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Highlights

▶ Developments in other fields are useful to advance benefit–risk analysis in Food and Nutrition. ▶ Decisions to focus on food risks without addressing benefits are often suboptimal. ▶ Benefit–risk analysis should be a joint process to create shared understanding. ▶ Assessors, managers and stakeholders each have an essential role in this process. ▶ Contributions from all relevant actors are required to improve benefit–risk analysis.

Food and Chemical Toxicology xxx (2011) xxx–xxx

Contents lists available at SciVerse ScienceDirect

Food and Chemical Toxicology

journal homepage: www.elsevier.com/locate/foodchemtox

Looking beyond borders: Integrating best practices in benefit–risk analysis into the field of Food and Nutrition

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ARTICLE INFO

Article history:
Available online xxxx

Keywords:
Benefit–risk
Food
Nutrition
Medicines
Microbiology
Environment

ABSTRACT

An integrated benefit–risk analysis aims to give guidance in decision situations where benefits do not clearly prevail over risks, and explicit weighing of benefits and risks is thus indicated. The BEPRARIBEAN project aims to advance benefit–risk analysis in the area of food and nutrition by learning from other fields. This paper constitutes the final stage of the project, in which commonalities and differences in benefit–risk analysis are identified between the Food and Nutrition field and other fields, namely Medicines, Food Microbiology, Environmental Health, Economics and Marketing–Finance, and Consumer Perception. From this, ways forward are characterized for benefit–risk analysis in Food and Nutrition. Integrated benefit–risk analysis in Food and Nutrition may advance in the following ways: Increased engagement and communication between assessors, managers, and stakeholders; more pragmatic problem-oriented framing of assessment; accepting some risk; pre- and post-market analysis; explicit communication of the assessment purpose, input and output; more human (dose–response) data and more efficient use of human data; segmenting populations based on physiology; explicit consideration of value judgments in assessment; integration of multiple benefits and risks from multiple domains; explicit recognition of the impact of consumer beliefs, opinions, views, perceptions, and attitudes on behaviour; and segmenting populations based on behaviour; the opportunities proposed here do not provide ultimate solutions; rather, they define a collection of issues to be taken account of in developing methods, tools, practices and policies, as well as refining the regulatory context, for benefit–risk analysis in Food and Nutrition and other fields. Thus, these opportunities will now need to be explored further and incorporated into benefit–risk practice and policy. If accepted, incorporation of these opportunities will also involve a paradigm shift in Food and Nutrition benefit–risk analysis towards conceiving the analysis as a process of creating shared knowledge among all stakeholders.

1. Introduction and approach

Benefit–risk analysis of Food and Nutrition is developing fast. Benefit–risk analysis aims to give guidance in decision situations where both benefits and risks have been identified; when the benefits do not clearly prevail over the risks, explicit weighing of benefits and risks is indicated. Benefit–risk analysis can be seen as a triad of the (1) assessment, (2) management and (3)

Abbreviations: CVD, cardiovascular disease; DALY, disability adjusted life year; EFSA, European Food Safety Authority; HTA, health technology assessment; QALY, quality adjusted life year.

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doi:10.1016/j.fct.2011.11.044

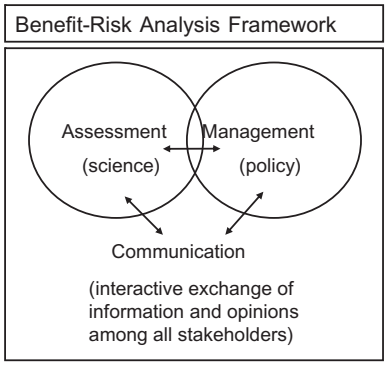

Fig. 1. Contemporary benefit–risk analysis framework. Based on the risk analysis framework by WHO/FAO (1995).

communication of integrated benefits and risks, analogous to the common contemporary risk analysis paradigm (Fig. 1) (WHO/FAO, 1995).

Benefit–risk *assessment* of Food and Nutrition comprises a science-based process intended to qualitatively or quantitatively estimate the benefits and risks for humans following exposure (or lack of exposure) to a particular food or food component and includes the potential to integrate them into comparable measures. Benefit–risk *management* entails the process of weighing policy alternatives in light of the results of benefit–risk assessment and other relevant information. Benefit–risk *communication* covers the interactive exchange of information and science-based opinions concerning benefits and risks among assessors, managers, consumers and other stakeholders.

The scope of Food and Nutrition risk assessment is fairly well established (Renwick et al., 2003); it deals with the assessment of adverse health effects caused by physical or chemical agents, occurring naturally in foods or as environmental contaminants, or resulting from food preparation or manufacturing processes. However, in the benefit–risk context, the scope of benefit-assessment is a point of discussion. A beneficial effect can be looked at as the reverse of an adverse effect (WHO, 1994), i.e. a physical or other change within a person that improves functional capacity or the capacity to deal with stress or that decreases susceptibility to harmful effects. This can be measured as prevention of disease, i.e. reduction of risk, but currently it is difficult to measure benefits directly, at an early stage or as an 'above-normal' capacity. Cases where the benefit is obvious but where different risks are involved (in severity and mechanism) could also be taken under the wing of benefit–risk analysis. Benefit–risk analysis presents up-to-date knowledge in a dynamic public health process, aimed at optimization, i.e. looking for ways to maximize benefits while minimizing risk.

In recent years, many projects have done significant work to identify the possibilities and difficulties of benefit–risk analysis in the Food and Nutrition field (Tijhuis et al., 2011). Much progress has already been made, but benefit–risk thinking and practise have not yet become commonly established. Therefore, for further development, the field of Food and Nutrition could benefit from looking beyond its borders and learning from other fields of research (and possibly also *vice versa*) and this is the explicit goal of BEPRARIBEAN project (http://en.opasnet.org/w/Bepraribean) (Verhagen et al., 2011). To serve this goal, we recently compiled reviews covering the state of the art in benefit–risk analysis for Food and Nutrition (Tijhuis et al., 2011) and five other fields: Medicines (Luteijn et al., 2011), Food Microbiology (Magnússon et al., 2011), Environmental Health (Pohjola et al., 2011a), Economics and Marketing–Finance (Kalogeras et al., 2011) and Consumer Perception (Ueland et al., 2011). The individual reviews were led by the researchers from within the respective fields and were contributed to by the researchers from the other fields. Summaries of the key issues from the reviews and a summary of the contemporary regulatory context for Food and Nutrition management and assessment are presented in Section 2.

In Section 3, the focus is on identifying how the benefit–risk approaches in the different areas compare to and differ from the benefit–risk approaches in the area of food and nutrition. In order to exemplify the (combined) perspectives and approaches from within the different areas, we include an example of a case: the effects of replacing current animal protein sources by more sustainable dietary protein sources. This topic was considered suitable because it is inherently multi-disciplinary and currently of global interest. This example is meant as an illustration and does not aim to be a conclusive analysis.

From this, in Section 4, we aim to identify opportunities for further development of benefit–risk analysis in food and nutrition.

In Section 5, we sum up the main points of this paper, and the whole BEPRARIBEAN project, and indicate some implications that these points will or may have for Food and Nutrition benefit–risk analysis in the future.

2. Summaries of key issues by focus area and EU regulatory context for Food and Nutrition

In 2.1–2.6 we summarize the key issues from the 6 state of the art reviews: Food and Nutrition (Tijhuis et al., 2011), Medicines (Luteijn et al., 2011), Food Microbiology (Magnússon et al., 2011), Environmental Health (Pohjola et al., 2011a), Economics and Marketing–Finance (Kalogeras et al., 2011) and Consumer Perception (Ueland et al., 2011). They are complemented in 2.7 with a short overview of the contemporary regulatory context for Food and Nutrition management and assessment in the European Union.

2.1. Benefit–risk analysis in Food and Nutrition (Tijhuis et al., 2011)

This paper addresses the three components of benefit–risk *analysis*, but focuses on *assessment*. Benefit–risk assessment in Food and Nutrition is geared to weigh the beneficial and adverse effects a food or food component may have, in an integrated measure, in order to make better-informed policy decisions regarding public health issues.

Historically, the assessments of risks and benefits have been separate processes. In risk assessment, toxicology is the main contributor as the toxicological approach is demanded by regulation. It traditionally assumes that a maximum safe dose can be determined from studies in experimental animals or sometimes humans and that division of this dose by appropriate safety factors defines the 'safe' intake for the human population. Epidemiology plays a minor role in risk assessment. Epidemiology describes associations between risk (or beneficial) factors and disease endpoints in humans. It has traditionally focussed more on relative than on absolute risks. Nutrition, as a science, uses a mixture of methodologies and is involved in estimating risks specifically for nutrients and other dietary factors. Benefit assessment for Food and Nutrition is newly developing in regulatory terms, but has been the subject of nutritional epidemiological research for a long time. Benefit assessment is working on concepts such as whether reduction of risk of disease should be termed a benefit, whether a benefit can be measured as a state rising above the average health and in which time frame (short or long term), and how broad its scope should be. In nutrition, current interest is in 'optimal' food and nutrient intake, implying knowledge of both intakes where risks occur and intakes where benefits occur. In this, there is a scientific development away from general population intakes towards an

intake based on subgroups. In summary, the goal of risk assessment in food and nutrition is to reasonably guarantee absence of an effect (risk) whereas the goal of benefit assessment is to reasonably guarantee the presence of an effect (benefit). This distinction affects the assessment approach, the evaluation of the generated data and the way these can be used. In both risk and benefit assessment, good dose–response data, i.e. with relevant intake levels and suitable for the target population, are scarce. Better integration of all underlying disciplines and an approach focussed more on humans and continuous data is indicated.

Current approaches to bring benefit and risk assessment together mirror the traditional risk assessment paradigm of hazard identification, hazard characterization, exposure assessment and risk characterization. A tiered approach is advocated, as this allows for transparency, in-between consultancy with the benefit–risk manager and the possibility of an early stop in the assessment and thus increased efficiency. There is agreement about the importance of a good description of the benefit–risk question and the uncertainties in its assessment. Benefit–risk comparison can be qualitative and quantitative, with increasing data requirements. In a quantitative comparison, benefits and risks are expressed in a common currency. Severity of disease can be taken into account by attributing weights, e.g. using disability adjusted life years (DALY's). These integrated measures need to be accompanied by at least (1) a description of the unintegrated benefits and risks on subgroups and (2) data uncertainties. In the quantification process, deterministic input may be substituted by probabilistic input; well-accepted methodology for probabilistic assessment is available.

Close communication, between and within benefit–risk assessors and managers, requires attention. In benefit–risk management some risk will have to be considered acceptable in order to achieve more benefits. Thus, current risk management will also need to consider a shift from striving for zero risk towards explicit weighing of risks and benefits in order to achieve an optimal outcome. The communication of benefits and risks to the public used to be separate, but the impact of combined benefit–risk messages is being explored.

In conclusion, benefit–risk assessment is developing steadily in the field of food and nutrition. General point of attention is the communication between fellow scientists, managers and the general public. General strengths are the ability to systematically and transparently show the current knowledge and its gaps and to provide what is likely the best answer to a question with a large potential impact on public health.

2.2. *Benefit–risk analysis in Medicines (Luteijn et al., 2011)*

Medicines can lead to significant health benefits. The health benefits come at the risk of potential adverse drug reactions. Since the thalidomide disaster in the early 1960s, increased regulatory attention has been placed in the benefit–risk profiles of medicines. This key-event has lead to not only demands on safety demonstration before registration of a medicine, but also to demands in regard to demonstration of efficacy, i.e. the effectiveness of a medicine under controlled conditions.

Benefit–risk assessment in medicine is highly regulated and has been developed for decennia. Benefit–risk assessment (and monitoring) takes place both in the pre-registration and the post-registration phase of a medicine. In the pre-registration phase, the candidate medicine goes through a process of phase I–III trials, involving populations of increasing size and different aims and designs as discussed in the state of the art paper. These clinical trials are conducted by the manufacturer and involve a considerable financial investment. Trials will only be continued if the manufacturer feels the drug stands a chance to successfully gain marketing authorization by sufficient proof of efficacy and safety. Data gathered by these clinical trials, reinforced by animal model data and possible post-marketing experience with similar compounds, will provide the safety and efficacy data for the marketing authorization procedure. The pre-marketing clinical trials have been criticized for being designed for fast approval instead of the generation of scientific knowledge. A number of mainly quantitative benefit–risk methods are employed during the pre marketing phase, including 'number needed to treat' and 'number needed to harm'. Expert opinions play a big role in benefit–risk assessment of medicines, both pre-registration and post-registration. There is no standard protocol for analyzing the benefit–risk profile of a drug, after the manufacturer submits the clinical trial data, responsible authorities will take the evidence into account and form an expert opinion on the registration submission. Both the benefits (efficacy) and the risk (adverse drug reactions, ADRs) play a role in this expert opinion: larger benefits can justify larger risks. No consensus has been reached on a standardized methodology for benefit–risk assessment in medicine registration. The European Committee for Medicinal Products for Human Use recommends the use of multiple types of mainly qualitative, benefit–risk methodology and argues that use of quantitative methodology can lead to a misleading feeling of precision.

2.2.1. *Pre-registration*

The pre-registration clinical trials themselves suffer from a number of practical limitations; these include the small number of subjects in clinical trials, a restricted population in terms of age, gender and ethnicity, restricted co-medication and co-morbidity, a short duration of exposure and follow up and statistical problems with assessing multiple outcomes. These problems are acknowledged by the responsible authorities. Because the clinical trials take place in a controlled environment, situations of off-label use, drug–drug interactions and non-compliance will be limited to theoretical consideration. Therefore, clinical trials will provide information on the efficacy of a medicine, rather than effectiveness of a medicine. Despite the differences between efficacy and effectiveness, efficacy will provide an indication of effectiveness of a drug. It should be realized there is no solution for the majority of these problems. For example; it would be ethically unacceptable to conduct safety experiments in pregnant women. Experience in this population will be limited to animal models and post-registration data.

During the application process, a risk management program will be submitted along with the clinical trial data, outlining risk minimization and post marketing surveillance activities.

2.2.2. *Post-registration*

After registration, the benefit–risk profile of medicines will be monitored by post-marketing surveillance. Pre-marketing knowledge on the benefit–risk profile of a medicine will be limited for reasons mentioned above. Post-marketing surveillance is conducted by responsible authorities, marketing authorization holders and independent researchers in order to collect data on ADRs and monitor the effectiveness of existing risk management activities. In case a new ADR is discovered, responsible authorities can reassess the benefit risk profile forming a new expert opinion. Information discovered during post-marketing surveillance can lead to modification of marketing authorizations, risk management programs or even suspension of marketing authorizations in the case of serious ADRs. Many recent developments and initiatives are currently ongoing in post-marketing surveillance, many of them involving large databases to collect information on ADRs. The more statistical power, the better the investigators are able to detect ADRs. For this reason, an increasing amount of international cooperation is taking

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place in Europe. Other problems include different legislation between European countries.

A different type of benefit–risk assessment in the post-registration phase is Health Technology Assessment (HTA). In HTA, the health impact and economic impact of a new health technology are assessed using (economic) modelling techniques, usually in order to be included in public formularies. The main challenge of HTA is to assess the trade-offs between financial investment and health benefits. For this purpose, indexes such as QALY and DALY have been developed. The trade-off between financial investment and health benefits is perceived as controversial by many. Marketing authorizations have become less meaningful without reimbursement (after a positive HTA assessment) in many countries. The mandate and methodology of HTA agencies differ between countries.

The state of the art paper concluded that no 'one size fits all' approach is available for benefit–risk assessment in medicines. Choice of methodology depends on the context of the benefit–risk assessment, including indication, patient groups and the stage of the regulatory process. Also, use of multiple methodologies is encouraged due to each having its own specific strengths and weakness. Furthermore, improved cooperation between responsible authorities and HTA agencies can be of value in benefit–risk assessment.

2.3. Benefit–risk analysis in Food Microbiology (Magnússon et al., 2011)

Microorganisms, i.e. bacteria, fungi and viruses, are all constituents of our natural environment. The field of food microbiology concerns the multitude of microorganisms that inhabit and contaminate our foods. Food and nutrition are essential for sustaining human life. However, no food carries zero risk for microbiological hazards. The risk varies considerably depending on food types and matrices. Some foods have a higher risk than others of containing microbiological contaminants and pathogenic microorganisms that can be hazardous to our health and well being. Furthermore, consumer sub-groups can be variably susceptible to foodborne infections and intoxications; the elderly, young children and individuals with underlying diseases being more at risk.

Food microbiology is largely focused on food safety and limiting public exposure to harmful foodborne pathogens. However, the great majority of microorganisms are harmless to our health and many microorganisms are even important to various food production processes e.g. the making of cheese, wine, beer and bread. Microorganisms are used in various ways for the benefits of humans e.g. through advances in medical technology, biotechnology, agriculture and in food processing, to name a few. Although microorganisms can be seen as indirectly beneficial to human health through the above-mentioned activities, the human health consequences of microorganisms in foods are often either neutral or adverse. In food microbiology the reduction in human exposure to foodborne pathogens can commonly be regarded as the main public health benefit. Probiotic microorganisms and the activities of the gut microflora can be mentioned as an exception to this – the effect of probiotics can be seen as *directly* beneficial to human health. It must be noted, however, that to date all such probiotic health claims have been refuted by the European Food Safety Authority (EFSA, http://www.efsa.europa.eu/en/topics/topic/article13.htm); currently, there is lack of evidence for the direct beneficial effects as judged by EFSA's criteria, but at the same time there is lack of evidence that beneficial effects do *not* exist.

Benefit–risk analysis is a relatively new and to-date largely undefined field of research within food microbiology. The benefit–risk analysis approach is concerned with issues affecting public health and improving public health management based on the balanced weighing of risks and benefits. From a food microbiological standpoint studies using methods that balance risks and/or risks and benefits using composite metrics are scarce. Published studies to date have mainly been intervention assessments or risk comparison studies that apply risk assessment criteria for comparing the level of two individual risk factors – with the purpose of identifying the most important health risks – commonly a chemical risk and the benefits of reduced microbiological risk. The criteria for the assessment of risks are well established within food microbiology (and are based on risk assessment criteria developed within toxicology), but at present the criteria for assessing positive health effects are not well defined.

A key issue in food microbiological benefit–risk analysis is how to address the assessment of benefits and the multidisciplinary discussion of how to aggregate risk and benefit estimates. The most straightforward approach to be used for benefit–risk analysis in food microbiology could be envisioned to follow the tiered approach for benefit–risk analysis formulated in the field of food and nutrition. Food microbiological benefit–risk analysis converges largely with that of food and nutrition. In addition, it often involves the evaluation of chemical as well as microbiological risks and benefits.

Disability adjusted life years (DALY's) have widely been opted for as a metric of choice for ranking microbiological risk, including foodborne pathogens. It can be used as the single metric for assessing both microbiological and chemical hazards and could similarly be implemented for evaluating benefits. DALY's have previously been used for assessing the global burden of disease, injury and risk factors and currently the global burden of foodborne disease is being estimated using DALY's (http://www.who.int/foodsafety/foodborne_disease/ferg/en/index3.html). Based on this extensive groundwork, as food microbiology benefit–risk analysis goes, DALY's are likely to be the common metric of choice, despite its shortcomings.

In conclusion, the field of benefit–risk analysis in food microbiology is in its infancy and the assessment criteria for benefits are not well defined. Reduced pathogen risk can be seen as the principal benefit regarding food microbiology while scientific data on direct microbial benefits are lacking.

2.4. Benefit–risk analysis in Environmental Health (Pohjola et al., 2011a)

The field of environmental health is very broad and involves significant physico-chemical, biological, technological and social complexity. Consequently there is no single state-of-the-art approach, but a multitude of approaches to assess environmental health risks and benefits have been developed for different purposes and contexts within the field. These approaches can be characterized e.g. as either regulatory or academic, depending on the context of development and application for the approach, or rather traditional or novel, depending on how strictly and narrowly the assessment scope and procedure are determined by the approach.

In comparison to the traditional and regulatory approaches the emphasis among the more novel and academic approaches is on (a) increased engagement between assessors, decision makers, and stakeholders, (b) more pragmatic problem-oriented framing of assessments, (c) integration of multiple benefits and risks from multiple domains, and (d) inclusion of values, alongside scientific facts, in explicit consideration in assessment. These tendencies can be considered as responses to the challenge of complexity within the field, but also as indications of the incapability of the currently established approaches to adequately address all aspects of this complexity. On the other hand, the all-embracing aims of the novel academic approaches may also lead to lack of clarity in comparison to the regulatory and traditional approaches, unless duly designed and implemented.

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The key issues in benefit–risk analysis in environmental health are not so much related to the technical details of performing the analysis, but rather to (i) the level of integration, and (ii) the perspective to consider the relationship between assessment and the use of its outcomes. The level of integration can range from producing health risk estimates for single substances to aggregation, weighing, and comparison of multiple benefits, risks, impacts, and costs alongside explicit account of values of those concerned. Significant differences are also brought about by whether an "assessment push" or an "information need pull" perspective is adopted. The perspective largely defines what, how and why, issues are considered in an assessment.

In the "assessment push" perspective, the issue to be assessed is defined by those responsible for the assessment, and the focus of assessment is to produce an objective estimate of the risks, benefits, etc. according to certain defined principles and means, whatever the estimate may be used for. Approaches taking an assessment push perspective thus also predetermine the possible levels of integration in terms of e.g. what phenomena are considered, whether also benefits or costs are considered in addition to risks, and what means of aggregation or comparison are used. In the "information need pull" perspective the issue to be assessed, as well as the principles and means for its assessment, is formulated according to a specified practical need. The need thus determines the suitable format of the assessment outcome, which further determines how the assessment should be made. Therefore inclusion of all relevant issues, all levels of integration, and all means of aggregation and comparison are, at least in principle, available for use as required to serve the need. Naturally, most of the approaches to environmental health assessment fall somewhere in between these extremes by incorporating aspects of both push and pull. However it can be identified that the regulatory and the most traditional, simultaneously the currently most established, approaches clearly position themselves closer to the assessment push end of the continuum.

Challenges lie in the aggregation, weighing, and/or comparison of multiple benefits and risks. For example: the use of DALY's, QALYs or euro's as general aggregate measures, incommensurability of benefit estimates aiming for avoidance of false positives and risk estimates aiming for avoidance of false negatives, and taking account of perceived risks and benefits together with "scientifically assessed" risk and benefit estimates.

In conclusion, probably most of all commonly known methods for benefit–risk analysis are applied among the various different approaches to environmental health assessment, but there is no single view to dominate the whole broad field.

2.5. Benefit–risk analysis in Economics and Marketing–Finance (Kalogeras et al., 2011)

Risk is a key component of economic behaviour. All market participants (e.g. investors, producers, consumers) accept a certain level of risk as necessary to achieve certain benefits. There are many types of risk including price, production, financial, institutional, and individual human (e.g. health-related) risks. All these risks should be effectively managed in order to derive the utmost of benefits and avoid disruption and/or catastrophic economic consequences for the food industry and market participants' wellbeing.

In (food) economics, finance and marketing-management literature, the *utility* concept (total satisfaction received from consuming a product/service) plays a crucial role in determining market participants' benefit–risk trade-offs that drive economic phenomena. This utility is often derived from outcomes such as wealth, income, profit, selling price, among others. That is, the outcome domain is a monetary one. Yet, in behavioural economics, behavioural finance, economic psychology, marketing and consumer behaviour literature, market participants may also derive utility from non-monetary outcomes by exposing a combination of cognitive and affective behaviour.

The dominant paradigm in business economics on which decision makers (e.g. farmer, food manufacturer, retailer, consumer) rely in their benefit–risk trade-offs is the expected utility model. This model is concerned with choices among risky prospects. The goal of a decision maker is the maximization of his/her expected utility. In the expected utility framework, the shape of the utility function is assumed to reflect a decision maker's risk preference. Therefore, the expected subjective utility function of any prospect reveals the individuals' attitudes towards risk. There is a continuous stream of research on decision makers' risk preferences in the fields of food economics and marketing–finance that employs expected utility models that are objective or normative, i.e. assumption and establishment of norms implying the rationality principle in economic behaviour of market-participants: maximization of their utility, by using time series and/or panel data for production, consumption, pricing levels of food products; and subjective, i.e. relaxing the rationality assumptions inherent in the normative models by using survey- and experimental-based data gathering instruments involving psychometric constructs or lotteries. Both theoretical and empirical research accounts show that decision makers can be simultaneously risk-seeking and risk-averse in different domains, implying that risk preference is context-specific.

In the context of agribusiness and food markets, concerns about food safety, quality, and nutrition have persistently been present at all levels of decision making (operational, tactical and strategic) by food producers, manufacturers, commodity traders, retailers, and consumers. However, business economic scholars are often confronted with conceptual and methodological challenges due to the unobserved and multidimensional nature of human decision making process. That is, the actual behaviour of market participants is not always consisted with the "true" level of risk that they face.

Recent research in management sciences and decision analysis argued that by decoupling the benefit–risk trade-offs of decision makers into separate dimensions a more robust conceptualization and prediction may be achieved. Specifically, market participants have two kinds of evaluation systems on which perceived and/or actual benefits of an investment or consumption object cognitively rely on: (a) *utilitarian* dimension of instrumentality and (b) a *hedonic* dimension. The first dimension refers to how useful or beneficial the investment or consumption action is. The second dimension of benefits refers to the experiential affect associated with the investment and consumption. These two dimensions are neither mutually exclusive nor need to be evaluative consistent. Similarly, risk behaviour may be decoupled into the separate dimension of *risk attitude* and *risk perception*. Risk *attitude* is formed by one's predisposition to the content of the risk in a specific market situation and reflects a decision-maker's interpretation of this risk content in a specific way, whereas risk *perception* refers to the likelihood of one's exposure to the risk content. This decoupling approach may serve as the basis for studying the decision-making process of market participants regarding food safety- and nutrition-related issues, in the light of benefit–risk trade-offs. Yet, one may recognize the challenges for operationalising such a framework, adapt it to specific decision contexts, and accounting for its dynamics.

In conclusion, the study of market participants' benefit–risk trade-offs in business economics rely on the utility concept. Although the dominant paradigm in economics is the expected utility model that has a normative nature, the behavioural study of market participants' benefit–risk trade-offs emerges. Nowadays,

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there are various and different approaches and techniques to businesses economics to identify and evaluate the benefit–risk trade-offs on institutional or individual market participants. Yet, there is no single view to dominate the whole discipline. The decoupling of benefit–risk behaviour into separate components that deal with both the utilitarian as well as hedonic aspects of benefits and risks may offer more robust conceptualizations and predictions for studying benefit–risk trade-offs in various highly uncertain decision contexts entailed in the agribusiness and food markets.

2.6. Benefit–risk analysis in Consumer Perception (Ueland et al., 2011)

Food and nutrition are central to the survival of human beings as well as to their well-being and quality of life. However, a "nutritionally perfect life" is not necessarily consistent with consumers' feelings of how a perfect life should be which again has implications for what motivates consumers' food choice. The inconsistencies are partly the result of consumers' perceptions of benefits and risks with regard to food and nutrition and of the way consumers trade off between benefits and risks in order to maximize the outcome they prefer. Thus, by incorporating the study of consumers' perception of benefits and risks in a food and nutrition context, possible outcomes of food and nutrition measures can be better understood.

For consumers, benefit perception of food is usually more important than risk perception. The benefits are particularly related to the hedonic perspective; food should taste good, be pleasurable and fulfil expectations to an enjoyable experience. Risks, on the other hand, are more often subject to conscious deliberations and external factors, such as available information, media coverage and personal interest that contribute to consumers' risk perception.

Consumers' perception of risks is associated with mortality and morbidity and goes along two main dimensions related to; the extent that the risk is unknown, and what are the consequences of the risk. Food risks are not perceived to be as severe as are for instance risks associated with firearms or airplanes. However, some foods, particularly those that score high on the unknown dimension, are perceived with trepidation by consumers. Conversely, foods that are perceived as risky are often foods that are unfamiliar or produced by novel technologies. Furthermore, foods that are (perceived to be) highly processed are considered to be less desirable and more risky, than foods perceived to have a low level of processing. The possibility to discern what the food product is made of, or what it is derived from, contributes to a feeling of safety and to lower risk perception among consumers.

There are ways to reduce perceived risk of foods for instance through familiarising the consumer with the food, or by adding characteristics that may be seen as benefits to the food product. Increasing healthiness and enhancing taste are factors that make consumers more willing to accept the product. Adding benefits to a product does not reduce the risk itself but reduces the consumers' perception of the risk. Benefit and risk perception of foods are in many cases inversely correlated: when something is perceived as being highly beneficial, it is correspondingly perceived as having low risk. However, slightly different paths are used in the formation of these perceptions; benefit perception is based on heuristics and experience, while risk perception is largely the result of cognitive information processing.

Nutrition is one aspect belonging to food products that is normally not associated with hedonic benefits of foods. However, nutrition is accepted as an essential part of consumers' life, and health attributes of foods are perceived as benefits when diet considerations are important for the consumers. Consumers easily perceive risks belonging to malnutrition, both related to over- and under-consumption of nutrients, but consumers' may choose not to pay attention to these risks.

In conclusion, in a food and nutrition setting it is important to understand which food attributes related to perceived and real benefits and risks that influence food choice, in order to provide for an optimal diet from both a health perspective as well as from a hedonic perspective.

2.7. Contemporary regulatory context for Food and Nutrition assessment and management

The EU Food Safety legislation (http://ec.europa.eu/food/food/foodlaw/index_en.htm)(EU, 2000) is built around high food safety standards, of which the final aim is to protect the health of the consumers and to reduce the risks connected to unsafe food (van der Meulen and van der Velde, 2008).

The development of the requirements is the result of stratified legislative measures, often approved by incidents (food safety crises consequent to foodborne diseases) rather than by a systematic legislative plan. Regulation EC/178/2002 is the General Food Law, containing general provisions useful to orientate the interpreter in understanding the mechanisms and procedures to be followed in order to reduce risks related to unsafe food. The general principles of food law may be considered the top of the ideal pyramid of a regulatory food control systems. Regulations and directives have been formulated within this frame.

The aim of EU food policy is to assure a high level of food safety, animal health, animal welfare and plant health within the European market. In this sense, the General Food Law constitutes the main reference point of the EU food legislation. It applies to all stages of the production, processing and distribution of food and also to feed produced for, or fed to, food producing animals. More in detail, the General Food Law establishes the principles of risk analysis in relation to food and establishes the structures and mechanisms for the scientific and technical evaluations which are undertaken by the European Food Safety Authority (EFSA). As an exception of the general tendency to regulate risks rather than benefits, it is worth mentioning the EFSA health claims procedure under Regulation (EC) No 1924/2006, which plays a relevant role in the regulation of the benefits. Nevertheless, also in this case, we may see that the final objective of regulating benefits turns into the legislative intention to prevent risks, both connected to the functioning of the market and to the consumers' protection, if we consider that the general objective of the Regulation is to ensure the effective functioning of the internal market as regards nutrition and health claims whilst providing a high level of consumer protection (EC, 2006).

Food law, and in particular measures relating to food safety have to be based on scientific expertise. The EU has developed its own risk analysis principles in conformity with the International standards. Regulation EC/178/2002 establishes in EU law that the three phases of risk analysis (risk assessment, risk management and risk communication) provide the basis for food law as appropriate to the measure under consideration. Therefore, the General Food Law states that scientific assessment of risk must be undertaken in an independent, objective and transparent manner based on the best available science. Risk management is the process of weighing policy alternatives in the light of results of a risk assessment and, if required, selecting the appropriate actions necessary to prevent, reduce or eliminate the risk to ensure the high level of health protection determined as appropriate in the EU. In the risk management phase, the decision makers need to consider a range of information in addition to the scientific risk assessment. These include, for example, the feasibility of controlling a risk, the most effective risk reduction actions depending on the part

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of the food supply chain where the problem occurs, the practical arrangements needed, the socio-economic effects and the environmental impact. Regulation EC/178/2002 establishes the principle that risk management actions are not just based on a scientific assessment of risk but also take into consideration a wide range of other factors legitimate to the matter under consideration (see http://ec.europa.eu/food/food/foodlaw/principles/index_en.htm).

In sum, at a legislative level we may observe that the main objective is to regulate risks connected to unsafe food, rather than benefits and the balance between risks and benefits. Risk management is a procedure which involves legislative tools together with scientific expertise. The choice to regulate risks rather than benefits is deeply linked to the necessity to reduce the risks on the market by defining the tasks of the European Commission, the European Food Safety Authority (http://www.efsa.europa.eu) and the national competent authorities in charge to implement at local level the European provisions.

3. Commonalities and differences, and illustration in a case study

This section contains some of the characteristics that the different fields, described in the previous section, share in common and in which they differ with respect to benefit–risk analysis.

The general settings in which benefit–risk analyses within the different fields currently may take place are described in Table 1. The general characteristics of integrated *assessment* of benefits and risks within different fields are described in Table 2. In order to illustrate the commonalities and differences, a conceptual case example of replacing animal protein with environmentally more sustainable dietary protein is presented in Table 3. The case example described here is meant as an aid, to illustrate and characterize the different fields that form this paper. The attributes in the tables, according to which benefit–risk analysis within the different fields are described, are adapted from the framework applied for characterizing approaches to benefit–risk analysis in the field of environmental health in Pohjola et al. (2011a)) and explained in Table 4.

In Section 3.1, general commonalities and differences are described, taking the main points from Tables 1 and 2. Issues arising from the illustrative case study in Table 3 are discussed in Section 3.2.

3.1. General commonalities and differences

The purpose of benefit–risk *management* is to arrive at the optimal decision, while accounting for all relevant issues. The purpose of benefit–risk *assessment* is to provide the science-based information on the integrated benefits and the risks to support in answering the benefit–risk management question, i.e. to contribute to evidence-based decision making. The focus of benefit–risk *analysis* in the different fields is

- *Food* and Nutrition: improving public health/preventing disease by better food and nutrition and generating knowledge for food improvement or innovation and general understanding.
- *Medicines:* curing, slowing or preventing disease by means of medication and monitoring benefit–risk profiles of marketed medicinal products with or without its impact on budget.
- *Food* Microbiology: preventing foodborne disease caused by micro-organisms and generating knowledge for microbiological product innovation.
- *Environmental* Health: preventing damage to health mediated through the environment, possibly also reducing impact on economy, society and environment.
- *Economics* and Marketing–Finance: optimising public economic policies, corporate investment and marketing strategies.
- *Consumer* Perception: stimulating good food choice by using insights in consumers' perceptions, attitudes and behaviour relating to a particular case and by increasing acceptance through information, increasing familiarity, reducing uncertainty, and product optimization.

The challenges of aggregating and weighing benefits and risks are shared by the different fields. Two issues coming up in this connection are the inclusion of multiple benefits and risks with different scopes, and the explicit inclusion of subjective information. Among the fields that are considered, assessments in Food and Nutrition, Food Microbiology, Medicines and Environmental Health focus predominantly at health/disease, mostly physical health/disease (though several approaches in Environmental Health are open to also include other domains). Quantitative weighing of benefits and risks via DALYs or QALYs has been performed in Food and Nutrition, Food Microbiology, Environmental Health and in post-marketing modelling studies for Medicines. Mostly this is done within strict and relatively narrow bounds, e.g. focusing on the health effects of food compounds. In Economics and Marketing–Finance as well as Consumer Perception, health is not the centre of attention. In the latter two, human perception and behaviour is an important topic of investigation, whereas the former four strive for more 'objective' health information. However, also there, the influence of perception and behaviour is acknowledged, at least to some degree, e.g. in the form of the placebo effect and compliance to prescriptions or advice. Qualitative comparison and use of expert judgment are part of all fields, but in differing degrees. For example, expert opinions/judgments in different phases have an important role in the progress of medicine benefit–risk analysis along the early stages of drug development. In Food and Nutrition, (expert) value statements are explicitly named only in comparison or combination of benefits and risks (e.g. qualitative comparison, and disability weights). Non-expert value judgments are increasingly taken into account particularly in Environmental Health.

Another notable issue relates to differences in the valuation of benefits and the acceptability of risks, both by consumers and managers. In Food and Nutrition and Food Microbiology, chemical, biochemical and microbiological risks are not accepted, i.e. food safety issues are minimised to such a low level that risks are virtually absent (see also Section 2.7). Especially Food Microbiology is illustrative of the important role of 'risk' in public health. In contrast, in many approaches to Environmental Health and in Medicines, some risk is accepted for a greater benefit. In Medicines, risk, in the form of adverse drug reactions, is accepted for the greater benefit of recovery or of alleviation of symptoms. Also, by observing the common everyday practices, some degree of risk coming from the environment in the form of traffic, energy production, radiation, disinfection, etc. can be considered as accepted in order to meet the needs of modern society. However, the perceptions of such risks may vary significantly among policy makers and the public, and the differing perceptions may not always be backed up with well-reasoned knowledge. Moreover, in Economics and Marketing–Finance and Consumer Perception, (high) risks can be accepted if the expected benefits are higher and at least some degree of risk is accepted as necessary to bring about benefits in general. Some differences with respect to the degree in which risk is accepted and benefit is valued are illustrated in Fig. 2. With respect to Food and Nutrition, there appears to be a discrepancy: risks brought about by unfavourable nutritional quality and/or quantity of the diet (i.e. unbalanced intake of nutrients and foods resulting in deficiencies and/or chronic disease), are more readily accepted (as voluntary, right to choose) both by consumers and policy makers.

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Table 1
Current general setting for benefit–risk analysis within different fields.

Attribute[a]	Food and Nutrition	Medicines	Food Microbiology	Environmental Health	Economics and Marketing–Finance	Consumer Perception
Management question	What is the optimal decision for public health, where and how can the largest net population health gains be realised, with respect to food-related questions, e.g. - recommendation of nutrients or foods - policy for fortification - food processing methods - introduction of novel foods	What is the optimal decision for public health, with respect to - drug safety - drug efficacy - drug safety monitoring and management - drug benefit–risk balance - eligible patient populations	What is the optimal decision for public health, with respect to microbial food safety and (to a lesser extent) microbiologically mediated health benefits?	What is the optimal decision for public health when focusing on environmentally mediated direct and indirect health impacts? Can be considered in the context of other issues such as - economic impacts - equity and social well-being impacts - impacts to the environment	What is the optimal utility that market participants derive from outcomes based on benefit–risk trade-offs such as production, costs, sales, or consumption of a food product? Other issues to be considered: - cognitive vs. affective decision making - risk attitudes (RA) and risk perceptions (RP) formation - drivers of RA and RP (e.g. trust, knowledge) - utilitarian vs. hedonic benefits/gains	What is the optimal decision from an acceptance perspective (as well as from a health perspective)? Who will benefit (identification)? How can target groups be reached (communication/marketing)? Food production (taste and health optimisation)
Main problem owners and stakeholders	Policy makers (decisions), scientists (assessment)	Policy makers (decisions), scientists (evaluation), pharmaceutical companies (assessment, evaluation), agencies (evaluation, supervision), general practitioners (advice on patient level), patients (decisions)	Policy makers (decisions), Scientists (assessment)	Policy makers, industry, citizens (decisions), scientists, industry, commerce, in some approaches[b], NGOs, citizens, in some approaches anyone (assessment), industry, commerce, NGOs, citizens (evaluation)	Producers, marketers, policy makers, consumers (decisions), financial analysts (assessment of technical feasibility), marketers (assessment of economic feasibility), industry managers and lobby representatives (managerial feasibility)	Consumers (decisions, ad hoc assessment), Risk managers, marketers (communication), Policy makers (decisions)
Assessment - management interaction	Separate (physically and intellectually), but becoming more interactive	Ranges from separate to intertwined. Also depends on the stage in the marketing process	Functionally separate approaches, increasing consultation and interaction between the two	Approaches[b] range from strictly separate to deeply intertwined	Approaches range from aggregate to disaggregate. They involve ad hoc self-assessment in decision situations by consumers. More systematic assessment, often by external assessors regarding policy decisions, marketing decisions, investment decisions	Ad hoc self-assessments by consumers in decision situations, communication of both scientific and marketing information to identified target groups

[a] Attributes are explained in Table 4 and adapted from the framework applied for characterizing approaches to benefit–risk analysis in the field of environmental health in Pohjola et al. (2011a).
[b] Approach refers to different approaches to making benefit–risk assessments within the field of environmental health, e.g. health impact assessment, REACH, open assessment, etc. (Pohjola et al., 2011a).

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Table 2
General characteristics of integrated assessment of benefits and risks within different fields.

Attribute[a]	Food and Nutrition	Medicines	Food Microbiology	Environmental Health	Economics and Marketing–Finance	Consumer Perception
Assessment question	- What are the integrated health benefits and risks of (a change in) consumption of a food or food component in a particular population? What is the current state of knowledge regarding a health issue?	- What is the pre-registration risk–benefit profile of a medicine? - What is the post-registration risk–benefit profile of a marketed medicine? - What is the cost-effectiveness of a health technology in a specific population?	What are the qualitative or quantitative microbiologically mediated health risks (and benefits) associated with foodborne microorganisms and food consumption in particular populations?	What are the direct and indirect environmentally mediated health impacts of e.g. - chemicals or chemical products - policies - industrial activity - other activities - in principle anything - Approaches vary significantly in terms of their inclusiveness/exclusiveness	- What drives market participants' decision making process and hence their actual behaviour under risk? - -What drives food producers'/farmers' risk–benefits trade-offs, e.g. regarding the use of optimal level of pesticides? - -What drives consumers' risk–benefit trade-offs, e.g. regarding acceptance of unfamiliar technologies?	- What are the characteristics of food items that influence consumers' perceptions of benefits and risks, attitudes and reactions? - What is/are the target population(s)?
Measurements of risk	Increased disease risk from food or food component	Adverse drug reactions, drug–drug interactions. misuse, non-compliance	Increased disease risk from foodborne pathogens Introduction of new and emerging pathogens	Risk of compromised health due to something. Non-health risks caused by the same something	Cognitive and affective information processing regarding market participants risk attitudes and risk perceptions	Consumers' cognitive and affective information processing regarding perceived risks measured by qualitative and quantitative techniques
Measurements of benefit	Reduced disease risk or improved health state from food or food component	Disease treated, disease progression stopped or slowed by medicines or lowering of risk factor, or increased benefit/cost ratio	Reduced risk from foodborne pathogenic microorganisms. "True" benefit from beneficial micro-organisms. Benefit of microorganisms as human food source	Expected health benefits due to something. Non-health benefits caused by the same something	Effective and efficient handling of risk-bearing activities in which market participants may be engaged at the different channels of the food supply chain	Consumers' cognitive and affective information processing regarding perceived benefits such as liking, and feeling good about doing the right thing, measured by qualitative and quantitative techniques
Answer	- Quantified benefits and risks - Comparison with guidance level or risk threshold - Quantitative comparison, Integrated measures (QALY[b], DALY[b])	- Quantified benefit and risk - Integrated measures (QALY, DALY, cost, mainly in HTA) - Qualitative judgment	- Qualitative comparison of benefits and risk - Quantitative comparison using integrated measures (QALY, DALY)	- Estimates of risks and benefits. - Comparisons and/or aggregated measures. Mostly quantitative, but qualitative also possible. Approaches vary greatly in breadth of inclusion as well means of weighing and/or integration. - Mostly health risk(s) considered in the context of other factors: e.g. other risks, benefits. - Comparison of impacts of different policy options or scenarios	- Combination of qualitative and quantitative analyses of the dynamics of decision making process. - Comparison of actual vs. perceived behavioural outcomes - Accounting for the influence of the unobserved heterogeneity on market participants' behaviour of the decision context characteristics and dynamics, and behavioural anomalies that may explain several patterns/paradoxes in economic behaviours	- Description of consumer segments - Strategies for communication

(*continued on next page*)

Table 2 (*continued*)

Attribute[a]	Food and Nutrition	Medicines	Food Microbiology	Environmental Health	Economics and Marketing–Finance	Consumer Perception
Approach	Tiered approach. When needed to answer the question, and possible: quantification of benefits and risks and quantitative comparison. Software is available to support this	Highly standardized and regulated. - Qualitative assessment of benefit and risk - Delphi procedure - Modelling studies	Tiered approach has been advocated for analysing benefits and risks. - Qualitative assessment - Quantitative assessment	- Traditional: assessment is an exclusive expert process. - Regulatory: assessment requirements are determined by legislation - Novel: assessment is an inclusive social process - Academic: assessments aim for right answers and optimal solutions	- Positive approach (study on what is the real economic behaviour), using both qualitative and quantitative empirical approaches - Normative research approach (study on what ought to be the economic behaviour), using mainly quantitative analytical frameworks. - Triangulated research approaches, using a combination of qualitative and quantitative research approaches	Identification of relevant consumer segments, using a combination of qualitative and quantitative research approaches

[a] Attributes are explained in Table 4 and adapted from the framework applied for characterizing approaches to benefit–risk analysis in the field of environmental health in Pohjola et al. (2011a).
[b] Should include separate presentation for all benefits and risks and for population subgroups, and address uncertainties.

The field of Medicines stands out by being aimed at a single product or technology, which is tested within a controlled environment (pre-registration); the situation in 'real life' (e.g. interference from other medication or from food, low compliance) can be observed only after market approval. In all phases of the life of a medicine, the benefit–risk balance can be different. The benefit–risk balance can also change during the life of an individual. Within Medicines, as well as Consumer Perception, there is a stronger individual basis than in the other areas.

Notable in Environmental Health is the development towards more interaction between all those who are in some way related to the process (assessors, managers, industry, NGO's, and citizens) and to let actual problems drive analyses. In Food and Nutrition, increasing engagement between assessors and managers is recognized to be valuable, but presently there is virtually no role for stakeholders in assessment.

3.2. Illustrative case example

The case example presented here (Table 3) to illustrate Section 3.1 from a practical viewpoint deals with dietary protein sources, in particular the effect of replacing less sustainable sources with more sustainable sources. Protein and the amino acids that build protein are important, as they form the body's system of structural and functional elements that exchange nitrogen with the environment and have many other functions (Millward et al., 2008; WHO, 2007). Converting plant protein sources into animal protein sources is relatively inefficient and negatively affects the ecosystem when applied on a large scale (FAO, 2006). With the increasing world population and the net increased affluence, the consumption of animal protein is increasing. Without policy action, the ecosystem is overly pressured and food security is endangered. Alternative protein sources, with less impact on the ecosystem, are known. They include plant sources, algae, insects and cultured meat. The aim of the benefit–risk assessment is to support well-informed policy making with respect to a protein transition by providing the best available science.

From Table 3 it can be seen that the fields of Food and Nutrition, Medicines and Food Microbiology have a rather tight focus, whereas the fields of Environmental Health, Economics and Marketing–Finance and Consumer Perception apply broader scopes in their assessments. Especially in the latter two the effect on health/disease is only one of many considerations in the broader implications that a shift in focus from animal to plant protein has. Table 3 also shows the different types of measurements and approaches used to answer the assessment question.

Furthermore, the case study shows that a successful protein transition, even when a net benefit is supported in terms of health and sustainability, co-depends on consumer perceptions and actions in terms of its actual realization. Sustainability and health are, for a large segment of consumers, less important drivers of food choice than e.g. the liking of animal protein rich products. For alternatives to be accepted, some criteria will have to be considered, among others: taste, expense, use of technology/naturalness, and trust. Marketing and communication strategies will be essential in creating acceptance. However, if long-term net benefit is to be achieved, there is also an essential role for the authorities in actively 'making the healthy and sustainable choice the easy choice' and implementing necessary regulations towards food industry.

From the regulatory point of view, the eventual choice to shift to dietary protein sources that are more sustainable than the current animal products should not constitute a further burden for the legislator. In case new products are being introduced, the general framework to regulate risks connected to these products remains the General Food Law and in particular the Novel Foods Regulation (EC 258/97).

Table 3
Illustration of the commonalities and differences between fields by means of a conceptual case example – replacing animal protein sources with more environmentally sustainable protein sources.*

Attribute[a]	Food and Nutrition	Medicines	Food Microbiology	Environmental Health	Economics and Marketing–Finance	Consumer Perception
Management question	- What is the net public health consequence of promoting and facilitating the consumption of sustainable protein sources? - Do certain subgroups require special attention?	- What impact on medical treatment does promoting and facilitating the consumption of sustainable protein sources have? - Do certain subgroups require special attention?	- What is the net public health consequence of promoting and facilitating the consumption of sustainable protein sources? - Do certain subgroups require special attention?	- What is the optimal way of reducing the environmental burden of animal protein containing food item production, in combination with optimal nutrition? - Do certain subgroups require special attention	- How can an effective and efficient economic decision be made regarding the shift of food production focusing on plant protein methods? - How can such food items be marketed effectively?	- How can food industry managers and policy makers assess, predict, and explain the impact of consumers benefit–risk perception on implementation and success of a shift in focus from animal to plant protein?
Assessment question	What are the weighted effects on nutrient adequacy and population health when changing to: - Higher dietary contribution of old and new plant foods and lower dietary contribution of meat and dairy. - "new" dietary source, e.g. insects; In differing degrees (scenarios)?Special attention for those with special needs, such as children	What is the benefit–risk balance of substituting animal proteins with alternative protein sources? - Who benefit from which positive health effects? - Who are at risk from which adverse health outcomes? - Is there a need for any post-marketing commitments of management plans?	What is/are - the weighted effects when substituting animal proteins with alternative protein sources, with respect to - microbiological health risks/benefits of alternative protein sources? - increased/reduced exposure to foodborne pathogens? - food safety of protein from microorganisms (single cell protein) for human consumption? - risk of new and emerging pathogens from new food production processes and/or alternative protein sources?	What is the health impact of changing animal protein to other protein sources? Both direct (via food) and indirect (via e.g. environment and societal change) health impacts are considered. Ecological and other impacts should be known for overall conclusions, but they may be assessed elsewhere. Options may also be assessed according to their environmental (ecological) impacts in order to weigh and compare their overall net benefits	- What drives consumers' willingness-to-pay for sustainable food products? - Evaluation of knowledge, experience, attitudes and perceptions concerning advantages/benefits and disadvantages/risks, and socio-economic and demographic information	In what way may a shift in focus from animal to plant protein be acceptable and for whom? How is the topic understood? What are preferable options, and why are these options preferred?
Measurements of risk	- Nutritional status, e.g. reduced iron, vitamin B12, calcium; - Morbidity and mortality, e.g. increase in allergy; e.g. soy, lupin, other new protein; insect poisons	Morbidity and mortality; e.g. increase in allergy, interaction between phytonutrients and medication	- Morbidity, and mortality. - Increased exposure to pathogens during storage of plant foods/insects e.g. mycotoxins, grain molds, spoilage organisms, foodborne pathogens. - Increased exposure or introduction of new pathogens	Health impacts of diet change, actual vs anticipated diet changes, pollutants in diet, possible health impacts of ecological changes	Consumers' rejection, perceived unnaturalness, alternative choices, buying behaviour, measured by qualitative and quantitative techniques	Consumers' rejection, perceived unnaturalness, alternative choices, buying behaviour, measured by qualitative and quantitative techniques
Measurements of benefit	- Nutritional status, e.g. reduced saturated fatty acids, increased vitamin C, folate, phytonutrients - Morbidity and mortality, e.g. reduced obesity, CVD	Morbidity and mortality, e.g. reduced obesity, reduced CVD; influence of reduced protein load, indirect influence on antibiotics resistance	- Reduced morbidity and mortality due to decreased exposure to foodborne pathogens. - Microorganisms as an alternative source of protein/food	- Health impacts of diet change. - Also non-health benefits such as use of land, water, energy; emission of greenhouse gasses; biodiversity	Ethical, environmental and health matters measured by qualitative and quantitative techniques	Ethical, environmental and health matters measured by qualitative and quantitative techniques
Answer	- Incidence of nutritional deficiencies and improved nutritional status - (net) incidence of CVD, cancer - DALY[b], QALY[b]	- Predicted preventions of CVD and other benefits, Number needed to treat to achieve a single beneficial outcome. - Predicted risks. Number needed to harm to achieve a single adverse health outcome.	- Incidence and morbidity of foodborne disease e.g. using DALY. - Health benefits of increased access to alternative source of protein ("single cell proteins", SCP)	- Incidences of health impacts, possibly summarised as e.g. DALYs. - Ecological and other impacts presented and discussed. Comparison of health and other impacts is done possibly qualitatively or quantitatively, using e.g. monetarisation	- Predictions of consumer reactions - Description of agribusinesses' risk–benefit trade-offs with respect to their corporate socially responsible behaviour: sacrificing monetary benefits with the aim to promote/produce socially, economi-	- Predictions of impacts of benefit–risk perceptions on consumer behaviour. - Identification of drivers for acceptance and how they should be presented for the consumers

(*continued on next page*)

Table 3 (*continued*)

Attribute[a]	Food and Nutrition	Medicines	Food Microbiology	Environmental Health	Economics and Marketing–Finance	Consumer Perception
		- Weighting of benefits and risks and assessment of needs of risk management and/or risk minimization			cally, and environmentally sustainable and healthy products/services that benefit society as a whole	
Approach	Tiered; - identification of benefits and risks of change to more plant foods and/or insects - exposure scenarios: substitute meat and dairy based meals in actual food consumption data - comparison of nutrient intakes with guidance values - quantification of benefits and risks, e.g. using literature for dose–response relations on animal and plant protein - integration of benefits and risks into common measure	Tiered approach.Identification of benefits, risks and risk groups. Assessment of need for risk management and/or risk minimization	- Identification of microbiological risks of alternative protein sources e.g. insects, plants, SCP. - Comparison with microbiological risk of conventional protein sources e.g. meat, dairy products. - Integration of risks and benefits	Traditional and regulatory approaches do not suit well in this complex case. Instead, novel, inclusive approaches could be used. This would mean e.g. an open participatory process using quantitative models that are developed, shared, and discussed in the Internet	- Normative Approach: maximization farmers' benefits e.g. when using biological pest controls, hedging strategies, insurance products, based on axioms and norms; - Positive Approach: - Predict and explain consumer preference structures for intrinsic versus extrinsic quality cues of sustainable food products	- Increase availability and information about of best product alternatives - Increase knowledge of best choices for different target groups - Enhance visibility and knowledge of benefits - Reduce impact of perceived risk through information

[a] Attributes are explained in Table 4 and adapted from the framework applied for characterizing approaches to benefit–risk analysis in the field of environmental health in Pohjola et al. (2011a).
[b] Include separate presentation for all benefits and risks and for population subgroups, and address uncertainties.
[c] This case example is meant to illustrate more tangibly what is described in Tables 1 and 2; the topic was considered suitable because it is inherently multi-disciplinary and currently of global interest.

4. Opportunities for Food and Nutrition benefit–risk analysis

In this section we discuss how benefit–risk analysis for food and nutrition may improve from looking at other research areas. A number of issues that require further attention in Food and Nutrition have been identified (Tijhuis et al., 2011). To name some key issues:

Paradigm. In the contemporary benefit–risk analysis paradigm (Fig. 1), assessment and management are marked entities. Communication and some degree of interaction, though acknowledged, may not currently receive the attention they deserve, both within and between the analysis components. In addition, management of public health in Food and Nutrition is currently still very much focused on risk and aimed at identifying numbers below which intake is presumed to be safe.

Data. The arms of the benefit–risk assessment paradigm are not symmetric; they currently serve different goals (i.e. to demonstrate presence of benefit and absence of risk), they are built on different methodologies, they are rooted in different research traditions, etc. For a benefit–risk analysis in Food and Nutrition it is essential that quantitative data on beneficial and adverse effects are available, covering the relevant exposure and target population. For many foods and ingredients this is currently not available. A fundamental difficulty in this is the translation of dose and effect found in animal studies to the human situation. Apart from this species issue, lack of dose–response data is also a problem for human studies. There are several possible reasons for this, not always easily solvable: performance of studies in humans is expensive, is ethically not acceptable or scientists are not used to quantifying or presenting dose–response information; also, in benefit assessment the legal situation is new.

Context and implementation. Besides issues relating to assessment and comparison of benefits and risks, there is currently often no explicit consideration of which benefits and risks should be considered in different contexts and why; and whether only health risks and benefits induced by foods and food ingredients are sufficient in light of the practical uses of the benefit–risk analysis results. With respect to outcomes in the form of advice, there is a discrepancy between results from assessment of benefits and risks in the form of advice, and consumers' behaviour. Input of the public and other more specified stakeholders into assessment and management, to drive the analysis or to find solutions, is currently not common.

Below, these issues are addressed further in the form of concepts and practices from other fields that may be incorporated (more) in Food and Nutrition benefit–risk analysis.

4.1. Paradigm

4.1.1. Increased engagement and communication between assessors, managers, and stakeholders

Thus far, benefit–risk analysis in Food and Nutrition has been building on (the clearly demarcated) assessment and management, and virtually no role has been provided for stakeholders in these processes. However, the experiences from other fields indicate that more intimate interaction between assessors, managers, and stakeholders is essential for effective implementation of existing and available knowledge. This would take form in assessors, managers, and stakeholders in the field of Food and Nutrition each having their specific roles and responsibilities while engaging in the shared process of developing and applying knowledge (Fig. 3). Increased engagement can enhance e.g. clarity of the relevance of assessment questions and applicability of assessment results as well as acceptance of the outcomes of their practical implementation.

Table 4
Explanation of the attributes applied in Tables 1–3.

Attribute	Explanation
Management question	The public issue that is to be addressed
Main problem owners and stakeholders	Those responsible for or involved in the analysis
Assessment-management interaction	The nature of the relationship between management and assessment
Assessment question	The issue that is to be addressed and requires an answer
Measurements of risk	The types of exposure and effect measurements used to characterize the risks
Measurements of benefit	The types of exposure and effect measurements used to characterize the benefits
Answer	The kind of information produced to answer the question
Approach	The main characteristics of the way the assessment is executed

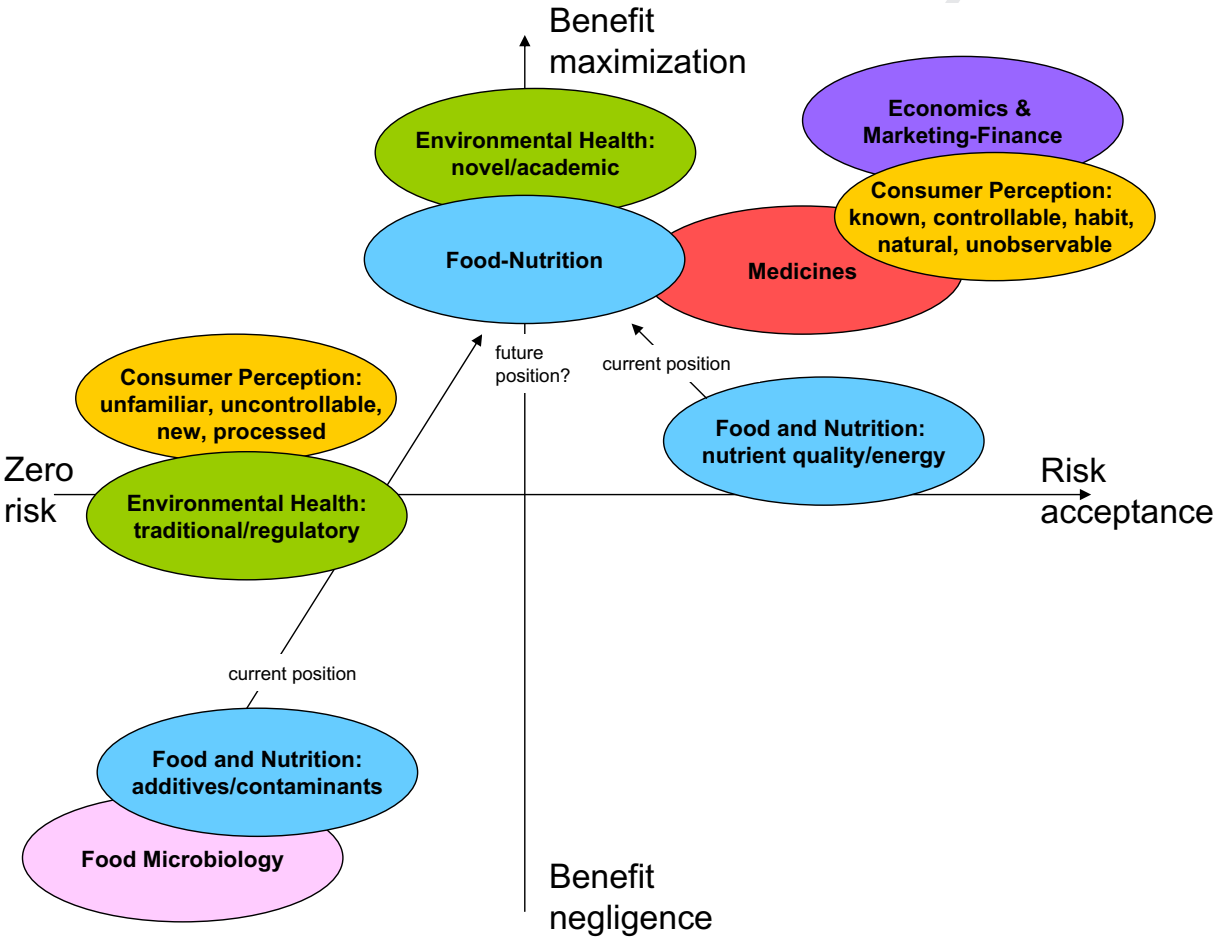

Fig. 2. Acceptance of risk and valuation of benefit within the different fields. Location of each node represents a stereotypical approach to benefit–risk analysis within a field. Fields with great variation regarding acceptance of risks and valuation of benefits are described as two stereotypical approaches representing two extremes within the field.

Communication is (increasingly more) important between all those involved in the analysis: next to a role for professional communication specialists to address the stakeholders/general public, the assessors and managers could benefit from increased communicational skills between and amongst them, to result in a shared understanding of science and values (Fig. 3). Standardized forms, formats, practices, and procedures can be helpful in facilitating communication e.g. by allowing participants in the analysis to focus on the content instead of the format or by making the general public more familiar with risk and benefit information. However, the standardized formats and practices should not be made too strict and coercive, yet be flexible enough so that they can adapt to changing needs and contexts. For example, the information structure of Opasnet, a web-workspace for conducting open assessments, provides a universal information structure that is applicable for describing any kinds of phenomena, but allows quite free formatting of the actual substance of the descriptions (Pohjola et al., 2011b). Another example is the web-based QALIBRA software for quantitative benefit–risk assessment in foods. The software is web-based and free to users after completing a short online training session (www.qalibra.eu). It provides a consistent conceptual framework to help think about, organise and execute risk–benefit assessment, and optional sharing and discussion of assessments and data with other users.

4.1.2. More pragmatic problem-oriented framing of assessment

One of the aspects that can be enhanced by increased engagement, as also mentioned above, is framing of assessments and formulation of assessment questions to better serve the practical needs of those who (are intended to) use the assessment results in practice. Although purely curiosity-driven question setting is defendable in traditional science, assessments may better be

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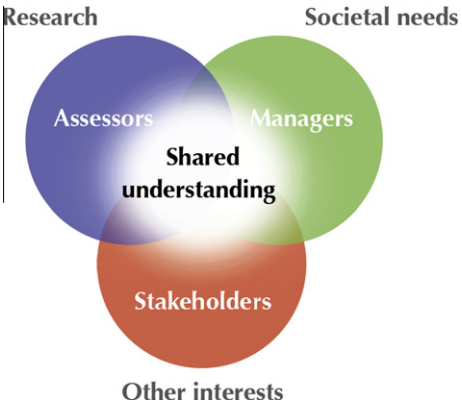

Fig. 3. A new framework for benefit–risk analysis emphasizing increased communication and engagement. Creation of shared understanding based on both science and values is at the core of the joint knowledge process. Communication is essential during the whole process of benefit–risk analysis. Stakeholders are explicitly acknowledged as participants in the process.

considered as processes of applying scientific means and knowledge for practical problem solving, and thus adopting a demand-driven pragmatic approach. In order to achieve this, incorporation of decision makers as well as stakeholders, e.g. consumers and industry, in analysis is necessary.

Along this line, in most cases food products that consumers actually ingest (whole foods) may be more relevant objects of benefit–risk than mere isolated food ingredients or substances in food. Also, in addition to looking at only the health risks or benefits of the food itself, the rest of the food pattern should receive some attention to be practically useful.

4.1.3. Accepting some risk: inevitable inter-linkage of risk and benefit

Risk is omnipresent, but it should be realised that so is benefit. Risk and benefit go together. Policy aimed at the combination of minimizing risk and maximizing benefit may result in a net higher benefit for public health than policy aimed at minimizing risk only (van Kreijl et al., 2006). This approach implies accepting some level of risk. Or, from a positive perspective, it means acceptance of taking benefit into explicit consideration. This will not only result in more informed public health decisions, but also create more public support and understanding of the broader picture within which decisions are made. Where the optimum for health lies needs to be assessed on a case by case basis, addressing also the needs and context of each specific case (see Section 4.3).

4.1.4. Pre- and post-market analysis of benefits and risk of food products

Based on the experiences from the medical area, both pre- and post-market analyses could be required for certain food products. A pre-market assessment may be conducted by the producer of relevant foods or food ingredients (and evaluated by independent authorities), prior to market introduction, to address benefits and risks according to the current knowledge level. A post-market analysis (also termed 'postlaunch monitoring' (de Jong et al., 2007) and 'post-market monitoring' (Hepburn et al., 2008) would engage all stakeholders, in particular authorities, with inputs from consumer organisations, science and industry. Post-market analyses may be triggered whenever new important evidence is gained, thus resulting in a follow-up over years. (Passive) surveillance systems can form the first step in identifying signals of potentially unknown risks. In addition, surveillance systems can also follow up on beneficial physiological effects of food or food ingredients (de Jong et al., 2007) and can be used for evaluation purposes: did a benefit–risk advice or decision have effect? Such post-market effectiveness monitoring may form an elegant and desirable addition to the health claims area (de Jong et al., 2007; Hepburn et al., 2008). This post market effectiveness monitoring could be part of a dynamic and pro-active management plan where there is feedback between public health efficacy, management and manufacturers.

4.2. Data

4.2.1. Explicit communication of the assessment purpose, input and output

If benefit–risk analysis intends to achieve its goals of improving public health through the realized net benefits of consuming food products, it needs to produce explicit messages of their benefits and risks as well as the factors that influence them. There is ongoing discussion regarding the common currencies being developed and applied for aggregating and communicating multifaceted health and other outcomes (Tijhuis et al., 2011). One area of research that is still open is how to better take account of above average health states within the aggregated measures, e.g. quality weights. Also, the long-accepted definition of health (WHO, 1948) is now increasingly being debated to include the ability to adapt (Anonymous, 2009; Huber et al., 2011).

Often it is advisable, if possible, to use more than one outcome measure, for example DALY and cost effectiveness. This will also show the broader perspective that surrounds each case, and may prevent or lower a false sense of security that quantification of complex issues in one measure may give. Finding optimal (combinations of) aggregated measures is important, however, it may be even more important to consider how to best explicate the essential aspects of the information produced in the analysis in different situations and contexts.

It needs to be realized that all models are inherently false if the goal is to 100% reflect reality; they can be useful, however, when used and interpreted in the right way. Some input into the models is surrounded by more uncertainty than other. This can be at least evaluated by sensitivity analyses or value of information analysis (Saltelli and Annoni, 2010; Tuomisto et al., 2004). The uncertainties can be made explicit. Some uncertainties may not be very important for the outcome. Uncertainty is more important for the parameters that drive the outcome, or in other words: that form the basis for the ultimate decision. It also needs to be realized that different expertises are involved and required in creating the output, such as mathematicians, nutritionists, toxicologists, medical doctors, etc. Increased interaction between disciplines and domains will optimize the modeling, the input the models require and their interpretation.

4.2.2. More human (dose–response) data and more efficient use of human data

Human data are more valuable than animal data for assessing both benefits and risks, as there is no need to extrapolate/translate dose, effects and physiological differences. Human data, however, are also less available: they are often more expensive and more difficult (sometimes impossible) to obtain than animal data. On two accounts, however, benefit–risk analysis could benefit relatively easily from data that already exists or is conveniently available.

Firstly, researchers often can present more quantitative data in their publications. For example, when presenting a group risk covering a range of exposures (e.g. a quartile), information on exposure and its variation can be included.

Secondly, human data can also be obtained in the post-market phase for products for human use (see also Section 4.1). Obtaining data in the post-market phase has advantages. It allows real-life information to be incorporated into the assessment, such as compliance, compensation behaviour and real-life effect size. Also, it benefits from high numbers compared to pre-market data.

Experience in Medicines has also shown limitations of post-marketing surveillance, however, such as reporting bias and selection bias. In the social sciences there is a new trend to actively let consumers participate in data generation, in the form of creating panels to obtain research data. It may be informative to follow this development.

As the availability of applicable data is hampering the use of benefit–risk analysis in Food and Nutrition, it may be relevant to establish a database on benefit and risk data and research to promote and coordinate its further development. However, selective reporting should be prevented and thus a system of registration before execution of the assessment (as required in the clinical trial database) would have to be considered.

4.2.3. Distinguishing physiologically different populations within the consumer population

As in Medicines, where the dynamics of the benefit–risk profile throughout the life cycle is recognized, some researchers in Food and Nutrition are also developing towards a more inter- and intra-individualised approach. For example, in the window of benefit approach, inter- and intra-individual variation is explicitly taken into account (Tijhuis et al., 2011). One disadvantage of population health measures is that its effects are not always visible for individuals (prevention paradox). This could be overcome by a more individualised approach, which may have an additional psychological advantage of increased compliance. Difficulty is that the more a subgroup approaches the individual (i.e., $n = 1$), the more difficult it becomes to show the effectiveness of a measure, using traditional statistical methods.

In some cases, benefits and risks apply to different population segments. For example, by fortifying a staple food with folic acid, the children of women in the 1st trimester of pregnancy (the target group) will benefit from the risk reduction of neural tube defects, but other groups may also be affected (and not always favorably) (Hoekstra et al., 2008). Both an opportunity and a challenge lie in specifically targeting the population groups that benefit most from the food product.

4.2.4. Explicit consideration of value judgments in assessment

Value judgments, based e.g. on opinions, interpretations and perceptions, have an important influence on decision making and behaviour e.g. by food safety managers, food producers, marketers and consumers. Therefore, identification and understanding of the values that drive e.g. decisions of managers and behaviour of consumers need to be explicitly taken into account in systematic assessment alongside scientific facts. This is essential for the assessments to serve the practical needs of decision making. This is not to say that subjective value judgment could replace systematically obtained research-based data and information in assessment (though assumptions, choices and interpretations are actually already an integral part of obtaining the objective quantitative data, and the use of assessment results is subsequently guided by subjective opinions in policy making). But it can complement scientific knowledge by making it more coherent, relevant, and applicable. For example, in the context of the case study (Table 3), a good benefit–risk assessment must systematically consider the differing value judgments regarding e.g. the importance of environmental protection, biodiversity, human health, personal preferences about different foods, and cultural traditions that relate to the issue of replacing animal protein with protein from other sources in the diet. Failing to do so would likely result in assessment outputs that are of little value in practical decision making. Value judgments are thus relevant and valuable input to the science-based assessments as parts of effective benefit–risk analysis.

4.3. Context

4.3.1. Integration of multiple benefits and risks from multiple domains

Integration of multiple benefits and risks from multiple domains is an essential means for achieving enhanced applicability of assessment results. Most often, a reductionist approach to benefit–risk analysis, focusing on narrowly bound problems, is not adequate for serving practical real needs that do not obey disciplinary boundaries. Therefore, assessment and management should allow for broad integration of both benefits and risks from multiple domains, according to needs. By taking a holistic view of benefit–risk analysis at an early stage, decisions on which scientific areas should be included in the benefit–risk analysis will focus the assessments. Not all other factors can be integrated into a common measure and aspects of health may remain in the focus of the process. However, they can be placed within a reasonable context, or bigger picture, provided by the other aspects to be considered. For example, benefit–risk assessment on fish consumption can show that benefits prevail over risks, but consideration of sustainability issues or consumer preferences may steer the analysis towards inclusion of farmed fish raised on sustainable feed or alternative non-fish sources.

The importance of integration and contextualization is also illustrated by the case study in Section 3.2. In the field of Food and Nutrition, dealing mostly with health, it can be quite relevant to consider also consumer perception and behaviour, ethics, environment, industry interests, etc. It should be noted that the relevance of context is already part of the principles of Food Law as "other legitimate factors" http://ec.europa.eu/food/food/foodlaw/principles/index_en.htm, making room for consideration also of benefits. However, good documenting of the factors and practices to incorporate them are still lacking.

4.3.2. Explicit recognition of the impact of consumer beliefs, opinions, views, perceptions, and attitudes on behaviour

Consumers are an essential stakeholder group regarding food and nutrition. In the process of benefit–risk analysis of Food and Nutrition, it needs to be taken into account in what direction and to what extent food and nutrition aspects may influence consumer behaviour. This includes studies on human decision making, on behaviour of market segments and on benefit–risk tradeoffs in these groups. Alongside benefit–risk assessment on a physiological level, consumer characteristics such as perceptions or values can be measured in order to correct for differences between consumers or target groups in how they behave with respect to the problem. For example, in the case of monosodium glutamate (MSG), concerns by consumers and consumer groups about MSG consumption (Freeman, 2006; Williams and Woessner, 2009), influenced by commonly available non-scientific information, override scientific knowledge (Singh, 2011) to the extent that food industry has begun reducing or removing MSG from their products (http://www.toro.no/index.php?mapping=344; http://www.unilever.com.vn/brands/foodbrands/knorr/index.aspx). Whether or not the consumer behaviour in this case can be backed up by Food and Nutrition research results, recognition of its existence and understanding of its basis and impacts is important in assessment as well as decision making by food safety managers, consumers, producers, marketers and other stakeholders. Consumer studies can qualitatively and quantitatively assess consumers' compliance with advice and why benefits and risks are acted upon in different ways, both cognitively and unconsciously. The data thus provided can be used as feedback in the benefit–risk analysis, to overcome the difficulties associated with the traditional science-decision-communication approach. Just as *a hazard is not a risk until there is exposure, a food is not healthy until it's eaten*. An important contribution of consumer research to benefit–risk analysis in food and

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nutrition is particularly related to how to implement measures to achieve the best effects. Identification of relevant target groups and formulating communication strategies that work, are major aspects that could benefit the goals of benefit–risk analysis in food and nutrition. From a management perspective, taking consumers' view-points into account is relevant in the implementation phase when the aim of the benefit–risk analysis is to provide advice, directions or action plans. Specifically: in case consumer's view-points are not in conformity with current scientific insights, risk managers should strive for means of an appropriate consumer information and education.

4.3.3. Segmenting market participants behaviour

Differentiation of sub-groups can take place in terms of physiological characteristics, as addressed before, but also in terms of their cultural, cognitive and behavioural characteristics.

The segmentation criteria for grouping the behaviour of market participants depending on whether the food offering is aiming to reach the end-user (e.g. consumer) or another business are different. The more typical criteria for segmenting prospects at a corporate business level usually entail the industry type, the size of the corporation, e.g. in terms of revenues or employees, time-related factors, access to competitive offerings, and the need for customization, among others. The criteria that are often used to group the behaviour of individual market participants (e.g. consumers) may include demographics, cultural-, economic-, religion-related, social-status, accessibility to food offerings, and avocation-related interests, among others. Yet, once the identification of specific segments has been achieved, there is a series of subtle influences on the buying behaviour such as the beliefs, views, concerns, attitudes, perceptions, information needs, brand awareness, and commitment to specific values and business operations of market participants. That is, a series of unobservable (e.g. latent) factors may influence the purchasing behaviour and/or decisions of different segments of food producers, wholesalers, retailers, managers, and consumers. Moreover, the differing preferences of market participants that are attributable to their heterogeneous desires and varying wants may be driven by several unobservable factors often referred in the academic literature as *behavioural anomalies*, such as humans' *personality traits* (e.g. need for cognition, ambiguity, need for certainty, risk-aversion, loss-aversion, myopia, overconfidence) or *heuristics* (i.e., rules of thumb) that lead people to find things out for themselves, usually by trial and error.

The consideration of a heterogeneous food market as a number of smaller homogenous food markets, highlights the diversity in market participants attitudes, perceptions and preferences and their driving forces. This view reflects the market-orientation of the food industry. Such an orientation is essential if segmentation of market participants' behaviour in the agribusiness and food markets may be used as one of building blocks of effective food and nutrition policy-making and marketing-management planning.

5. Conclusions

The BEPRARIBEAN project has looked into benefit–risk analysis within six different, but somewhat interrelated, scientific fields. The main findings of the project are described in the previous sections, particularly in the form of the key messages in the section 'Opportunities for food and nutrition benefit–risk analysis'.

While looking into benefit–risk analysis from different scientific perspectives we realized that different fields are facing similar problems. All fields struggle with the challenges of aggregation, weighing, and comparison of multiple benefits and risks. This stresses the need for an interdisciplinary approach and mutual learning. We identified some differences with respect to the degree in which risk is accepted (Fig. 2). Consumer and marketing sciences could give useful insight in the psychological mechanisms behind this and give advice in how to target specific groups or how to put risk perceptions into perspective. Stakeholder participation is increasingly valued as important, thereby granting it a position in the benefit–risk analysis-triad next to assessment and management (Fig. 3). Increasing interaction between the three is essential for making policy decisions addressing real public health issues, using the best available scientific data on diet-health relations. We want to emphasize again that interaction can and should take place without each losing its own responsibilities, roles and interests. The tiered approach and transparency in assessment proposed for the Food and Nutrition field (Tijhuis et al., 2011) is one way to support this.

Altogether, the key messages suggest that benefit–risk analysis in Food and Nutrition should be considered as a joint process where the experts, professional decision makers, as well as consumers and other stakeholders come together to create shared understanding (Fig. 3). In this, different domains of benefits and risks are explicitly considered, as are their greatest net benefits (taking subgroups into account). Focusing on food safety and not addressing food benefits is a risk management decision just as much as accepting some risk in order to achieve more benefits. Either way, both policy makers and consumers should let go of the artificial line between risk coming from chemicals and micro-organisms in the diet (captured in regulation for consumer protection) and risk coming from a bad quality and quantity of the diet (captured in dietary advice for consumer protection). In the end, for both situations, the result is disease and burden to society; as the former is currently relatively well taken care of, the latter currently has much larger impact on public health and resources (Tijhuis et al., 2011; UN, 2011; van Kreijl et al., 2006).

The identification of several key messages that describe how Food and Nutrition benefit–risk analysis, as well as benefit–risk analysis in general, should be practiced is not an end in itself. Rather, it gives guidance for developing and implementing such practices in order to make this vision a reality. This work will require further development of the systems and tools started in previous projects and adoption of new methods, tools, and data sources to support the improved benefit–risk analysis practices. Contributions are required from all relevant actors in the analysis in order to promote the realization of improved benefit–risk analysis. Regulatory frameworks may need to be adjusted to allow and support the new contexts and practices of analysis. Managers may need to adopt a more active role as participants in knowledge creation and allow for broader involvement of other participants in the analysis. Assessors also need to adapt their attitudes towards considering themselves in the role of facilitating the development of shared understanding, not only among experts, but also among managers and stakeholders.

Conflict of Interest

The authors declare that there are no conflicts of interest.

6. Uncited reference

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Acknowledgements

The preparation of this manuscript was funded through Safefoodera project BEPRARIBEAN (project ID 08192) by the Dutch Food and Consumer Product Safety Authority (VWA), the Research Council of Norway (RCN) and the Nordic Council of Ministers (NCM) and supported by Matís, The National Institute for Health

and Welfare (THL), the University of Ulster and the National Institute for Public Health and the Environment (RIVM).

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