Evaluation of food technologies across supply chain actors – A systematic review of explanatory models.

Abstract

Acceptance of novel technologies along the food supply chain is essential for technology-based innovations to be effective in tackling global challenges such as food security. In order to obtain insights and identify research gaps in the context of food technology evaluation research, this study conducts a systematic review of the extant research landscape. Our focus is thus placed on empirical studies that utilized established explanatory models to explain the factors and mechanics that underlie the evaluation of novel food technologies by chain actors. Out of 183 primary studies included from 1991 to 2017, a majority was conducted in developed countries, versus only 23% in developing countries. Further, most studies of food technology evaluation have looked at genetically modified food, with consumers being the most common stakeholder considered. Regarding the models, Theory of Planned Behavior and Protection Motivation Theory were by far the most frequently applied explanatory models. Our results highlight the need for research on the evaluation of novel food technologies by non-consumer actors for a holistic understanding across the supply chain as well as to give greater attention to developing settings.

Keywords

Evaluation; acceptance; adoption; explanatory models; theory of planned behaviour; TPB; protection motivation theory; PMT; food technology; food chain actors; farmer; processor; consumer; systematic review.

1. Introduction

The use of novel food technologies can potentially mitigate current societal challenges, such as food security and food safety issues, and can also foster a more sustainable resource use by valorising by-products to e.g. create functional ingredients (Floros et al., 2010). At the same time, consumers and the society at large are increasingly neophobic towards food (technologies) (Costa and Jongen, 2006; Bearth and Siegrist, 2016; Frewer et al., 2011; Siegrist, 2008; Ronteltap et al., 2007), which increases the risk of market failures, especially for radical food innovations (Costa and Jongen, 2006; Grunert et al., 1997). As food innovations need to be implemented first at the input level of the food industry (farmers and processors) (Bigliardi and Galati, 2013; Hellström, 2003), the ultimate success of an innovation depends on whether it is adopted along the food supply chain (Bigliardi and Galati, 2013; Bröring, 2008; Grunert et al., 2005). In other words, evidence of chain actors' evaluation is needed to obtain a holistic understanding of the potential of food technologies. Thereby, "evaluation" can be conceptualised through a diversity of concepts, such as acceptance, adoption, perceptions, attitude and willingness-to-pay (Hess et al., 2016; Mogendi et al., 2016b), as defined in Table 1.

Insert Table 1 here.

Although there is a large number of literature reviews on food technology evaluation, there are observable shortcomings that future studies ought to address. A primary concern is the scope used while conducting these reviews. When looking at existing reviews, it is striking that these centre only around one stakeholder – the consumer. This bias towards consumers has also been pointed out by Ronteltap et al. (2007), who suggest to explore food technology evaluation along the entire food supply chain. Moreover, these studies are often limited to one specific food technology. While the majority of reviews looked at GM technology, either through measuring consumers' evaluation of GM foods (Bredahl et al., 1998; Frewer et al., 2013; Hess et al., 2016) or eliciting their willingness-to-pay (Costa-Font et al., 2008; Dannenberg, 2009; De Steur et al., 2014; De Steur et al., 2017a, 2017b; Lusk et al., 2005), other reviews targeted other technologies, such as nutrigenomics (Ronteltap et al., 2007), nutritious foods (including GM and non-GM biofortification) (Mogendi et al., 2016b) and High Pressure Processing (HPP) and Pulsed Electric Fields (PEF) (Olsen et al., 2010), functional foods (Kaur and Singh, 2017; Siró et al., 2008), or did not specify the type of food technology (Bearth and Siegrist, 2016; Lusk et al., 2014). Only few consumer oriented reviews have extended their approach by including multiple food technologies (Rollin et al., 2011; Frewer et al., 2016). As such, there is a knowledge gap to extend this approach by including the broad spectrum of food technologies across relevant actors, especially with greater attention to the supply side.

Second, only one review made an attempt to aggregate evidence on explanatory models for evaluation of food technologies, using GM foods as a case (Bredahl et al., 1998). Since the last two decades, other reviews have developed their own case-specific models by synthesizing factors from primary studies. Although explanatory models have made an attempt to conceptualize and analyse the dynamics of food technology evaluation (e.g. on GM foods) (Costa-Font et al., 2008), it is striking that no review has taken this under consideration since the work of Bredahl et al. (1998).

Third, the majority of existing reviews did not apply the recommended methodology and academic rigor of a systematic review, hence could have missed relevant information needed to make reliable conclusions. Only few consumer-oriented reviews on food technology evaluation have systematically analysed the literature (Bearth and Siegrist, 2016; De Steur et al., 2017b; Frewer et al., 2013; Frewer et al., 2016; Kaur and Singh, 2017; Mogendi et al., 2016b).

This study aims to conduct a systematic review that addresses the aforementioned knowledge gaps on technology evaluation by (1) extending the focus beyond consumers and including the entire supply chain, (2) targeting a wide range of novel foods and technologies, and (3) examining the use of explanatory models. Due to the latter, this study will review only studies that analysed food technology evaluation based on a theoretical model. The following research questions are investigated:

- What types of existing food technologies are commonly applied in model-based evaluation studies?
- What levels of the food supply chain are targeted in model-based food technology evaluation studies?
- What well-established theoretical models have been used to examine food technology evaluation behaviour along the supply chain?

2. Methodology

2.1 Search scheme and identification of primary studies

A systematic literature review of published research papers on supply chain actors' evaluation of novel food technologies was undertaken by following the methodological approach of Petticrew and Roberts (2006). Here, we consider 'evaluation' as an umbrella concept that can be measured through various concepts such as 'acceptance', 'adoption', 'perception', 'attitude' and 'willingness-to-pay', which are sometimes used interchangeably, although they are based on different methods (Hess et al., 2016; Mogendi et al., 2016b), see also Table 1.
To identify international peer reviewed, primary studies, a search syntax was developed based on synonyms and similar key words to 'food technology' (e.g. food processing, nutrigenomics, biofortification) in combination with 'acceptance' (e.g. attitude, willingness-to-pay) and supply chain actors (e.g. consumer, farmer, retail, processor).

Thereby, search terms that refer to a specific food technology are based on the rational that the technology in question is of empirical relevance and topical. The targeted actors 'farmer', 'processor', 'retailer' and 'consumer' were included as search terms given that they are considered the main actors in the food supply chain (Bigliardi and Galati, 2013). The search syntax was developed in close consultation with other researchers' experiences with systematic reviews and was tested for its robustness. The syntax was entered into the electronic database 'ISI Web of Science' (Timespan: All years: 1945 - 2017).

2.2 Definition of screening criteria and screening of primary studies

The extant literature was screened to obtain a comprehensive dataset that is relevant to examine our main research questions. For a study to be included in this review, all screening criteria presented in Figure 1 had to be fulfilled. Given the focus on analysis of food technologies, we defined new food technologies as a production process that gives "rise to significant changes in the composition or structure of the foods or food ingredients which affect their nutritional value, metabolism or level of undesirable substances" (European Commission, 1997, Article 1). Thus, other technologies applied in the food sector that do not cause significant changes in food, such as novel approaches of packaging, were not considered for inclusion. With respect to the explanatory models used, studies were only included if their models were based on a theory that is widely applied (or refined) through empirical literature. Here, these models are referred to as well-established theoretical models, i.e. a model that is based on fundamental theories (for an overview of behavioural theories and models see Darnton, 2008). For the sake of comparison, we have also categorized articles using a study-specific model. Nevertheless, the latter were not used for deeper analysis of findings.

Insert Figure 1 here.

As a working database for categorizing included and excluded studies EndNote Web was used based on the above-named criteria. The four screening steps conducted in this review are shown in Figure 2. First, doubles were removed before title and abstract screening. Second, titles that did not fit in the scope of the review were removed and those that remained were subjected to an abstract screening. Third, a full-text review was completed to retain articles that applied an explanatory model for evaluation behaviour towards novel food technology among one or more groups of supply chain actors. This was the basis for final eligibility and data extraction. Some studies included more than one stakeholder but treated the whole study as a consumer study as the share of non-consumer stakeholders was small or negligible. Therefore, those studies were considered as consumer-oriented studies.

This whole process was performed by the first and second author of this paper who cross-checked each other to assure that no study is incorrectly in- or excluded while fulfilling the inclusion criteria. Whenever consensus could not be reached a third party was consulted.

Insert Figure 2 here.

2.3 Data extraction process

Pre-defined, literature-based and emerging categories were used to develop a data extraction sheet. In correspondence to the aforementioned research questions, the following study characteristics were extracted: the type of food technology, the targeted supply chain actor, data collection characteristics (method, location, sample) and model characteristics (type of model, constructs included). The final database represents a comprehensive overview of primary studies that used a well-established theoretical model to examine food technology evaluation of a supply chain actor. Given the diversity of methods and measures to examine food technology evaluation, it was not possible to extract a common parameter across studies needed for conducting a meta-analysis.

3. Results of the review

3.1 Main study characteristics

The database search and screening process resulted in 183 relevant papers that were selected for subsequent data extraction. As secondary data (e.g. Eurobarometer data) was only obtained in 5% of the technology evaluation studies, primary data (i.e. original empirical studies) can be considered the main data source. While 82% of all selected studies made use of online, face-to-face, postal or telephone interviews, about 13% conducted experimental designs (e.g. experimental auctions and choice experiments). With respect to region, most studies were conducted in developed countries (77%), while only 23% target developing countries. Europe was the chosen setting of 45% of the selected studies, as compared to America (South 4 %, North 19%) and Asia

(18%), Africa (9%, mainly East Africa) and Oceania (6%). Due to the screening criterion to include only studies applying well-established theory-based models with at least 3 independent variables (Figure 1), the sample mainly consists of quantitative studies (94%).

3.2 Targeted technology and supply chain actor

The number of publications over time highlights an increase of food technology evaluation studies after 2003 (Figure 3). This is especially the case for GM food literature, which had a peak in 2008, partially due to the EU moratorium on GM crops (Leibovitch, 2008). Figure 4 classifies the number of studies (in relative numbers) according to the targeted food technology, the applied model (discussed in 3.3), and the targeted supply chain actor. While most studies examined GM foods (62%), only 3% of studies targeted non-GM biofortified food (i.e. produced through conventional breeding or agronomic practices). Fortified foods, food enriched with health ingredients or additives, were investigated in 23% of the studies. Processing technologies, like nanotechnology, irradiation or high-pressure processing, were selected as a case in 12% of the studies.

Insert Figure 3 here.

Insert Figure 4 here.

Regarding the supply chain actors, the majority focused on consumers (92%), while relatively few dealt with farmers and producers (7%) and only one study included processors (1%). None of the studies specifically looked at retailers.

When the targeted actors were compared against the selected technology, farmer studies solely focused on genetic modification, and were, given their position in the supply chain, not involved in research on food processing technologies or functional foods. Consumers also participated in studies on biofortified food and food additives, though to a lesser extent compared to GM food. Furthermore, the consumer studies that scrutinized processing technologies mainly looked at nanotechnology approaches. From this follows that the stage of the supply chain where the technology is introduced, will determine which chain actors are selected in research on new food technology evaluation.

3.3 Explanatory models applied for analysing consumers' food technology evaluation

Only a small share of the sample has applied a well-established theoretical model. These studies were all oriented towards the consumer (26 studies) and drew upon well-known behavioural models: i.e. the attitude model (3 studies), the theory of reasoned action (3 studies) and of planned behaviour (10 consumer studies, 1 farmer study), the protection motivation theory (9 studies) (Table 1) as well as the health belief model (2 studies). A visual overview of included established models is attached in Appendix I and a matrix of the models related to the technologies as well as supply chain actors in Appendix II.

In contrast 156 other studies, the majority on consumers (85%) developed own explanatory models. This points out a growing tendency to go beyond existing, theory-driven established models (see also Figure 5); but perhaps at the drawback of external validity, since models in singular use do not allow for comparison of results. For an extensive evaluation of study-specific models, data from which are not used in this analysis, please refer to Kamrath et al. (2019).

Insert Figure 5 here.

Given the scope of this review, the remainder of this section will provide a detailed narrative synthesis of the 27 studies that have applied a well-established theoretical model, i.e. based on fundamental theory (an overview of behavioural theories and models see Darnton, 2008). Their characteristics in terms of the type of technology, study characteristics, model name and variables as well as the method of data analysis are described in Table 2.

Insert Table 2 here.

3.3.1 Attitude models at consumer level

The attitude-based theory (i.e. attitude model, theory of reasoned action and theory of planned behaviour) was used in 18 studies.

Attitude models (AM) – The multi-attribute attitude model developed by Fishbein (1963) measures individual's attitude toward an object as a function of his beliefs about the object and the evaluative aspects of those beliefs and is later analysed as predictor for behavioural intention (i.e. willingness to perform the behaviour) (Fishbein and Ajzen, 1975). Studies referred to different applications of attitudes to examine behavioural intention, e.g. attitude towards GM food, GM technology and food safety (Rodríguez-Entrena et al., 2013), or perceived benefits and risks (Chen, 2008; Rodríguez-Entrena and Salazar-Ordóñez, 2013). Overall, results of the studies indicated that a positive attitude towards the technology has a positive relationship to the intention to purchase the targeted technology.

Theory of Reasoned Action (TRA) – Attitude (i.e. feeling of favourableness towards the food technology) and subjective norm (i.e. support of important others towards implementing or consuming the food technology) are two key concepts from the TRA used as predictors of behavioural intention (Fishbein and Ajzen, 1975). Tsai et al. (2010) shows that both consumer attitude, subjective norm and salesperson's expertise enhance the intention to purchase nutraceuticals. Furthermore, the study by Rezai et al. (2017) illustrates a positive relationship between attitude and subjective norm with consumers' intention to purchase natural functional food, bases on an empirical integration of the TRA and health belief model. Similarly, Mulder et al. (2014) evaluated "innovativeness" (i.e. being the first adopting new ideas or inventions) by adapting the diffusion of innovation theory, showing that the purchase intention of in vitro meat is indirectly influenced by the innovator characteristics.

Theory of Planned Behaviour (TPB) – This theory is extensively used to explain human behaviour that behavioural attitude, subjective norm and perceived behavioural control (i.e. the perceived ability to identify or consume a novel food) affect behavioural intention (i.e. willingness to perform the behaviour), which in turn affects the actual behaviour (Ajzen, 1991). At the farmer level, only one study by Oparinde et al. (2017) analysed farmers' intention to cultivate provitamin A GM cassava in Nigeria by indicating a positive relationship of behavioural control (i.e. belief if GM is against nature, religion, is more nutritious, …), subjective norm (i.e. belief if household members, religious leaders, co-farmers support the cultivation of GM cassava, …), and control belief (i.e. belief if village head or government would approve or disapprove the cultivation of GM cassava). The rest (10 studies) focused on consumers, while evaluation of GM food was the most prevalent (Cook et al., 2002; Ghoochani et al., 2017; Kim et al., 2014; Lu and Gursoy, 2016; Prati et al., 2012; Spence and Townsend, 2006), followed by GM/conventional biofortified foods (Talsma et al., 2013) and processing technology (Cook and Fairweather, 2007). The majority of these studies indicated that consumers who expressed positive attitudes towards technology have a significant positive association with a specified behavioural intention (Chen, 2008; Cook and Fairweather, 2007; Cook et al., 2002; Ghoochani et al., 2017; Kim et al., 2014; Patch et al., 2005; Prati et al., 2012; Spence and Townsend, 2006; Tsai et al., 2010). Similarly, social pressure and beliefs by significant others (subjective norm) positively predicted behavioural intention in eight cases (Chen, 2008; Cook and Fairweather, 2007; Cook et al., 2002; Ghoochani et al., 2017; Kim et al., 2014; Lu and Gursoy, 2016; Prati et al., 2012; Tsai et al., 2010). The observed relationship between perceived behavioural control and behavioural intention is weakest, showing 3 times positive (Cook et al., 2002; Lu and Gursoy, 2016; Talsma et al., 2013) and 3 times negative (Kim et al., 2014; Prati et al., 2012; Spence and Townsend, 2006) relationships. As stated by Prati et al. (2012), this obvious contradiction may be related to the wording of the items used to measure this construct as 3 studies linked perceived control to purchasing GM food (Cook et al., 2002; Lu and Gursoy, 2016; Talsma et al., 2013), whilst 3 other studies measured control over avoiding GM food (Kim et al., 2014; Prati et al., 2012; Spence and Townsend, 2006).

3.3.2 Health Belief Models at consumer level

Models in accordance with health behaviour theory were used in 11 studies, i.e. the protection motivation theory (9 studies) and the health belief model (2 studies) – all at consumer level.

Protection Motivation Theory (PMT) – This theory is the second most applied theory to examine consumers (9 studies). This theory explains how the cognitive process of threat appraisal relates with coping appraisal to generate an intention to adopt a recommended preventive health behaviour (Maddux and Rogers, 1983). Threat appraisal estimates the arousal of fear for respondents to perceived seriousness of a depicted event (severity) and considers the susceptibility to the threat (vulnerability) (Neuwirth et al., 2000; Prentice-Dunn and Rogers, 1986; Rogers, 1975). Coping appraisal consists of one's belief that a given behaviour will or will not cope with the threat (response efficacy) and one's belief about being able to successfully perform the requisite health preventive behaviour (self-efficacy) as well as the estimation of the costs involved in the execution of the health behaviour (response cost) (Maddux and Rogers, 1983).

Eight studies focused on either functional (Cox and Bastiaans, 2007; Cox et al., 2004; Henson et al., 2008; Henson et al., 2010), GM enriched in omega-3 fatty acids (Cox et al., 2008) or non-GM biofortified iodine-enriched foods (De Steur et al., 2015; Mogendi et al., 2016a, 2016c), indicating increasing research interest in foods that positively affect consumer health (FoodDrinkEurope, 2016; see also Figure 5 for publication timeline). Only 1 study applied the PMT in the context of processing technologies, i.e. for irradiated food (Crowley et al., 2013).

Threat appraisal, severity and vulnerability were positively associated with protection motivation in seven studies (Cox and Bastiaans, 2007; Cox et al., 2004; Cox et al., 2008; Henson et al., 2008; Henson et al., 2010; Mogendi et al., 2016a, 2016c). Fear was only measured in five studies with positive associations from studies by Henson et al. (2008) and Mogendi et al. (2016a, 2016c). In a study on irradiated meat by Crowley et al. (2013), negative influences of severity and fear toward the likelihood of eating were observed. This could be explained by the partial and adapted approach of applying PMT, exemplified by variations in questionnaires used for measuring severity and fear as well as the differences between processing technology (irradiation) and health enriching foods. For coping appraisal, the positive relationships with respect to response efficacy and self-efficacy were reported in 6 studies (Cox and Bastiaans, 2007; Cox et al., 2004; Cox et al., 2008; De Steur et al., 2015; Henson et al., 2008; Henson et al., 2010) while the negative influence of response costs, i.e. estimation of the costs involved in the handling of the health behaviour, to the protection motivation was indicated by 2 studies (De Steur et al., 2015; Mogendi et al., 2016c). Consistent with Maddux and Rogers (1983), self-efficacy was the most significant predictor of behavioural intention (Cox and Bastiaans, 2007; Cox et al., 2008; De Steur et al., 2015; Henson et al., 2008; Henson et al., 2010).

Health Belief Model (HBM) – This model is the basis of the PMT and is applied in 2 studies whereby once in combination with the TRA (Rezai et al 2017). In this study, perceived susceptibility (≙vulnerability) exhibited no significant, perceived benefits (≙response efficacy) a positive, and perceived barriers (≙response costs) a negative relationship with consumer intention to purchase natural functional foods. Furthermore, Vlontzos and Duquenne (2016) only illustrated a positive influence of barriers on WTP for GM food.

3.4 Other applied models along the supply chain

At *farmers*' level in particular, adjusted equation models (i.e. probability or utility functions) (Breustedt et al., 2008; Luh et al., 2014; Useche et al., 2009), a trait-based model (Edmeades and Smale, 2006) and a survival model (Barham et al., 2014) were used. These 'models' are applied with different sets of variables in each research setting without examining other relationships between independent and dependent variables than to what is done with well-established theoretical models at consumer level.

At *processors'* level, one study developed a model analysing the influencing factors towards the adoption of product or process innovation in the Canadian food processing industry. Thereby different factors compared to farmers and consumers were used, i.e. impact of innovation (on business through entering international markets or keeping up with competitors) and factors hindering innovation (e.g. lack of information on markets, difficulty finding co-operators) (Brewin et al., 2009). The results of a second study at processor level indicate the positive influences of social acceptance as well as market attractiveness on firms' intention of using GMOs industrially. But the managerial interpretation of the industrial use of GMOs along the opportunity-threat dimension (i.e. whether the industrial use of GMOs will have a positive or a negative impact on firm performance and/or operations) had no significant effect on firms' intention (Sung and Hwang, 2013).

At *consumers'* level with regard to quantitative approaches, other well-established theoretical models are the classical diffusion model (Rogers, 1995) combined with a risk perception theory (Slovic, 1986), Schlenker's accountability model (Schlenker et al., 1994), the value-attitude-behaviour hierarchy (VAB) model (Rokeach, 1973; Tudoran et al., 2009), the regulatory focus theory (Higgins, 1997) and the model of corporate social responsibility (Carroll, 1979). Given that they were only applied once within the included studies, they will not be discussed in detail. While the aforementioned models were used for quantitative data collection, there was one study (Krutulyte et al., 2008) that applied a qualitative approach, i.e. in-depth interviews following the health action process approach (HAPA), adapted from Schwarzer (1992).

Only one study proposed a combined model of well-established theories with focus on *multiple (two) supply chain actors*, namely farmers and consumers, in a healthy-food supply chain. In their study on potential acceptance of biofortified vegetable legumes in Eastern Africa, Mogendi et al. (2016a) developed the so called PMTAM model that consists of the PMT as well as the technology acceptance model (TAM), of which the former is tested in a consumer study (De Steur et al., 2015; Mogendi et al., 2016c) and the latter in a farmer context (Mogendi, 2016). The TAM, which was originally applied in the field of information technologies and systems (Davis, 1986), assumes that the acceptance of new technology is established by two key beliefs: perceived usefulness, i.e., the extent to which using a technology will improve productivity and perceived ease of use, i.e. the extent to which using a technology will be free of effort.

4. Discussion

This comprehensive systematic literature review is considered the first of its kind to assess models applied in the domain of food technology evaluation along the supply chain. The paper delivers an extensive overview of targeted novel food technologies as well as subsequent application of well-established theoretical models to measure evaluation behaviour of different supply chain actors. Further, an exploration of the key determinants gives an indication of the key factors affecting the evaluation of new food technologies.

4.1 Findings

Our findings indicate that extant research has been primarily devoted to GM foods compared to other food innovations. Consequently, research on biofortified or functional foods and processing technologies (that build upon theoretical models) as well as research in developing countries is limited.

Regarding supply chain actors and use of well-established theoretical models, our results demonstrate that most studies apply study-specific models that focus on consumers. Other supply chain actors are hardly examined within this research landscape. This imbalance might be caused by smaller sizes for other supply chain actors than consumers which often follows a qualitative research approach. It is striking that only 15% of all included studies use similar approaches based on well-established theoretical models, while the remaining 85% (157 studies) make use of very particular relationships beyond existing theory-driven established models (see also Figure 5). Indeed, researchers tend to develop their own models with a combination of variables that could be part of well-established theoretical models. The application of different models produces heterogeneous results which makes it difficult to compare and validate findings, within as well as between food technologies and actors. An overview of 60 social-psychological models and theories of behaviour provided by Darnton (2008) shows that there is overall a substantial amount of established theories, aside from the large body of research using study-specific models. Study-specific models use a wide variety of different factors, particularly trust in institutions, information assessment, perceived risks and benefits among others (see Kamrath et al. (2019). However, in the context of new food technologies the application of well-established theories is rather rare.

Even though the dominance of consumers as actor was expected, it was very high. Only few studies (based on study-specific models) could be identified at farmer level, while adoption research on processors/retailers is almost lacking. No study with a vertical analysis along the food supply chain, systematically comparing adoption behaviour among several actors could be identified. This is a shortcoming as innovation diffusion is more likely to be successful if all supply chain actors initially adopt new technology (Bigliardi and Galati, 2013; Bröring, 2008; Grunert et al., 2005; Hermans et al., 2017) and raises the question how existing models, mainly applied at consumer level, are transferable to other actors who have different interests and concerns. Several actors are mentioned in some studies, but they are usually analysed as part of the public and therewith as consumers but the differences between actor groups are not mentioned. There is a current lack of research that uses different models according to the particular supply chain position. One exception is the model proposed by Mogendi et al. (2016a), that assigns well-established theories, like the PMT and TAM to different actors (farmers and consumers). While this approach is interesting, additional research is needed to validate these and other combined models. For example, the TAM and the TPB can effectively be used together, as shown by Mathieson (1991) for information systems, and is assumed to be effective in the context of novel food technology adoption as well.

Although there is limited use of models at the farmer level concerning food technology evaluation, well-established theoretical models have been empirically tested in other contexts (Borges et al., 2019). For example, the TAM has been used to investigate farmer behaviour towards adoption of precision agriculture (Adrian et al., 2005; Rezaei-Moghaddam and Salehi, 2010), dairy farming technology adaptation (Flett et al., 2004) and information technology (Aleke et al., 2011). Another example for farmer oriented research is the TPB, that is applied on other food related topics, such as farm diversification (Hansson et al., 2012), adoption of new stress-tolerant rice variety (Yamano et al., 2015), farmers' behaviour regarding water conservation (Yazdanpanah et al., 2014) and adoption of GM cassava (Oparinde et al., 2017). Overall, latent variables used in these studies explained significant variations observed in the adoption behaviour of farmers, hence showing reasonable predictive validity and the applicability of those theories in the context of farmers' adoption behaviour.

Only 2 studies at processor level was identified within this review although the processing industry is affected by the consumer demand for new foods and changes in eating habits (Zink, 1997). This research gap at the level of food processing needs to be filled to understand the adoption behaviour along the full supply chain. Processors play a key role in the food supply chain and should be investigated before implementing a novel food technology. Processors' motivation to adopt innovative technologies is primarily assumed to be influenced by economic or strategic factors and can be measured through perceived benefits (i.e. access to market, usability of technology, technologies impact on sustainability criteria) by best applying well-established theoretical models such as the TPB and TAM. This assumption and further influencing factors need to be tested by empirical research.

At consumer level, several well-established theoretical models could be identified; the most common are TRA, TPB (mostly applied to GM) and PMT (applied for functional food and non-GM biofortification). Several other theories exist that are widely applied to analyse consumers' evaluation behaviour but hardly in the context of novel food technologies, i.e. the TAM and its extensions such as unified theory of acceptance and use of technology (UTAUT) (Venkatesh et al., 2003), technology readiness index (TRI) (Parasuraman, 2000) and motivational model (Vallerand, 1997) applied in the information and communication technology (ICT) literature. In the context of health behavioural, the social cognitive theory (Bandura, 1986) and the trans-theoretical model of change (Prochaska and DiClemente, 2005) are applied but had limited prediction of health oriented behaviour (Baranowski et al., 1999). Other relevant attitude change models are the elaboration likelihood model (Petty and Cacioppo, 1986) and the social judgment theory (Sherif and Hovland, 1961). Those theoretical frameworks can be applied in this context or can be combined into a more comprehensive model out of the distinct constructs. In addition, results of qualitative approaches, such as Gutman's means-end chain analysis (1982), can support or replenish quantitative models. Based on the qualitative approaches, grounded theory could generate new concepts particularly to evaluation behaviour towards novel food technologies (Betts et al., 2010).

4.2 Future research

Beyond the food innovations identified in this systematic review, several new food technologies are developed meanwhile. These may comprise 3-D printers, upgrading residual streams and exploiting alternative sources of protein or radical approaches like synthetic biology or CRISPR/Cas. Many new food innovations are purely technology push and call for intensive evaluation research. Therefore, several recommendations based on this systematic literature review are made: generally, it is observed that there is no consensus on the terminologies used in this domain of research. Appropriate use of terminology related to evaluation of food technology requires harmonization of definitions, measurement approaches and use of supply chain actors' evaluation frameworks (Mogendi et al., 2016b). Future research should therefore focus on a greater consistency in use of validated measures that would assist comparability across studies to identify overarching concepts enabling the identification of factors influencing technology evaluation.

Based on this review, we suggest following steps for future evaluation studies in the field of food technologies:

(A) Based on the diversity of methods and models of supply chain actors' evaluation, a comprehensive synthesis of factors from food evaluation research can result in novel, actors-specific food technology acceptance frameworks. When looking at consumer evaluation research, for instance, models were suggested by Bredahl et al. (1998), for GM technology, and by Kamrath et al. (2019), for more generic food technologies.

(B) Expand research beyond the consumer level to capture the entire supply chain: As a starting point, studies at the supply side (e.g. supplier, farmer, processor) based on well-established theoretical models (e.g. Technology Acceptance Model) are suggested for the purpose of comparison between studies and to test external validity. Thereby, variables from well-established theoretical models need to be adapted to the specific research context and supply chain actor. Such a boundary spanning assessment of how the different stakeholders evaluate novel food technologies, seems especially promising for so-called systemic innovations, which are involving different supply chain actors to adhere to for example new more sustainable practices based on new technologies such as by-product valorisation (Bröring and Cloutier 2008).

(C) A holistic model for analysing the whole food supply chain can be developed. For example, one could adapt the technology, regulatory and market readiness level simulation model based on Kobos et al. (2013) or the innovation readiness level by Jullien (2014). The former assessed the maturity of a given technology as well as the commercial success by providing the political capital and market acceptance criteria (Kobos et al., 2013). The latter combines five readiness levels, these are the technology readiness level, the IP readiness level, the market readiness level, the consumer readiness level and the society readiness level (Jullien, 2014). This tool allows assessing the innovation potential of a given technology considering the maturity of those five dimensions, including several supply chain actors (i.a. manufacturers, politics, consumers) but also fosters an alignment between technology push and market pull, to avoid rejection of especially technology driven innovations.

5. Conclusions

This paper systematically reviewed the research landscape on the evaluation of new food technologies, with a particular focus on the models that have been applied. The heterogeneity of those models points out the need to explore novel or combined theoretical frameworks to allow for comparison of key factors between technologies and across countries. In conclusion, we identified the lack of applied well-established theoretical models, needed for comparing technology evaluation behaviour, as well as the lack of a chain approach, a requirement for a comprehensive understanding of evaluation behaviour along the food supply chain. To enable the sustainable transition, new upcoming food technologies, like the valorisation of by-products or cultured meat, will be even more massively affecting and disrupting the entire supply chain. Thus, there is an urgent need to move food technology evaluation studies beyond the consumer and target other stakeholders in the food ecosystem.

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Tables

Concept	Definition
Acceptance	Acceptance is the stage at which point individuals are held to form a favourable or unfavourable attitude toward the innovation and to take a decision to adopt or reject an innovation.
Adoption	Adoption is a decision (process) to make full use of an innovation as the best course of action available.
Rejection	Rejection is a decision not to adopt an innovation.
Perception	Perception can be viewed as an external factor, which concerns one's view, understanding, belief, or reaction to an innovation.
Attitude	Attitudes are defined as an overall evaluation of an innovation that is based on cognitive, affective, and behavioural information.
Intention	Intention towards an innovation indicates of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behaviour, e.g. using an innovation.
Willingness-to-pay	Willingess-to-pay is the highest price an individual is willing to accept to pay for an innovation.
Evaluation	Evaluation is defined as the assessment of the positive and/or negative qualities of an innovation.

Table 1: Overview of concepts to measure chain actors‘ evaluation of new food technology

Remark: In general, a high variety of different definitions of the above mentioned concepts exist. Thus, this table is not universal but presents overall accepted definitions. The table is an own compilation based on: Ajzen (1991); Breidert (2006); Jarvis and Petty (1996); Johnson (2010); Maio and Haddock (2015); Rogers (1995); Upham et al. (2015).

Author	Type of technology	Study Characteristics	Model data			Method of data analysis
		Study Location and Sample size	Model name	Latent variables	Dependent variable	
Farmer						
Oparinde et al. (2017)	Bio-technology/ GM	Nigeria; *N*=288	TPB	• Behavioral belief (+) • Subjective norm (+) • Control belief (+)	Intention to cultivate	OLS regression
Consumer						
Chen (2008)	Bio-technology/ GM	Taiwan; *N*=564	Attitude Model merged with TPB	• Attitude to technology° • Attitude to nature° • Food neophobia° • Alienation from the marketplace° • Perceived knowledge° • Perceived benefits from GM foods° • Perceived risks from GM foods° • Attitude to GM foods° • Attitude to purchase GM foods (+) • Subjective norm (+) • Perceived behavioral control (ns)	Intention to purchase GM foods	Structural Equation Model
Rodriguez et al. (2013)	Bio-technology/ GM	Spain; *N*=448	Attitude model	• Attitude towards GM food (+) • Perceived benefit of GM food° • Perceived risk from GM food° • Attitude towards GM technology° • Attitude to food safety° • Trust in institutions°	Purchase intention	Structural Equation Modeling
Rodríguez and Salazar (2013)	Bio-technology/ GM	Spain; *N*=448	Attitude model	• Perceived benefits (+) • Perceived risks (-) • Knowledge (ns) • Atitude to GM technology° • Trust in institutions°	Purchase intention	Structural Equation Modeling
Mulder et al. (2014)	Bio-technology/ GM	Netherlands; *N*=579	adapted from TRA + diffusion model	• Knowledge° • Attitude (+) • Injunctive norm° • Descriptive [social] norm (+) • Innovator characteristics° • Risk perceptions°	Intention to use	Structural Equation Modeling
Rezai et al. (2017)	Functional Food/natural functional food	Malaysia; *N*=2004	TRA + Health Belief Model	• Perceived susceptibility (ns) • Perceived benefits (+) • Perceived barriers (-) • Attitude (+) • Cue to action/subjective norm (+)	Purchase intention	Structural Equation Modeling

Tsai et al. (2010)	Functional Food / nutra-ceuticals	Taiwan; *N*=500	TRA	• Trust belief (ns) • Attitude (+) • Subjective norm (+) • Salesperson's expertise (+)	Intention to purchase	Structural Equation Modeling
Chen (2017)	Functional Food	Taiwan; *N*=487	TPB	• Attitude towards consuming FF (-) • Subjective norm (ns) • Perceived behavioral control (+) • Attention to foods with additives° • Perceived credibility of information° • Perceived risk (+)	Behavioral intention	Structural Equation Model
Cook and Fair-weather (2007)	Nano-technology	New Zealand; *N*=565	adaptation of TPB	• Attitude tow performing behavior (+) • Subjective norm (+) • Perceived behavioral control (ns) • Self-identity (-)	Behavioral intention	Linear Regression
Cook et al. (2002)	Bio-technology/ GM	New Zealand; *N*=266	adaptation of TPB	• Attitude (+) • Subjective norm (+) • Perceived behavioral control (+) • Self-identity (+)	Intention	Orderet Logit Model
Ghoochani et al. (2017)	Bio-technology/ GM	Iran; *N*=108	TPB	• Attitude towards GMOs (+) • Subjective norm (+) • Perceived behavioral control (ns) • Knowledge° • Benefit (ns) • Risk (ns) • Trust (+) • Ethics (ns)	Behavioral intention	Structural Equation Model
Kim et al. (2014)	Bio-technology/ GM	South Korea; *N*=387	TPB	• Ecological concern (-) • Attitude (+) • Subjective norm (+) • Perceived behavioral control (-) • FTNS-Questions°	Behavioral intention	Structural Equation Modeling
Lu, Gursoy (2016)	Bio-technology/ GM	USA; *N*=220	TPB	• Attitude towards GM foods (-) • Subjective norm (+) • Perceived behavioral control (+) • Social trust° • Consideration of future consequences (ns)	Purchase intention	Structural model
Patch et al. (2005)	Functional Food/omega-3 fatty acide	Australia; *N*=42	TPB	• Attitude towards eating enriched product (+) • Belief strength towards purchasing novel foods° • Subjective Norm (ns) • Normative belief° • Motivation to comply° • Perceived behavior control (ns)	Intention	Linear Regression
Prati et al. (2011)	Bio-technology/ GM	Italy; *N*=1009	TPB	• Subjective norm (+) • Perceived control (-) • Attitude (+) • Perceive risk (ns) • Perceived benefit (+)	Intention to consume GM	Structural Equation Modeling
Spence and Townsend (2006)	Bio-technology/ GM	UK; *N*=99	TPB	• Attitude toward GM food (+) • Subjective norm (ns) • Peceived Behavioral control (-) • Moral norms (ns) • Self-identity (+) • Emotional Involvement (+)	Intention to buy	Linear Regression
Talsma et al. (2013)	Non GM bio-fortification/ Pro-Vitamin A	Kenya; *N*=150	TPB	• Health behavior identity (+) • Attitude towards behavior (ns) • Perceived barriers (-) • Subjective norms (ns) • External control beliefs (-) • Cues to action (+) • Knowledge° • Perceived susceptibility° • Perceived severity° • Health value°	Intention	Multiple Regression
Cox and Bastiaans (2007)	Functional Food / selenium enriched foods	Australia; *N*=212	PMT	• Severity (S) (+) • Vulnerability (V) (+) • Product-efficacy (PE) (+) • Self-efficacy (SE) (+)	Importance of protecting myself against the risk of cancer	Multiple Regression Analysis
	Biotechnolog y/ GM	Australia;	extended PMT	• Behavior (product) efficacy° • Self-efficacy (different products) (+)	Likelihood to purchase farmed	

Cox et al. (2008)* * here only summary of variables presented		*N*=220 (milk and bread consumer)		• Perceived severity of CHD° • Perceived vulnerability to CHD° • Belief that GM oilseed is unnatural(+) • Belief that fishmeal is unnatural° • Perceived risk/benefit of GM oilseed° • Perceived risk/benefit of fishmeal°	fish or product with fish oil or with GM oilseed	Multiple Regression Analysis
Cox et al. (2004)	Functional Food	Australia; *N*=290 (age between 40-60)	adaptation of PMT	• Self-efficacy (+) • Efficacy (+) • Severity (+) • Importance of vulnerability (+) • General vulnerability (+) • Importance others vulnerability (+) • Inevitable (+)	Intention to naturalness, sweetener, effectiveness of genetic modification or supplements	Multiple Regression Analysis
Crowley et al. (2013)	Irradiation	North America-USA; *N*=478	adaptation of PMT	• Perceived safety of meat irradiation (+) • Perceived relative severity (-) • Fears associated with meat Irradiation (-)	Likelihood of eating irradiated meat	Structural Equation Modeling
De Steur, Mogendi et al. (2015)	Non GM bio-fortification/ iodine	Africa-Uganda; *N*=400 (1st sample *N*=360 are parents and 2nd sample *N*=40 are school heads of primary school)	PMT	• Perceived fear (ns) • Perceived vulnerability (ns) • Perceived severity (ns) • Response efficacy (ns) • Self-efficacy (+) • Response cost (-) • Academic performance satisfaction (ns) • Knowledge about iodine and iodine Deficiency Disorders (ns)	Intention to adopt biofortified foods	Multiple Regression Analysis
Henson et al. (2008)	Functional Food / lycopene	North America-Canada; *N*=268 (male, primary food purchaser in housheold)	PMT	• Fear (+) • Own health status (-) • Vulnerability of close others (+) • Relative risk (ns) • Severity (ns) • Inevitability (ns) • Response efficacy (+) • Knowledge (-) • Self-efficacy (+)	Intention to buy FF or nutraceutical	Probit Regression
Henson et al. (2010)	Functional Food / phytosterols	North America-Canada; *N*=446	PMT	• Severity (+) • Vulnerability (+) • Cholesterol risk (+) • Response efficacy (+) • Self-efficacy (+)	Behavioral intention	Structural Equation Modeling
Mogendi et al. (2016c)	Non GM bio-fortification/ iodine	Africa-Kenya, Tanzania, Uganda; *N*=1200 (1st sample *N*=1080 households/ parents and 2nd sample *N*=120 schools heads)	PMT	• Severity (+/-) • Vulnerability (+/-) • Fear (+/-) • Response efficacy (+/-) • Response cost (+/-) • Self-efficacy (ns) • Protection motivation (behavioral intention) (+/-) • Satisfaction level (ns) • Knowledge (ns/-) • Information (ns)	WTP at premium or at discount level	Tobit Regression
Mogendi et al. (2016a)	Non GM bio-fortification/ iodine	Africa-Kenya, Tanzania, Uganda; *N*=1080 households/	PMT (consumer) + TAM (farmer)	• Protection motivation (behavioral intention) (+) • Perceived Severity (+) • Perceived vulnerability (ns) • Perceived fear (+) • Response efficacy (+) • Response cost (ns) • Self-efficacy (ns)	WTP at premium or at discount level	Structural Equation Modeling
Vlontzos, Duquenne (2016)	Bio-technology/ GM	Greece; *N*=1461	Health Belief Model	• Behavioral intention (-) • Severity (ns) • Nutritional confidence (ns) • Barriers (+) • Susceptibility (ns) • Health benefits (ns)	WTP for GM foods	Logistic regression model

Table 2: Models applied for food technology evaluation at farmer and consumer level

Remarks: (+) positive-, (-) negative significant or (ns) non-significant relationship between independent and dependent variable; or relationship ° not tested. *TRA*= Theory of Reasoned Action. *TPB* = Theory of Planned Behavior. *PMT*=Protection Motivation Theory. *WTP*=Willingness to Pay.

Figures

increasing level of detail

- Peer reviewed article, written in English
- Analyzed at least one supply chain actor (e.g. farmer, processor, consumer)
- Dealt with evaluation of food technologies
- Examined a model of at least three independent variables to measure technology evaluation

Figure 1: Inclusion criteria.

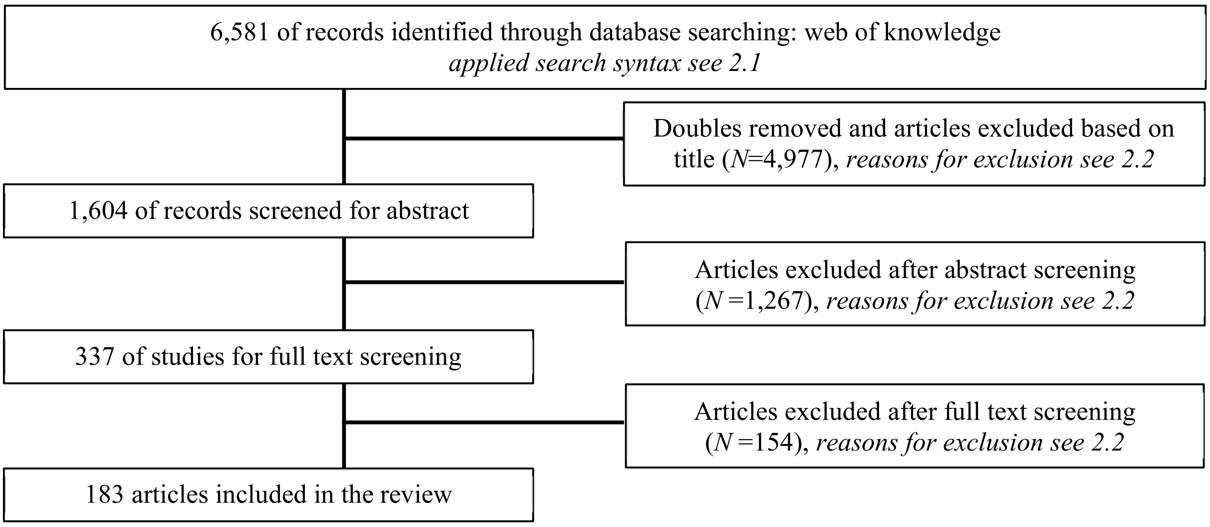


Figure 2: Flow diagram of studies selected for review.

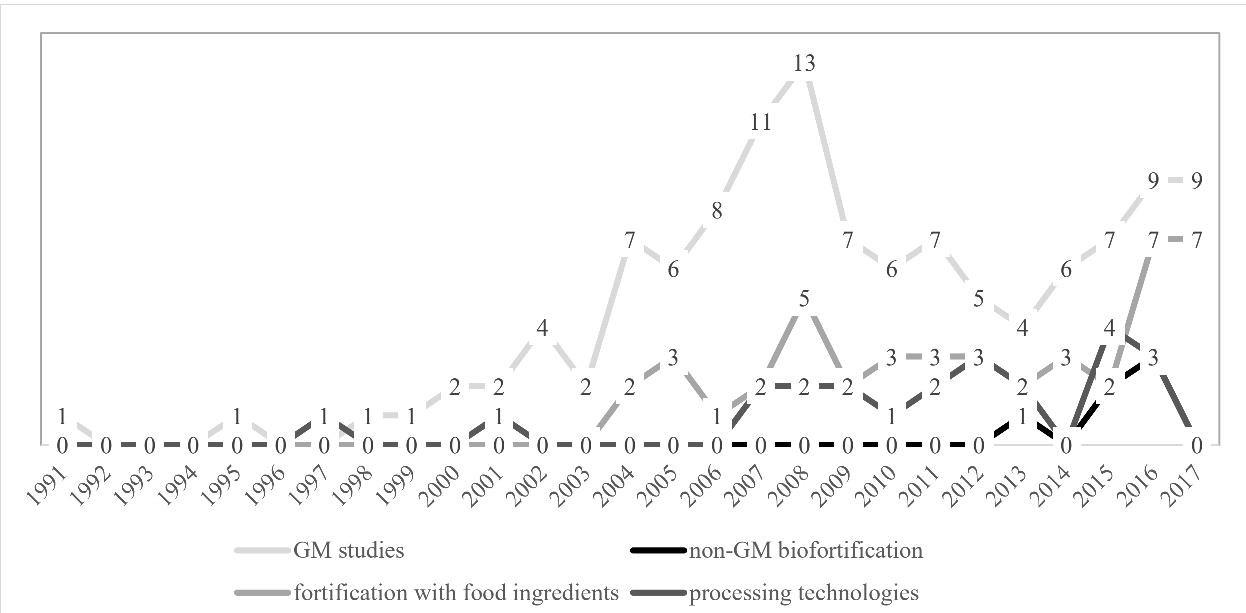


Figure 3: Publications on different food technology innovations, in total number of papers

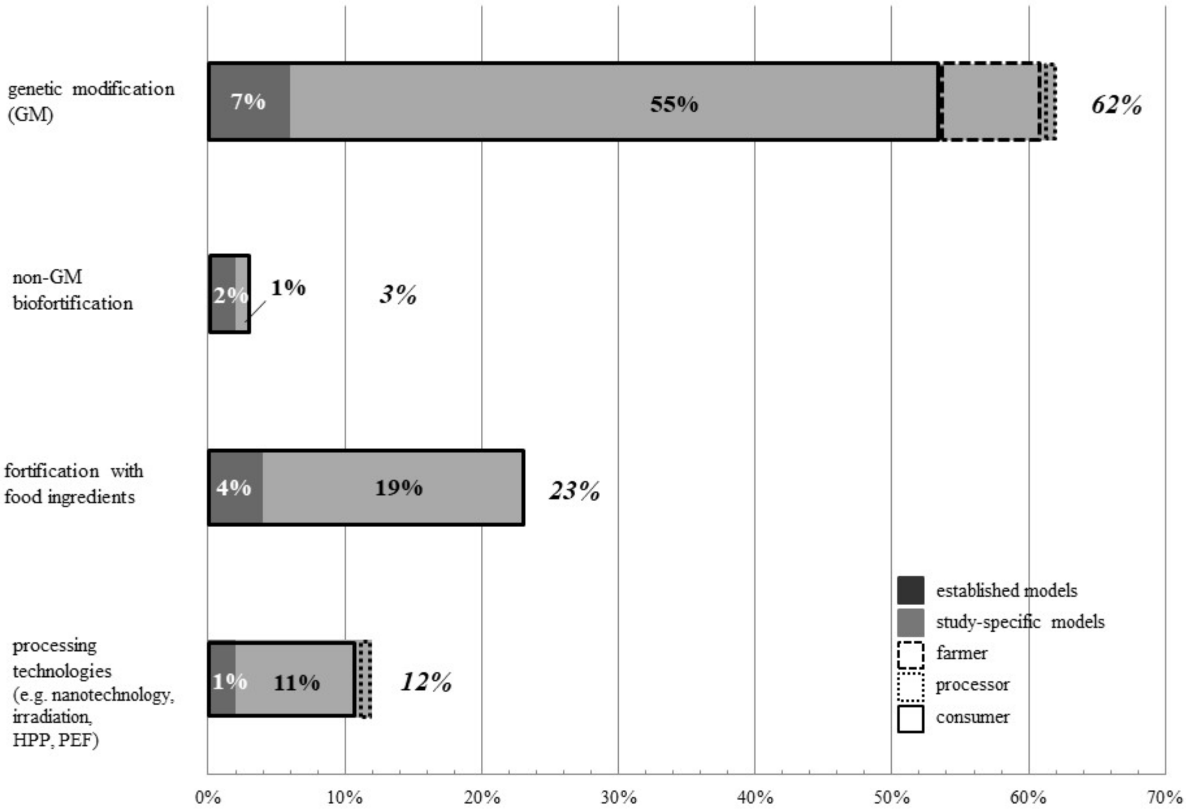


Figure 4: Studies according to type of innovation, supply chain actor and applied model, in relative numbers.
Remark: established models are models based on well-known theory; study-specific models are models with particular relationships; retailer is not included due to lack of studies.

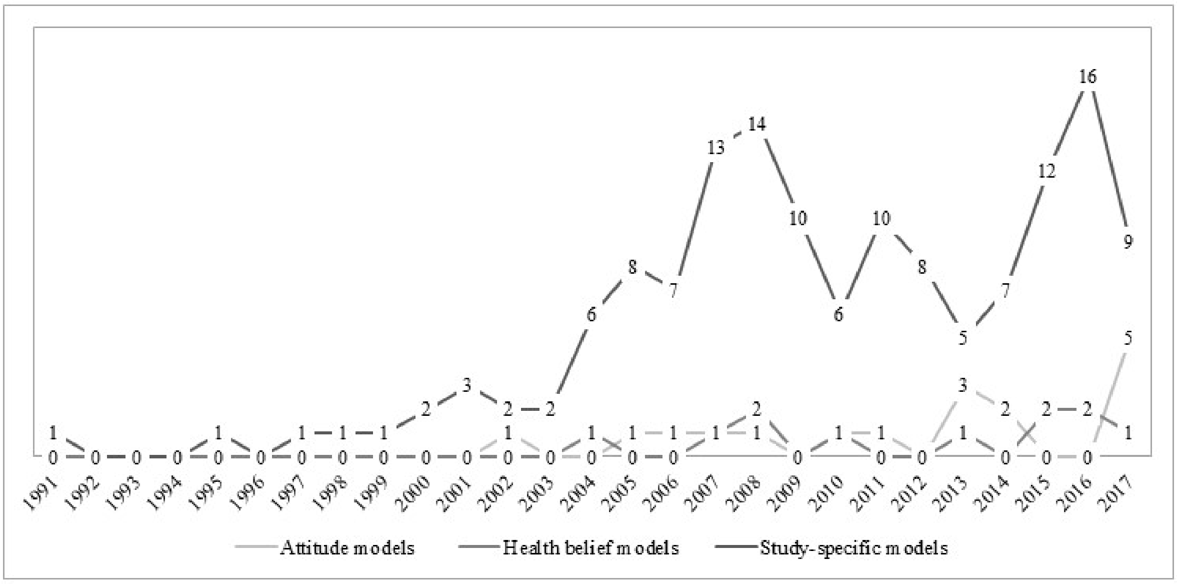
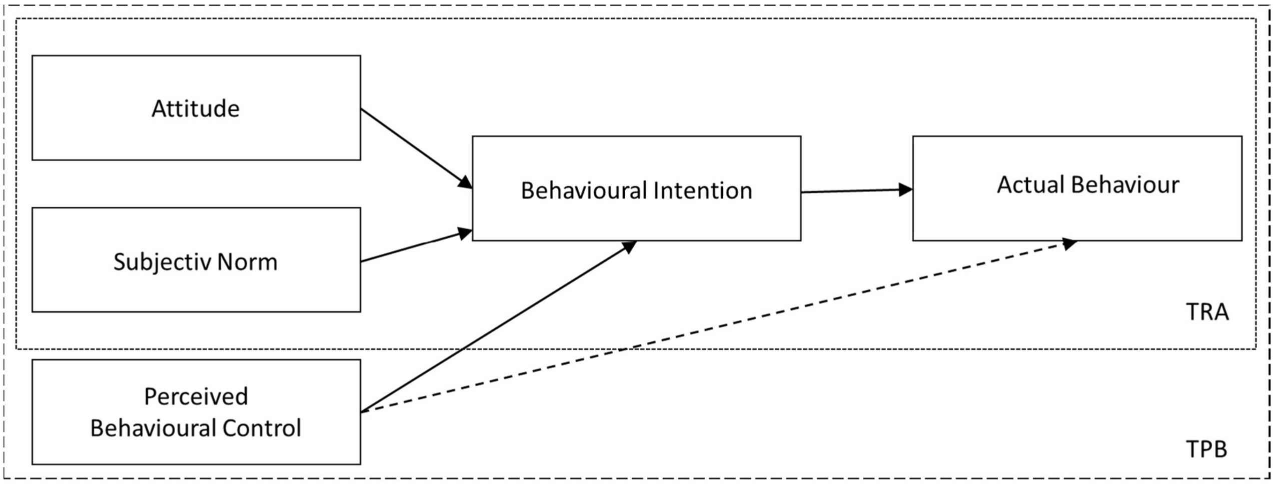


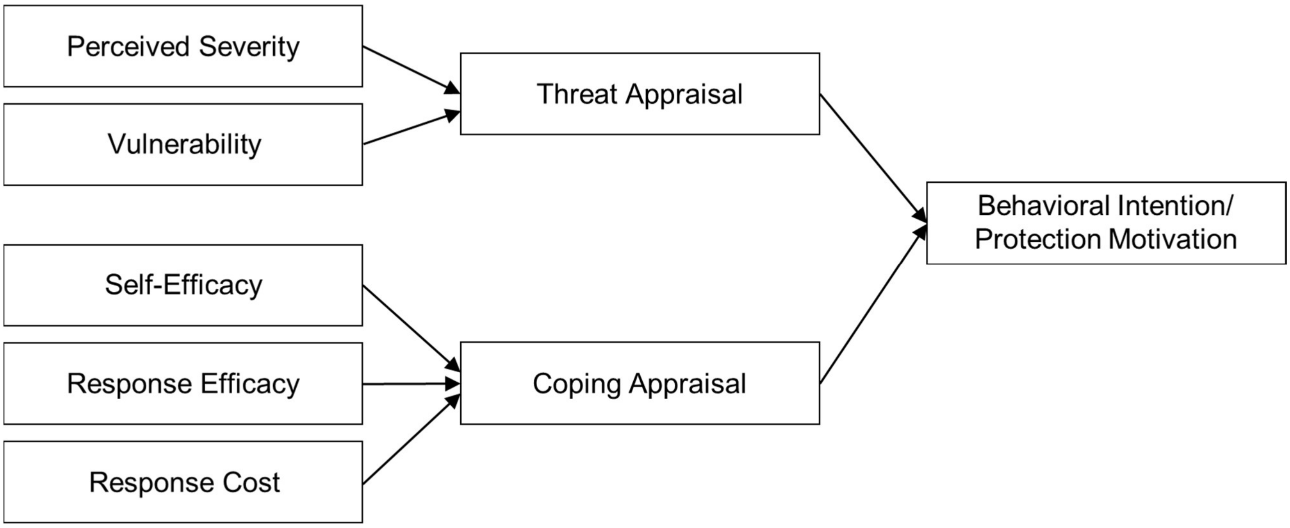
Figure 5: Publication timeline with focus on applied models

Appendix I

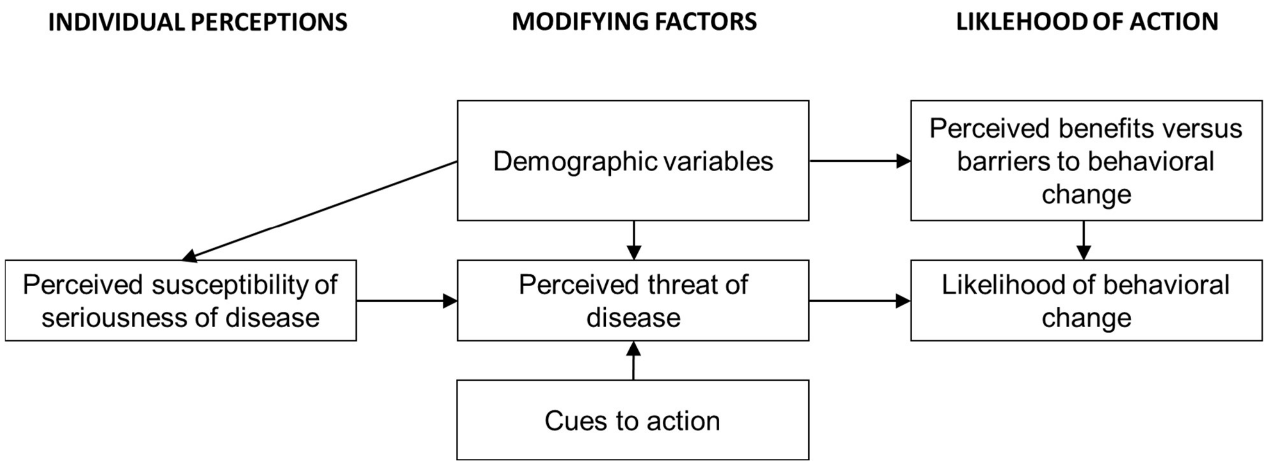
Theory of Reasoned Action by Fishbein and Ajzen (1975) and Theory of Planned Behaviour by Ajzen (1991)



Protection Motivation Theory by Rogers (1975)



Health Belief Model by Rosenstock (1966)



Appendix II

			models		
			Attitude models: attitude model (AM), theory of reasoned action (TRA), theory of planned behavior (TPB) (9%)	**Behavioral health model:** protection motivation theory, health belief model (6%)	study-specific models (85%)
type of technology/innovation	**product innovation**	genetic modification (GM) (61%)	11 (6%) Ref: *AM: 27, 135, 136; TRA: 117; TPB: 27, 34, 61, 86, 104, 125, 132, 157*	2 (1%) Ref: PMT: 42 HBM: 174	105 (54%) Ref: 1, 3, 5, 6, 7, 8, 10, 11, 12, 13, 15, 16, 17, 19, 21, 22, 24, 26, 29, 31, 32, 33, 37, 38, 39, 40, 46, 47, 48, 49, 50, 54, 56, 57, 58, 59, 60, 64, 65, 66, 67, 68, 69, 70, 71, 72, 74, 76, 77, 78, 79, 80, 82, 83, 84, 85, 88, 89, 90, 91, 92, 99, 101, 102, 103, 105, 106, 107, 108, 109, 110, 112, 115, 116, 118, 119, 120, 122, 127, 130, 131, 133, 138, 140, 141, 144, 147, 149, 152, 153, 158, 160, 162, 163, 164, 165, 169, 176, 177, 178, 179, 180, 181, 182, 183
		non-GM biofortification (4%)	1 (1%) Ref: TPB: 161	3 (2%) Ref: PMT: 51, 113, 114	2 (1%) Ref: 123, 124
		fortification with food ingredients (24%)	4 (2%) Ref: TRA: 134, 166; TPB: 30, 128	5 (3%) Ref: PMT: 41, 43, 73, 75; HBM: 134	36 (19%) Ref: 2, 4, 9, 10, 14, 17, 20, 25, 28, 36, 44, 54, 55, 58, 63, 74, 81, 93, 94, 95, 96, 97, 98, 100, 126, 129, 143, 145, 146, 150, 167, 168, 170, 171, 172, 173
	process innovations	nano-technology (6%)	1 (1%) Ref: TPB: 35	0 (0%)	10 (5%) Ref: 18, 58, 87, 111, 139, 148, 151, 154, 159, 176
		irradiation (4%)	0 (0%)	1 (1%) PMT: 45	5 (3%) Ref: 53, 62, 74, 142, 175
		high pressure processing (3%)	0 (0%)	0 (0%)	4 (3%) Ref: 121, 137, 155, 156
		pulsed electric field (1%)	0 (0%)	0 (0%)	1 (1%) Ref: 155
		pre-gelatinization (1%)	0 (0%)	0 (0%)	1 (1%) Ref: 52
		not specified (1%)	0 (0%)	0 (0%)	1 (1%) Ref: 23
chain actors		farmer (7%)	0 (0%)	0 (0%)	12 (7%) Ref: 13, 15, 22, 56, 69, 72, 80, 92, 105, 149, 169, 179
		processor (1%)	0 (0%)	0 (0%)	2 (1%) Ref: 23, 160
		consumer (92%)	16 (9%) Ref: AM: 27, 135, 136; TRA: 117, 134, 166; TPB: 27, 30, 34, 35, 61, 86, 104, 128, 132, 157, 161	11 (6%) PMT: 41, 42, 43, 45, 51, 73, 75, 113, 114; HBM: 134, 174	143 (77%) Ref: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 16, 17, 18, 19, 20, 21, 24, 25, 26, 28, 29, 31, 32, 33, 36, 37, 38, 39, 40, 44, 46, 47, 48, 49, 50, 52, 53, 54, 55, 57, 58, 59, 60, 62, 63, 64, 65, 66, 67, 68, 70, 71, 72, 74, 76, 77, 78, 79, 81, 82, 83, 84, 85, 87, 88, 89, 90, 91, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 106, 107, 108, 109, 110, 111, 112, 115, 116, 118, 119, 120, 121, 122, 123, 124, 126, 127, 129, 130, 131, 133, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 150, 151, 152 , 153, 154, 155, 156, 158, 159, 162, 163, 164, 165, 167, 168, 170, 171, 172, 173, 175, 176, 177, 178, 180, 181, 182, 183

Table: Studies according to type of innovation, supply chain actor and applied model, in absolute (relative) numbers

References:

ID	Short citation
1	Abdulkadri et al. (2007)
2	Ahn et al. (2016)
3	Ali et al. (2016)
4	Amin et al. (2013)
5	Amin, Ahmad et al. (2011)
6	Amin, Azad, Ahmad et al. (2014)
7	Amin, Azad, Gausmian et al. (2014)
8	Amin, Othman et al. (2011)
62	Giamalva et al. (1997)
63	Gineikiene et al. (2017)
64	González et al. (2009)
65	Govindasamy et al. (2008)
66	Grimsrud et al. (2004)
67	Grobe, Douthitt (1995)
68	Grunert et al. (2001)
69	Guehlstorf (2008)
123	Oparinde et al. (2016)
124	Oparinde et al. (2016)
125	Oparinde et al. (2017)
126	Pappalardo, Lusk (2016)
127	Pardo et al. (2002)
128	Patch et al. (2005a)
129	Patch et al. (2005b)
130	Pino et al. (2016)

9 Annunziata et al. (2016)
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11 Baker, Burnham (2001)
12 Bardin et al. (2017)
13 Barham et al. (2014)
14 Barrena et al. (2017)
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16 Bekker et al. (2017)
17 Beltran et al. (2016)
18 Bieberstein et al. (2013)
19 Boecker et al. (2008)
20 Brecic et al. (2014)
21 Bredahl (1999)
22 Breustedt et al. (2008)
23 Brewin et al. (2009)
24 Canavari et al. (2009)
25 Carrillo et al. (2013)
26 Chema et al. (2006)
27 Chen (2008)
28 Chen (2011)
29 Chen (2011)
30 Chen (2017)
31 Chen et al. (2016)
32 Chen, Li (2007)
33 Connor, Siegrist (2011)
34 Cook et al. (2002)
35 Cook, Fairweather (2007)
36 Coppola et al. (2014)
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38 Costa-Font, Gil (2009)
39 Costa-Font, Gil (2012)
40 Costa-Font, Mossialos (2005)
41 Cox et al. (2004)
42 Cox et al. (2008)
43 Cox, Bastiaans (2007)
44 Cranfield et al. (2011)
45 Crowley et al. (2013)
46 Curtis, Moeltner (2007)
47 Curtis, Moeltner (2007)
48 De Liver et al. (2005)
49 De Steur et al. (2010)
50 De Steur et al. (2012)
51 De Steur, Mogendi et al. (2015)
52 De Steur, Odongo et al. (2015)
53 Deliza et al. (2010)
54 Ding et al. (2012)
55 Dobrenova et al. (2015)
56 Edmeades, Smale (2006)
57 Emberger-Klein et al. (2016)
58 Evans et al. (2010)
59 Florkowski et al. (1998)
60 Gaskell et al. (2004)
61 Ghoochani et al. (2017)
70 Gutteling et al. (2006)
71 Hagemann, Scholderer (2009)
72 Han et al. (2015)
73 Henson et al. (2010)
74 Henson, Cranfield et al. (2008)
75 Henson, Masakure et al. (2008)
76 Hu et al. (2009)
77 Hudson et al. (2015)
78 Irani et al. (2002)
79 James, Burton (2003)
80 Kaup (2008)
81 Kavoosi-Kalashami et al. (2017)
82 Kikulwe, Birol et al. (2011)
83 Kikulwe, Wesseler et al. (2011)
84 Kim (2010)
85 Kim (2012)
86 Kim (2014)
87 Kim, Kim (2015)
88 Kimenju, de Groote (2008)
89 Klerck, Sweeney (2007)
90 Knight (2007a)
91 Knight (2007b)
92 Krishna, Qaim (2007)
93 Krutulyte et al. (2008)
94 Krutulyte et al. (2011)
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146 Shan et al. (2017)
147 Siegrist (2000)
148 Siegrist (2007)
149 Siegrist (2016)
150 Siegrist, Stampfli, Kastenholz (2008)
151 Siegrist, Stampfli, Kastenholz, Keller (2008)
152 Simon (2010)
153 Sjöberg (2008)
154 Sodano et al. (2016)
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156 Sorenson, Henchion (2011)
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158 Spence, Townsend (2007)
159 Steenis, Fischer (2016)
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Supplementary data file

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