for providing calibration parameters for soft sensors and recommendations on how to improve food quality by minimizing risk for con-

tamination and spoilage. The PhasmaFOOD cloud platform will store collected sensory and contextual data and analysis results into database based on data model defined during the project.

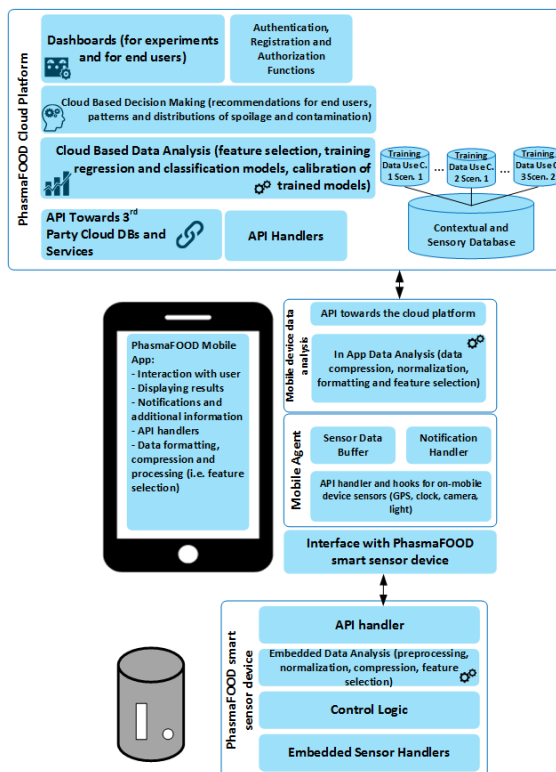


Figure 43 PhasmaFOOD software architecture

PhasmaFOOD system Functionalities will include:

- Smart sensing device provides: spectrum sensing, sensory data stream analysis based on embedded food analysis algorithm, LED indication for safe/not safe food, communication interface (LE Bluetooth, USB port), API for integration with mobile applications and cloud platform, data compressing/formatting/filtering, uses inputs received from mobile application/cloud platform to calibrate analysis algorithms, battery powered (rechargeable via micro USB port);
- Mobile application provides: additional food analysis in context obtained from mobile device (GPS, calendar, camera, light sensor), API towards the cloud platform and smart sensing device, GUI for presenting end user with result of food analysis and recommendations, GUI for end user to provide parameters necessary for food analysis algorithm calibration (i.e. type of food being scanned);
- Cloud platform provides: database for collecting formatted contextual and sensory data from smart sensing devices and end user mobile devices running PhasmaFOOD application, complex data analytics for determination of patterns and sources of food contamination/spoilage, provides web dashboard for presentation of analysis results and inter-

facing with database, context aware algorithms for calibration of food analysis algorithms, APIs towards 3rd party databases and for developers.

Functionalities of the PhasmaFOOD system can be adapted (different GUI elements for mobile application, depth of food analysis results shown to user, food analysis algorithm embedded on smart sensing device/mobile application) to specific stakeholder (i.e. food manufacturer, supermarket, food/sanitary inspectors, end users).

3.1.2 Product Portfolio

PhasmaFOOD product portfolio will include various product packages that are expected to serve the needs of the identified segments, considering the competition. Overall, 3 product versions will be offered: **Consumer edition**, **Enterprise edition** and **Science edition**; each targeting a different segment in the market⁸.

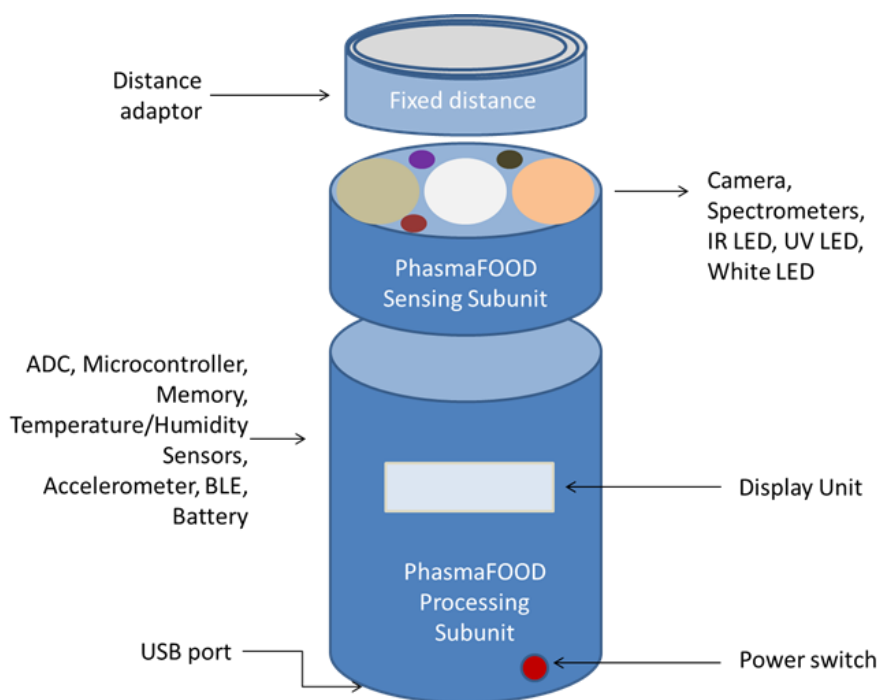


figure 44.Functional subunits of the PhasmaFOOD multisensory device

The **Consumer Package** will include (Target Price: €300 - €600 + shipping costs):

1. One PhasmaFOOD Scanner, USB cable and Charger
2. A license for one PhasmaFOOD platform account
3. Instructions on how to create an account and connect the device with the PhasmaFOOD App for up to 3 smartphones/tablets.

⁸ This image is not of a final product but of a very preliminary concept. The shape and features of the final design may be very different.

4. Detailed instructions on how to use the App which will be freely available from App store and Google play (compatible with iOS 8 and above and Android 4.3 or higher)
5. Perpetual firmware updates as new products/services are added
6. A gift card with 100 free scans and several free applets for hobbyists willing to explore the fascinating world of spectroscopy

In the entertainment applets, consumers will have the opportunity to create their own categories of food or non-food products based on their spectral properties. These data will be stored to the user's profile and will not be used for the improvement of PhasmaFOODs algorithms. For these applets, clients will have unlimited free scans. On the other hand, for the advertised use cases (and those that will be added later), since data from consumer scans will be used for PhasmaFOOD's algorithms, a small charge per scan shall be adopted to discourage intentional or unintentional abuse from users. Scan prices will depend on the country of the user and should be comparable to SMS charges effective by the local carriers (e.g. a price per scan of between a third and a half of SMS prices in that country is considered a reasonable estimate). Finally, several options for scan bundles will be available (e.g. 100, 200, 300) that will proportionally reduce the cost per scan.

The **Enterprise Edition** will include (Target Price: €2000 - €3000 + shipping costs)⁹:

1. One PhasmaFOOD Scanner (possibly a more rugged version), USB cable and charger.
2. A license for three PhasmaFOOD platform accounts (plus one in case of bulk purchases) with different access rights (Owner, Manager, Administrator).
3. Instructions on how to create an account and connect the device with the PhasmaFOOD App for 5-10 smartphones/tablets.
4. Detailed instructions on how to use the App which will be freely available from App store and Google play (compatible with iOS 8 and above and Android 4.3 or higher)
5. Perpetual firmware updates as new products/services are added.
6. Unlimited scans after signing agreement with PhasmaFOOD¹⁰

The **Science Edition** will include (Target Price: €2000 - €3000 + shipping costs):

1. One PhasmaFOOD Scanner (possibly a more rugged version), USB cable and charger.
2. A license for three PhasmaFOOD platform accounts with different access rights (Lab Manager, Senior Scientist, Lab Assistant).
3. Instructions on how to create an account and connect the device with the PhasmaFOOD App for 5-10 smartphones/tablets.

⁹ Special rates for bulk purchases will apply on a case-basis. For such purchases, a license for a parent account will be available

¹⁰ In case non-conforming behaviour is detected, PhasmaFOOD will retain the right to stop service provision without any compensation for upfront costs. In any case, as a precautionary measure, user data will be included in PhasmaFOOD's algorithms only after a trial period with limited number of outliers.

4. Detailed instructions on how to use the App which will be freely available from App store and Google play (compatible with iOS 8 and above and Android 4.3 or higher)
5. Perpetual firmware updates as new products/services are added.
6. Unlimited scans after signing agreement with PhasmaFOOD¹¹
7. Data collection tool to export raw spectrum data and build their own models
8. Eligibility for participation to an annual contest where PhasmaFOOD will nominate grants for the best new algorithms and application; these will be subsequently tested and added to PhasmaFOOD services.

Optional features for PhasmaFOOD App could include the following:

- 1) For the consumer version, a personal profile on the platform that will retain historical scan data and will allow the user to create “freshness profiles” as a decision support tool for future choices. After consumption of scanned products, consumers can rate the product’s freshness for future reference. When a similar product is scanned in the future, the App will return a percentage of similarity with products previously rated and a predicted rating, based on relevant algorithms. These algorithms will also combine data from other users’ ratings and return an average predicted rating for the scanned product.
- 2) When scanning a food product, the user will be able to instantly share it with peers through social media such as Facebook, Twitter, Google+, Pinterest, Instagram. This way, consumers can share his/her concerns with friends and the public and PhasmaFOOD can gain publicity from the power of social networks. This is very important, especially for some of the identified consumer segments such as millennial moms (targeted in milk powder adulteration). PhasmaFOOD could offer free scan packages as a reward for sharing results.
- 3) Users could be able to share their remaining scans with other PhasmaFOOD users that will be identified through their Facebook account, mobile number and/or ID number. The recipient will be notified by SMS about the sent scans and will redeem the gift at their PhasmaFOOD accounts.
- 4) Scans could be provided directly from the smartphone application using credit or debit card, PayPal and other payment options. Networking with mobile phone to use scratch cards readily available for their clients could also be considered.
- 5) For the enterprise version (especially for retailers), there could be an option to register their business on the platform, so that consumers can select the specific store they performed the scan of each food product. The enterprise user (business owner) will have access to these data in real-time and may create alerts in the case of undesirable outcomes. These data can also be combined to create scan profiles of consumers. For mar-

¹¹ In case non-conforming behaviour is detected, PhasmaFOOD will retain the right to stop service provision without any compensation for upfront costs. In any case, as a precautionary measure, user data will be included in PhasmaFOOD’s algorithms only after a trial period with limited number of outliers.

keting purposes, this functionality could be combined with check out options, so that scanning results and choices can be analysed in combination. PhasmaFOOD will treat these data as proprietary and will only be accessible by the specific enterprise account; they will not be transmitted to the cloud. To incentivize consumers to use this functionality, retailers could offer discounts, electronic coupons and other benefits such as free scanning packages.

- 6) In big multinational or local chains, if devices are purchased in bulk for all franchising spots, an extra functionality will be offered. A parent account on PhasmaFOOD platform that will allow access to scan data of all production/selling points for monitoring and analysis purposes. This can be combined with information on supplier choices and total sales.
- 7) A PhasmaFOOD Wiki that will be constantly updated with new use cases and offers from PhasmaFOOD or collaborating partners (if the user provides agreement).

3.2 Competition

PhasmaFOOD's direct competitions comes from SCiO by Consumer Physics and Tellspec. Both devices use similar technology, though only Tellspec is focused on food products as PhasmaFOOD. More rugged devices such as the IDRaman mini by Ocean Optics and MicroNIR Pro 1700 ES from Viavi have also been used in food applications (mostly food adulteration) but due to size and price considerations are more targeted towards the supply chain than to final consumers. Ellis et al. (2015) show a list of commercially available handheld Raman and infrared spectrometers that is reproduced in the Appendix. Aside from these devices, Distell's Torrymeter, BFD-100 by Freshdetect and FOODSniffer seem to be the most important in relation to the Phasmafood solution, although using a completely different technological approach.

Canadian **Tellspec** had a successful crowdfunding campaign in 2013 that raised more than \$380.000 from 1.765 supporters. However, the original promotion was based on using Raman Spectroscopy was then abandoned to near-infrared (NIR) spectroscopy. In 2017, Tellspec was also one of the three winners of the Food Scanner Horizon Prize, awarded by the European Commission Horizon 2020 and has received €100.000. By March 2015, the company had made 2,200 online sales worldwide; Tellspec is developing a hand-held food scanner that can inform users about specific ingredients, macronutrients, contaminants, food fraud, food adulteration or food quality. It is a three-part system containing a pocket-sized spectrometer, a cloud-based patented analysis engine, and a mobile app. Tellspec is currently manufacturing two different

“TELLSPEC’S MISSION IS TO HELP
CREATE A CLEAN FOOD REVOLUTION
BY PROVIDING FOOD SECURITY TO
ALL. WE HOPE THAT WE WILL SPARK
A VITAL CHANGE IN THE WAY PEOPLE
EAT AND THE WAY FOOD IS CURRENT-
LY GROWN AND MANUFACTURED.
CLEAN FOOD IS AN UNDENIABLE HU-
MAN RIGHT”

<http://tellspec.com/en/>

devices (Generation 1 scanner and Enterprise scanner) that are combined with software and offered in three different solutions to customers.

Table 2. Tellspec specifications

Spectroscopy	Near-infrared
Physical Dimensions	82.2mm (L) x 66mm (W) x 45mm (H)
Weight	136 grams
Time	1-3 seconds
Distance	In contact (beta units) or near-contact mode (final units)
Illumination Mode	Reflective with two integrated tungsten halogen lamps.
Spectral Wavelength	900nm to 1700nm
Power	USB or built-in Li-ion battery (3.7V/1000mAh)
Battery Usage	~1200 scans from full charge to empty.
OS Support	iOS
Data	Bluetooth, WiFi, broadband
Colors	Black, White, Red, Green, and Turquoise Blue

The first solution is the consumer package which includes one Generation 1 Scanner (Tellspec estimates that scanners purchased after January 2017 will be delivered in Q3 of 2017); An iOS mobile app, the Tellspec Consumer App, with scanning, tracking and results capability. This app works with several iOS devices including iPod, iPhone and iPad that have Bluetooth Low Energy (Bluetooth 4.0 or later) and can run iOS version 8 or higher and; One year free scanning and scanning with a small subscription fee (not specified) after the first year. According to the company, this solution is ideal for consumers who wish to track their intake of calories, macronutrients, fiber, sugar etc. as well as those who wish to screen their food for known allergens, contaminants and substitutes of cheaper ingredients (food adulteration). The device comes in several colors (Black, White, Red, Green and Turquoise) and its dimensions are 9cm (L) x 6cm (W) x 2.5cm (H).

The second solution is the enterprise scanner (currently available). It includes one Enterprise Scanner (Dimensions: 9cm (L) x 6cm (W) x 4.5cm (H)); An iOS mobile app, the Tellspec Consumer App, with scanning, tracking and results capability; An iOS mobile app, the Tellspec Data Col-

lection app, with the tools to collect data and download data collected by exporting it to a format that can be read by M.S. Excel and; The Consumer app and the Data Collection app are integrated into one and will work with several iOS devices including iPod, iPhone and iPad that have Bluetooth Low Energy (Bluetooth 4.0 or later) and can run iOS version 8 or higher; A free scanning subscription for life as long as new data is being submitted to the Tellspec database with the Data Collection app. The device is available in black and addressed to anyone who is willing to scan food on a regular basis and contribute to the growth of Tellspec's database, which the company has committed to make available to any group that may want to use it for any valid International Humanitarian organization. In addition, it is ideal for enterprises that want to scan food for specific purposes or non-food samples and need access to the raw spectra data. The latter includes the F&B industry who can customize the device to their specific needs.

Finally, Tellspec offers the software development kit (the full SDK was expected in the Fall of 2016). This includes one Enterprise Scanner; An iOS mobile app, the Tellspec Consumer App, with scanning, tracking and results capability; An iOS mobile app, the Tellspec Data Collection app, with the tools to collect data and download data collected by exporting it to a format that can be read by M.S. Excel; The Consumer app and the Data Collection app are integrated into one and will work with several iOS devices including iPod, iPhone and iPad that have Bluetooth Low Energy (Bluetooth 4.0 or later) and can run iOS version 8 or higher; Free Storage space in Tellspec's cloud server for the first year and; the SDK, the tool that allows building an application on the phone. As far as algorithms is concerned, Tellspec's CEO claims that the company has 10 different detection algorithms that all focus on celiac and diabetes or pre-diabetes or obesity.

SCiO sensor is a handheld device that uses the near-infrared region of the electromagnetic spectrum and is developed by Consumer Physics, an Israeli startup that raised about \$2.7 million from 13.000 in 2015 through crowd-funding. SCiO is not targeted to food products but meat, dairy, fruit and vegetables are promoted as possible cases the device can prove to be useful. In terms of food, SCiO consumer app seems more focused on the analysis of nutritional values (e.g calories, fat, proteins) of beef, poultry, pork, meat and fish. It is also explicitly stated that mold detection for spoil avoidance is quite unlikely with the device since sensor's sensitivity has a threshold of at least 1%; by the time mold reaches that level, spoilage will be obvious with naked eyes. Unlike tellspec, Consumer Physics does not have a database of scanned food and as such it relies on scans done by consumers.

**“SCAN MEAT, DAIRY, FRUIT, AND
VEGETABLES FOR MACRO-NUTRIENT
INFORMATION AND SELECT THE BEST
QUALITY PRODUCE FROM THE PRO-
DUCE STAND”**

[“https://www.consumerphysics.com](https://www.consumerphysics.com)

The device is offered as a standalone pocket molecular sensor along with a mobile app that is compatible with iOS 9 and higher, Android 4.3 or higher and requires a Bluetooth connection.

The app includes: Applets that provide insights about objects scanned (only dairy and painkillers are advertised); SCiO Workshop: An app to create one's own basic applets to classify the objects of his/her choice by teaching SCiO about them and; SpectroScan: a way to Scan an object and receive its molecular fingerprint on the smartphone. This can be compared to scans in the app to find the molecular differences and similarities between materials.

Customers may also acquire the SCiO Development License separately or bundled with the sensor for a total. With the license, sensor users can have access to a single SCiO account for developing molecular sensing models and mobile apps based on these models. In particular, the license includes access to the SCiO Lab model development software tools: SCiO Mobile Lab for collecting spectral information and the SCiO Lab for spectral analysis and modelling; SCiO Mobile SDK: includes libraries, sample code and documentation that enable the integration of SCiO functionality in your own mobile app and; License to trial and develop fully functional SCiO applications prior to releasing them for commercial use. The apps are compatible with iOS 9 and higher, Android 4.3 or higher and Chrome, Internet Explorer Firefox or Safari browsers. The full package is also available for educational use and in this case, it includes 10 devices and a license for the development software. At last, an add-on liquid accessory can be also purchased, giving customers the opportunity to use the sensor for the measurement of various liquid materials.

Table 3. SCiO specifications

Spectroscopy	Near-infrared
Physical Dimensions	54mm (L) x 36.4mm (W) x 15.4mm (H)
Weight	35 grams
Time	1.5 seconds
Distance	5-15mm from object
Illumination Mode	Wide-Band NIR
Spectral Wavelength	~700nm to 1100nm
Power	USB or built-in Li-ion battery (3.7V/1000mAh)
Battery Charging Time	3 hours
Battery Usage	~250 scans from full charge to empty.
OS Support	Android, iOS
Data	Bluetooth, WiFi, broadband
Colors	Black

FOODsniffer is promoted as the world's first handheld mobile device that determines the freshness of raw meat, poultry and fish. The device measures raw meat gas levels and once wirelessly connected to smartphones via Bluetooth it analyses results and instantly informs the user the level of its freshness and safeness to eat. The technology was developed in the framework of the EU project "FOOD Safety at the point-of-Need via monolithic spectroscopic chip identifying harmful substances in fresh produce" that was funded under the FP7-ICT-2011.3.2 "Smart components and Smart systems integration" programme. FOODsniffer is field-deployable and simple-to-use device using the integration of a transducer, an all-silicon fully integrated optoelectronic platform, wafer-scale microfluidics and filtration systems, and a low-power reader. The company started a pre-ordering campaign on April, 2014, raising more than \$77.000 from 535 backers. The device has four types of sensors: temperature, humidity, ammonia and volatile organic compounds sensors. The sensors detect volumes of volatile organic compounds in the sample, and readings are then adjusted taking into account temperature and humidity. These data are used to calculate findings and results; the app is user-friendly and easy-to-use.

"A SMART PORTABLE KITCHEN GADGET TO CHECK IF RAW MEAT, POULTRY OR FISH IS FRESH, SPOILED, OR STARTING TO SPOIL. IN THE MATTER OF SECONDS."

<http://www.myfoodsniffer.com/product.html>

Table 4. FOODSniffer specifications

Spectroscopy	NA (Mass Spectrometry)
Physical Dimensions	200mm (L) x 80mm (W) x 50mm (H)
Weight	250 grams
Time	10-20 seconds
Distance	1-5cm
Power	Charger, MICRO-USB
Battery Usage	~12 hours
Charging time	12 hours straight use
OS Support	iOS 8 or later and Androids 4.3 or later
Data	Bluetooth 4
Colors	White, Black, Violet, Green

FreshDetect was founded in 2013 and develops/markets products and solutions for the quality assurance of foodstuffs, particularly for the meat industry with its flagship being the new mobile handheld **BFD-100**. FreshDetect relies on partnerships and cooperates with universities, institutes and companies in optoelectronics. With the fresh capital, the start-up wants to further develop the technology and promote marketing. FreshDetect GmbH has received financing from nbr biotec ventures GmbH, Bayern Kapital GmbH and a group of business angels to develop and market the device. The consortium behind nbr biotec ventures is the private investment company Kuenheim Familiaris GmbH, a Kuwaiti investor and other business angels. Bayern Kapital is a wholly-owned subsidiary of the LfA Förderbank Bayern and is a venture capital company of the Freistaat Bayern, a founder of the high-tech sector. BFD-100 by Freshdetect is a portable measurement instrument for determining the total viable count (TVC) in raw meat products. Using a patented measurement method based on fluorescence spectroscopy, the device detects the metabolic products of characteristic bacteria on the surface of the meat and calculates the total viable count using a reliable analysis algorithm. For the time-being, the device can only be used for pork meat. The BFD-100 comes with a carrying case, analysis and evaluation software, a calibration kit, battery charger and protective goggles.

Table 5. Freshdetect specifications

Spectroscopy	Fluorescence
Physical Dimensions	201mm (L) x 79mm (W) x 37mm (H)
Weight	400 grams
Time	5 seconds
Distance	In contact
Illumination Mode	laser beam via a laser diode 3B
Spectral Wavelength	405 nm
Power	rechargeable lithium-ion battery
Battery Charging Time	3 hours
Battery Usage	up to 300 measurements
OS Support	Windows, iOS
Data	USB
Colors	Black-Green

Distell.com is a UK company producing hand-held meters for measuring fat content of fish and meat and the freshness of fish (**Torrymeter**). The Torrymeter is a device that assesses fish freshness from the dielectric properties of the fish skin and muscle and returns instant results regarding taste grading, shelf-life, etc. Although this technology has nothing to do with spectroscopy, their services in terms of Fish freshness are competitive to the Phasmafood solution, especially for the business actors within the supply chain. The device is bigger and heavier but it provides remarkable accuracy and relative fish freshness in a simple and simple way. Also, the meter can identify fish that have been previously frozen. The kit contains the meter, along with its charger; a USB Datacomms Cable; CD Disks (USB Comms + Data Management Software); a user manual and Organoleptic Charts and; a Carry Case. Distell.com offers leasing opportunities to clients as well.





Table 6. Torrymeter specifications

Spectroscopy	NA (Dielectric properties)
Physical Dimensions	155mm (L) x 80mm (W) x 30mm (H)
Weight	250 grams
Time	10-20 seconds (x3)
Distance	In contact
Power	Charger, 100-240VAC, 50/60 Hz
Battery Usage	~full day scans from full charge to empty.
Charging time	12 hours
OS Support	Windows XP or later
Data	USB
Colors	Orange-Black

3.2.1 The Competitive Strength Grid and Risk Matrix

Aaker and McLoughlin (2010) introduced a visual tool to represent competition in terms of advantages and disadvantages of a company's product/service relative to the ones offered by the competitors.

Table 7. Competitive strength grid

PhasmaFOOD Solution	Tellspec Tellspec Inc.	SCiO Consumer Physics	FOODSniffer FOODSniffer	Torrymeter Distell.com	BFD-100 Freshdetect	Other (Table 10)
Essential						
Portability						
Price						
Ruggedness						
Easy-to-use						
Accuracy						
Safety						
Publicity (Negative)						
Publicity (Pos- itive)						
Aflatoxin Al- gorithms						
Spoilage Algo- rithms				Meat	Fish, F&V	Fish, F&V
Food fraud Algorithms						
Other Food Algorithms						
Secondary						
Technology						
Non-food Algorithms						
Maintenance						
Back-end						
3-point scale:  3 = Above Average  2 = Average  1 = Below Average  0 = No comparison can be made						

The Competitive Strength Grid, as they named it, requires identification and classification of competitors and their products or services and a qualitative comparative examination of their features using a 3-point scale (1=below average, 2=average, 3=above average) and color coding. To use this tool, one needs to decide upon the features that should be evaluated across products, separate them into two categories, those which are essential for the value proposition and those which are of secondary importance and finally conduct the qualitative evaluation discussed above. Table 7 shows such the Competitive Strength Grid for the PhasmaFood solution.

Day's (2007) risk matrix is another tool that can be used to help businesses estimate the probability of success or failure of an innovative product before its introduction to the market. The matrix includes two dimensions – how familiar to the company (or to the consortium in this case) the intended market is (x axis) and how familiar the product or technology is (y axis). The risk matrix is a visual representation of the assumption that the probability of success increases the more we move from the business-as-usual scenario.

Table 8. PhasmaFOOD's risk matrix (Day, 2007)

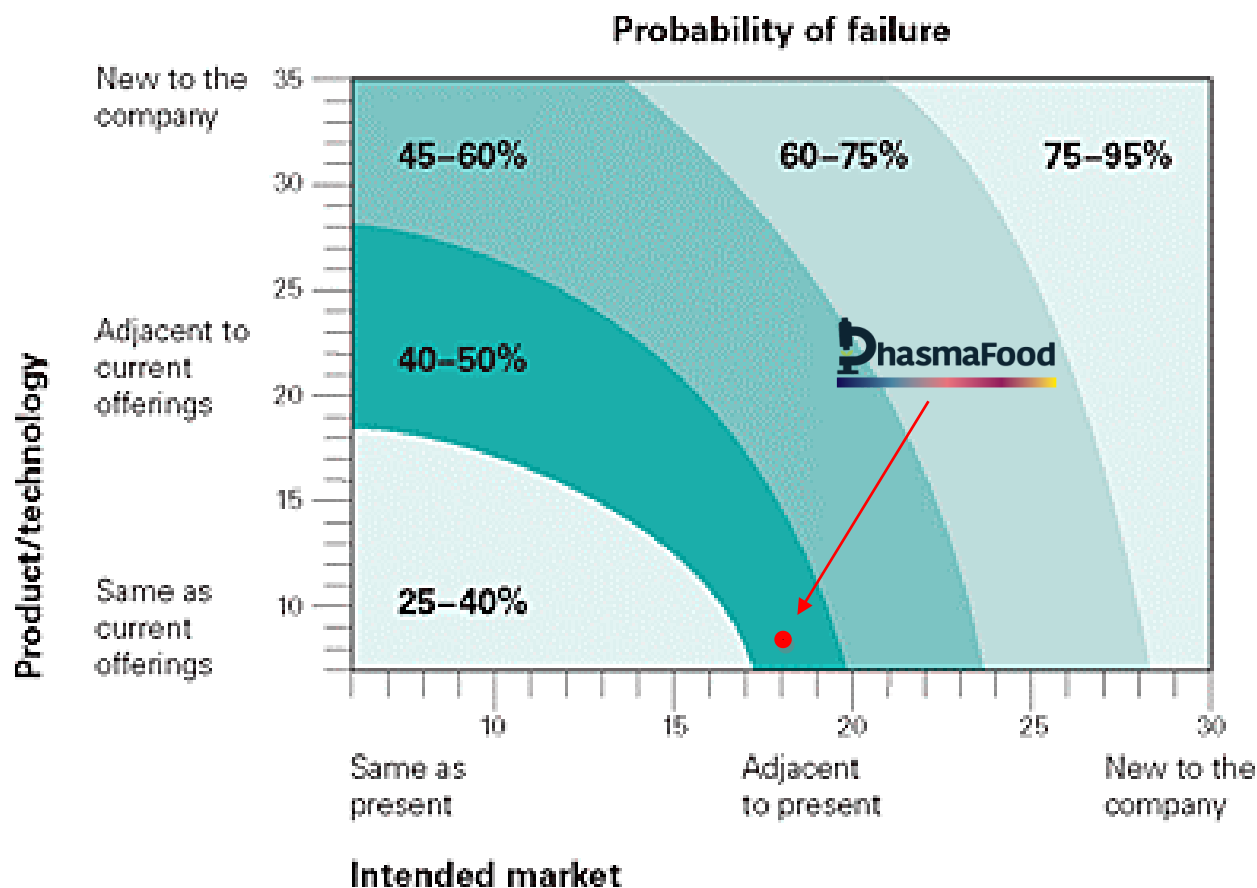
	Intended Market					SCORE
	...be the same as in our present market		...partially overlap with our present market		...be entirely different from our present market or are unknown	
Customer's behavior and decision-making processes will...	1	2	3	4	5	3
Our distribution and sales activities will...	1	2	3	4	5	4
The competitive set (incumbents or potential entrants-) will...	1	2	3	4	5	3
	...highly relevant		...somewhat relevant		...not at all relevant	SCORE
Our brand promise is...	1	2	3	4	5	2
Our current customer relationships are...	1	2	3	4	5	3
Our knowledge of competitors' behaviour and intentions is...	1	2	3	4	5	3
TOTAL: (x-axis)						18

	Product or Service					SCORE
	...is fully applicable		...will require significant adaptation		...is not applicable	
Our current development capability...	1	2	3	4	5	1
Our technology competency...	1	2	3	4	5	1
Our intellectual property protection...	1	2	3	4	5	1
	...are identical to those of our current offerings		...overlap somewhat with those of our current offerings		...completely differ from those of our current offerings	SCORE
The required knowledge and science bases...	1	2	3	4	5	1
The necessary product/service functions...	1	2	3	4	5	2
The expected quality standards...	1	2	3	4	5	1
TOTAL: (y-axis)						7

PhasmaFOOD's risk matrix is given in Table 8 and the projection of the results on the risk matrix plot are given below in figure 45. Based on the figure, the probability of failure seems to be relatively high for the PhasmaFOOD solution, however recent surveys show that the overall failure rate of new products is close to 40% which makes PhasmaFOOD's estimated probability of failure reasonable. The consortium counts 5 academic and 3 industrial partners, among which 2 SMEs. It is spread between Belgium (coordinating country), Germany, Greece, Serbia, Italy and Netherlands. With a wide range of expertise in complementary fields of R&D validated by various successful national and international projects, the skills of the partners span the whole chain of values for smart food quality sensor prototyping. Moreover, partners have excellent networks and synergies with manufacturing companies such as Hiperscan GmbH that is a spin-off company of Fraunhofer IPMS and is considered as an excellent candidate to undertake the task of manufacturing the PhasmaFOOD device. We need to note here that another reason for the estimated high risk of failure is that the risk matrix is based on the current consortium and manufacturing networks and does not take into consideration future collaborations, especially in terms of marketing and promotion activities. Since the is currently active in the B2B ICT sector, it falls short in B2C and B2B food sector expertise and thus external collaborations with

food manufacturers, retailers and brokers will be established to reach final consumers. Given the excellence of the consortium in scientific and B2B practices, this would skyrocket the probability of success by bridging the gap between the solution and its main market, moving PhasmaFOOD'S dot to the left of the risk matrix plot below. The reason behind the need for an external marketing partner for the PhasmaFOOD solution is more than that. Since, PhasmaFOOD is expected to be highly benefited from network effects (i.e. its value will grow along with the number of users) that will come at a later very high campaign expenses such as advertisements, social media coverage, constant identification of and promotion to distributors, etc. These costs could reach somewhere between €400.000 and €800.000 without such deal.

figure 45. PhasmaFOOD risk matrix plot



3.3 PhasmaFOOD Value proposition

PhasmaFOOD seeks to serve the needs of multiple customer segments presented above. These segments have different needs and expectations from PhasmaFOOD solution and here we summarize them. The value propositions for each segment were presented in “Market Segments Identification” so here is a collection of these.

It's what you don't see that matters the most in food...

***PhasmaFOOD** is a pocket-size device that connects to your smartphone and instantly informs you about **afatoxin** levels, **spoilage** and **adulteration** of food products in a **simple, comprehensive** and **analytic** way*

*Whether you are a **consumer**, a **food scientist** or you own a business active in the **food supply chain**, PhasmaFOOD will benefit you and/or your business by:*

- *Keeping you and your family **safe** from contaminated and spoiled food consumption*
 - *Protecting you from **lawsuits, bad reputation** or **medical costs***
 - *Reducing your dependence on the **trustworthiness** of your provider*
 - *Saving you **money losses** from food wasted in your facilities or household*
 - *Introducing you to the fascinating world of **spectroscopy***
-

3.3.1 Save your meat(’s authenticity)

In terms of the meat food supply chain, PhasmaFOOD will reduce food waste through detection of early signs of spoilage and shelf-life estimation. It will also combat incidents of food fraud such as adulteration of pork and beef into raw minced meat and adulteration of horse and beef into raw minced meat samples. Regarding food waste, PhasmaFOOD would be a service/product more easily marketed to the meat processing and retailing industry where long or short-term storage and cooling takes place. At the moment, the industry’s needs are not properly addressed by any other device/service except from the BFD-100 device by Freshdetect which is currently only applicable to pork and is much costlier than PhasmaFOOD. Other solutions for the industry are the Raman, IR and FT-IR devices from Table 10 that cover a range of 400-2500 nm. On the other hand, detecting food fraud, is more critical within the food service industry and it is currently not being addressed by any other device. Same for consumers, where detection of food adulteration in meat would help grocery shoppers reduce their food safety concerns (and probably save by avoiding foodborne illnesses) and promote price competition by allowing consumers to purchase their goods from retailers with the lowest price, without thinking whether they and their families run a risk of consuming adulterated products. In

this case, existing NIR devices (table 10) with a wavenumber length of 1000-1900 nm can void the gap but are quite costly compared to PhasmaFOOD. Finally, food spoilage recognition and shelf-life estimation will facilitate better management of grocery shopping and cooking plans, thus minimizing economic losses due to food waste at the household level. FOODsniffer seeks to cover consumers' needs while Tellspec appears to have initiated a project in collaboration with Università degli Studi di Torino, The Queen's University of Belfast and Nielsen Company (Europe) Sarl, that aims to create rapid and portable monitoring tools for better control of meat quality and safety.¹²

3.3.2 Appearances corn be deceptive

Within the supply of corn, the use of PhasmaFOOD would be of value to the logistics and processing industry. In the processing sector, PhasmaFOOD solution is suitable for mills, livestock farmers and the compound feed industry. These segments receive raw material, previously stored at other facilities and/or processed goods that have been found to retain their aflatoxin levels even after processing takes place (e.g. bran or germ after milling). However, since food processing (milling, thermal processing and extrusion processing as well as other processes used in the F&B industry) seems to result in considerable reduction but not elimination of aflatoxin in the by-products aimed for human consumption (Bullerman & Bianchini, 2007), the F&B manufacturers also have a high interest in PhasmaFOOD. This is mainly to reduce negative publicity in case random controls reveal high aflatoxin levels in their products. To our knowledge, there is no handheld device targeted to corn safety in a non-disruptive manner. A promising project is that of Alfagoogles, whose goal is to develop portable, fluorescence spectral-based technology for rapid and non-invasive aflatoxin detection in maize (and peanut). However, although the original plan was to develop a goggle device, in their latest external evaluation report (USAID, 2016) it is stated that a Box Detector and using the strip tests with a tablet scanner is currently being explored. Yet, no marketable product has come coming out of this, at least for the moment. Since mycotoxins can be directly analyzed in food matrices by IR based methods (see D 1.1 of this project), all devices of Table 10 having this functionality are potential competitors in this segment; Raman spectrometers have also proven effectiveness to this end. PhasmaFOOD is a valuable solution small bakeries and local shops that do not have the ability to buy and use sophisticated and expensive equipment. Finally, consumers using PhasmaFOOD would be benefited by avoiding future costs from aflatoxin consumption or from excluding certain food categories due to this risk. Again, no other solution satisfies the needs of these customers yet although both Tellspec and SCiO devices cover the near-infrared wavelength required for Aflatoxin detection, so could potentially get active in this market. However, they lack spectroscopic techniques available from PhasmaFOOD.

¹² <http://tellspec.com/eit-food/beefproject/>

3.3.3 **Baby food was never safer; and you can take this to the bank (or Facebook)**

In the dairy sector, PhasmaFOOD is valuable to the groups that receive or forward fresh milk from and to other actors within the chain. These groups include the dairy processing and packaging industries and at a lower degree exporters, importers and wholesalers. Milk adulteration is not an uncommon phenomenon at these stages while aflatoxins that are carried on from animal feed are most likely to be more profound and easily detectable at these early steps in the production; Mid- and Near-Infrared handheld devices (Table 10) have been successfully used in this case (Santos et al. 2013). Milk powder adulteration takes place mainly during fresh milk production or the manufacturing process which leaves the processing, logistics and retailing business as potential PhasmaFOOD target actors. Nevertheless, because milk powder and infant formulas reach the logistics and retail stage as packaged products and not in bulk, the non-destructive nature of PhasmaFOOD solution loses its advantage and thus the offered services are not considered competitive. In the retail market of developed countries, PhasmaFOOD has probably the clearest target group, which is also the most widely studied by modern marketers, Millennial Moms. This demographic group has is more educated both academically and technologically than the average mother while the majority is in the middle of career building. They are also keen users of social media and smartphones, they often make online purchases and are seeking advices from other peers. Finally, they place food safety as their number one priority when grocery shopping for their kids. Giving them the opportunity to detect foreign substances and aflatoxins in baby food would be a service that this group would value highly. Tellspec is currently developing algorithms for the detection of melamine in milk powder while SCiO's wavelength (700-1100nm) might be restrictive for this use-case; no other solution is currently on the market.

3.3.4 **Aflatoxin detection in a (nut)shell**

PhasmaFOOD's contribution in aflatoxin detection in pistachios and other nuts is more relevant to the retail, processing and logistics chain. Also, cross-border food safety checks seem to be the most common reason for uncovering aflatoxin incidents. As in the case of corn, there are no readily available handheld, non-disruptive devices for the identification of these risks but IR based methods and devices can be employed for such purposes. As pistachios and other nuts will be entering the daily diet of consumers, health concerns about aflatoxins PhasmaFOOD will be there to reduce grasp the anxiety and add value to the consumer. Since nuts are considered a superfood, consumers who are trying to adopt healthier lifestyles and are currently including such products in their diets will use PhasmaFOOD to make sure that this action is indeed increasing their welfare and not encumber their organisms with undesirable substances. Again, wavelength-wise, Tellspec and SCiO could potentially be used in this use-case too.

3.3.5 **Edible oil authenticity under the prism**

PhasmaFOOD will contribute to the reduction of oil adulteration incidents. As in the case of baby food above, after packaging, PhasmaFOOD loses its competitive advantage and as a result monitoring is mostly relevant to companies in the packaging, wholesaling and retailing sector,

as well as to importers and exporters of oils in bulk, a current trend in many countries, including USA¹³. The value of PhasmaFOOD in this chain is created by the reduction of the economic loss incurred by negative publicity, both from the side of exporting and importing countries as well as of private companies. Based on the relevant literature, Raman, NIR and FT-IR handheld devices of Table 10 can be used by the industry for the detection of oil adulteration. For consumers buying in bulk, a common practice mainly in the Mediterranean olive oil countries, PhasmaFOOD will reduce the risk associated with such purchases and thus will capitalize the price differences between packaged olive oil and in bulk. The wavelengths reported in the literature (400nm-1900nm) allow Tellspec and SCiO to potentially cover some cases of edible oil authenticity using adequate algorithms.

3.3.6 Don't "fresh" out of fruits & vegetables

Within the supply chain of fruits and vegetables, the logistics and retail segments, excluding local markets, seem to be the ones with the highest interest for PhasmaFOOD. The use of the PhasmaFOOD device and algorithms for determining shelf-life would greatly benefit the aforementioned segments by reducing food waste within the value chain; a task that can be accomplished by some of the IR and FT-IR devices of Table 10 as well as from handheld visible spectrophotometers which are not very widespread in the food industry. For final consumers, environmental and socioeconomic concerns also factor into purchase decisions. According to a global research contacted by Nielsen (2015), sustainably sourced (35%) and organic (33%) ingredients are very important in consumer's purchasing decisions while more than 25% of consumers consider local herbs/ingredients to be very desirable. PhasmaFOOD will be largely appealing to this kind of concerned consumers, since freshness will be one of their main choice criteria. Also, since food waste is in complete nonconformity with sustainable development, the growing environmental concern of these consumer segments will urge them to use PhasmaFOOD. Current direct competitors (Tellspec and SCiO) have very limited range compared to the 190-2500 nm wavelength that has been studied in the literature for this use case and thus are not expected to fill the gap soon. These devices, also lack imaging capabilities and thus PhasmaFOOD has a superior value proposition.

3.3.7 You can detect Freshness: It's now ofishal

Regarding business actors in the fish supply chain, the statistics show that the logistics and retail industries are the ones who are suffering the greatest losses and thus PhasmaFOOD should target these industries for the specific use case. PhasmaFOOD will eliminate transactions and trust costs from the part of consumers since it will provide objective information in a reliable and comprehensible way. At the moment, the methods used by these actors in terms of quality assessment require substantial time, are labour-intensive and are usually destructive. An exemption is the Torrymeter by Distel.com that is a direct competitor of PhasmaFOOD in this use case but is not suitable for fish that are or have been frozen at some previous stage(s) of the supply chain. Also, as the infrared wavelength range of significance for study of fish is the same

¹³ <https://www.oliveoiltimes.com/olive-oil-business/u-s-olive-oil-imports-increasingly-bulk/54726>

as the one for meat. Since the determinants of this market are again the growing health consciousness, and rising disposable income, PhasmaFOOD's features are expected to be appealing to fish consumers. At the consumers' end, currently available solutions are again FOODsniffer and Tellspec.

3.3.8 Drink (even more) responsibly: That's the *spirit*!

Ready-made counterfeit and non-conforming alcoholic beverages may enter the supply chain presented in by illegal producers and then passed by to a set of illegal actors, before they reach consumers. This chain is irrelevant to PhasmaFOOD, since actors involved in such practises cannot be considered legitimate target groups, nor are likely to take precautionary measures against a fraud they are part of. As a result, PhasmaFOOD's business segments for this use case should be restrained to logistics and retail actors within the legal chain and especially wholesalers, retailers and food service industries. The most common methods for alcoholic beverage fraud detection are the chromotropic acid colorimetric method, gas chromatography – mass spectrometry (GC-MS), high performance liquid chromatography (HPLC), radiocarbon dating and others. All these are costly and time-consuming and require trained personnel. As far as handheld devices are concerned, IDRamani mini and some other NIR, FT-IR devices have been successful in detecting counterfeit alcohol. Still, these devices are quite costly and require training to operate. Due to the above, such devices and methods are mostly relevant to monitoring authorities and large enterprises, usually wholesalers and retailers. Using this reasoning, F&B service industries, a fragmented market consisting mostly of SMEs, prevails among other business actors in targeting PhasmaFOOD solution. Finally, the most seriously affected segment is that of consumers that face the probability of serious food poisonings by the consumption of such products. Given that NIR in the 1100 – 2100 nm range is used for detection of diluted spirits by water/ethanol mixtures and for the detection of methanol or other technical alcohols, Tellspec but not SCiO is can cover a wide range (up to 1900 nm) and thus challenge the market. PhasmaFOOD however offers a better value proposition due to the visible spectroscopic techniques that will be employed.

3.4 Selling Channels

For each market and product, PhasmaFOOD needs to choose **a number of different distribution channels**. Due to the global nature of the sales and to the geographic expansion strategy that PhasmaFOOD should follow, **in-house distribution channels are almost impossible**, so **collaboration with local distributors** is considered necessary. PhasmaFOOD will capitalize the consortium's familiarity with the European market and will seek to collaborate with external distributors for special distant markets.

Because most distributors specialize in specific markets and segments while PhasmaFOOD is a device targeting a variety of such segments and markets, **multiple distributors in each country should be identified and approached**. The choice of local distributors is a strategic decision for PhasmaFOOD, since Asia-Pacific markets, which are the most promising markets in the majority

of use cases and products, have ***various specific characteristics, usually unexplored by foreign actors***. This is also the reason that many multinational companies are collaborating with local distributors or establishing facilities in these areas before they circulate their products there. Especially for B2B channels, distributors that are currently offering products for the specific segments are the most appropriate to promote PhasmaFOOD.

PhasmaFOOD will have a fancy ***website and e-shop*** that will be a unique experience for the visitor. The device will be just a click away for the average user, with payments options including credit card, bank transfer and cash. Devices will be shipped to consumers with mail service or via international couriers with additional charge. Along with the device, the user will create a ***personal account at PhasmaFOOD's online platform***. The e-shop will present several videos in HD quality that will demonstrate how the device can be unpacked, assembled and deployed for all use cases and products. The ***Q&A section*** will describe the technology behind the front-end in a simple and understandable way; several scientific conclusions about aflatoxins, food spoilage and food fraud will also be presented there in an objective and clear manner. ***Distribution of online sales will be handled by TNT (or other similar carriers)***.

Exhibitions in retail stores will be an essential promotional activity for PhasmaFOOD, given that target audiences will be able to familiarize themselves with PhasmaFOOD technology and see its functionality and user experience. However, unlike similar devices like FOODsniffer who target retail stores as selling points, can hardly be considered as suitable selling points for PhasmaFOOD devices to be sold.

4 Strategic planning

4.1.1 PEST analysis

Before any strategic planning can take place, scanning the external environment is necessary to avoid future surprises and ensure long-term success. PEST analysis is a typical method of macro-environment analysis that includes the forces that influence the long-run decisions of an organization, although irrelevant to the decisions of the company at the micro-level. PEST analysis aims to identify. Economic forces include factors that have to do with the general economic situation of areas of interest while the political/legal dimension includes the laws, governmental and other pressure groups that affect an organization's operation. Finally, the sociocultural and technological dimensions constitute of the general social and cultural and technological environment as well the relevant changes that are observed or are expected. The former may include income distribution, citizens' education level, demographic pressures and evolving lifestyles while technological innovations or new ways of deployment of existing technologies are classified in the latter category. PEST analysis not only facilitates the understanding of changes in an organization's environment but can also help us foresee changes that are about to happen and that may have an effect on the framework within which the organization operates. The PEST analysis for the PhasmaFOOD is given below.

(P)OLITICAL-LEGAL	(E)CONOMIC
Foreign Direct Investment (FDI) plans in India and other developing countries	Rising middleclass population (1.5 billion households globally would be in the middle-class category by 2020, up from 1.2 billion households in 2012)
Growing political action to battle climate change	China and India have the greatest growth in middle class with growing per capita income
Growing public investments for food security	Food chain value added is very high in all economies
	Globalization of the food market
	By 2030, global food demand is expected to rise by 35%
	Food waste costs \$1 trillion per year while environmental costs reach around \$700 billion
	Digital Health Market Size to Reach \$379 billion by 2024 ¹⁴

¹⁴ <http://www.prnewswire.com/news-releases/digital-health-market-size-to-grow-at-over-259-cagr-to-reach-379bn-by-2024-global-market-insights-inc-602612195.html>

(S)OCIOCULTURAL	(T)ECHNOLOGICAL
Rise in the global population	Growing number of smartphone users (projected to amount to nearly 2.7 billion by 2019)
Growing level of education, urbanization and adoption of western lifestyles	China has become the leader in the smartphone market (688 million by 2019); India is expected to become second over the next few years
Changing customer preferences	Mobile spectroscopy in rapid development
Increasing urbanization	
Busy life schedules	
Social costs of food waste are estimated around \$900 billion	
Growing food security concerns	
trust in the food and drink industry declined in 2015 compared to 2014 (Edelman Trust Barometer 2015)	
Population growth	
Ageing population	
Increased waste management challenges	
Millennials and Generation Z consumers will hold 47% of gross income by 2025 (Euromonitor, 2016)	

4.1.2 Porter 5 forces

Within the industry, a famous model of scanning the environment is Porter's Five Forces model. According to this model the when scanning its micro environment, a corporation should assess the importance to its success of each of the 5 forces, which are: rivalry among existing firms; bargaining power of suppliers; bargaining power of buyers; threat of substitute products or services; and threat of new entrants (Porter 1980). Using the model in the case of PhasmaFOOD, we end up with the following.

As far as suppliers is concerned, non-essential parts of PhasmaFOOD technology, such as plastic cases and generic microelectronics can be found by many suppliers without noticeable differences and with very low switching costs. The UV-VIS spectrometer will be supplied by Hamamatsu and the camera by Ximea. To control material flow, strategic partnerships with these manufacturers is essential. Several other close substitutes to the above components are currently available but extra caution should be taken in the algorithm development stage to avoid heavy reliance upon these suppliers. if the smart algorithms that will be developed are sensitive to replacements of one component with a market substitute, then these suppliers will have tremendous control over PhasmaFOOD, since replacement of a component would equal to the loss of existing data points. PhasmaFOOD needs to consider this beforehand and create robust

algorithms or develop costless calibration methods to reduce the power of suppliers. For the other essential parts of PhasmaFOOD technology (e.g. sensing components, electronic board and algorithms) the suppliers will be the project's partners. To avoid conflicts of interest and risks of suppliers selling their know-how or materials to other competing solution, the members should sign binding contracts that would restrict the use of these specific technology outside PhasmaFOOD without the consent of all parties involved. If robust algorithms/calibration methods are feasible, **the power of suppliers is considered as low** otherwise **suppliers' power is very high** and a critical fact that will determine the success of the project.

In terms of buyers, PhasmaFOOD targets a wide variety of business actors and of course, consumers. In terms of consumers, the bargaining power is low since they are numerous and each of them represents a minimal proportion of total sales. For business actors, there are two distinct groups: Multinational manufacturers or retailers who will demand a large number of devices to serve their global network and SMEs who will buy the device individually or in small numbers to serve their limited needs, In the first case, the buyers' power is high while in the second case it is low. In all cases however, the cost of switching to other devices will be high since transferability of the data to other devices will be infeasible while the device will only operate with the associated platform. **Overall, this force is considered as mild.**

Since this is a very new market, new players are expected to be attracted by the growing demand. However, the size of the investment required for R&D as well as the technology protection from intellectual property holding will be serious obstacles to new players. Also, the very high expertise required to build the algorithms as well as the fact the fact that the algorithms are expected to advance as the number of users is growing, are extra barriers for interested investors. Existing data companies with similar are most likely to enter the food market, using existing hardware as SCiO. Based on the above, **the threat of new entrants is considered mild.**

Substitutes are other products that cover the same needs without being identical to PhasmaFOOD. A number of such products has been presented in the competition section above. More rugged devices that target PhasmaFOOD's target segments are already there while other are expected to appear in the near future. These solutions target the needs of a small number of segments in the food chain and are available long before PhasmaFOOD so for these segments, they represent a very important threat. Also, since they have large sunk costs (high price and long time to train personnel), the cost of switching to PhasmaFOOD is considerable. Smart-packaging is another possible threat but it may prove an actual supplement if sensors are trained to read smart packages and combine available information. Therefore, **the threat of substitute products and services is high.**

The final thread comes from competitive rivalry within the industry. Looking back at Table 7, we see that PhasmaFOOD scores well in comparison to the direct competitors (Tellspec and SCiO). The market is expected to grow as customers start to gain confidence in such solutions and PhasmaFOOD can take advantage of Tellspec's negative publicity and SCiO's lack of algorithms to reduce the power of the competitors. Finally, since R&D and sunk costs are very high, leaving the market is considered as a costly option. Overall, **the rivalry among existing firms is expected to be mild to high** for PhasmaFOOD

4.1.3 SWOT

SWOT analysis is an essential part of strategic planning. The Strengths, Weaknesses, opportunities and threats of PhasmaFOOD are presented below. The findings of the analysis should be used as a guidance for designing a mix of cooperative, competitive and functional strategies that use strengths, take advantage of opportunities, minimize weaknesses and avoid threats.

(S)TRENGTHS	(W)EAKNESSES
Better technology than competitors (wider spectral range)	Lack of experience in B2C channels
Intellectual Property rights	Heavy reliance on overseas suppliers
Strong R&D and product development	High R&D and production costs
Solid academic background	Long delivery period for online sales
High level of expertise in food algorithms	Unable to read through opaque packaging
Proven technology	Difficult transition from prototype to large scale manufacturing
Richest database for the specific use-cases	
Good international image of partners	
Not too soon, not to late	
Firmware updates on the fly	
Small size of the device	
Relatively low cost	
Easy to use	

For PhasmaFOOD, **strategies that use its product's strengths to avoid threats** (often called ST strategies) could be: Use its website and **targeted campaigns** to highlight its unique and proven technology, that offers a wide spectral range along with the rich database, that is expected to be created through the project, to mitigate the high competition; Using the **strong R&D skills**, food algorithms expertise and property rights to further **differentiate the product**, so that the risk of imitation gets weaker; **Differentiation focus**, concentrating on **informed buyers** to avoid parallelisms with the negative publicity of existing devices. This can be accomplished through the image and the solid academic background of the partners along with the correct timing; **Cost focus** in the **B2B market** combined with the small size of the device and the swiftness of updates to reduce the indirect competition coming from more rugged devices, designed for industrial use; **Emphasize on non-disclosure statements** and the image of the partners to mitigate privacy concerns of consumers about their scan data.

(O)PPORTUNITIES	(T)HREATS
Increasing online retail shopping	Close substitutes for industry use
Supply chain effectiveness is increasing in developing countries	Privacy concerns of consumers about their scan data
Increasing health and nutritional concern among food consumers	Negative publicity of existing devices (mainly) ay influence consumer attitudes towards the technology
Investment of India on F&B sector	Lack of sufficient broadband services in developing n countries
Strict regulations regarding allowed mycotoxin levels in food	Risk of imitation
Fragmented manufacturing industry with numerous local SMEs	Smart and active packaging are gaining ground
Growing environmental concerns regarding food waste	Very high competition
45% of F&V, 35% of fish and 20% of meat is wasted	Packaged foods accounts for 47.4% of total food retail sales, some opaque
Foodborne diseases are highly visible	Fragmented F&B market
Shrinkage costs Europe's FMCG grocery industry €24 billion in 2003 (ECR, 2004)	
The organic market in Europe grew 7.4% in 2014 (FiBL, 2016)	
Corporate Social Responsibility (CSR) and sustainability continue to gain importance	
Importers search for niche channels	
EU F&B markets are highly regulated	
21.757 estimated aflatoxin-related illnesses and 19.455 deaths in 2010 (WHO)	
Sensor market in the global food and beverage industry approximately \$2,9 billion in 2012 and estimated to reach \$4,2 billion in 2018 (Frost & Sullivan, 2013)	
Agricultural policy reform in China affecting maize stocks	

PhasmaFOOD should also develop **strategies that minimize weaknesses and avoid threats** (WT strategies). Such strategies could be: **Value-chain alliances or licensing arrangements with overseas partners** to avoid non-formal reliance on other companies and combat the intense competition, using the local networks. This will also help in reaching the fragmented B2C market in countries with low access to PhasmaFOOD partners and reduce the delivery period for online sales (by having a certain amount of stock at the partners' countries); **Recruiting scientists from companies that are already active in the handheld spectrometry sector**, a fact that could make the transition from prototype to large scale manufacturing easier because of

knowledge transfer; **Focusing on the specific use-cases** where PhasmaFOOD has expertise could reduce high R&D costs and reduce the high risk of imitation.

To **take advantage of opportunities using its strengths**, PhasmaFOOD could employ a number of different (SO) strategies such as: **Cost-focus** on the large number of local manufacturing SME's who cannot afford the cost and expertise needed for more professional devices; Take advantage of the strong academic background of the partners to **use ongoing research results** regarding sustainability, food waste and foodborne diseases for designing **effective information campaigns**. Also, **use existing B2B channels** will be used to communicate the economic benefits from using the device in terms of CSR and shrinkage reduction; Using the unique characteristics of the product with respect to other (i.e. Firmware updates on the fly, small size of the device, Relatively low cost, state of the art algorithms, easy to use) **a differentiation competitive strategy** would help in acquiring a share of the growing sensor market in the global food and beverage industry; Taking advantage of the numerous campaigns and projects **rising environmental concerns regarding food waste**, PhasmaFOOD could use the reputation of the partners to have **active participation in such campaigns/projects** and promote the use of the device.

Finally, possible strategies that can **take advantage of opportunities by overcoming weaknesses** (WO strategies) could be: **value-chain partnerships with importers serving niche markets** in India (or in the wider Asia-Pacific region) to overcome the lack of experience in B2C channels in such regions; **Differentiation focus** on the **organic market** that is usually unpacked to overcome the barrier of opaque packaging.

5 Conclusions

According to Hambrick and Fredrickson (2005), if a business must have a strategy, then the strategy must clearly identify the 5 parts. Based on the strategy diamond, this deliverable seeks to answer specific questions of PhasmaFOOD activity arenas: 1) Which products? 2) Which market segments? 3) Which geographic areas? 4) Which core technologies? And, 5) Which value creation stages? At this very early stage, these are of course essential considerations one has to decide upon, before anything else. The above are included in the respective sections of the deliverable in a concise and clear way. PhasmaFOOD intends to use spectrometry to develop the miniaturized smart integrated system will be able to detect food hazards, spoilage (incl. early sign of spoilage) and food fraud through the combined bio-chemical data analysis. PhasmaFOOD consortium will control the software research and development activity while manufacturing of the design will be outsourced to a manufacturing company within the network. Overall, PhasmaFOOD has a great market potential as it will the target business actors and consumers' segments have combined revenues/expenditures in the magnitude of trillions and the per unit scanned of PhasmaFOOD device, plus the fee (where applicable) is not expected to constitute a very high premium throughout the chain. The competitive advantage of PhasmaFOOD is its size, along with the unique technology that combines visible and NIR spectra along with white light imaging, as well as its algorithms and focus only on specific food products and problems. The possibility of data integration and user-friendliness will enable the wide spread of the technology to non-technical end users. PhasmaFood's direct competitions comes from SCiO by Consumer Physics and Tellspec. Both devices use similar technology, though only Tellspec is focused on food products as PhasmaFood. More rugged devices such as the ID-Raman mini by Ocean Optics and MicroNIR Pro 1700 ES from Viavi have also been used in food applications (mostly food adulteration) but due to size and price considerations are more targeted towards the supply chain than to final consumers. Also, Distell's Torrymeter, BFD-100 by Freshdetect and FOODSniffer seem to be the most important in relation to the Phasmafood solution, although using a completely different technological approach.

In this deliverable, a wide variety of segments and markets are identified for each use-case. The market scoping exercise facilitates the identification of markets that have a high potential of adopting PhasmaFOOD. It aims to help the consortium identify regions with potential business opportunities for each use case, based on the size of the relevant customers (business or consumers) in terms of output values, revenues and expenditures. The market segmentation on the other hand, is crucial for later stages of PhasmaFOOD marketing, where specific actors (firms) should be identified and approached in the aforementioned regions. This work should guide the demand estimation and the identification of customers' preferences for the PhasmaFOOD solution, that will be essential before PhasmaFOOD is introduced into the market. However, these are out of the R&D scope and more related to the product commercialization phases.

References

- Aaker, D. A., & McLoughlin, D. (2010). Strategic market management: global perspectives. John Wiley & Sons.
- BCC Research (2016). Global Markets for Spectroscopy Equipment. Available at: <https://www.bccresearch.com/market-research/instrumentation-and-sensors/spectroscopy-equipment-markets-ias004f.html>
- Bullerman, L. B., & Bianchini, A. (2007). Stability of mycotoxins during food processing. International Journal of Food Microbiology, 119(1), 140-146.
- Efficient Consumer Response (ECR) Europe (2004). Shrinkage in Europe: A Survey of Stock Loss in the Fast Moving Consumer Goods Sector. Available at: <https://www2.le.ac.uk/departments/criminology/people/bna/ShrinkageinEuropeASurveyofStockLoss2004pdf>
- Ellis, D. I., Muhamadali, H., Haughey, S. A., Elliott, C. T., & Goodacre, R. (2015). Point-and-shoot: rapid quantitative detection methods for on-site food fraud analysis—moving out of the laboratory and into the food supply chain. Analytical Methods, 7(22), 9401-9414.
- Euromonitor International (2016). 2016 Digital Consumer Index: Identifying the Next Digital Frontiers. Available at: <http://www.euromonitor.com/2016-digital-consumer-index-identifying-the-next-digital-frontiers/report>
- FiBL (2016). European market data 2014. Available at: <http://orgprints.org/29779/7/willer-schaack-2016-european-data.pdf>
- FoodDrinkEurope (2017). FoodDrinkEurope Annual Report 2016. Available at: <http://www.fooddrinkeurope.eu/publication/fooddrinkeurope-annual-report-2016/>
- Frost & Sullivan (2013). Sensors Market in the Global Food and Beverage Industry. Available at: <http://www.frost.com/c/10118/sublib/display-report.do?id=M893-01-00-00-00>
- Grunert, K. G. (2006). Future trends and consumer lifestyles with regard to meat consumption. Meat science, 74(1), 149-160.
- Hambrick, D. C., Fredrickson J. W., 2005. Are you sure you have a strategy? Academy of Management Executive, 19(4).
- IFOAM EU Group (2016). Organic in Europe: Prospects and developments 2016. Available at: http://www.ifoam-eu.org/sites/default/files/ifoameu_organic_in_europe_2016.pdf
- Jourdan A., Tajistsu N. (2013). Fonterra challenged in China's milk powder market. Available at: <http://www.stuff.co.nz/business/farming/dairy/9526212/Fonterra-challenged-in-Chinas-milk-powder-market>

MarketsandMarkets (2017). Food authenticity market – Global forecast to 2022. Available at: <http://www.marketsandmarkets.com/PressReleases/food-authenticity.asp>

Nielsen (2015). We are what we eat: Healthy eating trends around the world. Available at: <https://www.nielsen.com/content/dam/nielsen-global/eu/nielseninsights/pdfs/Nielsen%20Global%20Health%20and%20Wellness%20Report%20-%20January%202015.pdf>

Research and Markets (2016). Global Fresh Fish and Seafood market 2016-2020. Available at: http://www.researchandmarkets.com/research/k2q8fw/global_fresh_fish

Santos PM, Pereira-Filho ER, Rodriguez-Saona LE (2013). Application of Hand-Held and Portable Infrared Spectrometers in Bovine Milk Analysis. J Agric Food Chem. 2013; 61:1205–11

Transparency Market Research (2015). Nuts and Seeds Market: Global Industry Analysis, Size, Share, Growth, Trends and Forecast, 2015 - 2021. Available at: <http://www.transparencymarketresearch.com/nuts-seeds-market.html>

USAID (2016). External Evaluation of Feed the Future Innovation Lab for Collaborative Research on Peanut Productivity and Mycotoxin Control. Available at: http://pdf.usaid.gov/pdf_docs/PA00MFGK.pdf

World Health Organization (2014). Global status report on alcohol and health. Available at: http://www.who.int/substance_abuse/publications/global_alcohol_report/en/

Appendix

Table 9. Food and Alcoholic Beverages Expenditure in 2015 (€ million)

Country	Food	Alcoholic Beverages
Austria	15.864	2.378
Belgium	24.381	3.318
Brazil	134.500****	25.500**
Canada	65.625	15.295
China	490***	124.236**
Costa Rica	5.864	296
Czech Republic	12.111	2.836
Denmark	12.490	2.113
Estonia	2.045	623
EU28 countries	867.782	122.901
Finland	12.288	3.319
France	141.469	20.687
Germany	143.192	21.467
Greece	20.490	1.110
Hungary	8.747	1.687
Iceland	1.172	229
India	340*****	23.239
Ireland	7.182	2.029
Israel	23.482	1.349
Italy	130.667	9.113
Japan	250***	26.947**
Latvia	2.504	791
Lithuania	5.116	1.083
Luxembourg	1.459	431
Mexico	114.671	11.297
Netherlands	31.646	3.767
Norway	14.342	3.089
Poland	36.978	8.219
Portugal	19.570	1.695
Russia	162.801	30.877
Slovak Republic	6.886	1.050
Slovenia	3.000	390
Spain	79.049	5.131
Sweden	3.337	604
United Kingdom	99.020	21.741
United States	642.865	125.860

* Source: OECD DATA, values converted to Euros based on current (March 2017) exchange rate

** Source: Mintel, 2015

*** Source: Euromonitor estimates, 2013

**** Source: Berners Consulting estimates (Food market, 2012); Euromonitor (foodservice, 2013)

Table 10. A snapshot of commercially available handheld Raman and infrared spectrometers under 4 kg *

Spectroscopy	Company	Product	Spectral range (cm⁻¹)	Weight (kg)	Size (cm)
Raman	Metro-Ohm	Mira M-1	400–2300	0.54	12.5 × 8.5 × 3.9
		Mira M-2*	400–2300	0.82	14.4 × 9.3 × 6.4
	Ocean Optics	ID Raman Mini	400–2300	0.33	9.1 × 7.1 × 3.8
	Rigaku	Progeny	200–2500	1.6	29.9 × 8.1 × 7.4
	Thermo Scientific	First Defender RM	250–2875	0.82	4.4 × 19.3 × 10.7
		First Defender RMX	250–2875	0.92	19.6 × 11.4 × 6.1
		TruNarc	250–2875	0.505	16.3 × 10.4 × 5.1
		TruScan GP	250–2875	0.9	20.8 × 10.7 × 4.3
		TruScan RM	250–2875	0.9	20.8 × 10.7 × 4.3
	Snowy Range	CBEx	400–2300	0.33	9.1 × 7.1 × 3.8
		CBEx 1064	400–2300	0.77	11.3 × 7.9 × 5.7
	Sciaps	Inspector 300	175–2875	1.7	19 × 17.5 × 4.3
		Inspector 500	100–2500	2.7	20 × 17.5 × 4.3
	Airsense Analytics	LS-ID	ns	0.4	13 × 7 × 4
	Chemring Detection Systems	THOR-1064	160–2200	1.5	22.9 × 11.5 × 5.1
		PGR-1064	ns	1	6.4 × 19 × 16.7
	BWTEK	NanoRam	176–2900	1.2	22 × 10 × 5
		TacticID	176–2900	0.9	19 × 10 × 5
	Wasatch Photonics	NOVA	200–2500	0.82	16.2 × 13.2 × 3.7
	Agiltron	Pin Pointer	200–3000	1.36	21.4 × 10.8 × 6.3
	TSI	ASSURX	250–2350	1.9	23.1 × 10.1 × 22.2
	Bruker	BRAVO	300–3200	1.5	27 × 15.6 × 6.2

Spectroscopy	Company	Product	Spectral range (cm ⁻¹)	Weight (kg)	Size (cm)
FT-IR/Raman	Thermo Scientific	Gemini Analyzer	250–2875 (Ra- man) 650–4000 (IR)	1.9	25.6 × 14.6 × 6.1
FT-IR	Agilent	4300	650–4500	2.2	10 × 19 × 35
		4100 Exoscan	650–4000	3.2	17.1 × 11.9 × 22.4
	Thermo Scientific	TruDefender	650–4000	1.3	5.3 × 19.6 × 11.2
	Pyreos	Mid-IR	909–1818 or 2000–4000	0.71	16.5 × 7.4 × 3.5
	Arcoptix	FTIR-Rocket	1700–5000 or 830–4000	1.2	18 × 16 × 8
NIR	Sentronic	SentroID	5800–11 000	1.1	23 × 8 × 4.2
	BWTEK	i-Spec nano	4500–7700	ns	12 × 6 × 3
	Thermo	microPHAZIR	4100–6250	1.8	26.6 × 25.1 × 10.9
	JDSU	MicroNIR Pro	6000–11 000	0.2	4.5 × 4.4
	ASD	QualitySpec	4000–28 500	2.5	31 × 10 × 30
	Ocean Optics	NIRQUEST256-2.5	4000–11 000	1.18	18.2 × 11 × 4.7
	Avantes	AvaSpec-NIR256- 2.5-HSC	4000–10 000	3.5	18.5 × 14.5 × 18.5
	Brimrose	Luminar 5030	4300–9000 (oth- ers available)	ns	ns
	Arcoptix	FT-NIR Rocket	3800–11 000	1.7	18 × 12.6 × 7.8

*Reproduced from Ellis *et al.* (2015).