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Functional Food in the European Union

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The mission of the IPTS is to provide customer-driven support to the EU policy-making process by researching science-based responses to policy challenges that have both a socio-economic and a scientific or technological dimension.

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Executive summary

Scope

Conventionally, food has the role of providing individuals with the nutrients they need for their metabolism (nutritional function) and, through its taste, that of contributing to individual well-being (sensory or hedonistic function). Over the last years a new, potential role of food has emerged, that of fulfilling a specific "physiological" function. While food that fulfils this role – called "functional" food – is consumed as part of the usual diet, it provides health effects that go beyond traditional nutritional effects. As such it is closely related to – but different from – concepts such as food supplements or nutraceuticals. For this report the definition of functional food required (i) that the base product was a food, (ii) that it contained or was fortified with an ingredient, a micronutrient or a naturally occurring chemical with a beneficial effect on health, well-being or disease prevention and (iii) that this effect went beyond normal and adequate nutritional effects, (iv) that these effects had been "demonstrated" or were at least claimed and communicated to the consumers and (v) that these effects can be expected to materialise when the food is consumed in normal amounts.

Analysis of the market for functional food

Due to limited data and differences in definitions, information and figures on the absolute size of the functional food market within the EU and globally are not consistent across different studies and reports and vary widely; recent estimates for the global market fall into the range of EUR 30-60 billion, while the estimates for the EU market range from EUR 6-20 billion. However, the information from all sources indicates consistently that the functional food market is growing and that it is expected to continue to do so for the foreseeable future. Industry sources and reports confirm that new products are constantly marketed and new target groups are targeted.

Within the functional food market dairy products seem to have the biggest market share, followed by beverages and then cereals, snack food and fats. In the dairy market innovations that cater for consumers' convenience, like "daily dose" bottle, seem to be a driver in the market expansion of functional dairy products. In the beverages category a clear distinction between energy drinks, sports drinks and functional drinks is difficult, but the general success of these products may indicate that drinks are an accepted vehicle by consumers. In terms of ingredients, probiotic bacteria cultures seem to be the dominant bioactive ingredient, which can be explained by the dominance of dairy products, followed by dietary fibres and then plant extracts and other ingredients.

Given available data, there are at least 168 EU companies active in the field of functional foods. Yet, no company from new Member States was found to produce functional food, whereas many companies from the older Member States have subsidiaries in these countries. More generally, the overview of manufacturers of functional foods shows a dominance of established and internationally active companies that are also strong in conventional food products and have now diversified into functional foods. This may also indicate that barriers for entry in the functional food market are high and that the successful

introduction of a functional food into the market is relatively costly, not least because of the necessary research and marketing activities and because of the product approval requirements.

Compared to Japan or the USA the functional food market in Europe is generally less developed, although within the EU there is considerable heterogeneity across Member States. For instance in Japan the per-capita expenditure on functional foods and beverages is four times as high as in the EU and in the USA it is still twice as high. However, consumers in both Japan and the EU seem to have a more genuine interest in functional food as such, while market development in the USA seems to be more driven my marketing activities and the novelty of products. Still, it is estimated that at least 75 percent of newly launched functional food products are withdrawn from the market within the first two years. Selling their products through big retailers instead of specialty stores and collaborations between companies from the food and pharmaceutical industries seem to be some strategies of functional food companies to develop and market their products.

In the past the difficulties in getting a clear overview of the functional foods sector stemmed from limited data availability and varying definitions of the concept of functional food, which prevented any analysis from being comprehensive. The new health claims regulation will help clarify this issue and thus also facilitate future research in this field.

Consumer awareness, attitudes and willingness to pay

A survey analysed attitudes and behaviour of grocery shoppers regarding functional food in four selected Member States (Germany, the United Kingdom, Spain and Poland). Among the respondents the term "functional food" was hardly known, but most respondents knew specific products or brands of functional food. And most respondents had already bought a functional food product at least at one point in time. Generally, correct knowledge of the functionality of ingredients corresponded to a more positive attitude towards functional food. This knowledge seemed to depend on how long the ingredients were on the market, and, to a lesser extent, how strongly they had been advertised or promoted. Regarding the socio-demographic background of buyers and non-buyers of functional food among the respondents, it was found that women were more likely to buy functional food than men and that younger respondents and respondents with higher incomes generally were also more likely to buy functional food than others. The influence of education was mixed and other characteristics did not play a role in this context.

The main reasons for which respondents (would) buy functional food was "to stay healthy", followed by "to do myself good" and "good taste". This suggests that functional food has not only to be "functional", i.e. have an effect on the health and well-being of consumers, it has also to be "food" in that consumers expect it to taste good. On the other hand, the reasons for not buying functional food were more heterogeneous across the four countries, including general concerns about novel food, bad taste, preference for organic food, focus on the present rather than on the future, absence of illness, fear of side-effects, aversion towards artificial additives, distrust of effectiveness and price. However, if functional food products would be recommended by a doctor or nutritionist, most non-buyers among the respondents would reconsider their decision and buy functional food products. Whereas across all Member States the national governments were considered to be least trustworthy in the context of functional food, resulting from a general mistrust in government, a perceived lack of competence in the field of nutrition and food scandals in the various countries.

In a simulated purchase of (functional) orange juice respondents in all countries considered the quality of the juice (i.e. the fruit content) to be very important. Next came the convenience aspect (i.e. the packaging of the juice) and only then its "functionality". Except for Poland the price of the juice did not play a major role in the purchasing decision. Some national differences also became apparent when the influence of the health claim was analysed, where claims with a preventive character were set against more tangible health claims for direct effects. This assessment of the importance of the various health claims was also reflected in the respondents' derived willingness to pay for functionality.

Cost-effectiveness of functional food

With regard to the economics of functional food, the analysis of the market for functional food and consumer attitudes indicates that functional food could indeed present new economic opportunities for the food industry and the competitiveness of the EU economy. However, there is virtually no information on the cost-effectiveness of functional food, i.e. it is unclear at what cost the expected health benefits come. Studies indicate that functional food may help prevent diseases that currently impose a heavy drain on health care budgets. Only, by how much functional food can do so is as of yet unascertained. And given moreover the absence of information on the cost side of the production, promotion and consumption of the corresponding functional food products, it is impossible to decide whether spending public and private resources on this approach represents a more efficient use than spending them on alternative approaches (like dietary supplements, behaviour change, etc.). Studies in somewhat different settings indicate that food-based approaches can indeed offer a cost-effective way of addressing health problems; this could also be the case for functional food, but corresponding research is still lacking.

Analytical methods and anti-fraud

To ensure consumer trust in functional food, the health claims regulation stipulates that health claims have to be scientifically substantiated. However, to prevent fraud – and thus to maintain consumer trust – there is also a need for analytical methods to verify the composition of functional food products and the compliance with labelling requirements. This is the more important because the analytical evaluation of food and dietary products has evolved significantly as a result of the functional food debate. There is a continuing need for reliable analytical methods for use in determining compliance with national regulations as well as international requirements in all areas of food quality and safety. Nevertheless, in total 223 standardised methods to analyse functional food have already been compiled, accounting for about 100 individual compounds.

R&D landscape of functional food

In general, food and nutrition research has already been funded in all EU framework programmes since 1989. The importance of research related to functional food in particular has risen significantly, both in terms of number of funded projects and of the budget allocated to these projects: on the EU level, approximately 10-20 percent of the overall research budget in the field of food and nutrition is allocated to functional food. This relative importance of functional food in research is also reflected by a large number of research institutes in the public as well as the private sector within the EU that are active in this field in

all aspects along the production chain. Current research topics are the use of new bioactive ingredients, the better understanding (including safety issues) of ingredients that are already in use, the effectiveness of dietary interventions, technological developments, regulatory issues and, this being a particularly forward looking field, nutritional genomics.

With respect to the research output, publications on functional food had a share of 5-7 percent in all food-related publications and publications from scientists and institutes in the EU made almost 40 percent of all (English language) publications on functional food worldwide, compared to about 25 percent of the publications that stemmed from the USA. Measuring the more applied research output by patent applications, the number of which has increased dynamically over the past years, the share of the EU is also about 40 percent, again compared to a share of the USA of about 25 percent.

Conclusions

Although the report points to a lack of consistent quantitative data and information in various fields relating to functional foods, a first conclusion is that functional foods already constitute a significant market in the EU with a large development potential. It may be important to analyse to what extent the new EU regulation on health claims made on food (and the related approval process) impacts the development of this market and facilitates or not market entry for new companies. On the demand side, the report concludes that EU consumers are generally open towards functional food (for reasons of health and well-being, but with taste also being an important factor). However, certain mistrust in government that EU consumers have in relation to some food issues also appears in the context of functional food. Hence, addressing this mistrust may be a necessary first step of any intervention by policy makers trying to promote functional food among consumers; developing analytical methods to test the composition of functional food products and to substantiate health claims is one important area to promote consumer confidence and to eliminate fraud. Yet, whether promoting functional food is an efficient way of improving public health in the first place is the subject of a debate that is in need of more research: while the general research output on functional food in the EU is bigger than in the USA or Japan, the scope of the potential impact and cost-effectiveness of functional food are little researched topics so far. Therefore it may be pertinent to focus on these issues to substantiate the economic rationale of functional foods from a public health perspective and to allow both policy makers and consumers make informed decisions.

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1 Introduction

Conventionally, food has two roles, first providing individuals with the nutrients they need for their metabolism (nutritional function) and second – through its taste – contributing to individual well-being (sensory or hedonistic function). Over two decades ago a third, potential role of for food has emerged, that of fulfilling a specific "physiological" function; food that falls into this category was first regulated in Japan as "Food for Specified Health Use" (FOSHU) (Shimizu 2003). Since a couple of years this kind of food is generally referred to as "functional food" – if it is taken as part of the usual diet and has beneficial effects that go beyond traditional nutritional effects (Roberfroid 2002).

However, while the markets for functional food in Japan and in the USA are dynamic, the corresponding European markets are less developed. This has partly been explained by the various national legislative frameworks that existed within the EU and that were often highly inconsistent across different Member States. And partly it has been ascribed to a more critical view of Europeans of the truthfulness of the products' health claims (Bech-Larsen and Scholderer 2007). Yet, apart from conventional nutrition labels on food, such health claims have the potential to contribute to the achievement of public health objectives if they inform consumers about the nutritional and health advantages of particular foods or nutrients (Hawkes 2004).

In the meantime the European Parliament and the Council have adopted a new regulation "on nutrition and health claims made on foods" (EC 2007a). This regulation is expected to ensure that consumers are not misled by unsubstantiated, exaggerated or untruthful claims about foodstuffs and to provide food producers and manufacturers with clear, harmonised rules that would ensure fair competition and help protect innovation in the food industry (EC 2007b), thus not only tying in with the EU campaign for healthier lifestyle choices and the Commission's consumer protection objectives, but also benefiting the food industry. Moreover, life-style modifications – inclusive dietary changes – may reduce the risk of chronic diseases such as heart disease, stroke, colon cancer or type II diabetes. Therefore, increasing health care costs on the one hand and growing scientific understanding of diet-disease interactions as well as rising consumer awareness of this link on the other hand may help develop the functional food marked in future (Singletary and Morganosky 2004).

Given this background, the regulation is a decisive step forward for the development of the functional foods market in Europe. And indeed, following the adoption of the new regulation, which also contained a deadline for submitting new health claims for acceptance, Member States' regulators have received thousands of health claim proposals from industry (McNally 2007) – even if the view held by industry representatives is that the requirements that have to be met under the new regulation are too high (Wijnands 2007). In this context a comprehensive overview of functional foods in the EU is timely and necessary for any future evaluation of the impact of the new regulation – for instance, in the light of the Lisbon Strategy, to assess the potential contribution of functional food to the EU's economic competitiveness. Similarly, providing an overview of functional foods is also a pertinent exercise to build a basis for analysing the contribution of functional foods to key challenges of the revised Sustainable Development Strategy, like public health or sustainable consumption. The questions that need to be answered are therefore: what are current and future products, which are the "functional" ingredients, which research and development activities are going on, what

production and validation techniques are there, what are the market and industry structures, what are the attitudes of consumers, and how cost-effective are these products?

Within its mandate to work on technology foresight for early identification of newly emerging issues and of elements that need a policy response in the field of agriculture, food and health, the Institute for Prospective Technological Studies (IPTS), an institute of the Joint Research Centre (JRC) of the European Commission, had initiated a prospective study on the functional food sector within the EU. This study should also be seen as supporting the call for action to increase investment in research and technological development and to close the gap with Europe's main competitors that was issued by the Barcelona European Council in March 2002 (Vidry and Lheureux 2004).

The points outlines above will be discussed in the following chapters: Chapter 2 provides a definition of the concept of functional foods and delimits from similar products, chapter 3 gives a short overview of functional foods, the main bioactive ingredients and the functional food market in Europe, chapter 4 gives a detailed overview of the market of functional food from the supply side, chapter 5 discusses the demand side of the functional food market, by looking at consumer awareness and their willingness-to-pay for these products, chapter 6 attempts to assess the desirability of functional food from an economic and public health point of view, by looking at the cost-effectiveness of some exemplary products, chapter 7 discusses the analytical methods to test for the bioactive ingredients – upon which the feasibility of the concept of functional food as a serious product relies, chapter 8 reports on the international R&D landscape related to functional food and chapter 9 concludes.

2 Delimitation of the concept of functional foods

2.1 Definition of functional foods

While no universally accepted definition for functional foods exists (see Kotilainen *et al.* 2006), in the consensus document on "Scientific Concepts of Functional Foods in Europe" of the European Commission Concerted Action on Functional Food Science in Europe (FUFOSE) the following working definition was used (Diplock *et al.* 1999: S6):

> A food can be regarded as 'functional' if it is satisfactorily demonstrated to affect beneficially one or more target functions in the body, beyond adequate nutritional effects, in a way that is relevant to either an improved state of health and well-being and/or reduction of risk of disease. Functional foods must remain foods and they must demonstrate their effects in amounts that can normally be expected to be consumed in the diet: they are not pills or capsules, but part of a normal food pattern.
>
> A functional food can be a natural food, a food to which a component has been added, or a food from which a component has been removed by technological or biotechnological means. It can also be a food where the nature of one or more components has been modified, or a food in which the bioavailability of one or more components has been modified, or any combination of these possibilities. A functional food might be functional for all members of a population or for particular groups of the population, which might be defined, for example, by age or by genetic constitution.

For the preparatory work of this report, which the European Science and Technology Observatory (ESTO) had carried out for the Institute for Prospective Technological Studies (IPTS)[1], the definition of functional food required (i) that the base product was a food, (ii) that it contained or was fortified with an ingredient, a micronutrient or a naturally occurring chemical with a beneficial effect on health, well-being or disease prevention and (iii) that this effect went beyond normal and adequate nutritional effects, (iv) that these effects had been "demonstrated" or were at least claimed and communicated to the consumers and (v) that these effects can be expected to materialise when the food is consumed in normal amounts. Furthermore, with some exceptions due to limitations in the available data, in the preparatory work food products fortified only with vitamins or minerals were excluded; similarly, sometimes food supplements were included due to pragmatic reasons. Products containing alcohol or other "unhealthy" ingredients were not excluded as long as they fulfilled the other requirements.

2.2 Disambiguation of the terms functional foods, food supplements and nutraceuticals

Apart from the term "functional food" there are more terms for dietary products that explicitly link nutrition with health, namely "food supplements" (or "dietary supplements") and nutraceuticals (or "nutriceuticals"). According to the DG Health and Cownsumer Protection of the European Commission "food supplements are concentrated sources of nutrients or other substances with a nutritional or physiological effect whose purpose is to supplement the normal diet. They are marketed 'in dose' form i.e. as pills, tablets, capsules, liquids in measured doses etc." (EC 2007c). Similarly, the US Food and Drug Administration defines a dietary supplement as "a product taken by mouth that contains a 'dietary ingredient' intended to supplement the diet. The 'dietary ingredients' in these products may include: vitamins, minerals, herbs or other botanicals, amino acids, and substances such as enzymes,

1 The IPTS is one of the seven scientific institutes of the European Commission's Joint Research Centre (JRC), see http://www.jrc.es/.

organ tissues, glandulars, and metabolites. Dietary supplements can also be extracts or concentrates, and may be found in many forms such as tablets, capsules, softgels, gelcaps, liquids, or powders. They can also be in other forms, such as a bar, but if they are, information on their label must not represent the product as a conventional food or a sole item of a meal or diet" (FDA 2007). Hence, the main difference between functional food and food supplements is that the former "are similar in appearance to conventional foods and are consumed as part of a normal diet" (Zeisel 1999: 1853), whereas the latter are not considered to be proper "food".

For nutraceuticals the concept is less clear. The common definition of the term that can be found on the internet is that a nutraceutical is "a food or naturally occurring food supplement thought to have a beneficial effect on human health." And MedicineNet (2007) defines it as "a food or part of a food that allegedly provides medicinal or health benefits, including the prevention and treatment of disease. A nutraceutical may be a naturally nutrient-rich or medicinally active food, such as garlic or soybeans, or it may be a specific component of a food, such as the omega-3 fish oil that can be derived from salmon and other cold-water fish." Following these definitions, both functional food and food supplements could be considered nutraceuticals – as long as they can be derived from natural sources.

In contrast, the Canadian Ministry for Agriculture and Agri-Food considers a nutraceutical to be "a product isolated or purified from foods that is generally sold in medicinal forms not usually associated with foods. A nutraceutical is demonstrated to have a physiological benefit or provide protection against chronic disease" (Canada 2007). And, calling for stricter regulation of these products, Zeisel (1999: 1853) even proposes "to define nutraceuticals as those diet supplements that deliver a concentrated form of a presumed bioactive agent from a food, presented in a nonfood matrix, and used to enhance health in dosages that exceed those that could be obtained from normal foods." In a recent report commissioned by the European Commission the distinction made is somewhat different, though: "dietary supplements that are used to enhance health [...] are also called nutriceuticals and nutraceuticals. The 'nutri' type contains mixtures of essential primary nutrients, while the 'nutra' type consists of non-essential secondary nutrients. Bioactivity for essential nutrients is not in doubt, but still has to be proven for the nutraceuticals" (Wijnands 2007: 30). Yet, in all these cases nutraceuticals are seen to be a special or more bioactive sort of food supplement – and the definition does not cover functional food.

Finally, the Nutraceutical Institute of Rutgers University and Saint Joseph's University limits its definition of nutraceuticals to "natural, bioactive chemical compounds that have health promoting, disease preventing or medicinal properties" (NI 2007), whereas the National Nutraceuticals Center of Clemson University extends the concept by adding the category of "medicinal foods" (e.g. transgenic plants for oral vaccination against infectious diseases) to the other two nutraceutical categories of dietary supplements (e.g. vitamins, minerals and plant extracts) and functional foods (e.g. omega-3 milk, cholesterol reducing oils and fats) (NNC 2007).

To summarise, there is a clear distinction between functional food and food supplements, while the term nutraceuticals can cover functional food and food supplements, refine the concept of food supplements, merely refer to the "functional" compounds in either or even include medicinal foods. Therefore, in this report use of the term "nutraceuticals" will be avoided where possible. However, given the difficulties of delimiting the various concepts,[2] the report may now and again include food supplements or nutraceuticals in parts of the analyses; where this is done it will of course be clearly highlighted.

2 "Diet supplements, nutraceuticals, and functional foods are designed to supplement the human diet by increasing the intake of bioactive agents that are thought to enhance health and fitness" (Zeisel 1999: 1853).

2.3 Classification of functional foods

Functional food can be classified according to several principles, namely the food group it belongs to (e.g. dairy products, beverages, cereal products, confectionary, oils and fats), the diseases it is expected to prevent or alleviate (e.g. diabetes, osteoporosis, colon cancer), its physiological effects (e.g. immunology, digestibility, anti-tumour activity), the category of its specific biologically active ingredients (e.g. minerals, antioxidants, lipids, probiotics), its physico-chemical and organoleptic properties (e.g. colour, solubility, texture), or the processes that are used in its production (e.g. chromatography, encapsulation, freezing) (Juvan *et al*. 2005).

While in the literature various of these topical groups are used to classify functional foods, in the preparatory work for this report food groups were used for classification where possible and appropriate (e.g. beverages, dairy products, cereal products, oils and fats, convenience food, confectionery, bakery products, fresh produce, miscellaneous), although there is no unified classification of food, either (see EC 2005, Eurostat 2007). The second level classification groups the functional food products within each food category by the biologically active ingredient (e.g. phenols, terpenoids, saccharides, lipids, peptides, fibres, plant extracts, bacteria cultures).

3 Overview of functional food products, ingredients and companies

In the present chapter, the products identified on the European market are described with regard to their respective food sector, active ingredients and food producing companies.

3.1 Functional food products by food sectors

The number of new functional food products cannot be determined comprehensively with 5,500 new functional foods introduced since 1990 in Japan alone (Nutra 2004a) and with the varying definitions mentioned before. Although the products identified here cannot fully represent the whole market, the following results give an approximate impression of the situation on the European market.

Table 3-1: Functional food products on the European market in 2004, by sectors

Food sector	Number of products	Percent of all products
Dairy (incl. yoghurt drinks)	209	54.3
Beverages	116	30.1
Cereals	13	3.4
Confectionery	12	3.1
Fats and fat supplements	12	3.1
Infant foods	9	2.3
Bakery	6	1.6
Convenience	5	1.3
Miscellaneous	3	0.8
Total	385	100.0

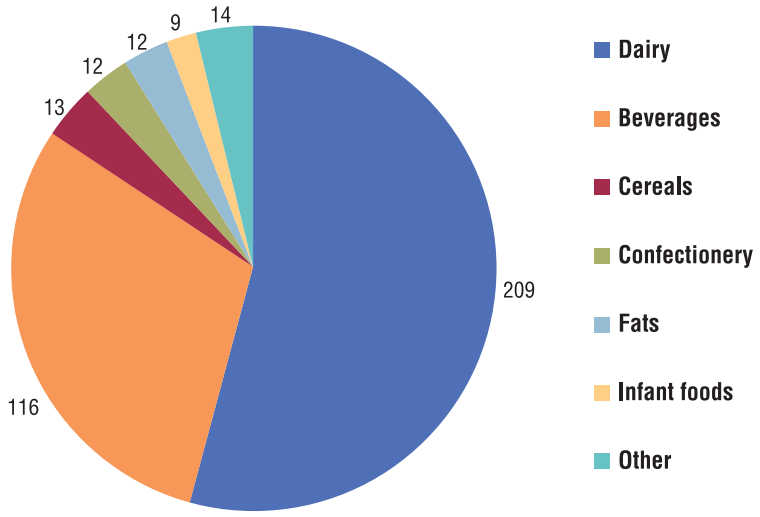
Table 3-1 and Figure 3-1 indicate that the dairy sector (including yoghurt drinks) is by far the largest and most diversified sector, followed by functional beverages.[3] To date other sectors play only a minor role.

3.2 Functional food products by types of bioactive ingredients

The 385 functional food products that were identified for the European market contained 503 different "functional" ingredients. About one third of the products were enriched with (probiotic) bacteria cultures, one sixth of the products contained functional saccharides (most of them prebiotics), plant extracts without explicit specification of their active molecules were added to one tenth of the products and terpenes to another 8 percent. About one third of the products contained more than one bioactive ingredient (Table 3-2). The most frequently

3 The "European market" includes both EU Member States and other European countries. Moreover, for those products for which no information could be obtained on the area where they are marketed, as an approximation it was assumed that they are also marketed in Europe.

Figure 3-1: No. of functional food products on the European market in 2004, by sectors



Source: Based on Table 3-1.

occurring bioactive ingredients and combinations are shown in (Figure 3-2). Products that were only fortified with vitamins or minerals were excluded from the study, unless they contained other functional ingredients as well.

3.3 Companies active in the functional food market in Europe

In the EU, 168 companies were found that market at least one functional food product. About half of the companies have their headquarters in Germany, almost one sixth in the UK, somewhat more than one tenth in Spain and about 5 percent in the Netherlands (Figure 3-3). Furthermore, 26 US companies were found to market functional food products on the European market, plus 11 Japanese companies and around another 30 companies from outside the EU.

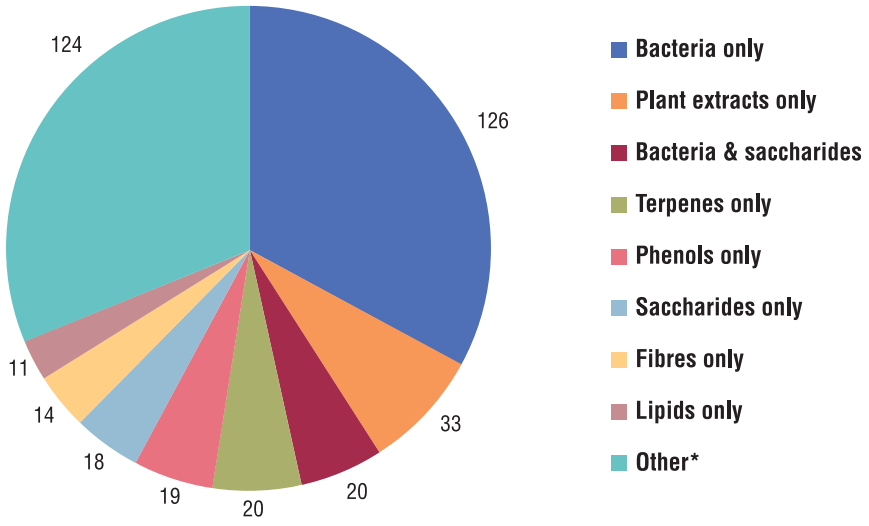
More forward-looking, within the patent analyses (section 8.4) 10 European companies were identified that had filed a total of 15 patent

Table 3-2: Food products on the European market in 2004, by ingredients

Ingredient type	Number of products	Percent of all products
Bacteria cultures (mostly probiotics)	173	44.9
Saccharides (mostly prebiotics)	78	20.3
Plant extracts	53	13.8
Terpenes	41	10.6
Miscellaneous	37	9.6
Fibres	35	9.1
Phenols	33	8.6
Peptides	30	7.8
Lipids	23	6.0
Total	503	130.6*

*Note: * Total bigger than 100 percent because products that contained two or more bioactive ingredients are listed under each ingredient type (see Figure 3-2).*

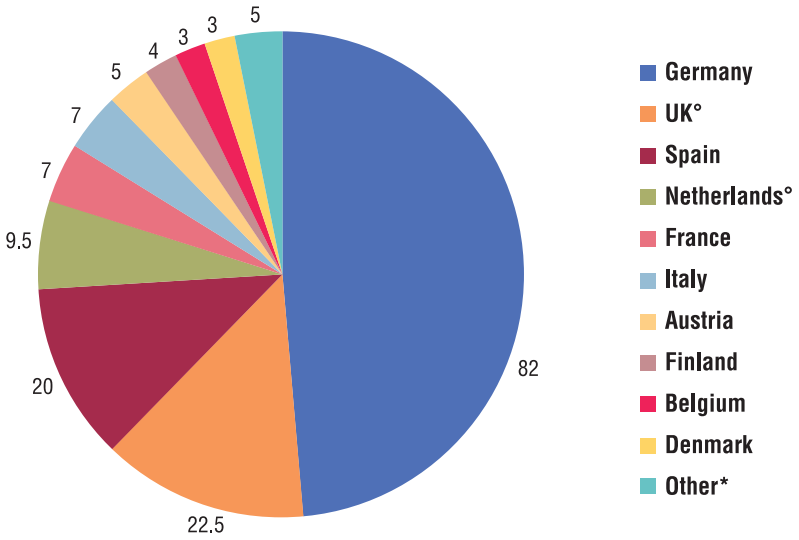
Figure 3-2: No. of functional food products on the European market in 2004, by ingredients



*Note: * Occurrences of less than 10 are summed up in "Other".*

applications for new products in the field of functional food in 2001 (Table 3-3). The company with the most (5) patent applications in 2001 in Europe was Societé des produits Nestlé s.a., which was not included in the table because its headquarters are in Switzerland and not in the EU. Of these companies Unilever had, for instance, a global market volume in foods of EUR 23,490 million, thereof EUR 1,270 million with functional food products. And apart from these companies that are directly involved in the production of functional foods, others, like DSM Nutritional Products Europe Ltd., the successor of Roche's vitamins and fine chemicals division, are important for the functional food sector as suppliers of vitamins, carotenoids and other fine chemicals.

Figure 3-3: No. and location of companies on the European market for functional food in 2004



*Note: National affiliation by headquarter location. * Occurrences of less than 3 are summed up in "Other". ° One company, Unilever, had headquarters both in the UK and in the Netherlands.*

Table 3-3: No. of patent applications from EU companies in 2001, only functional foods

Applicant	Headquarters	No. of applications
Loders Croklaan B.V.	Netherlands	3
Unilever n.v.	Netherlands / UK	3
Aventis Pharma Deutschland GmbH	Germany	2
Ökopharm Forschungs- und Entwicklungs-GmbH	Austria	1
vis-vitalis Lizenz- und Handels GmbH	Austria	1
BRIF	France	1
Roquette Frères	France	1
Senpeker, Mustafa	Germany	1
Sigma-Tau Industrie Farmaceutiche Riunite S.p.A.	Italy	1
Consejo superior de investigaciones cientificas	Spain	1

4 Analysis of the market for functional food

The analysis of the supply side of the market for functional food comprises two themes. The first part is a more general overview of the different product categories and the global market for functional food in general and where possible for Europe in particular. The second part provides an analysis of individual national markets within the EU and of the corresponding framework conditions. Special attention is given to the analysis of the market size, developments in individual product categories and important individual products (by market share and turnover).[4] The analysis is based on independent market reports (from market research or consulting companies, mainly Frost & Sullivan), company publications and company interviews (although the information obtained through the latter was rather limited); more reliable or representative data was not available.

For pragmatic reasons in this market analysis a broader definition of "functional food" had to be used because too narrow a definition would have resulted in a very restricted overview of the field. Therefore in this market analysis anything is considered to be functional food for which there is (only) a health claim or which was referred to as "functional food" in the primary literature sources (i.e. in most cases the market figures probably also include food products fortified with vitamins and minerals); market estimations only for products with scientifically well-demonstrated health effects do not exist. Given these varying definitions of functional food, market shares are not always comparable between studies from different sources, and neither are regional aggregates (especially market data on Eastern European countries are very scarce).

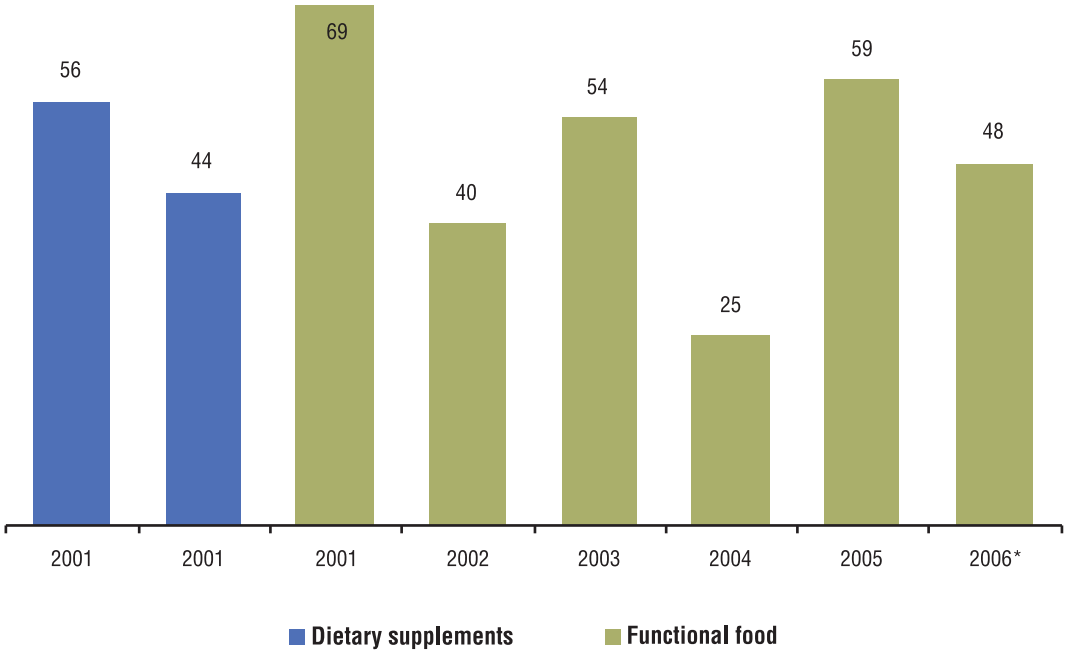
4.1 Current market size and outlook

Estimates for the global market for functional foods that were identified during the preparatory work for this report range from EUR 40 billion in 2002 to EUR 69 billion in 2001, depending on definitions. Other estimates indicate a total global market value of functional foods in the range of EUR 25 billion in 2004 to EUR 53 billion in 2003 (see Kotilainen *et al.* 2006), of EUR 59 billion in 2005 (Just-food 2007) or of EUR 48 billion in 2006 (for Europe, the USA and the Asia Pacific only, Starling 2008). As a comparison, the global market for food *supplements* in 2001 was estimated to range from EUR 44 billion to EUR 56 billion. According to estimates from the Nutrition Business Journal,[5] the largest market worldwide is Japan (EUR 21.8 billion in 2001), followed by the USA (EUR 20.7 billion) and Europe (EUR 20.1 billion), although more conservative estimates for the latter only amount to about EUR 11.2 billion in 2000/2001. A more recent report puts the figure for the functional food market value in Europe also lower – at only at EUR 6.4 billion, with the US market being valued at EUR 17 billion (Datamonitor 2007). The respective market shares of functional food in the total food market are estimated to fall into a range of 1-3 percent (see Kotilainen *et al.* 2006). Yet, even the lower estimates indicate that functional food represents a sizeable market: for instance, it can at least be compared to the EU market for health biotechnology applications of EUR 9 billion or to the combined economic contribution of the application of modern biotechnology in the primary production and agro-food sectors of EUR 3-6 billion – the significance of which has been highlighted in a recent JRC Reference Report (Zika et al 2007). In comparison, a recent figure

4 US Dollars were converted into Euros by applying average annual exchange rates (Fed 2007).

5 See http://www.nutritionbusiness.com/data.htm.

Figure 4-1: Estimates of the global market for functional food from different sources



*Note: Figures are billion Euros. *The figure for 2006 is for Europe, the USA and the Asia Pacific only.*

Source: Various, see text.

for China's "health food products" market is EUR 5.1 billion,[6] which is expected to double by 2010 (Sun 2006).

These different figures reported above underline the difficulties in finding consistent economic data on functional foods that were already described (see also Figure 4-1). Yet, all reports concur in that the functional food market is a growing, dynamic market worldwide – which is conservatively estimated to exceed that for organic foods (Williams *et al.* 2006).

The "functionality" of more and more new ingredients is continually proven and, therefore, functional food might find larger acceptance in the future, when, for instance, food may help control elevated blood pressure, reduce body fat, improve the glucose metabolism (Sloan 2004) – or may cater for a growing market of men's health (e.g. helping address benign prostate hyperplasia or erectile dysfunction) (Tallon 2004). The importance of addressing health issues that matter to consumers as key factors for market success were underlined in a survey among US producers of prepared foods (O'Donnell 2004).

According to this survey (O'Donnell 2004), US industry representatives consider food products that help maintain cardiovascular health to be very promising, given that such claims are supported by an FDA authorisation and that the production of such food is facilitated by the availability of a large array of suitable ingredients. Other opportunities were seen by industry representatives for products helping people loose weight, improve digestion, support women's health or enhance immunity. Among the most relevant ingredients survey respondents mentioned dietary fibres and antioxidants, while new market opportunities were also seen in turning less obvious products – like chocolate – into functional food. Other studies suggest, for instance, skin health is a growing market for functional foods, resulting from a general

6 Chinese Renminbi were converted into Euros by applying the daily exchange rate (OANDA 2008).

wish to look young and healthy (Roza 2004). Another driver for the growth of the functional food market could simply be convenience as busier lifestyles make it more difficult to cover one's nutritional needs with conventional food and drinks (Datamonitor 2007). On the other hand, according to interview partners, for some types of ingredients, like polyphenols, but also for products that were marketed under a general "wellness" claim, a reduction of market growth rates is expected under the new health claims regulation because of the costs that need to be incurred to substantiate health claims.

4.2 The functional food market by relevant product categories

Dairy products

According to a Frost & Sullivan report of 2003 (Frost & Sullivan 2003), the European market for probiotic dairy products was worth about EUR 3.5 billion in retail prices – with predicted annual growth rates in this sector of 20 to 26 percent. According to this source, more than two thirds of the total turnover is made with yoghurts and the rest with dairy drinks. Other estimates fall in a similar range: Patton (2004) reports for 2003 a value of EUR 1 billion for probiotic drinks alone, with projected annual growth rates of 30 to 40 percent. Because of their convenience for consumers, "daily dose" bottles helped make single-dose probiotic drinks the fastest growing segment of the functional foods market in Europe (Patton 2004). However, for 2002 other sources only reported a sales value of EUR 857 million for all products that were marketed for their gut health with corresponding projections for 2007 only reaching EUR 1.2 billion (Dairyreporter 2003). On a global level, in 2003 almost half the sale of all functional dairy products took place in the Asia-Pacific & Australasia region, more than one third in Europe and 10 percent in the Americas.

Beverages

Global sales of "functional" soft drinks are growing, albeit growth is slower in Western Europe than in the US or Japan. In 2002 the global functional drinks market grew by 11 percent, bringing the share of functional drinks in the international soft drinks market to 6 percent (Food & Drink 2003). During the preparatory work for this report, on a global level – and in difference to the sales figures for functional dairy products – in 2003 about 40 percent of all sales of functional beverages took place both in the Asia-Pacific & Australasia region and in the Americas, respectively, and only 20 percent in Europe. Altogether, for the global market for functional drinks in 2003 estimates fell into the range of EUR 16 billion to EUR 18 billion.

However, there is no clear borderline between energy drinks, sports drinks and functional drinks. One well-known energy drink, "Red Bull", for instance not only claims to increase performance, concentration & reaction speed or vigilance, it also claims to improve emotional status and to stimulate the metabolism.[7] Other drinks, all containing various mixtures of vitamins, minerals, fibres, isolated proteins like taurine, sugars, ginseng, and other active substances, with or without caffeine, are more targeted at helping athletes coping better with physical strains. Among this special group of soft drinks, sports drinks have a share of 39 percent of total sales value and even 69 percent of the overall sales volume, followed by energy drinks (about one third of total sales value). Other categories, consisting mainly of vitamin- and mineral-enriched juices and drinks,

7 Red Bull Energy Drink is a functional beverage... It has been specially developed for times of increased mental and physical exertion... increases performance, increases concentration and reaction speed, improves vigilance, improves the emotional status, stimulates metabolism. Red Bull's effects are appreciated throughout the world by top athletes, busy professionals, active students and drivers on long journeys (http://www.redbull.com/#page=ProductPage.Benefits).

near-water drinks and herbal drinks, make up the remaining share.

Oils and fats

Polyunsaturated fatty acids (PUFAs) as such are an important ingredient for functional foods, but also for food supplements. In 2004, the Omega-3 PUFA market in the EU-15 plus Switzerland and Norway was estimated to be worth EUR 172 million, i.e. 28 percent of the global market volume. By far the greatest market share (about two thirds) was accounted for by fish oils, followed by algae oils and flax oils. While PUFAs are rather ingredients than real food products, more direct functional food products are fat spreads – like those enriched with plant sterols. Raisio of Finland was the first company to develop a margarine including plant sterol esters. While the company is still supplying the Scandinavian market, by now the ingredient is added to a range of different foods and sold by a number of companies. Raisio itself has a market volume of EUR 418 million, but other companies like Unilever Bestfoods have become strong competitors.

Snack food and bakery goods

In the bakery and snack sector functional food products still only occupy a niche market. According to Euromonitor, in 2003 functional bread accounted for just six percent of sales in this market, while biscuits, cakes and pastries made up another seven percent. Snack bars accounted for 15 percent of sales (mainly energy or sports nutrient bars and not conventional snack bars) and almost three quarter of the market were taken by confectionary (mostly functional gum). But even if functional bread had only a low share of the total segment, it is nevertheless a product that has shown a dynamic volume growth over the last years. Besides fibres, functional bread that is on the market now contains soy isoflavones, omega-3 and omega-6 fatty acids, as well as prebiotics like inulin or L-carnitine (Food & Drink 2004).

4.3 The functional food market by ingredients

Probiotics

The potential health benefits of ingesting probiotic bacteria were recognised as long ago as 1910. By now it is accepted that probiotics may decrease constipation and both bacterial and viral diarrhoea, with other reported effects being the stimulation of lactose decomposition, an improved defence against pathogen bacteria in the gut, effects against colon cancer, a reduction of overgrowth in the small intestine, a modulation of the immune response, a decrease of allergic reactions, a decrease of blood pressure and a decrease of infection with Helicobacter pylori (Snel 2001). Nevertheless, the probiotics market within Europe is still relatively little developed. In 2003 the Western European market for probiotic bacteria cultures across the four main application areas – dairy products, animal feed, supplements and infant nutrition – was valued at EUR 30-36 million, and the US market was worth EUR 127 million. During the preparatory work for this report market forecasts for the Western European probiotic ingredients market projected a value of about EUR 100 million for 2010. First and most well know examples of probiotics foods are yoghurts (e.g. Danone Activia) and fermented milk drinks (e.g. Yakult or Nestlé LC-1). This market is becoming more competitive, with other food companies also investing in probiotics (e.g. Sweden's Skåne mejerier or Spain's Leche Pascual.)

One problem for manufacturers of probiotic-based functional food is the inherent instability of the – living – bacteria (Lactobacillus and Bifidobacterium). Hence one of the biggest challenges for food manufacturers is to maintain vitality of the bacteria until they have reached the intestines, otherwise they will die either during manufacturing, shelf life or in the acid stomach. Apart from selecting stable strains, also the medium and medium conditions matter. In this

context dairy products are especially suitable as they are usually stored at low temperatures and have a favourable pH and composition. For other products freeze dried probiotic powder or micro-encapsulated bacteria may be used in future to, for instance, produce probiotic sausages or cheeses. Currently, however, surveys and product tests still indicate that many probiotic products fail to deliver sufficient doses of the bacteria to deliver a beneficial health effect.

Prebiotics and dietary fibres

Similarly to probiotics, prebiotics –oligosaccharides in general and fructooligosaccharides in particular– have a positive impact on the composition of bacteria in the digestive tract. However, "prebiotics are nondigestible food ingredients that beneficially affect the host by selectively stimulating the growth and/or activity of one or a limited number of bacterial species *already resident* in the colon, and thus attempt to improve host health" (Gibson and Roberfroid 1995: 1401, own emphasis). Consequently, the limited stability of probiotics may offer the more stable prebiotics a larger market potential: nearly all carbohydrate-based food product, such as bread and cereals, but also margarines, fruit juices and dairy drinks, can be enriched with prebiotics.

Although the European market has been growing over the last years, it is still little developed; with an estimated size of about EUR 80 million in 2003, the fructan market (which includes inulin and fructooligosaccharide) is the biggest segment. However, the fructan market is predicted to grow to EUR 180 million by 2010, attracting several new market participants (Nutra 2004b).

In general, the consumption of dietary fibres is said to be rising as they are added to a range of products, bread in particular. Fibres are also increasingly used to replace fat in food products and, thus to reduce their nutritional value. Yet, a mere reduction of a food's calorie content does not fall within the definition of functional foods. (Nevertheless, by 2008 the market for fat replacement ingredients is estimated to reach EUR 9 billion (Nutra 2003).)

Peptides

Proteins and peptides are a group of functional ingredients that is of growing interest for several reasons: they are not only frequently used in sports drinks, it is also claimed that they have the ability to lower cholesterol and blood pressure, they are attributed relaxing properties and they are used to replace carbohydrates within the Atkins diet.

Terpenes

In the context of functional food, the terpenes sub-category of carotenoids is relevant. This family includes beta-carotene, lycopene, astaxanthin and lutein – which are also widely used for animal feed, as food colouring, in cosmetics, in pharmaceuticals and in dietary supplements. During the preparatory work for this report the Western European carotenoids market was worth EUR 308 million; with beta-carotene having the largest share. While the figure comprises more than just the components that enter functional food, as stated before, there is no more disaggregated figure available.

The beta-carotene on the market is usually synthetic and its production is concentrated at Roche (now part of DSM) and BASF, which have a combined share of over 80 percent. However, the use of naturally-derived carotenoid is increasing, particularly in functional food and health food applications.

Phenols

Polyphenols, being traditional food colorants, are increasingly marketed as antioxidants in functional food. Research findings suggest that

polyphenols can protect against cancer and cardiovascular diseases, as well as increase anti-inflammatory activity and immune function. The market for polyphenols in Western Europe has grown to an estimated EUR 78 million in 2003, but analysts question its further growth once food manufacturers have to validate the health claims they make (as this may involve costly clinical trials and regulatory burdens (Nutra 2004c).

Plant extracts

Plant extracts (which include herbal extracts, oleoresins, essential oils and fruit and vegetable extracts) had a market value of over EUR 1 billion in Western Europe in 2002. The market share for herbal extracts (e.g. Ginkgo Biloba, Ginseng, Green Tea or St. Johns Wort) was about EUR 340 million and the corresponding US market share was worth EUR 315 million. The market share for fruit and vegetable extracts and powders was about EUR €410 million and the corresponding US market amounted to about EUR 600 million. However, these ingredients are not only used because of their potential health benefits but also as colorants and flavours. As ingredients for functional foods and food supplements, during the preparatory work for this report the market revenue of fruit and vegetable extracts and powders was only EUR 169 million for Western Europe and EUR 286 million for the USA.

Miscellaneous

Other ingredients for functional food as well as food supplements include antioxidants (like hindered phenols, gallates, vitamin E, ascorbates and erythorbates) and key ingredients of "sports nutritionals" (like whey protein, casein and caseinates, soy protein, L-carnitine and creatine). During the preparatory work for this report the Western European market for the former was worth EUR 58 million and the US market was EUR 143 million, while the alone the Western European market value of the latter amounted to EUR 529 – with nearly one half of the market share being accounted for by carnitine and one third by whey protein.

4.4 The functional food market by countries

In the preparatory work for this report selected Member States from various regions within the EU as well as the EU's main economic competitors were used as case studies for analyses of their respective functional food markets. Although little comprehensive and country-specific information was available, it seems as if there is considerable heterogeneity across Member States. For instance, while functional foods in Spain seem to be more readily accepted, consumers in neighbouring France put more emphasis on pleasure than health when eating. And while functional foods constitute a market of considerable size in Germany, awareness of functional foods in neighbouring Poland is only growing more recently. Attitudes towards functional foods can also be influenced by country-specific health or dietary patterns: Finland has one of the most diverse range of cholesterol-lowering products, which can be explained by the relatively high prevalence of coronary heart disease in this country, while Denmark has banned certain fortified cereal products in 2004 because Danish consumers, who also take many dietary supplements, may otherwise exceed safe levels of the nutrients in their overall diet. In most countries fortified food products (e.g. breakfast cereals), functional dairy products and beverages or functional fats and oils (e.g. cholesterol-lowering margarine) are available and consumed, though. But only in countries where these products are already more deeply entrenched, like in the UK, new markets are opening up (for instance anti-ageing food or products directed at children or the elderly).

Among the EU's main economic competitors functional foods and beverages play the biggest role in Japan, where the first functional food

were produced 70 years ago and where related health claims are already regulated since over 15 years. In Japan, where functional foods are preferred over food supplements, the per-capita expenditure on functional foods and beverages is twice as high as in the USA, and the Japanese spend even four times more money on these products than Europeans – but also in the USA as many as 60 percent of the population regularly purchase fortified and functional food products.

4.5 Conditions for the development and marketing of functional food

Interview partners that were questions during preparatory work of this report also commented on the framework conditions for the development and marketing of functional food in the EU compared to those in the USA and Japan. These comments are summed up and structured in the following; in as far as they related to R&D conditions they are discussed in chapter 8 (although the situation in the USA and, to a lesser extent in the Netherlands, was seen more favourably).

Market characteristics

Although the range of functional food products in the three markets was considered to be similar, the consumption of functional foods in Japan and the EU was considered to be more sustainable because of a genuine consumer interest in these products; the perception was that in the USA demand was more driven by companies marketing activities, which in turn was seen to be influenced by companies need to demonstrate their uniqueness by bringing new products to the market.

Regulation

Views on differences between the regulatory frameworks differed between interview partners. While at that time the situation in the EU was not fully clear yet, the Japanese regulatory system was considered to be quite industry-friendly because approval of health claims would be possible with relatively low efforts. On the other hand, the advantage of the US system was seen in the possibility of using generic claims for a large number of products. However, too much international harmonisation was estimated to be negative (by a smaller company) because a certain degree of national individuality could stimulate the market. Within the EU the new common regulation may help to liberalise the market for functional foods in some new Member States, while it may reduce the freedom for manufacturers in markets where there were more liberal rules in place already.

Market failure

About 75 percent of newly launched food products are withdrawn from the food market within the first two years, a figure which is assumed to be higher for functional food products due to the specific challenges in their development and marketing. In general price and lack of consumer interest are the main reasons for the market failure of products; this is also true for functional food, but there consumer awareness of the benefits of the functional ingredients is paramount to create and sustain consumer interest. Yet, while some advertisement may therefore be necessary, misleading advertisement can also result in a consumer backlash, thus also leading to market failure. Another threat to the successful marketing of functional foods can also arise if consumers perceive the product as "pharmaceutical" food rather than a substitute for normal food that can be joyful to eat and easy to integrate into their normal diets.

Distribution channels

There was not much information available on distribution channels for functional foods in the different countries. In both the USA and the bigger markets in the EU, the biggest outlet for functional

food seem to be supermarkets. And while in some countries functional food seems to be sold also in special health food stores or pharmacies, for instance for the German dairy market some data indicates that functional products are increasingly sold by discount retailers.

4.6 Market-entry strategies of food and pharmaceutical companies

Given that functional foods carry a health claim, these products fall in a grey zone between food and pharmaceutical products (e.g. dietary supplements), and both food companies and pharmaceutical companies have entered the market for functional foods, for which there are various examples. According to Heasman and Mellentin (2001), they follow seven main marketing strategies:

- using existing brands to add functional ingredients,
- using "functionality" as a source of competitive advantage in a segment of the own market where there are no functional foods of major brands yet,
- entering new markets (e.g. a pharmaceutical company entering the food sector) with new products to challenge existing brands,
- creating a new product category based on an innovative product (e.g. as Yakult did for probiotic yogurt drinks),
- increasing incremental sales in existing markets (e.g. by getting consumers to buy higher-value products, drawing more consumers to the product category, or getting existing consumers to consume more,
- using the health claim to attract more users to the own category at the expense of another category (e.g. calcium-fortified juices instead of milk), or
- leveraging hidden nutritional assets (e.g. using generic health claims for the company's products).

For strategic reasons companies may also collaborate to combine research competences or market know-how, to share distribution channels or to protect (mutual) supply agreements. These collaborations can take various forms, ranging from contracts over licensing to joint-ventures.

5 Consumer awareness, attitudes and willingness to pay

5.1 Background of the consumer survey in selected Member States

Food choice behaviour is driven by the optimisation of both nutrition and enjoyment derived from food. However, food choice is not just one-dimensional, but a complex human behaviour influenced by many interrelating factors. Usually several dimensions influence the consumers' food choice decision-making process. One relates to the properties of the food, one comprises the person-specific factors another one covers the environmental factors at the time of purchasing and a last one integrates the role of communication, which is related with the three other dimensions.

For this chapter, which focuses on the demand side of the market for functional food, the person-specific factors are of importance. They include the sensory attributes of food (e.g. aroma or texture) and physiological (e.g. hunger or appetite) and psychological factors (e.g. mood, beliefs or attitudes), as well as routine and habits, for the present analysis of functional food, the physiological factors are regarded as being less relevant. A typical buying process leads the consumer through five stages: problem recognition, information search, evaluation of alternatives, purchasing decision and post purchase behaviour. During the evaluation of alternative food products, selection is not only based on the sensory properties of the food but also on verbal information about the product, such as advertisement in the media, recommendations or the description on the packaging. Finally it is assumed that by buying a particular food product consumers maximise their utility given their limited budgets. The following analysis of consumers' attitudes regarding functional food and their willingness to pay price premiums for such products was based on this theoretical background.

Consumer attitudes were explored based on surveys (n=626) carried out in Germany (n=116), Poland (n=110), Spain (n=279) and the United Kingdom (n=121). Germany was chosen as a continental European country and due to the overall size and the rather competitive character of its food market and because of specific features like the high consumption of functional beverages in Germany and its otherwise more sceptical consumers. Poland was chosen as Eastern European country and to reflect the development of the functional food market in a new Member State. Spain was selected as a Mediterranean country and because of its high-volume food market and the interest of its consumers in new products, as well as the profile of its food industry. Finally, the United Kingdom was chosen as a Western European country and because of its high-value food market and the profile of its food industry and food retailing.

While the preparatory work of this report was more detailed, more generally the following aspects were explored:

- the profile of grocery shoppers by age, gender, social categories and education,
- their general understanding of food components and the link between food intakes, nutrition and health,
- their awareness, attitudes and perception of functional food,
- the reasons for them (not) buying functional food products,
- their willingness to pay price premiums for functional food products,
- their (mis-)trust in the food-related information received from various stakeholders,

- the reasons for their view of the (lack of) reliability of the stakeholders' information, and
- the suitability of different communication channels to inform about functional food.

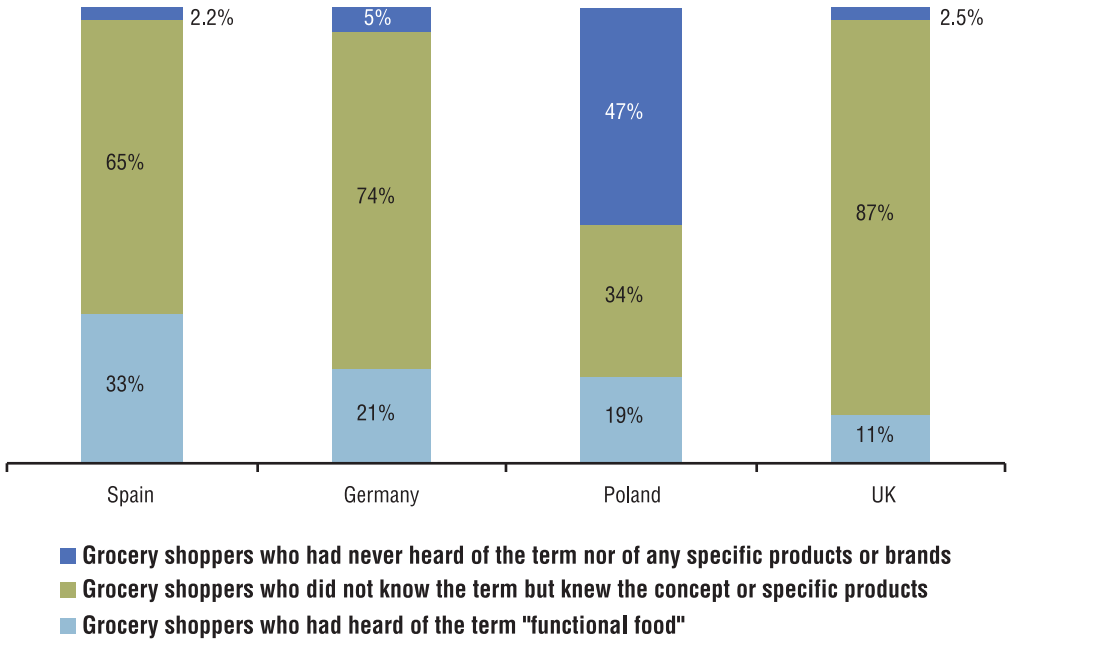
5.2 Consumer awareness of the term "functional food"

An important prerequisite for consumers' interest in a specific group of foods is the identification of this food group. In this sense it is important to know whether consumers are aware of the concept of functional food and what they associate with it.

In the surveys carried out for this study, awareness of the interviewed grocery shoppers differed across the four case studies. In Spain one third of the interviewees knew the term "functional food", in Germany and in Poland it was about one fifth of the interviewees and in the United Kingdom only one out of ten respondents knew the term "functional food". Of those claiming to know functional food, in Spain about 30 percent could name a concrete example or a known brand, in Poland it was about 15 percent, in Germany 10 percent and in the United Kingdom less than 2 percent. Yet, after explaining the concept of functional foods and after naming some products and brands, in all countries but Poland most interviewees stated they would know this type of food: In Spain, the United Kingdom and Germany only 2-5 percent of respondents claimed never to have heard of the described foods or brands; in Poland about half the respondents said they would be unaware of functional foods, though (Figure 5-1). The overall tendency, which is also reflected in the literature, seems to be that the term "functional food" as such is not widely known in most Member States, whereas the underlying concept and specific products or brands are known to a greater extent.

In line with earlier studies, of those respondents who had heard about functional food products most had learnt about them through

Figure 5-1: Awareness of "functional food" among survey respondents in four Member States

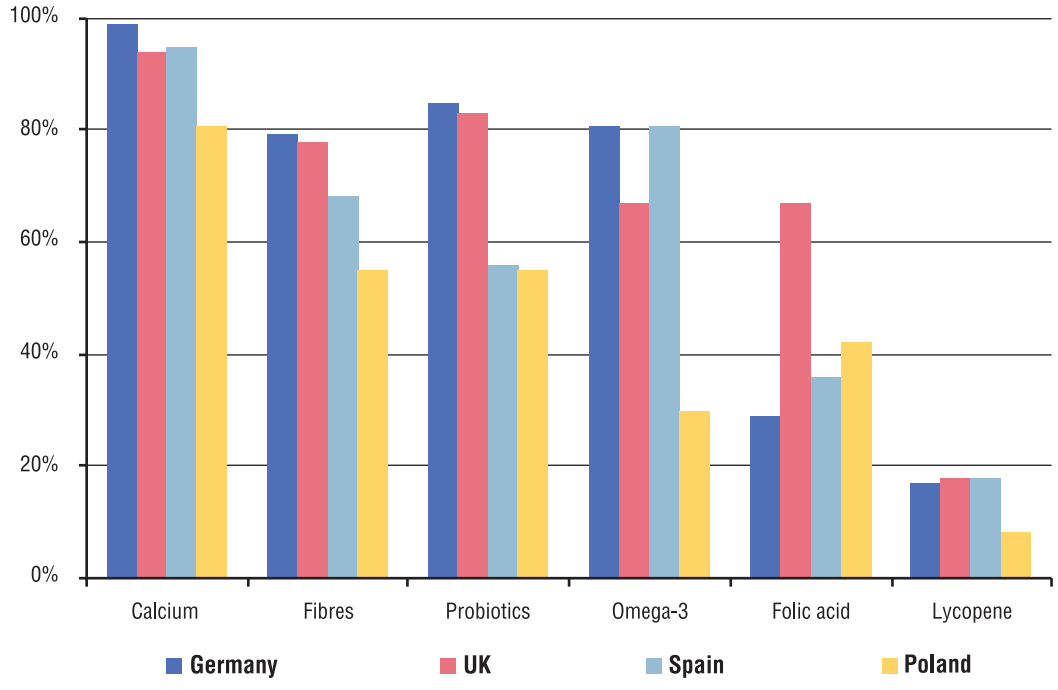


product advertisements (e.g. in newspapers, on TV or on the internet): in Spain 83 percent of interviewees had heard of functional food products through product advertisements, 77 percent in the United Kingdom, 75 percent in Germany and 42 percent in Poland (where this was still the most important source of information). Product advertisements were then followed by reports in the media and the product description on the packaging as next important sources of information about functional food.

5.3 Understanding of the role of functional ingredients in nutrition and health

Functional food products are intended to influence the health and well-being of consumers through specific ingredients that are added or concentrated in the respective products. Therefore it is important for consumers to understand the basic relationship between specific functional ingredients and their potential impact on their own health status. However, previous research indicates that European consumers only have limited knowledge about the interaction of specific food components, nutrition and health. Yet, it is of interest for both public authorities (to independently inform consumers about the health effects of functional food) and private companies (to market the specific health properties of their products to consumers) to know more about consumer understanding of specific functional ingredients. Therefore the consumer survey also contained multiple-choice questions regarding specific functional ingredients (offering one correct answer, two wrong answers and the option "I do not know"). The results show some inter-country variation, but most respondents are best informed about the functional properties of calcium, followed by dietary fibres, probiotic cultures, omega-3 fatty acids, folic acid and lycopene (Figure 5-2).

Figure 5-2: Relevant nutrition knowledge of grocery shoppers



Note: Correct answers of grocery shoppers to multiple-choice questions about the health effects of functional ingredients. The relatively good knowledge in the UK about the health effects of folic acid may be due to previous information and communication campaigns of public institutions to inform the public about these health effects and to recommend folic acid to women during pregnancy.

The results of the consumer survey show that in all countries consumer knowledge about the health effects of functional ingredients that are established in the market since a long time (like calcium) is high and by far outmatches the knowledge of health effects of more recently introduced functional ingredients (like lycopene). However, the examples of probiotic cultures, omega-3 fatty acids or dietary fibres, which are also relatively new ingredients, show that a relatively high level of consumer knowledge can be achieved within a shorter period of time when ingredients are strongly advertised. (In the case of probiotic cultures this was done by private food manufacturers, while dietary fibres were promoted in public health campaigns over the recent years.)

These findings of the survey correspond to results of previous research. For instance, the high consumer acceptance of calcium and probiotic cultures was also found in a representative population survey of a German market research institute (GfK Market Research 1998), where "new" groups of functional ingredients (like carotenoids or flavonoids) were regarded more critically by German consumers – probably mainly due to lack of knowledge of the health effects and efficacy of these ingredients. Similarly, a study in Denmark showed that 88 percent of Danish consumers were aware of the health effects of calcium and 71 percent were aware of those of fibres, while only 48 percent of the Danes knew about the health impacts of probiotic cultures and 43 percent about those of omega-3 fatty acids (Bech-Larsen *et al.* 2001).

In the analysis also the influence of the respondents' socio-demographic background on their knowledge about functional food was tested (also see section 5.4). For Poland and Spain a tendency could be observed that grocery shoppers with a higher education were also better informed about the health effects of functional ingredients; for Germany and the United Kingdom no such correlation could be discerned. Regarding a correlation between the age of the respondents and their knowledge about functional ingredients, in Poland and also in Germany there was a tendency for younger respondents to be better informed, in the United Kingdom age had no impact and in the Spain the older grocery shoppers were somewhat better informed. The other socio-demographic parameters (income, family size and gender) did not show any clear correlations with consumer knowledge of functional food. Overall it seems other factors influence knowledge of functional food to greater extent than these factors.

Drawing some tentative conclusions based on the results of this survey and on the literature, it could be concluded that the influence of socio-demographic parameters on consumer knowledge in this field is more limited. However, there seems to be a national influence on the perception of what constitutes "healthy eating". And the survey results indicate that consumers can be sensitized to new functional ingredients if more comprehensive information and communication activities are carried out over several years, whether by private or public entities.

5.4 Socio-demographic background of respondents

Given that there was only limited previous knowledge available about the basic population of buyers and non-buyers of functional food in the survey countries, the data obtained through the survey can be taken as a starting point to tentatively describe the socio-demographic background of the two groups of respondents, buyers and non-buyers of functional food – even if a relatively small sample of grocery shoppers that is obtained at a limited number of supermarkets only cannot be considered representative. In Table 5-1 the most relevant socio-demographic characteristics of the respondents are reported by buyer group (buyers or non-buyers of functional food); characteristics that did not seem to influence the respondents' group affiliation, like the number of persons in the household or the number of children, were not included.

Table 5-1: Socio-demographic characteristics of buyers and non-buyers of functional food

	Germany			United Kingdom			Spain			Poland		
	Total	Buyers	Non-buyers	Total	Buyers	Non-buyers	Total	Buyers	Non-buyers	Total	Buyers	Non-buyers
Buyer group (percent)	100	73	27	100	66	34	100	77	23	100	71	29
Gender (percent)												
Male	36	32	48	36	34	42	52	48	66	45	41	53
Female	64	68	52	64	66	59	48	52	34	56	59	47
Education (percent)												
No school leaving certificate	0	0	0	2	1	2	8	5	19	1	0	0
Secondary school	10	8	16	13	13	15	27	31	14	6	1	19
Univ. entrance qualification	8	7	10	9	11	5	7	7	9	42	49	25
Profession. training certificate	67	71	58	34	30	42	20	19	22	27	21	44
College or university degree	14	13	16	42	45	37	33	33	31	24	30	9
Other	1	1	0	0	0	0	5	5	5	0	0	0
Average age (years)	47	45	51	48	49	47	41	40	43	42	37	53
Average net income (EUR/month)	2,490	2,560	2,240	3,060	3,170	2,870	1,690	1,760	1,410	390	380	400

Note: Values may not add up because of rounding.

Across the whole survey between two thirds and three quarters of all interviewees answered the question "Have you already bought functional food products?" in the affirmative. This range is in accordance with other results reported in the literature (ESTP 2005).

Apart from the finding that most respondents had already bought functional food products at least once in their life, the only other constant finding across all countries is that women seem to be more likely to buy functional food than men (also see Arnoult *et al.* 2007). Except for respondents in Poland a higher income seems also be positively correlated with the likelihood to buy functional food; in Poland the considerably younger average age of the buyers of functional foods could perhaps explain the different finding for the role of income this country. In the other countries buyers of functional food tend also to be younger, but there this difference is much less pronounced. Only in the United Kingdom the respondents who already bought functional food were slightly older – perhaps because of the particular attraction of functional food products like cholesterol lowering spread in this country. Finally, the influence of education seems to be mixed, which may be due to the difficulties in comparing schooling achievements and certificates across different countries.

5.5 Grocery shoppers motives of buying functional food

Purchasing behaviour of buyers of functional food

In the consumer survey already described above those consumers who declared to buy functional food where asked how often they buy products from the major functional food product categories (milk and dairy products, bakery products, cereals, confectionery, beverages and other functional food – according to previous studies of functional food these are the most important categories). The given answers were "every week or more often", "every two weeks", "once a month", "less than once a month" and "never". The most frequently bought functional food products by the interviewees

were in all countries functional milk and dairy products, followed by functional beverages, functional bakery products, other functional food and functional confectionery. There are some variations between countries, though. For instance, in Germany relatively few functional bakery products are bought, whereas in Poland a relatively high share of functional beverages is bought and in the United Kingdom functional cereals and other functional food products (mainly cholesterol-lowering spread) are bought relatively often. Such differences may in part be explained by national dietary patterns, e.g. with cereals playing a more important role in English breakfasts than elsewhere.

The observed purchasing frequencies of products from the different functional food groups are in line with the market structure of functional food products in Europe (see chapter 3). Apart from this general market structure, a further reason for the observed purchasing frequencies may be the different relevance of the various food products in consumers' diets where milk, yoghurt and bread have a bigger importance than cereals or confectionery. Moreover, milk, yoghurt and bread are fresh products that have a limited shelf life and need to be bought more often.

Reasons for buying functional food

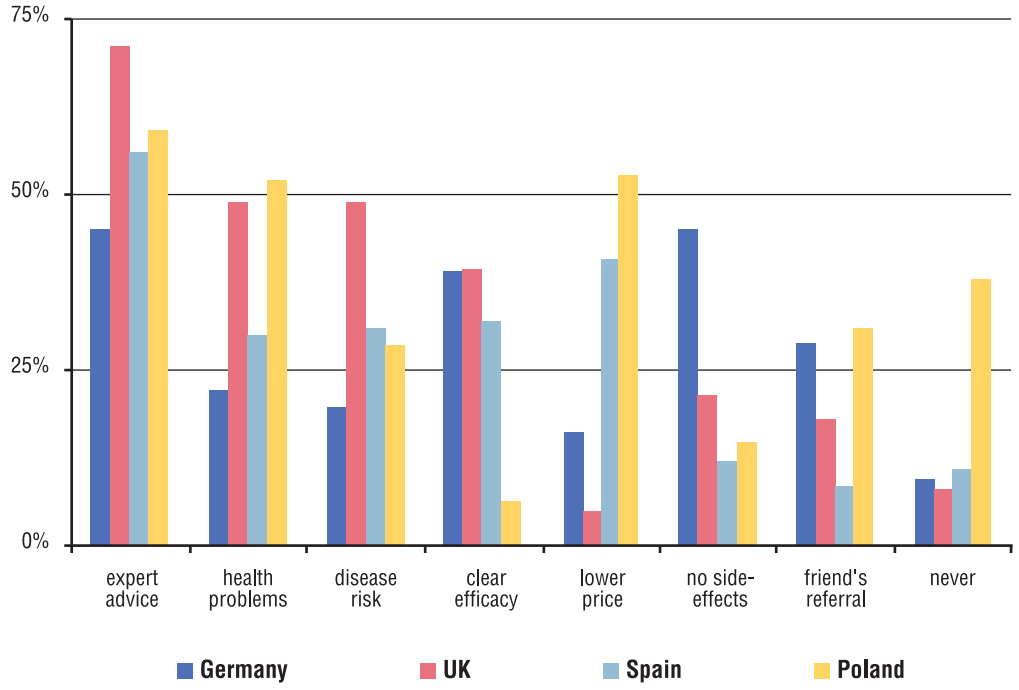
To obtain information about what induces consumers to buy functional food, the respondents who declared to be buyers of functional food products were asked for their reasons for purchasing this type of food (by means of a list of ten common reasons that had to be rated on a scale from 1 to 5 for being not important to being very important). Consistent across the four countries, the most important reason for buying functional food was "to stay healthy", followed by "to do myself good" and then because of "good taste" and "to avoid medical treatment"; "for my child or my children" was also generally considered to be of some importance for the purchasing decision. Less important as reasons to buy functional food was "to stay attractive" and even less so "to salve my conscience". The options "recommended by medical doctor or nutritionist", "interest or curiosity" and "to retard aging" generally had less impact on the purchasing decision.

Taken together, it can be concluded that there is not just one single motive that induces consumers to buy functional food. However, what these survey results indicate is that functional food not only has to be "functional", i.e. is has to have a proven efficacy and a clear effect on the health and well-being of consumers, consumers also expect it to be "food" in that it has to taste good. While these options were not given, this latter point also indicates that functional food has to fulfil the general expectations of consumers regarding (innovative) food products, more particularly, that it not only has to taste good and work, but also to be convenient, to show a reasonable price-benefit ratio, to have an attractive design and a practical packaging.

Reasons for not buying functional food

Those respondents who declared that they would not buy functional food were asked about their motives for not doing so. In analogy to the procedure for the reasons to buy functional food, the interviewees were asked to rate nine given reasons for not buying functional food, as described above. On average there were no clearly predominant reasons for not buying functional food, i.e. the reasons – general concerns about novel food, bad taste, preference for organic food, focus on the present rather than on the future, absence of illness, fear of side-effects, aversion towards artificial additives, distrust of effectiveness, price – were weighted differently in the four countries. For instance in Poland and in Spain the price of functional food products is a much more important deterrent for purchasing them then it is in the United Kingdom or in Germany. And the fear of side-effects is a more important reason among Polish respondents to reject functional food than it is among British interviewees. The latter tend to prefer organic food, though, whereas this option is of less

Figure 5-3: Reasons for non-buyers of functional food to reconsider their purchasing decision



importance for respondents in Spain. In turn, there the issue of taste is much more important than in Germany.

Hence, as with the motives for buying functional food there are many reasons why people prefer not to buy such products. In the literature many of these reasons are confirmed for various countries; other reasons for not buying functional food are reported to be that a majority of consumers in Western Europe believe they eat a healthy diet already, or that people are subjected to an "optimistic bias" by assuming that they are less at risk than other people from the particular hazards functional foods are expected to address (e.g. Frewer *et al.* 2003).

Reasons for non-buyers of functional food to reconsider and buy functional food

Following up on the non-buyers of functional food, the next step was to investigate under which conditions these respondents were willing to change their behaviour. For this, the non-buyers were again given a list with reasons that would need to be fulfilled for them to consider buying functional food. Of these given reasons the interviewees could choose as many as applied to them. Generally and consistently across all four countries many respondents who so far did not buy functional food would consider buying it if it was recommended to them by a medical doctor or nutritionist; only in Germany this figure was below 50 percent, but there non-buyers were in general less likely to change their mind and, in particular, many German interviewees were suspicious of side-effects. Other reasons that could entice non-buyers to buy functional food are own health problems that could thus be addressed, or if they had a disposition to a specific disease. Also clearer proof of the efficacy of functional food products could convince many non-buyers to buy functional food. In Poland and Spain also a lower price of functional food products could be a decisive factor. However, about ten percent of non-buyers among the respondents would never consider buying functional food; in Poland it is even over one third (Figure 5-3).

Summarising these results, there are three main motives that could persuade current non-buyers of functional food among the

interviewees to purchase this type of food in future. The first factor relates to the own health of the consumers ("if recommended by medical doctor or nutritionist", "occurrence of health problems" and "disposition of specific diseases"), which means that these consumers potentially would buy functional food if there is a personal and health-related need. The second factor is product-related and affects specific characteristics of functional food products ("evidence of efficacy of functional food" and "certainty of no side effects"). The third factor is simply the cost of functional food products. These factors are in line with findings in the literature concerning the purchasing decisions of consumers related to functional food, and underline the high consumer expectations that have to be fulfilled by companies that intend to develop and launch functional food products.

5.6 Consumer trust in stakeholders in the field of functional food

Generally, consumers cannot themselves verify health-related claims related to food. As shown for the consumer survey (section 5.2), most respondents receive information about functional food through product advertisements or, to a smaller extent, reports in different media (also see section 5.7). Hence, consumer understanding of functional food depends on "second hand" or mediated information – which opens the question of the credibility that consumers attach to this information. In part this depends on the perceived competence of the institutions involved as well as on their suspected motivation (e.g. are the actors motivated by self-interest or do they have a more neutral, public interest in mind (Barber 1983). Such questions related to the trust and confidence in institutions that are involved in the development of science and technology.

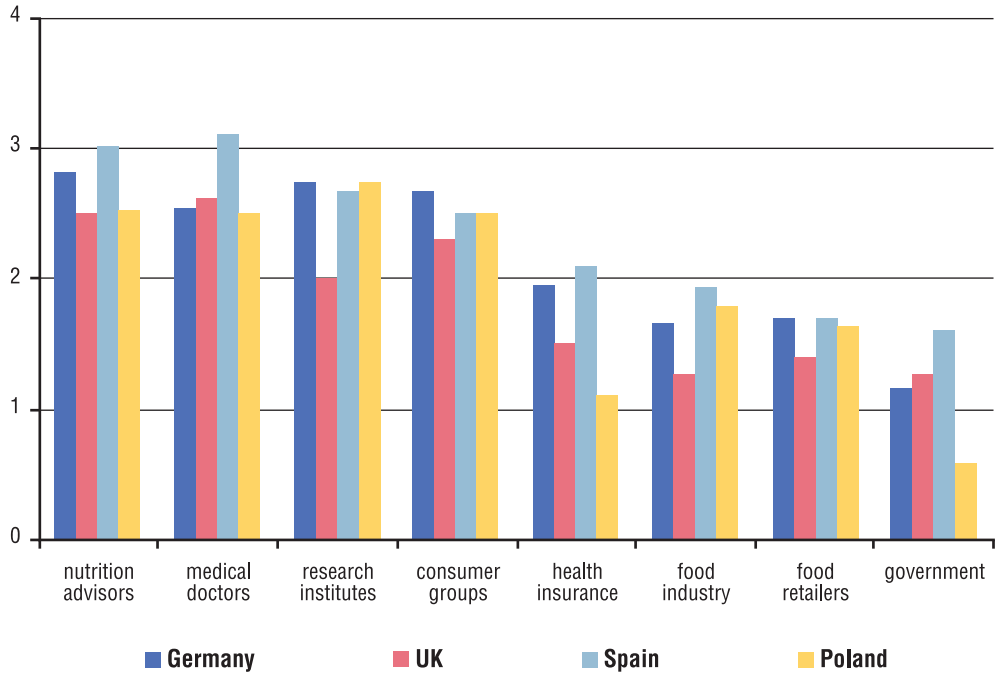
Survey results on consumer trust in stakeholders

Since functional food represents a novelty for European consumers, in the survey respondents were asked to rate the trustworthiness of seven stakeholders involved in the development, marketing, control or use of functional food. Each of the given stakeholders could be classified as being "not at all trustworthy", "little trustworthy", "trustworthy", "very trustworthy" and "totally trustworthy". On average – and consistently across the four countries – nutritionists, medical doctors, consumer associations and research institutes or universities were considered to be trustworthy. In Spain and Germany also the health insurances were deemed to be rather trustworthy, whereas the food industry as well as food retailers were generally considered to be less trustworthy. Yet, in all four countries respondents rated the government to be least trustworthy. Across the four countries, the interviewees in the UK and Poland were most critical of the trustworthiness of any of the stakeholders, whereas respondents in Spain were most trusting (Figure 5-4). These findings are in line with the literature, where health professionals and doctors, as well as university scientists and consumer and patient organisations tend to be rated "credible", whereas industry scientists, the media, environmental groups and the European Commission are rated less favourably.

Reasons for consumer mistrust in stakeholders

In the consumer survey, following up on the rating of the trustworthiness of the various stakeholders in the field of functional food, if they had rated a stakeholder little or not trustworthy at all, the interviewees were asked to give reasons for their assessment. As this part of the survey was covered by an open question, in the following the answers are analysed qualitatively. There is a wider and more consistent basis of reasons given by the respondents why they do not trust the government, the food industry, food retailers or health insurers. In contrast, the reasons for

Figure 5-4: Trust in stakeholders in the field of functional food



Note: 0 = not trustworthy at all, 1 = little trustworthy, 2 = trustworthy, 3 = very trustworthy, 4 = totally trustworthy.

distrust related to the other stakeholders is more vague.

In Germany the government is blamed to be inactive: respondents state that the government does not protect consumers from food-based risks, reacts too late when food scandals materialise and does not control the food production and processing chain strictly enough. Further reasons given are missing competence, dishonesty and unreliability of the government, as well as a general mistrust in politics and the institutions involved. German respondents do not trust the food manufacturers and the food retailers because of their commercial self-interest, but also because of dishonest communication. In the case of food retailers some interviewees also noted that their personnel is not able to give advice on functional food products. Regarding medical doctors, mistrust results from the suspicion that they are also influenced by financial considerations and because of a perceived diversity of opinion among them. Germans blame the health insurance companies to have a commercial self-interest and to show generally a bad performance. In contrast, German respondents gave hardly any reasons to mistrust consumer organisations, nutrition advisors and universities.

In the United Kingdom a "general mistrust" is the reason most stated for mistrust in the government (also see Chambers *et al.* 2006). Further allegations are, the government does not care about the people, that it lacks incompetence and that its communication is not honest. Respondents also viewed the government to be under the influence lobbies and to follow an erratic policy. (In this British consumers may still remember the BSE crisis and the governments' shortcomings in managing it.) Also in the United Kingdom food manufacturers and food retailers are generally mistrusted by respondents because of commercial self-interest. The respondents also stated that the food industry's communication policy is weak and that food retailers have no knowledge about the functional food products they sell. British interviewees mistrust the "health insurance" because of commercial self-interest

and because food security would not be their field of activity. With regard to research institutes and universities mistrust is mainly based on the influence of third party funders and financial self-interest; some institutes are also regarded to be less reputable. A further comment was that the diversity of opinions between researchers does not generate much trustworthiness. Medical doctors, consumer organisations and nutrition advisors are also suspected to follow financial considerations.

Spanish respondents distrust their government because of disappointments in other political areas and because of recent food scandals. The government is blamed to be uninformed and incompetent and it is perceived not to care about food-related issues and not to exercise resolute and effective control in this area. In addition, respondents accuse the Spanish government of dishonesty and self-interest. Also in Spain, interviewees see the industry to have a strong commercial interest. Furthermore, respondents found general fault with bad products, too many artificial ingredients and insufficient product development, efficacy and quality. Also the retailers are accused of strong financial self-interest and respondents also blamed the health insurers to be only profit-oriented. Unclear funding of experts like researchers, doctors or nutrition advisors lead to scepticism of their trustworthiness; respondents did not want these stakeholders to be dependent on the government.

In Poland respondents mentioned the highest number of reasons to mistrust the government, which is in line with its bad rating. The most stated reason is "general mistrust". Furthermore, Polish respondents stated that the Government does not adopt a clear position and has no expert knowledge and no competence in the field of functional food. Food retailers and the food industry are blamed to be motivated by commercial self-interest and to be dishonest in their communications. An additional suspicion relating to the manufacturers is that the quality control of their products is insufficient. Regarding the health insurance, Polish interviewees stated that it has no competence and does not adopt a position. Those respondents who assessed consumer organisations negatively did so because of their low profile. For the other stakeholders the interviewees did not specify the reasons of their mistrust.

Apart from "general mistrust", summarising the reasons for mistrust in the stakeholders in the four countries, it seems that national governments are not perceived to have the technical expertise but to be a political institution. Food manufacturers and food retailers are distrusted because they are suspected to have commercial self-interests. This is also true to some extent for experts like nutrition advisors or medical doctors; in this context respondents often drew a comparison with the pharmaceutical sector, where industry activities and funding are also found in public institutions (e.g. in the context of clinical trials). During the preparatory work for this report also the information about functional food that was provided by national public authorities in the four survey countries was analysed. Generally they did not provide much or easily accessible information for the general public and confined themselves to inform about functional food regulation (claims, labelling, etc.). Hence, their target group seems to be industry rather than consumers. However, other organisations, such as consumer organisations or NGOs specialised in food issues provide more substantial information for the public.

5.7 Factors influencing the purchasing behaviour of grocery shoppers

A first analysis of the socio-demographic characteristics of the interviewed grocery shoppers in section 5.3, with regard to their knowledge of functional ingredients, has shown that these characteristics do not entirely explain

the differences between buyers and non-buyers of functional food. It can simply be observed that, as a tendency, buyers of functional food are more often female, that they are younger and that they have a higher income than non-buyers; in some countries buyers also seem to have a higher education. Socio-demographic attributes may therefore help explain who buys functional food, but they cannot explain *why* somebody does so. This section therefore looks at the background of purchasing decision in the context of functional food, including the respondents' inside motivation and outside drives. First the influence of knowledge on a purchasing decision will be investigated and then the influence of trust will be explored.

Knowledge related to functional food and purchasing behaviour of this type of food

In the consumer survey the knowledge of grocery shoppers regarding functional ingredients was probed (Figure 5-2). If this knowledge is matched, at the level of the individual, with the purchasing behaviour regarding functional food, in all countries but the United Kingdom there seems to be a positive correlation between the respondents' level of knowledge of functional ingredients and the likelihood of buying functional food products (Figure 5-5). This general trend is true for the various product groups of functional food (dairy, cereals and beverages) for which the purchasing frequency was elicited. In the case of the United Kingdom, only two respondents of the 121 interviewees fell into the category "1" of nutrition knowledge – and both happened to be buyers of functional food. This may justify considering this particular data point as an outlier. However, in the United Kingdom the purchasing behaviour regarding functional food seems generally be less affected by the level of related nutrition knowledge.

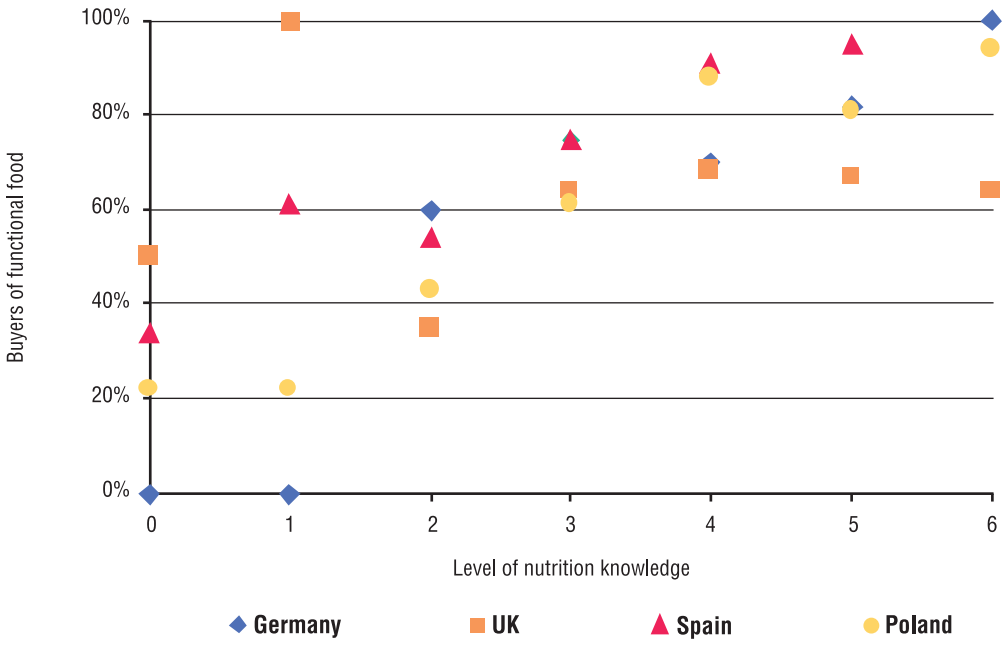
While the correlation between the respondents' level of knowledge and the likelihood of buying functional food is generally positive, the frequency of these purchases differs between the different food groups. In part this may be explained by differing relevancies of these food groups for the diets of the respondents or by different shelf lives of the different products (section 5.5). Furthermore, the different functional food products may also be situated at different stages of their life cycle in the different countries. Summing up these tendencies it can be stated that the likelihood of buying functional food increases for respondents in all four countries with an increasing knowledge about functional ingredients and their positive effects on health. Respondents with a higher nutrition knowledge may also be more likely be early adopters of newly launched functional products and buy them more frequently than other interviewees. In this sense, knowledge about the relationship between functional ingredients, nutrition and health can be regarded as an important impetus for buying functional food.

Trust and purchasing behaviour

Numerous people or institutions can be involved in a person's decision making process regarding functional food. Of course, there are the food retailers – where consumers buy such products – and the food manufacturers – whose products consumers buy. These stakeholders communicate with the consumer through advertisement or product labels. Furthermore there are medical doctors and nutrition advisors who may given advice on functional food; friends or relatives recommend an interesting, tasty or useful product or they report their bad experiences with some products; researchers communicate their findings and the government carries out information campaigns and implements related regulations.

Next to the nutrition knowledge of the grocery shoppers, in the consumer survey also their trust in these stakeholders in the field of functional food was determined (Figure 5-4). If this average level of trust in the stakeholders

Figure 5-5: Knowledge of functional ingredients and purchasing behaviour of functional food



Note: The level of nutrition knowledge is based on the number of correct answers in Figure 5-2; the higher the level of nutrition knowledge, the better informed the respondents.

is matched with the respondents' purchasing behaviour relating to functional food, it becomes clear that, on average, buyers of functional food have more trust in these stakeholders than non-buyers (Figure 5-6). A more detailed analysis has also shown, that there is a positive correlation between the level of trust of an individual and the purchasing of functional food across all countries, i.e. the more a respondent trusts the stakeholders involved, the more likely the respondent is to be a buyer of functional food.

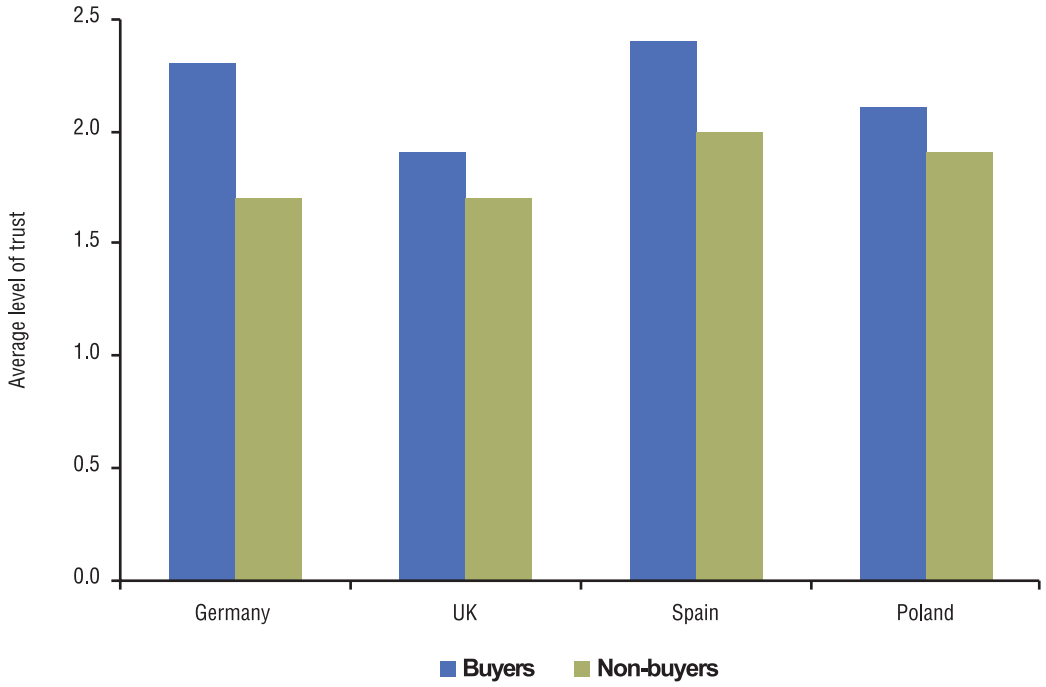
5.8 Example: consumer preferences for functional orange juice

Background and study design for analysing consumer preferences

In the consumer survey that was carried out, grocery shoppers were not only asked (abstract) questions on their views and attitudes regarding functional food, they were also confronted with a more realistic purchasing decision in which they had to choose between different orange juices. From these decisions their related preferences could then be inferred. (The theoretical background and the details of the design of this simulation, a conjoint analysis, had been developed during the preparatory work for this report.) For instance, orange juice was chosen because it is a basic food product that is widely consumed in all four study countries and available in practically all grocery shops. In addition, it is a product that is suitable for enrichment with different functional ingredients (as it is already done with calcium). Taken together, using orange juice for the simulated purchase offered a realistic scenario.

For the study six relevant product characteristics inclusive two functional ingredients (with the alternative of conventional juice) were combined in 20 different product cases; the different characteristics are reported in Table 5-2. These 20 cases were represented on photo cards that the respondents had to arrange in an order from 1 to 20, with the most preferred product being number 1 and the least preferred

Figure 5-6: Average level of trust in stakeholders by buyers and non-buyers of functional food



Note: The level of trust in stakeholders is based on Figure 5-4; the higher the level, the more trustworthy the respondent considers the stakeholders to be.

Table 5-2: Basic characteristics of orange juice used in the study

Characteristics	Expressions
Packaging	Glass bottle
	Plastic bottle
	Tetra Pak carton
Colour	Natural (yellow-orange)
	Stronger (orange-red)
Lycopene enrichment	No enrichment
	Soft claim "Lycopene improves the skin's protection against ultraviolet radiation."
	Prevention claim "Lycopene reduces the risk of prostate cancer."
Dietary fibres enrichment	No enrichment
	Soft claim "Dietary fibres ease digestion."
	Prevention claim "Dietary fibres reduce the risk of colon cancer."
Fruit content	20%
	50%
	100%
Price	Cheap (30% below base price)
	Normal (base price)
	Expensive (30% above base price)

Note: The base price was in the range of branded orange juices with 100% fruit content (EUR 1.29 in Germany and Spain, EUR 1.81 (GBP 1.29) in the UK and EUR 0.69 (Złoty 2.99) in Poland).

product being number 20. By choosing one alternative over the other, the respondents revealed their preferences, which could then be analysed statistically to calculate the importance on the purchasing decision (or "utility value") of each characteristic; the sum of each interviewee's utility values was then set at 100 percent.

Orange juice preferences of the interviewed grocery shoppers in the analysed countries

In the conjoint analysis the interviewees' results were aggregated for each country; Figure 5-7 shows the result in the form of relative average importance values of the different product characteristics for the respondents in each country, while the utility values of the expressions of the different characteristics are reported in Table 5-3. In this table the values in bold represent the expression for each characteristic that is preferred by the majority of respondents in the respective country over the other expressions for this characteristic. For instance, these results indicate that the German and British respondents prefer functional ingredients with a preventive character whereas Polish respondents seem to prefer more tangible, direct effects. (In the case of Spain the preferences regarding the health claims are mixed, but the softer claim for the lycopene enrichment of protection against ultraviolet radiation may be explained by the sunnier climate in this country.) Respondents in all countries on average strongly prefer orange juice with a high fruit content. Also, for respondents in all countries the price is never a positive characteristic; a low price is simply the lesser "evil".

Segmentation of the sample and group-specific analyses for buyers and non-buyers of functional food shows that overall there are some pronounced differences between buyers and non-buyers of functional food among the respondents in the four countries (Figure 5-8). For German and Polish buyers of functional food the fruit content of the orange juice is much more important than for the non-buyers; interestingly for the Spanish respondents it is the reverse. On the other hand the importance of the functionality of the orange juice seems to more dependent on nationality than on whether the respondents buy (other) functional products or not. The most important difference between buyers and non-buyers of functional food can be seen for the role of the price of the orange juice on Polish respondents, which is a very important factor for the purchasing decision of non-buyers.

Summarising the findings of the conjoint experiments for all respondents (Table 5-3), it can be stated that the fruit content of orange juice is the most important factor for the purchasing decision of the interviewees in all countries. Therefore, if the fruit content is taken as proxy for product quality and taste, the most important characteristic of a (functional) orange juice is a high quality and good taste. On the other hand, the respondents attached a much lower importance to the colour of the juice; it seems not to be a decisive factor in the purchasing decision. As can be expected, respondents prefer to pay a lower price for their orange juice, but in comparison with the other characteristics it is a less important factor. Of course, in part this can be influenced by the fact that the respondents only faced photo cards of the products and only made a virtual purchase where they did not have to actually pay money in consequence of their decision. Enrichment with the two tested functional ingredients (lycopene and dietary fibres) mostly obtained positive utility values Even though there are national differences, it seems that prevention claims are more positively assessed by the respondents than soft functional claims. National differences between the respondents become more apparent with regard to the packaging of the orange juice. In the case of Germany the preference for glass bottles could be explained by the traditional deposit system for bottles that exists in Germany, where consumers can buy juice in glass bottles for which they pay a deposit that they get back when returning the empty bottles to the supermarket. Respondents in other countries may consider Tetra Pak cartons to

Figure 5-7: Relative importance of the different product characteristics

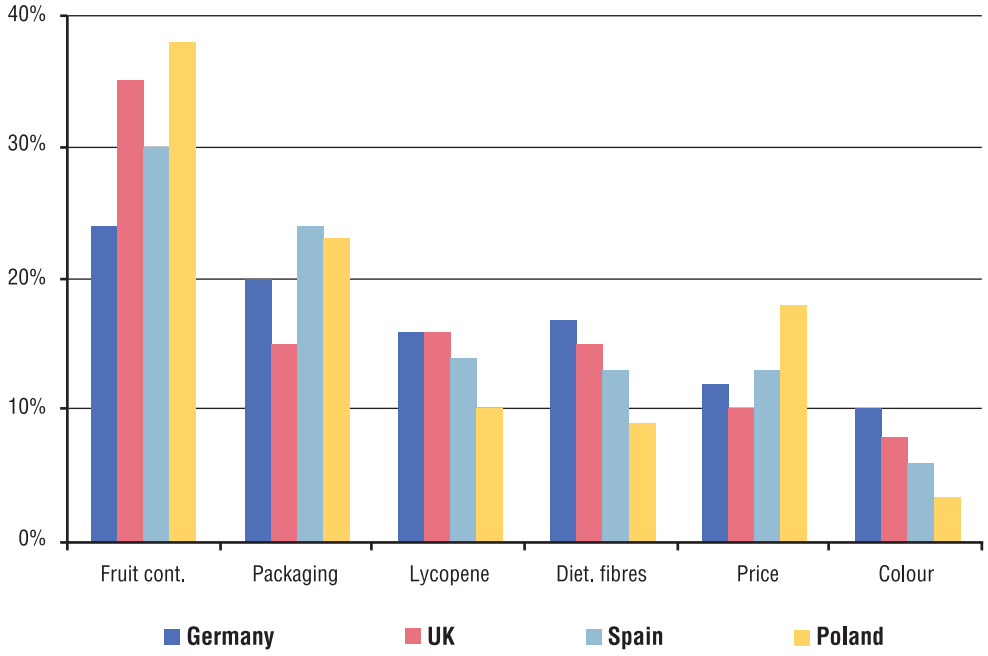
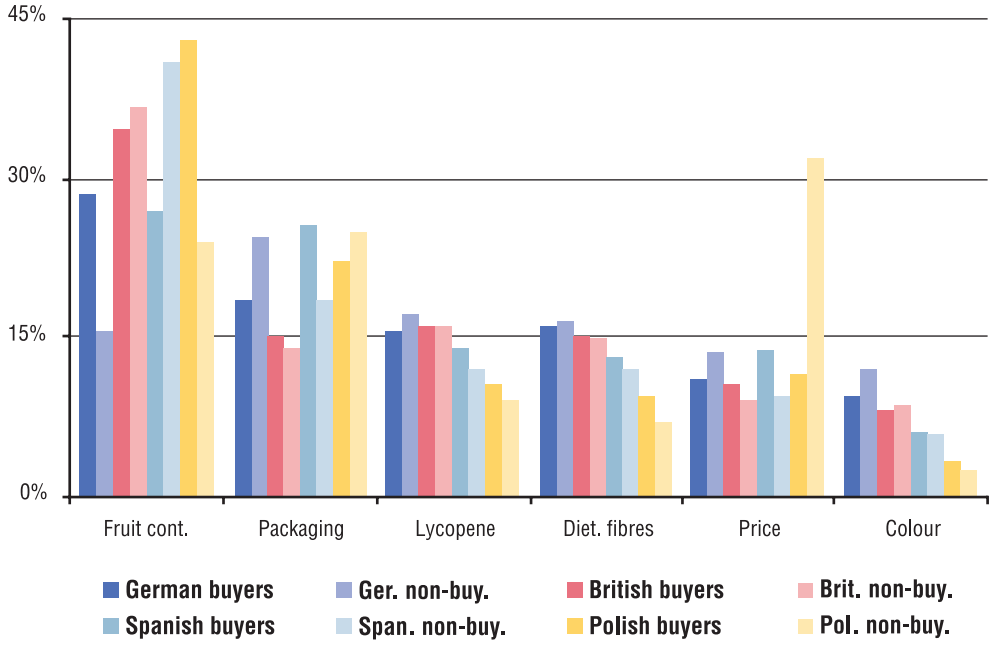


Table 5-3: Average utility values of the different expressions of each characteristic

Variables	Values	Utility scores			
		Germany	Poland	Spain	UK
		n = 115	*n = 111*	*n = 255*	*n = 113*
Constant		6.0323	4.6359	5.9929	3.3498
Packaging	Glass bottle	0.8093	1.3333	-0.0597	-0.7510
	Plastic bottle	-0.3498	-1.6667	-0.8898	-0.4264
	Tetra Pak carton	-0.4595	0.3333	0.9495	0.5015
Colour	Natural	-0.1644	-0.1554	-0.0103	0.3153
	Stronger	0.1644	0.1554	0.0103	-0.3153
Lycopene	No enrichment	-0.2072	-0.5916	-0.4902	-0.3679
	Soft claim (UV protection)	-0.2447	0.4595	0.3051	0.1637
	Prevention claim (prostate cancer)	0.4520	0.1321	0.1850	0.2042
Dietary fibres	No enrichment	-0.6937	-0.7913	-0.5164	-0.5045
	Soft claim (digestion)	-0.1517	0.4429	0.1890	-0.0270
	Prevention claim (colon cancer)	0.8453	0.3483	0.3274	0.5315
Fruit content	20%	2.4017	3.6847	2.5003	3.4047
	50%	4.8033	7.3694	5.0007	6.8093
	100%	7.2050	11.0541	7.5010	10.2140
Price	Cheap	-0.6404	-1.2267	-0.7451	-0.3821
	Normal	-1.2808	-2.4535	-1.4902	-0.7643
	Expensive	-1.9212	-3.6802	-2.2352	-1.1464

Note: The values in bold represent the expression for each characteristic that is preferred by the majority of respondents in the respective country over the other expressions for this characteristic.

Figure 5-8: Relative importance of the different product characteristics by buyer groups



be more convenient as a one-way packaging or less harmful in terms of waste volume that these cartons produce. However, as the group-specific analysis has shown, in most analysed cases also the non-buyers of functional food among the interviewees evaluate the conventional alternative (non-functional orange juice) more negatively than functional orange juices. This result may indicate a more general acceptance of functional food by consumers, which has already been found in previous studies.

Willingness to pay price premiums for functional orange juice

Another aspect of the consumer study was to analyse the respondents' willingness to pay price premiums for functional food products. In the conjoint analysis price was taken as one factor characterising the different orange juices. Based on inferred differences in the respondents' utilities between alternative product profiles monetary evaluation of these differences, expressed in "utility units", was possible. This monetary value could then be used to translate the respondents' utility gain for a product profile they prefer into their willingness to pay for the factor that lead to the utility gain (e.g. the enrichment with a functional ingredient and the related health claim). If an orange juice contains a functional ingredient and displays a corresponding health claim, consumers might be willing to pay higher prices for this product than for an orange juice with no enrichment. Table 5-4 shows the respondent's average willingness to pay price premiums for the analysed functional ingredients in the four countries. If no positive utility score is given this means the respondents' utility was not calculated to be improved by the respective ingredient-claim combination and, thus, their induced willingness to pay is negative. However, because of several theoretical caveats the reported price premiums should not be regarded as absolute but rather as indicative values. In this context it should also be kept in mind that the segmentation of subgroups is based on the general purchasing behaviour related to functional food and not specifically to functional orange juice – and that the analysed alternative orange juices are not available on the market, i.e. the respondents had no direct experience with this type of product.

Table 5-4: Overall willingness to pay for functional ingredients in orange juice (EUR)

	Germany	UK	Spain	Poland
Price range	0.89-1.89	1.25-2,65 (£ 0.89-1.89)	0.89-1.89	0.48-0.90 (Zł 2.09-3.89)
Price per utility unit	0.63	1.47 (£ 1.05)	0.54	0,17 (Zł 0.73)
Lycopene with UV protection claim	No positive utility score	0.78 (£ 0.56)	0.16	0.18 (Zł 0.77)
Lycopene with prostate cancer prevention claim	0.41	0.84 (£ 0.60)	0.10	0.12 (Zł 0.53)
Dietary fibres with digestion improvement claim	No positive utility score	No positive utility score	0.10	0.21 (Zł 0.91)
Dietary fibres with colon cancer prevention claim	0.96	1.51 (£ 1.08)	0.18	0.19 (Zł 0.84)

Note: The figures in bold indicate the ingredient-claim combination for which, on average, the highest utility gain can be achieved – in the eyes of the interviewees in each country.

For respondents in Germany and the United Kingdom the highest willingness to pay could be derived for the cancer prevention claims and in particular for dietary fibres as ingredients (perhaps because of the familiarity with this ingredient). In Spain it is also the cancer prevention claim in connection with dietary fibres for which the highest willingness to pay could be derived, but there the UV protection claim with lycopene seems to boost willingness to pay more than the cancer prevention claim. In Poland it is also for dietary fibres where the highest willingness to pay could be derived, but there it is the more tangible protection and improvement claims that seem to boost the respondents' willingness to pay more. Overall the derived willingness to pay for functionality in orange juice is highest in the United Kingdom and lowest in Poland, but so are the price ranges for orange juice (Table 5-4). The findings of this analysis are in line with results from previous studies in Germany and Denmark, where respondents were mostly willing to pay a higher price for food for which there was a (credible) positive health effect (see Poulsen 1999).

6 Cost-effectiveness of functional food

So far in this report the concept of functional food has been presented and the market for functional food has been analysed both from the supply side and from the demand side. The results indicate that there is a – growing – market for functional food because industry is marketing new products on the one hand and, on the other hand, because most consumers seem to be generally open to this kind of products and the related information and communication activities. Therefore, in the context of the private sector and in line with the EU's Lisbon Agenda, functional food could indeed present new economic opportunities for the food industry and contribute to make the EU a competitive and dynamic knowledge-based economy that is capable of sustainable economic growth. Moreover, with the new regulation on nutrition and health claims made on foods, these claims have to "be based on and substantiated by generally accepted scientific data" (EC 2007a).[8] Hence, it is also ensured that functional food does provide the benefits it promises.

What has not been discussed so far is whether functional food is a cost-effective means of improving nutrition and health? For instance, at the level of the individual clarification is needed whether the nutrition and health benefits of functional food come at a reasonable price, i.e. whether buying functional food represents an efficient use of one's resources to improve one's own health and well-being compared to spending them on alternative approaches. (In this context differentiation may be necessary between individuals who are disposed to certain diseases and those who are not.) Similarly, at the societal level clarification is needed whether promoting functional food is efficient and welfare enhancing, i.e. whether spending public resources in the field of functional food generates a bigger improvement in public health compared to spending them on alternative approaches (for instance on more general nutrition education programmes or lifestyle-change campaigns). Or, as the recommendation of one expert commission puts it:

> "It is essential for public health officials to ascertain the costs and benefits of functional foods relative to alternative mechanisms of public health improvement.... Substantial evidence has to be gathered on whether the support of functional foods by public health measures would be the best way to use scarce resources. Two alternative scenarios that warrant investigation are: 1) supply of nutraceutical ingredients in pill form aimed at "at risk" groups and 2) consumer education on diet and lifestyle. Developing new functional food products to fight obesity or diabetes 2, for instance, could be regarded as a 'technical fix' with a preference given in the first place for prevention of those diseases through well-balanced, healthy diets and exercise" (Chadwick *et al.* 2003: 12, quoted in Schroeder 2007).

Unfortunately there is very little information available on the cost-effectiveness of functional food – as also a recent World Bank report on health enhancing foods found: "Currently, *cost-effectiveness of functional foods in reducing disease burden and lost productivity is an important research gap*", even though "the popularity of functional foods is increasing and the effect on the food industry is evident" (Kotilainen *et al.* 2006: 5-6, emphasis added).

One study on the potential use of trans fat-free canola for hydrogenated vegetable oils estimated the resulting reductions in trans fat-intakes to project likely changes in cholesterol levels and the related reduction of the incidence of

8 For instance, in the USA a class action was filed against Dannon, the US arm of Danone, allegating that it has used fraudulent health claims to sell some of its branded yoghurts (Merrett 2008).

coronary heart disease in Canada where treatment of cardiovascular-related diseases is a major cost in the health care budget (Malla et al 2005). Using a cost-of-illness approach and various scenarios, the authors then estimated the potential benefits of trans fat-free canola in monetary terms: the derived annual health cost savings that could result from the use of trans fat-free canola oil fall into the range of CAD 0.3-1.8 billion, with annual health cost savings in the base case being CAD 1.1 billion (EUR 732 million).[9] This study shows the potential of new crop varieties to provide substantial health benefits and related health cost savings. However, the study did not include an analysis of the cost side of the potential use of trans fat-free canola, for instance it is unclear whether trans fat-free canola is more expensive as an input for the production of hydrogenated vegetable oils than other crops or canola varieties, whether there are costs involved for the food manufacturing industry when switching inputs, what kind of information and communication activities may be necessary to promote trans fat-free canola, etc. Therefore it is unclear whether, as a minimum, the benefits of this approach exceed its cost. Similarly, estimates for the USA predict that of a total annual cost of treating chronic illnesses of USD 659 billion in 2001 as much as USD 60 billion (EUR 67 billion) could have been saved through preventative healthcare strategies – including nutritional approaches (Hasler 2002). Yet, again, the costs of these "nutritional approaches" are not quantified and therefore their cost-effectiveness cannot be ascertained.

Another new crop variety with potential health benefits that some consider being a functional food is Golden Rice (see Hasler 2002, Poletti *et al.* 2004, Kotilainen *et al.* 2006, Williams *et al.* 2006, Davies 2007). This rice has been genetically engineered to produce beta-carotene (a provitamin A) within its kernels to help combat vitamin A deficiency in developing countries. Hence, this is an example of "biofortification", i.e. the use of plant breeding to accumulate micronutrients in the edible parts of crops (also see section 8.3). However, whether Golden Rice or similar crops should be regarded as functional food is open to debate: While affecting "beneficially one or more target functions in the body", these crops "remain foods" and they should be effective "in amounts that can normally be expected to be consumed in the diet" as "part of a normal food pattern". Yet, these crops are not meant to provide health benefits "*beyond* adequate nutritional effects" (see Diplock *et al.* 1999 and section 2.1). It is rather the opposite: these crops are developed to help ensure that poor populations in developing countries who suffer from micronutrient malnutrition can satisfy the *minimum* dietary requirements for these nutrients. This is what makes them indeed rather fortified than functional food: "Fortification or enrichment means the addition of one or more essential nutrients to a food whether or not it is normally contained in the food for the purpose of preventing or correcting a demonstrated deficiency of one or more nutrients in the population or specific population groups" (Codex 1991: 2). Moreover, with regard to Golden Rice, in the EU (where vitamin A deficiency is not an issue) beta-carotene is mostly used as a simple food colorant (E160a) and not as functional ingredient (see EC 1995). Nevertheless, given the scarcity of studies on the cost-effectiveness specifically of functional food, it is interesting to note that – in the corresponding context of a developing country where vitamin A deficiency is a sizeable public health problem and where a big share of the population consumes rice – the food-based approach of Golden Rice promises to be a very cost-effective alternative to pharmaceutical interventions (Stein *et al.* 2006, 2008). More generally, also industrial fortification with micronutrients is usually considered to be a very cost-effective intervention, at least in a developing country context (WHO 2002, Tan-Torres Edejer *et al.* 2003, Allen 2006). And, as one study for the United Kingdom indicates, while people may be

9 Canadian dollars were converted into Euros by applying the average exchange rate for 2005 (OANDA 2008).

willing to pay for functional "agricultural" food, many are polarised against anything that may be perceived as artificial ore genetically engineered (Arnoult *et al.* 2007).

The very limited information on the cost-effectiveness of functional food – or rather on fortified food in developing countries, which is beyond the scope of this report – does not allow drawing any firm conclusions on the individual or social desirability of consuming and promoting functional food within the EU from a consumer protection and public health point of view. Still, these results indicate the preconditions under which the general consumption and promotion of (certain types of) functional food can make sense, namely (i) if the health benefits cannot easily be achieved with traditional food (Schroeder 2007) or if it is unlikely that people change their diets accordingly, (ii) if the potential health gains can be enjoyed by a large share of the population, i.e. the food prevents a common health problem and (iii) if the functional food product is only marginally more expensive than its conventional counterpart when introduced on a large scale, e.g. through the exploitation of economies of scale when allocation R&D costs or in the production process.

It should be noted that not all functional foods are functional for the entire population: some may only produce beneficial effects in individuals with specific risk factors or for intakes beyond a certain threshold. Therefore, many functional foods may be functional only under specific conditions (Kotilainen *et al.* 2006). Yet, functional food products that prevent health problems that are less common (i.e. whose health benefit only materialises in relatively few cases) may still be cost-effective if their cost is correspondingly low – or if the health benefit they confer in the few cases is big enough. While it is questionable whether the benefits of nutrients lie in the cure of diseases rather than in the prevention of health problems (Daniells 2008), the cost-effectiveness of functional food products that can address existing problems obviously depends on the size of the health improvement they can provide compared to alternative interventions (like over-the-counter drugs) and relative to the additional cost of the product compared to the cost of these alternatives. It is exactly these kinds of analyses that are missing, though.

Such assessments at the level of society can be made based on average expected costs and average expected (health) benefits. Yet, at the level of the individual, prevention is also an issue of the individual's risk aversion (see e.g. Frewer *et al.* 2003). An individual may or may not fall ill with a common disease; hence she or he may decide not to worry about prevention, hoping to belong to the group of the population that will not be affected by the disease. Similarly, another individual may prefer to spend money to prevent a disease she or he is unlikely to attract, just to feel save. In this context, to express their personal preferences, individuals need to be able to base their decisions on accurate information about their likelihood to attract the disease in question. The new field of nutritional genomics is catering for this need for more and better information (see section 8.3). Nevertheless, particularly with regard to substantiating preventive health claims, evaluating the (clinical) efficacy of functional food or drugs is expensive, laborious and time-consuming because large sample sizes are needed and the necessary studies have to extend over several years. From there to demonstrating a product's effectiveness in real-life situations and, ultimately, its efficiency – or cost-effectiveness – is an even longer way (see Asp *et al.* 2005). Given this timeline, the growing market for functional food and the regulatory requirements to substantiate health claims, studies on the cost-effectiveness of functional food may become easier to carry out in future. For a comprehensive and more conclusive assessment of functional food from a public health point of view, research in this direction is urgently needed.

However, there are also doubts in the literature whether functional food will have the

desired effect as people may behave differently, or the concept of functional food is considered to be flawed in principle:

> One wonders if people will increase their 'non-healthy' food choices if they feel they are 'buying-in' to healthy eating through the consumption of functional food (Frewer *et al.* 2003: 722).

> Proponents argue that functional foods and drinks allow people to eat and drink more healthily without radically changing their diet. Certainly, big changes in diet are needed. Functional foods and drinks may be legal, make money, and reshape the way we think about food and drink. However, at best they are likely to be technical fixes, and at worst, another confounding factor that nutritional epidemiologists will have to unravel for years to come (Lang 2007: 1016).

Yet, others concede that functional food may not be the best option to address nutrition-related problems or to prevent non-communicable diseases (which would be dietary and behaviour change) but that it is the most feasible or second-best solution given that it is difficult to change people's habits:

> Dietary habits are notoriously difficult to change and even more difficult to sustain, even if the positive health effects are known. Functional foods can offer a means of providing some health or well-being benefits in a way that requires smaller behavioral changes by the individual consumer (Kotilainen *et al.* 2006: 5).

> Could functional foods fare better than educational campaigns in an attempt to reach public health goals of reducing non-communicable diseases of over-consumption? If one looks at selective examples and applies common sense reasoning, one would expect so (Schroeder 2007: 250).

7 Analytical methods to test functional food

7.1 Relevance of standardised analytical methods

During the legislative procedure of the new health claims regulation (EC 2007a), a perceived need was recognised for a careful investigation into the availability of standardised analytical methods to be used to verify compliance with labelling at least of the composition of functional food products. The analytical evaluation of food and dietary products has evolved significantly as a result of the functional food debate. The ability to identify and quantitatively measure levels of nutrients and other compounds has become even more essential as a tool to differentiate products in the marketplace. While measuring the traditional macronutrients relies on basic chemical techniques, identifying more specific components, such as individual polyphenols, is a complex process involving intricate extraction, detection and measurement phases: polyphenols constitute one of the most numerous and widely distributed groups of substances in the plant kingdom, with more than 8000 phenolic structures currently known. In many cases, scientific information about these components is relatively sparse and of the hundreds of methods developed, only a small percentage attains official status. Yet, although the pressure to adopt these methods is intense, they must meet the standards required to withstand scientific scrutiny and must be validated using established and well-designed criteria.

There is a continuing need for reliable analytical methods for use in determining compliance with national regulations as well as international requirements in all areas of food quality and safety. Standardised methods ensure that results reported by different laboratories at different times are comparable, provided the laboratories involved follow the standard method, or have documented evidence that changes they have made to the method do not result in a loss of precision or accuracy. The reliability of a method is determined by some form of a validation procedure. Certain method performance information should be available. This includes specificity, accuracy, precision (repeatability, reproducibility), limit of detection, sensitivity, applicability and practicability, as appropriate. At the national level many methods are used for routine food control analyses. In many cases, however, these methods have not been subjected to interlaboratory validation trials.

"Full" validation for an analytical method is usually taken to comprise an examination of the characteristics of the method in an interlaboratory method performance study (also known as a collaborative study or collaborative trial). During a Joint FAO/IAEA expert consultation on validation of analytical methods for food control the ideal validated method was defined as follows: "The ideal validated method is one that has progressed fully through a collaborative study in accordance with international harmonized protocols for the design, conduct and interpretation of method performance studies" FAO (1998: 3).

In this chapter we compile available standardised analytical methods that could be used with confidence by regulatory agencies, regulated industry, product testing laboratories and academic institutions to determine active ingredients in functional foods

7.2 Design of a database of standardised analytical methods

In order to organise the information obtained from the considerable number of harmonised

analytical methods gathered a database was designed that contained he following items:

- Identification number
- Group name (see below)
- Compound class
- Compound subclass
- Compound target
- Compound notes
- Natural sources (examples for possible natural sources)
- Method source (see below)
- Method number
- Method title
- Publication
- Method notes
- Matrices
- Health claims (examples for possible health claims)

In order to systemise the number of "functional" components, a classification was used based on group names: bacteria cultures, saccharides, plant extracts, terpenes, fibres, phenols, peptides, lipids, miscellaneous (Table 3-2). This is a slightly modified version of a Japanese classification proposed by Ichikawa (1994) that involves 12 groups, including e.g. minerals and vitamins, which are out of the scope of this study. If possible, the bioactive compound was further classified using the items "compound class" and "compound subclass".

The following method sources were used to search for standardised analytical methods:

- International Organization for Standardisation (ISO)
- European Committee for Standardisation (CEN)
- Online compendium of Joint FAO/WHO Expert Committee on Food Additives (JECFA)
- Amtliche Sammlung von Untersuchungs-verfahren § 35 LMBG (LMBG)
- Official Methods of Analysis of AOAC International (AOAC)
- Official Methods and Recommended Practices of the American Oil Chemists Society (AOCS)
- Approved Methods of the American Association of Cereal Chemists (AACC)
- Online compendium of International Olive Oil Council (IOOC)
- Online compendium of International Dairy Federation (IDF)
- Online compendium of Institute for Nutraceutical Advancement (INA)
- Online compendium of European Pharma-copoeia (EP)

Most standards writing organisations have instituted a process for review of methods with the aim of confirming, revising or deleting them. In the case e.g. of AOAC International, there is rigorous peer review by a number of committees, primarily of the way in which the collaborative study was conducted, before adoption as an AOAC First Action method. CEN is less rigorous in terms of assessing the conduct of a study but does go through an exhaustive consultation and international voting process before final adoption of a method as a European Standard.

7.3 Summary of standardised analytical methods database

In total 223 methods have been collected, which account for about 100 individual compounds. A short summary of the number of methods for individual compounds of each group is given in Table 7-1. A more complete compilation of standardised analytical methods, which could be considered for suitability in the process of method selection for the analysis of active compounds in functional foods to verify compliance with labelling, is reported in Buchgraber and Karaali (2005).

The compilation was limited to standardised analytical methods, which ensure that by applying those procedures the data produced can stand up

Table 7-1: Number of methods compiled for target compounds in each group

Compound group	No. of target compounds	No. of methods
Bacteria cultures	1	4
Saccharides	5	9
Plant extracts	12	13
Terpenes	13	36
Fibres	15	36
Phenols	12	18
Peptides	5	11
Lipids	20	41
Miscellaneous	16	55

to scrutiny. The investigation has shown that for many components used in the field of functional foods there is still a lack of available, reliable and harmonised analytical methods due to the tremendous challenges posed by the rapidly increasing number of functional components. Moreover, validated, standardised methods are only available for a few specific matrices. Even if existing methods, modified for a new matrix, may undergo a less-extensive validation process, the validation steps still have to be followed. A more detailed exploration including methods published solely in literature would show that much more methods have already been developed (see Hurst 2002). However, only a small percentage will attain official status.

The ability to efficiently develop, validate and implement a new method is an essential prerequisite for the successful completion of an analytical study. A full validation requires a comprehensive evaluation of a variety of components which indicates not only the accuracy of the data, but the scientific limits and parameters as well. Well-characterised reference standards are essential components of method development and validation processes and their limited availability has definitely hindered researchers in some cases. However, researchers have to focus on developing and validating methods to fill the gap and to satisfy the continuing need for reliable standardised analytical methods, which can offer an important measure to assess compliance with labelling provisions.

8 R&D landscape of functional food

The present chapter provides a review on current research and development (R&D) activities in functional food products within the EU. Considering them to be an R&D input, regional, national and trans-national (EU) programmes, budgets and research topics, as well as national funding programmes in the USA, are analysed and the current R&D situation is described for selected European research institutions and for particular research topics. Moreover, using them as indicator for R&D output, European and worldwide patents and publications in the food sector are reviewed in a bibliometric analysis and compared with the USA and Japan. Finally, on the basis of interviews and literature reviews, research needs and research trends are analysed and the specific strengths and weaknesses of R&D within the EU are discussed and compared to the USA and Japan.

8.1 Public research funding in the field of functional food

Public research funding can be an important research input. Therefore in this section selected research funding programmes with possible relevance for functional food are reviewed. Food and nutrition research has been funded in all EU framework programmes since 1989. The importance of research related to functional food has risen significantly, both in terms of the number of funded projects and even more so in terms of the allocated budget (Table 8-1). According to this table the number of funded projects has decreased between the fifth and the sixth framework programme. This can be due to several factors: The sixth framework programme was still ongoing at the time of data collection; hence Table 8-1 only reflects the number of projects that were funded until 2005.. In addition, in the sixth framework programme two new instruments, "Networks of Excellence" and "Integrated Projects" were introduced; these instruments aim at combining competence and research resources in fewer, but larger projects with bigger budgets and bigger number of participating research institutes. An overview of the research topics addressed in these projects of the sixth framework programme is given in Table 8-2.[10]

EU funding only accounts for a minor part of EU-wide public research funding. Therefore, a search for national funding programmes under which functional food projects might receive funding, was performed. For most EU countries no corresponding programmes could be found. National funding programmes under which functional food projects might have received funding were found for Ireland, Germany, the United Kingdom and France. In most cases it was difficult to determine which share of a funding programme in the food sector was (also) covering functional foods. In the USA only a few national funding programmes in the field of food and nutrition could be identified (Table 8-3), but others will exist at the level of the federal states. It seems, though, as if within the EU there is more public research funding in the field of nutrition than in the USA.

10 Another overview of EU-supported R&D in functional foods is given on http://www.functionalfoodnet.eu/asp/default.asp?p=6.

Table 8-1: EU research funding of functional food projects

Framework programme (FP)	Funding period	Total budget (million EUR)	Fct. food budget (million EUR)	No. of fct. food projects
6th FP: Food quality and safety	2002-06	753	(73)	(15)
5th FP: Key Action 1 "Food, nutrition and health"	1998-02	204	51	33
4th FP: Agriculture and fisheries incl. agro-industry (FAIR)	1994-98	110	12	12
3rd FP: Agro-industrial research (AIR)	1991-94	62	5	5
2nd FP: Food-linked agro-industrial research (FLAIR)	1989-94	25	2	4

Note: For the data on the sixth framework programme the status is 2005.

Table 8-2: Research projects on functional food by funding instrument

Funding instrument	Project title
Networks of Excellence (NoE)	▪ European Nutrigenomics Organisation: linking genomics, nutrition & health research ▪ Global Allergy and Asthma European Network
Integrated Projects (IP)	▪ Health-improving, safe seafood of high quality in a consumer-driven fork-to-farm concept ▪ Diet, genomics and the metabolic syndrome: an integrated nutrition, agro-food, social and economic analysis ▪ New strategies for improving grain legumes for food and feed
Specific Targeted Research Projects (STREP)	▪ Development of natural alternatives to anti-microbials for the control of pig health and promotion of performance ▪ Plants and their extracts and other natural alternatives to antimicrobials in feed ▪ Dietary exposures to polycyclic aromatic hydrocarbons and DNA damage ▪ Quantitative risk assessment strategies for novel foods
Coordination Actions (CA)	▪ Improving the quality of life of elderly people by coordinating research into malnutrition of the elderly
Specific Support Actions (SSA)	▪ Encouraging agri-food in Poland ▪ Setting up a network of technology dissemination centres to optimise SMEs in the olive and olive oil sector ▪ Networking in associated candidate countries towards food, GI tract functionality and human health ▪ Disseminating the results of EC funded research into food quality and safety to facilitate their transfer and exploitation into new products and processes to improve European health and well-being ▪ Development of a system for appropriate management of access and transfer of microbial resources: microorganisms sustainable use and access regulation integrated conveyance system ▪ A multimedia repository of European food science: production, quality and safety

Table 8-3: National funding programmes in the USA covering the field of food and nutrition

Programme	Funding year	Budget (million EUR)	Thematic issues
USDA national research initiative: improving food quality & value	2005	5	Food and nutritional improvements
National Institutes of Health (NIH)	2002	134	Dietary supplements
USDA national research initiative: nutrition, food quality & health	2001	15	Quality characterisation, preservation & enhancement; new processes, uses & market opportunities; value-added foods & biobased products

8.2 Research on functional food by academic and private entities

Based on a comprehensive, systematic search of the databases FSTA (Food Science and Technology Abstracts) and MEDLINE (Medical Literature Analysis and Retrieval System Online) as well as the internet (see 8.4), 106 research institutes or company departments were identified that – in 2005 – did research related to functional foods in the EU (Figure 8-1). The entities with most publications are presented in Table 8-4 and the ten institutes with the most publications are shortly described in the following.

The Institute of Food Research (IFR) at Norwich Research Park is a semi-privatised public research organisation (company limited by guarantee with charitable status). The IFR is the United Kingdom's only integrated basic science provider focused on food; its research is concerned with the safety and quality of food and with improving people's diet and health.

The Unilever Health Institute in Vlaardingen is part of the food company Unilever Bestfoods. It is located in the Netherlands and has regional centres in Asia, Africa and Latin America that support innovations in developing and emerging markets. The institute's tasks is to provide key inputs for product development by providing insights into local consumers' dietary needs, preferences and food-related tastes and traditions. The institute has an annual budget of about EUR 15 million and about 50 scientific staff.

ILSI Europe is part of the International Life Sciences Institute (ILSI), which is a non-profit, worldwide foundation established to advance the understanding of scientific issues relating to nutrition, food safety, toxicology, risk assessment, and the environment. ILSI Europe is based in Brussels and identifies and evaluates scientific issues through symposia, workshops, expert groups and publications; it is funded primarily by its members from industry.

The Department of Food and Nutritional Sciences of the University College Cork in Ireland has a over 20 senior scientific staff. The faculty considers itself to be one of the world's largest multidisciplinary educational and research institutions in the area of food sciences. In 2005 in its Department of Food and Health five scientists worked on three functional food projects.

The Human Nutrition Unit of the National Institute for Research on Food and Nutrition

Figure 8-1: Number of research facilities in the EU active in the field of functional food

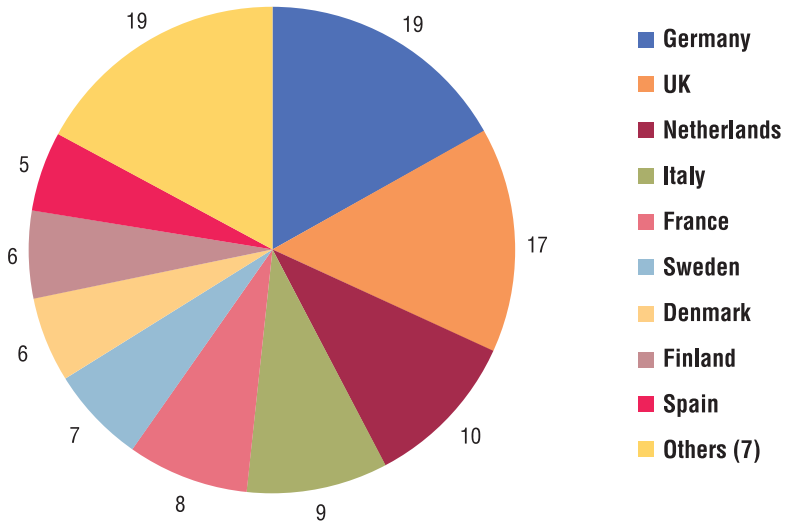


Table 8-4: Research entities in the EU with most publications on functional food

Institute	Location	Country	Publications
Institute of Food Research, Norwich Research Park	Norwich	UK	12
Unilever Health Institute	Vlaardingen	Netherlands	7
ILSI Europe	Brussels	Belgium	6
Department of Food and Nutritional Sciences, University College Cork	Cork	Ireland	6
Human Nutrition Unit, National Institute for Research on Food and Nutrition (INRAN)	Roma	Italy	6
VTT Biotechnology	Espoo	Finland	5
Department of Food Chemistry and Preventive Nutrition, German Institute of Human Nutrition (DIfE)	Potsdam	Germany	5
Nutrition and Toxicology Research Institute Maastricht (NUTRIM), Maastricht University	Maastricht	Netherlands	5
Leatherhead Food International	Leatherhead	UK	5
School of Food Biosciences, University of Reading	Reading	UK	5
Institute of Food Safety and Nutrition, Danish Veterinary and Food Administration	Soeborg	Denmark	4
Food Chemistry, Deptartment of Applied Chemistry and Microbiology, University of Helsinki	Helsinki	Finland	4
Department of Nutrition Science, University of Bonn	Bonn	Germany	4
Research Institute for Child Nutrition (FKE)	Dortmund	Germany	4
Jungbunzlauer Ladenburg GmbH	Ladenburg	Germany	4
Food and Nutrition Division, Food and Agriculture Organization of the United Nations (FAO)	Roma	Italy	4
Department of Food Technology, Polytechnic University of Valencia	Valencia	Spain	4
Institute of Sciences and Technologies of Nutrition and Food	Paris	France	3
Federal Dairy Research Centre, Institute for Dairy Chemistry and Technology	Kiel	Germany	3
J. Rettenmaier & Soehne	Rosenberg	Germany	3
Institute of Food Technology, Hohenheim University	Stuttgart	Germany	3
Dairy Products Research Centre, Irish Agriculture and Food Development Authority (TEAGASC)	Cork	Ireland	3
Department of Pharmacological Sciences, University of Milano	Milano	Italy	3
Division of Human Nutrition and Epidemiology, Wageningen University	Wageningen	Netherlands	3
Division of Milk Biotechnology, Warsaw Agricultural University	Warsaw	Poland	3
Puleva Biotech S.A.	Granada	Spain	3

Note: Only entities with more than two publications are listed. (A total number of 1001 publications was analysed, 387 came from entities within the EU).

(INRAN) in Rome is a governmental research organisation under the aegis of the Italian Ministry of Agriculture. It provides strategic and applied research in the fields of food science and nutrition, as well as providing advice and guidance for the food industry. It has a staff of 200 full or part-time employees.

VTT Biotechnology is a subsidiary of the VTT Technical Research Centre of Finland, which is a large contract research organisation. VTT Biotechnology develops bioscience applications for the industry. Its functional foods department works in the fields of plant biotechnology and consumer and sensory studies.

The German Institute of Human Nutrition (DIfE) in Potsdam, Germany, is a public research institute with more than 300 staff members. A number of the institute's departments work in the

field of functional food. The main target diseases are metabolic syndrome and cancer.

The Nutrition and Toxicology Research Institute Maastricht (NUTRIM) at Maastricht University in the Netherlands is an interfaculty research institute of the university's faculties of health sciences and medicine in co-operation with the University Hospital Maastricht. Within NUTRIM fifteen biomedical, clinical and behavioural-science departments co-operate to carry out scientific research and education in the fields of nutrition and toxicology. The total number of scientific staff participating within NUTRIM is over 200.

Leatherhead Food International, based in Leatherhead in the United Kingodm, is a private company that is globally active in the field of food information, market research and technical and food research services. It delivers consultancy services for large-scale government research project through to individual client information projects or nutritional, sensory and consumer studies.

The School of Food Biosciences at the University of Reading is the largest facility of its kind in the United Kingdom. It has a staff of about 60 senior scientists involved in teaching and research, covering a wide range of topics on most of the elements of the food chain.

8.3 Current research topics

One indicator for current research issues and trends are presentations at high-level international conferences. One of the most important conferences on functional food during the data collection during the preparatory work was the 5th International Conference and Exhibition on Nutraceuticals and Functional Foods (Worldnutra 2004), held on 7-10 November 2004 in San Francisco. There the plenary lectures were given on:

- regulation (intellectual property issues and management),
- economic aspects (global trends in functional foods and dietary supplements, new functional food products and science in Japan, research as support to the industry),
- health benefits (spice bioactives' relation to cancer, polyunsaturated fatty acids impact on cardiovascular health) and
- research issues (applications of genomics and proteomics or pharmacological principles in the development of nutritional products).

Parallel sessions with oral presentations were held on regulation, specific diseases and threats to health, safety and toxicological aspects, specific types of bioactive compounds and strategies and issues in product development and marketing; Table 8-5 gives a quantitative overview of the research topics and the nationality of the presenters (as proxy for research activities in the various regions – although it has to be kept in mind that the conference took place in the USA). A large number oral presentations concentrated on toxicology and preclinical testing, followed by presentations about regulation, legislation, IPRs and marketing authorisation. Clinical efficacy testing and technological aspects were other important general research topics.

Other indications for research trends can be taken from the literature, especially review articles or symposia summaries in relevant journals. Based on these sources, in the preparatory work for this report the following target groups and targeted health threats were differentiated: the ageing population in general as well as related health problems (sarcopenia, Alzheimer's disease, cataracts and age-related macular degeneration, osteoporosis) are important issues for functional foods research (Charlton 2002, Ordovas and Mooser 2004, Weaver and Liebman 2002). Another important target group are children, for instance in relation to their calcium intakes

(Nicklas 2003). Other targeted health threats are cancer, where increased lycopene intake can play a preventive role) (Giovannucci 2002), and obesity, cardiovascular diseases and immunology issues, which were also topics of plenary lectures at WorldNutra 2004. Moreover, while the risk of disease is often associated with genetic polymorphisms, the effect is dependent on dietary intake and nutritional status. Hence, nutritional genomics is another research field of growing importance, whose objective it is to elucidate the effect of genetic variation on the interaction between diet and disease (Desiere 2004, Ordovas and Mooser 2004).

Among the research trends regarding the bioactive compounds in functional food, there is work on well-known ingredients like antioxidants (e.g. lycopene, lutein and zeaxanthin), folates or calcium (Charlton 2002, Finglas *et al.* 2003, Nicklas 2003). Newer ingredients in the focus of scientific research are proteins and plant sterols (Charlton 2002, Thomsen *et al.* 2004); at WordNutra 2004 prominent ingredients were polyphenols, lipids, biopeptides and probiotics (Table 8-5). Especially for the ingredients that are already being used for a longer period of time like vitamin C or E, researchers strive for a better understanding of the metabolic mechanisms behind the ingredients' health benefits (Charlton 2002). Another important issue in recent research on bioactive ingredients is their overconsumption, which was also reflected by the large number of presentations on toxicology and preclinical testing at WorldNutra 2004.

For the delivery of the functional ingredients collaboration between food technologists and nutritionists is imperative (Henry and Heppell 2002). There are many technological developments that contribute to an improved delivery of the bioactive components, like microencapsulation technologies that permit incorporating health-promoting ingredients into food without reducing their bioavailability or functionality (Schrooyen *et al.* 2001). However, not only technological developments can help incorporate desired components into food: For instance plant breeding can be used to accumulate micronutrients in the edible parts of crops (also see chapter 6). While this approach ("biofortification") is predominantly pursued on a humanitarian basis in a developing country context and not necessarily based on a marketable health claim (HarvestPlus 2006), it is also an option with potential for applications in industrialised countries (Poletti *et al.* 2004, Broadley *et al.* 2006, Finglas *et al.* 2006). Similarly, "metabolic engineering" is expected to increase levels of human health-related compounds in plants in the near future, for instance to produce novel long-chain polyunsaturated fatty acids in oil-seed crops or to

Table 8-5: Presentation topics and numbers and nationality of presenters at WorldNutra 2004

Topics of oral presentations	No.
Toxicology and preclinical testing	55
Regulation, laws and marketing authorisation	20
Clinical efficacy testing	14
Extraction and processing technologies	13
Specific food sectors (fat supplements and dairy products)	8
Presentations on specific ingredients	**No.**
Polyphenols	13
Lipids	8
Probiotics	8
Peptides and proteins	6
Carotenoids	3
Dietary fibres, plant sterols and vitamins (each)	1
Presenters in normal symposia	**No.**
from the USA	45
from EU25	11
from Japan	10
from other countries	37

increase amounts of flavonoids and carotenoids in tomatoes and potatoes (Davies 2007).

Another important field of research is the substantiation of health claims made for functional food and dietary supplements; well-designed clinical studies to prove their efficacy are still missing to a large extent (Montgomery 2004). For interventions with small effect sizes, as are expected for most functional food products, large – and costly – sample sizes are necessary to statistically detect effects and current experimental design also has other limitations; future research will require the integration of various disciplines and it will require investigators to work on large population studies (Giovannucci 2002, Ordovas and Mooser 2004, Thomsen *et al.* 2004). Because although the credibility of health claims is considered a prerequisite for the economic success of a functional food product, the high investments that are needed to substantiate these claims can represent an economic hurdle for companies (Nutra 2004b).

Finally, research trends that can be derived from the interviews with representatives from academia and industry, which were carried out for the preparatory work of this report, can be summarised as follows: Generally the represented research entities worked on dairy or cereal products and on probiotics, dietary fibres and n-3 fatty acids, but also on other ingredients. Regarding the ingredients, the measurement and enhancement of their uptake and bioavailability was considered to be another field for new research. And a new field for research on functional food were also seen in personalised, genotype-specific nutrition. For the planning of policies and regulations, the need for supportive socio-economic research was seen (e.g. to determine factors that contribute to consumers' willingness to pay additional cost of functional foods).

8.4 Research output

The number of scientific publications can be used as an output indicator to analyse and compare research activities of actors at an institutional or country level. For such a bibliometric analysis in the field of functional food, for the preparatory work for this report the online databases FSTA and MEDLINE have been used. FSTA is a database that contains scientific and technological publications on all aspects of processing and manufacturing human food products; MEDLINE is an international database that covers biomedical publications. For the search strategy suitable classification codes and controlled terms were used. For the ten year period from 1994 to 2003 a total number of 5,121 "functional food publications" were found, compared to a total of 86,626 publications on the food sector. For the analysis of the country of origin of the publications a more limited and more recent sample was used.

During the analysed period there were between 6,000 and 9,000 food-related publications each year; the share of publications on "functional food" among these publications fluctuated between 5-7 percent. On a per-country basis researchers in the USA had most publications on functional food, but researchers in all EU Member States together had over 1.5 times more publications than their US counterparts. Within the EU researchers in the United Kingdom and Germany had the biggest share of publications (Table 8-6)

A similar approach as for the bibliometric analysis was also pursued for a patent analysis on functional food, using the databases EPAT (European Patents) and DWPI (Derwent World Patents Index). For the period from 1994 to 2001 for the functional food sector 554 patents were identified (against 9,865 patents for the whole

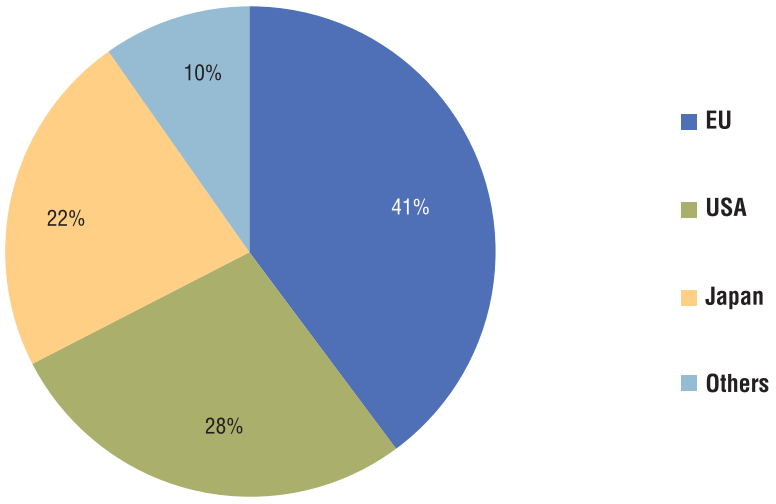
food sector). Between 1994 and 2001 the number of patent applications in the food sector as a whole grew from about 500 applications to over 1,200 applications. In the same time the share of applications for patents in the field of functional food rose from 3.2 percent to 7.7 percent, i.e. the patenting activity in the field of functional food was more dynamic than in the overall food sector. This indicates that the research that is carried out on functional food issues is also translated into industry innovations and new products. Moreover, unlike for the number of publications (Table 8-6), Japan's share in the regional distribution of the patent applications is almost at par with the share of the USA (Figure 8-2). This could indicate that language indeed introduces a bias in the results of the bibliometric analysis, as explained in the note to Table 8-6.

Table 8-6: Number of publications on functional food and country shares

United Kingdom	84	22%
Germany	64	17%
The Netherlands	39	10%
Italy	37	10%
Spain	35	9%
Finland	21	5%
France	20	5%
Belgium	18	5%
Sweden	14	4%
Denmark	13	3%
Ireland	11	3%
Poland	11	3%
Czech Republic	8	2%
Others	12	3%
EU	387	39%
USA	238	24%
Japan	42	4%
Switzerland	26	3%
Others	308	31%
World	1001	100%

Note: Ninety-two percent of the records in MEDLINE in the years 2005/06 refer to publications in English (NLM 2007); this may indicate a certain bias in favour of the USA and the UK.

Figure 8-2: Regional distribution of patent applications on functional food (1994-2001)



9 Conclusions

Over the past decades a new concept of food – food that provides additional health effects – has emerged, particularly in Japan but also in the USA. In the EU the market for this kind of food is less developed and, until recently, there was no coherent regulatory framework for functional food in the EU. In this context and within its mandate to work on technology foresight in fields where policy responses in the field of agriculture, food and health may become necessary, the Institute for Prospective Technological Studies (IPTS), an institute of the Joint Research Centre (JRC) of the European Commission, had initiated a prospective study on the functional food sector within the EU.

The overarching finding of the subsequent work is that *there is a serious lack of consistent data and information in various relevant fields that may need to be addressed*. Nevertheless, this report found that the market for functional food within the EU certainly has a size of several billion Euros (estimates fall into the range of EUR 6-20 billion). This is a sizeable figure if, for instance, compared to the EU market for health biotechnology applications of EUR 9 billion or to the combined economic contribution of the application of modern biotechnology in the primary production and agro-food sectors of EUR 3-6 billion – the significance of which has been highlighted in a recent JRC Reference Report (Zika et al 2007). And all analysts concur in that the market for functional food is set to grow further, not only within the EU but also worldwide. Hence, especially given the EU's lead in related R&D, *it seems as if functional food is indeed a market whose development could help increase the EU's economic competitiveness*. While there are some exceptions, currently the EU market for functional food is dominated by established and internationally active food companies that have diversified into functional foods. This could indicate that entering the market for functional food is relatively costly, not least because of the costs related to research, product approval and marketing. *It may be necessary to observe to what extent the new EU regulation on health claims made on food and the related approval process facilitates market entry for new companies or raises the barriers to enter the European market for functional food.*

On the demand side the report found that a majority of *consumers are generally open towards functional food*. For instance, most grocery shoppers covered by the survey carried out for this report stated that they had already bought a functional food product at least at one point in time. Correct knowledge of the "functionality" of a bioactive ingredient seems to be one of the factors (positively) influencing consumers' attitudes towards functional food. This knowledge, in turn, seems to depend on the length of time a functional ingredient is already used in food products on the market and, to a lesser extent, on information and communication activities. Among the socio-demographic factors, there is an indication that women buy more functional food than men. It also seems as if younger and richer consumers are more likely to buy functional food. The main motives to buy functional food that were reported by survey respondents related to reasons of health and well-being. But also the sensory attributes of the functional food (especially taste) were considered to be important. In contrast, in most cases price played a lesser role. Among those trusted most by respondents to advise on functional food were medical doctors and nutritionists; *there was a general mistrust in government*, though. *In as far as EU or national government interventions related to consumers are planned in the field of func-*

tional food, people's mistrust in the competence and credibility of these institutions may need to be addressed first.

Another aspect of functional food, namely its potential contribution to key challenges like public health or sustainable consumption, could not be addressed satisfactorily. While limited data availability already posed a hurdle for the market analysis, there was virtually not information available to assess functional food as possible intervention in a public health context. There is no doubt that non-communicable diseases impose a heavy economic and human burden on the EU's Member States and its citizens. It is also acknowledged that the leading risk *factors contributing to this burden of disease are often directly or indirectly related to unhealthy diets and other lifestyle factors* – where functional food could have a preventive role to play. But *the scope of the potential impact of functional food on public health remains obscure and, in particular, there is no information on the cost-effectiveness* of functional food. Therefore, only tentative observations could be made regarding the efficiency of using public or private resources on this approach: while by definition functional food has to provide health benefits, it cannot be determined whether these benefits justify the costs that need to be incurred to produce, promote and consume functional food. Food-based approaches often can offer a cost-effective way of addressing health problems, but whether this is also the case for functional food – and for which types of functional food – is a topic that requires further research. Otherwise, *for research on functional food in general the output in the EU in terms of academic publications and patents is larger than the output of either the USA or Japan*, at least in quantitative terms. This research, which is regularly funded by the EU, currently covers the use of new bioactive ingredients, the better understanding of ingredients that are already in use, the effectiveness of dietary interventions, technological developments, regulatory issues and, as perhaps most forward-looking field, nutritional genomics. Given the lack of research on this topic, *it may be pertinent to enlarge the research focus to include the cost-effectiveness of functional food; this information is necessary to allow both policy makers in the field of public health and consumers to make informed decisions*.

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Abstract

Functional food is defined as food that is taken as part of the usual diet and has beneficial effects that go beyond traditional nutritional effects. So far this functionality is mainly created during the industrial processing of the food through the addition of bio-active ingredients. Over the last years functional food has gained an increasing market share and the health claims made on food have recently been regulated at the EU level. It is therefore pertinent to analyse the potential market for functional food and its likely future development. It is also important to understand consumer attitudes and expectations regarding functional food, and the competitiveness of the different approaches to confer functionality in terms of their respective cost-effectiveness needs to be clarified.

There is considerable uncertainty regarding the size of the market for functional food, both within the EU and globally. Estimates of the global functional food market from various sources and different years fall into a range of EUR 25-60 billion. A recent, lower-bound estimate indicated a size of EUR 6.4 billion for the EU market. By far the biggest market share is still occupied by dairy products and beverages – followed by cereals only as a distant third category. In terms of bioactive ingredients plant extracts are used more frequently, although – due to the large number of dairy products – probiotic bacteria cultures clearly dominate, followed by prebiotics. On the demand side a survey in four selected Member States of the EU showed that many grocery shoppers were not familiar with the term "functional food", although, when given some examples, most of them had already bought such products. Better nutrition knowledge was thereby correlated with a more positive attitude towards functional food and female, younger and richer respondents were more likely to buy functional food products. Concerning reasons for purchasing functional foods, surveyed customers considered important that functional food helps them stay healthy and well; yet the taste and the general food quality was also very relevant in their answers. Regarding research in the field of functional food, the output of public and private entities within the EU – measured as scientific publications – is larger than that of either the USA or of Japan. Finally, one field that is policy-relevant and has so far received hardly any attention in research is the cost-effectiveness of functional food as public health intervention. Yet, tentative comparisons with similar approaches suggest that food-based approaches may indeed offer a cost-effective way of addressing health problems.

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