What Do We Know About Chain Actors' Evaluation of New Food Technologies? A Systematic Review of Consumer and Farmer Studies

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Abstract: New food technologies, such as genetic modification, food fortification, and processing technologies, are of growing interest for future food security and safety. For ensuring successful implementation of such technologies, consumers and other food supply chain actors should embrace them. We present a systematic review to identify and compare key factors of supply chain actors' evaluation of new food technologies. Evaluation encompasses indicators such as likelihood or intention to perform a behavior, perceived benefits/risks, willingness to pay, acceptance/adoption, and attitudes. Results from 183 studies showed several imbalances in research. Although studies mainly focused on (1) genetically modified foods, (2) by consumers, (3) in developed countries, only very few studies have targeted other food technologies, other supply chain actors such as farmers (13 studies) or processors (two studies), or developing countries (43 studies). With respect to consumers' evaluation, key determinants were trust in institutions, information assessment, perceived risks and benefits, attitudes toward the product or technology, perceived behavioral control, quality perception of the product, and impact on health. Farmers' evaluation of new food technologies was explained by the factors of perceived risk and benefits and of actual source of information. For the few processor evaluation studies, no convergence of factors could be reached. This systematic review contributes to a better understanding of consumers' and farmers' evaluation behavior and opens up avenues for future research on supply chain actors' food technology evaluations. The differences in the conceptualization and measurement of extracted factors demonstrate the need for standardized approaches in future studies.

Keywords: factors, food evaluation, network analysis, new food technology, supply chain actors

Introduction

Although the global food system is facing increasing pressure from population growth and severe resource constraints coupled with climate change upheavals, new food technologies offer a potential avenue for tackling these challenges (Floros et al., 2010; Frewer, 2017). The European Commission (1997) (Regulation (EC) No 258/97, Article 1) has defined novel foods as foods containing or produced from genetically modified organisms; consisting of plants or animals not obtained by traditional propagating or breeding practices and having a long history of safe food use; and foods and food ingredients to which has been applied a production process not currently used, where that process gives rise to significant changes in their composition or structure of the foods or food ingredients which affect its nutritional value, metabolism, or level of undesirable substances. Widely known examples of such novel foods and technologies are genetically modified (GM) food, functional food, nanotechnology, radio frequency, high-pressure processing, and use of pulsed electric fields. As many emerging food technologies require safety assessment (Augustin et al., 2016; Wilcock, Pun, Khanona, & Aung, 2004), they often face public controversies in society (Gupta, Fischer, & Frewer, 2012; Lusk, Roosen, & Bieberstein, 2014; Rollin, Kennedy, & Wills, 2011). Consumers' reluctance to highly processed food, often caused by lack of knowledge about new food technologies, for example, hinders the adoption of new food technologies worldwide (Lusk et al., 2014). This is particularly the case for genetic modification in food, where public concerns on human and environmental safety affect its acceptance by supply chain actors (Bawa & Anilakumar, 2013; Uzogara, 2000). This has led to an enormous, growing body of research that has looked at the perceptions and reactions of consumers (Frewer et al., 2011; Lyndhurst, 2009) in order to examine the market potential of the respective new food technology.

Within the chain actor literature on evaluation of food technologies, there is a huge variety of different outcome (or dependent) variables, as also indicated in a meta-analysis on consumer evaluation of GM food (Frewer et al., 2013). Behavioral intention (intention to perform a behavior), for example, is included in the renowned Theory of Planned Behavior (Ajzen, 1991), together with attitude, in order to explain (future) behavior. Willingness to pay, another concept that is linked to chain actor evaluation, is elicited through preference methods and is distinct from an attitude someone holds about, for example, a food technology. Even though these concepts clearly measure different aspects of chain actor evaluation, they are often used interchangeably (Frewer et al., 2013; Mogendi, De Steur, Gellynck, & Makokha, 2016b), resulting in the need to use a more general concept. According to Hess, Lagerkvist, Redekop, and Pakseresht (2016) and Mogendi et al. (2016b), evaluation is that kind of comprehensive concept for chain actors' views on new food technologies and represents indicators such as likelihood or intention to perform a behavior, perceived benefits/risks, willingness to pay, acceptance/adoption, and attitudes. These indicators do not focus on actual behavior, but rather on chain actors' willingness to perform a behavior. Many researchers have developed explanatory models to obtain a better understanding of consumers' new food technology evaluations. These models were either derived from theories like the Theory of Planned Behavior (Ajzen, 1991) and the Protection Motivation Theory (Rogers, 1975)—in the following called "well-established theoretical models"— or specifically developed for the purpose of a study (Bearth & Siegrist, 2016; Lyndhurst, 2009)—further called "study-specific models." A comprehensive analysis of the outcomes of such models, however, is currently lacking.

Furthermore, befitting the complexity of the food supply chain, it is not only crucial to identify the factors of technology acceptance or adoption by consumers (Frewer et al., 2011; Ronteltap, van Trijp, Renes, & Frewer, 2007; Siegrist, 2008), but also by other supply chain actors (Bigliardi & Galati, 2013; Bröring, 2008; Grunert et al., 2005; Hermans, Sartas, van Schagen, van Asten, & Schut, 2017). According to Rogers (1975), an innovation adoption process needs to consider all relevant decision-maker units, that is, chain actors. For the global food system, key actors are farmers, processors, retailers, and consumers (Michalak & Schroeder, 2011). However, the number of relevant actors that can be targeted depends on the type of technology, and at which level the technology is introduced. For example, chain actors' evaluation research on functional foods departs at the level of processor (up to consumer), while GM food research can also focus on farmers.

In order to contribute to the limited research and knowledge gaps related to this topic, that is, (1) lack of a comprehensive analysis of factors describing chain actors' new food evaluations, and (2) the lack of the nonconsumer perspective, this study aims to conduct a systematic review of the key factors of supply chain actors' new food technology evaluations. Therefore, we will (1) synthesize and analyze the frequency distribution of included factors and (2) evaluate the significant relationships between factors. Our analysis on primary studies is comprehensive in different ways. It systematically analyzes and compares factors that influence chain actors' new food technology evaluation indicators; it includes outcomes from both well-established theoretical and study-specific models; and it goes beyond the findings of consumer-oriented research by including one or more other food supply chain actors, technology-specific, or nonsystematic reviews. The outcomes of this study aim to contribute to a better understanding of the main factors influencing chain actors' new food technology evaluations, which will be relevant for the conceptualization and measurement of future studies. This is also of interest for the implementation of future new food technologies along the food supply chain.

Methodology

Search strategy and identification of primary studies

A systematic literature review of published evidence on the conceptual analysis of supply chain actors' evaluations of novel food technologies was undertaken using the methodology approach of Petticrew and Roberts (2006). Following the generic search strategy used in systematic reviews, a search syntax with keywords agreed upon by four researchers (the authors of this study) was developed. These were systematically applied in one electronic database (ISI Web of Science), hence only restricting the search to peer-reviewed and indexed studies. The search syntax used a combination of terms referring to "novel food technologies," "evaluation," and "target population" keywords. Regarding the latter, the search syntax was extended to include all supply chain actors (that is, farmers, food processors, retailers, and consumers). However, as the search did not reveal sufficient articles on supply chain actors other than consumers and farmers, we have focused the remainder of this study on these two target groups. The following search syntax was adopted and used to identify the primary studies: "food tech*" OR "agri-food tech*" OR "food innovation" OR "food process*" OR "food approaches" OR "nutrigenomics" OR "nano-tech*" OR "pulsed electric field" OR "PEF" OR "HPP" OR "high hydrostatic pressure" OR "HHP" OR "high pressure" OR "radio-frequency pasteurization" OR "ultraviolet light" OR "irradiat*" OR "novel food" OR "non-conventional food" OR "innovative food" OR "altered food" OR "functional food" OR "nutraceuticals" OR "fortif*" OR "enriched food" OR "biofortif*" OR "bio-fortif*" OR "bioeng*" OR "biotech*" OR "agro-biotech*" OR "GM food" OR "gm" OR "gmo" OR "genetic modification" OR "transgene*" OR "cisgene*" OR "clon*" AND "accepta*" OR "adopt*" OR "attitud*" OR "opinio*" OR "percept*" OR "valuation" OR "willingness" OR "WTP" OR "willingness-to-pay" OR "willingness-to-accept" OR "WTA" OR "willingness-to-try" OR "preference" AND "consumer*" OR "public" OR "social" OR "citizen" OR "farmer*" OR "processor*" OR "retail*" OR "stakeholder*" OR "supply chain*."

Screening of primary studies

Screening of relevant studies was based on well-defined criteria before data extraction was performed, that is, a study had to have been published in a peer-reviewed journal, written in English, focused on one or more supply chain actors (for example, consumer, processor, and farmer), analyzed food technology evaluation, and explored the relationship between at least three variables (that is, explanatory model).

Endnote web was used as a working database for sorting included and excluded studies based on the aforementioned criteria. The screening steps included in this review are shown in Figure 1. First, studies with double records were removed, followed by those with titles that clearly did not fit the scope of the review. It was only after abstract screening that a full-text review was made to retain articles that measured evaluation of novel food technology among supply chain actors. Finally, during data extraction, included studies were checked for final eligibility. All studies meeting

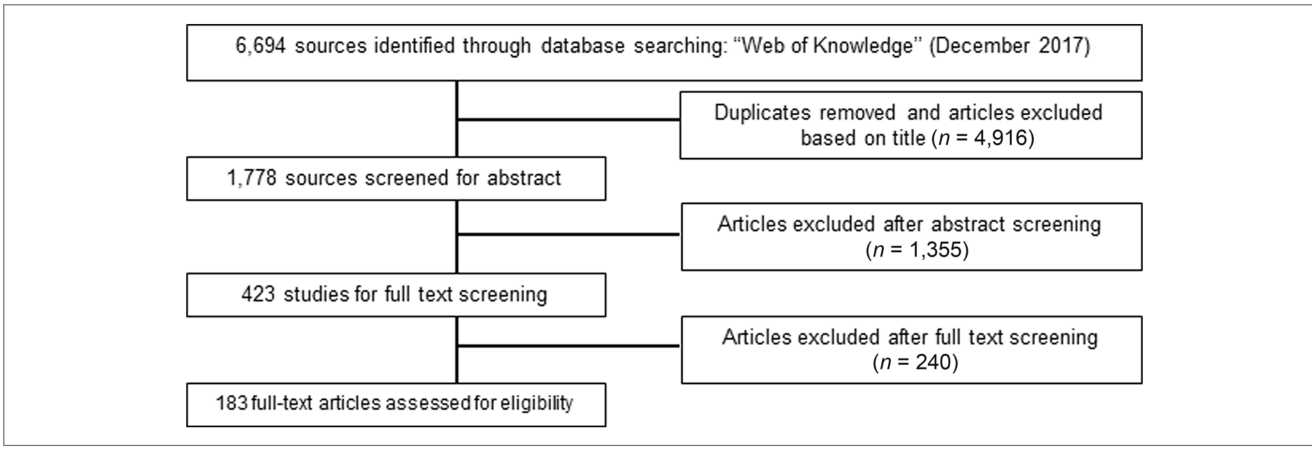

Figure 1–Flow diagram of the studies used in the review.

the inclusion criteria in the three stages were therefore retained and used in the present review.

This whole process was performed by two researchers who cross-checked each other to ensure a study is only included if it fulfills the set criteria. A third party was always consulted whenever consensus could not be reached.

Data extraction

After screening the relevance of selected studies, a final database was constructed. The following information was extracted from selected studies: types of food technology, supply chain level, location of study, factors influencing technology evaluation, data analysis method, and significant relationships between identified factors and the evaluation concept of interest.

The final database represents a comprehensive overview of articles focusing on the conceptual analysis of evaluation behavior toward different novel food technologies among actors along the food supply chain. As a variety of models and methods were used to measure chain actor evaluation in this research context, it was impossible to extract a common parameter across studies that in addition would suit a meta-analysis. Thus, a systematic review that extracts, checks, and summarizes information on determined methods and identified results was applied.

Procedure of grouping variables

One of the research objectives was to analyze significant relationships between variables that describe chain actors' evaluations of novel food technologies. Therefore, included studies used more or less similar variables with different wordings, for example, attitude toward technology, opinion about the technology, or technology optimism. The large database, or list of variables, had to be summarized and grouped to broader variables. Therefore, the procedure of qualitative content analysis, widely used for analyzing text data (Hsieh & Shannon, 2005), was adapted to reduce the number of variables. More specific, the conventional content analysis (Hsieh & Shannon, 2005; Schilling, 2006), also described as inductive category development (Mayring, 2000), was applied as this procedure allows the categories and their names to flow from the data instead of using preconceived categories (Hsieh & Shannon, 2005). The procedure of category development out of extracted variables is presented in Figure 2 and was carried out by two researchers.

In order to process the huge amount of information, the basis for coding a category was having at least three studies using the same variable. When a study reported findings from different contexts (that is, supply chain actors, countries, or products), similar variables for both contexts were extracted (for example, Mogendi, De Steur, Gellynck, and Makokha (2016a) counted double as focus was on consumer and farmer). Therefore, percentages in Table 1, Table 2, and Figure 3 are presented based on the total number of extracted variables, but not on total number of included studies. Furthermore, variables referring to case-specific intrinsic (related to the physical aspects of a product, for example, level of on-farm chemical use, organic-produced crops) or extrinsic (related to the non-physical part of the product, for example, brand name, domestic versus imported food, patenting need) attributes

Table 1–Type of technology, data collection method, and variable type used by the included studies.

				Consumer	Processor	Farmer
No. of studies ($N = 183$)*				169	2	13
Type of technology	Genetic modification (62%)			54%	1%	7%
	Non-GM biofortification (3%)			3%	0%	0%
	Fortification with food ingredients (23%)			23%	0%	0%
	Processing technologies (12%)			11%	1%	0%
Data collection	Primary	Quantitative	Survey	68%	1%	7%
			Experiment	12%	0%	1%
		Qualitative	Interviews	6%	0%	0%
	Secondary	Eurobarometer		5%	0%	0%
Type of variable ($N = 1{,}986$)	Dependent			191	3	17
	Latent	Quantitative		873	8	38
		Qualitative		228	0	0
	Descriptive			550	3	89

*Note: Mogendi et al. (2016a) counted double as focus was on consumer and farmer.

Table 2–Frequency table of variables.

Type of variable	Method data collection	Supply chain actor: Consumer – Variable name	%	Farmer – Variable name	%
Dependent	Quantitative	Intention/likelihood to accept	45%	Likelihood/probability of adoption	35%
		Attitude to food or technology	16%	Adoption	35%
		Willingness to Pay	16%	Perceived risks or benefits	29%
		Acceptance	15%		
		Perceived risks and benefits	9%		
Latent	Quantitative	Information Assessment (knowledge; familiarity; search of info)	18%	Perceived risks/benefits of product/seeds	66%
		Trust in Institutions	11%	Source of information	34%
		Attitude towards product or technology (innovation)	10%		
		Perceived benefit/convenience	9%		
		Risk (perceived risk; risk acceptance)	9%		
		Quality perception of product	7%		
		Impact on health/perceived severity	5%		
		Perceived behavioral control+self-efficacy	3%		
		Attitude to environment	3%		
		Religiousness/ethical and moral concern	3%		
		Willingness to pay/price perception	3%		
		Health consciousness	3%		
		Food neophobia	2%		
		Subjective norm	2%		
		Acceptance	2%		
		Vulnerability	2%		
		Attitude towards the behavior	2%		
		Fear	2%		
		Self-efficacy	2%		
		Attitude towards food safety	2%		
		Response of product efficacy	1%		
		Enjoyment	1%		
		Self-identity*	1%		
		Response cost	0%		
	Qualitative	Perceived characteristic of product	18%		
		Impact on health	11%		
		Perceived quality of life	11%		
		Quality of product	10%		
		Risk and health concern/vulnerability	9%		
		Enjoyment	9%		
		Knowledge/uncertainty of knowledge	8%		
		Benefits	7%		
		Responsibility to others and nature/subjective norm	6%		
		Impact on nature	5%		
		Trust in product and institutions	3%		
		Performance improvement	2%		
Descriptive	Quantitative	Age	17%	Farming practices	26%
		Gender	17%	Farm size	16%
		Education	16%	Education	11%
		Income	12%	Age	10%
		Presence of children/household Size	9%	Financial benefits	10%
		Health care/status	8%	Presence of children/household Size	7%
		Residence	5%	Farm location	6%
		Employment/occupation	4%	Income	6%
		Family status	3%	Barriers	4%
		Ethinicity/race	3%	Gender	4%
		Kind of religion/religious yes/no	2%		
		Agricultural household (farmer status)	2%		
		Household head	2%		
		Social class	1%		

Remark: Percentages are calculated for each subsection, for example, section "consumer-latent-quantitative" is based on all latent variables at consumer level using quantitative approaches; *self-identity can be understood as a label that people use to describe themselves that suggests identification with a social group or category (Cook & Fairweather, 2007).

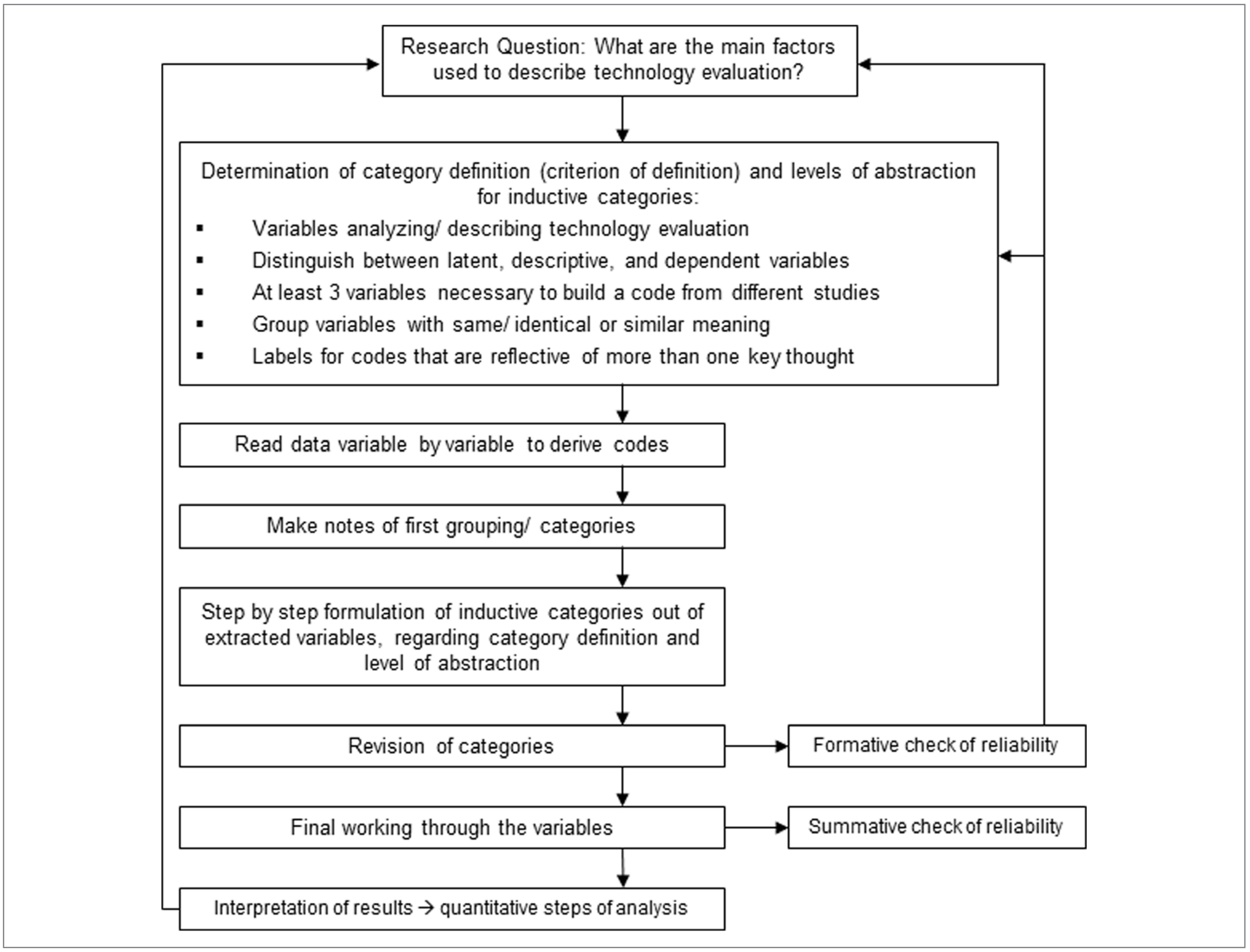

Figure 2–Procedure of inductive category development, adapted from Mayring (2000) and Schilling (2006).
Remark: *formative check of reliability*—two researchers checked the agreement of categories while discussing cases of doubt and problems about the scope and overlapping of the categories; *summative check of reliability*—final working through the variables and codes, check of interrater reliability of the coding (how much researchers had overlaps to ensure reliability).

(Bernués, Olaizola, & Corcoran, 2003) were excluded from subsequent analysis as no common coding variable could be identified. This was also true for the study-specific factors, political values, emotional involvement, and perceived standard of living. With respect to dependent variables, those derived from cluster analysis (that is, segments) were too implicit to be grouped and coded across studies.

All coded variables were categorized as either dependent, latent, or descriptive variables. Dependent variables are a function of other variables and the explanation of its variation is of research interest. The independent (latent) variables normally explain the variation observed in dependent variables and are usually not explained by any other construct in the model (Hair, Black, Babin, & Anderson, 2014). Additionally, descriptive (manifest) variables defined as consumer characteristics (for example, gender, income, and family status) or farmer/farming characteristics (for example, age and farm size) are also considered as factors influencing dependent variables.

Data analysis

Using coded groups of variables, descriptive statistics (that is, frequency distributions) were applied to describe concepts used in the chain actor evaluation of food technologies. This was integrated into the multilevel ecological model of factors influencing behavior (Sallis, Owen, & Fisher, 2008). In the context of environmental influences on food choices, Story, Kaphingst, Robinson-O'Brien, and Glanz (2008) presented an ecological model of individual factors (personal and psychological factors), social environments (networks, interactions with family, friends, peers, and others), physical environment (settings of where behavior takes place, such as home, schools, supermarkets), and macrolevel environments (societal and cultural norms, food industry, agriculture policies), which was also related to the ecological framework by Bronfenbrenner (1979). This approach helps to understand how people behave while interacting with their environment (Sallis et al., 2008). In this review, this approach is used in the context of perception toward the individual, social, physical, and macrolevel environments. For visualization and analysis of significant relationships between main factors, Gephi—a visualization and exploration software—by building networks was utilized. Thereby, the "Circular layout" is chosen—data are represented as a circle, with nodes (variable codes) arranged around the perimeter (dependent variable) and edges (relationships between variables), criss-crossing through the center of the network (Cherven, 2013).

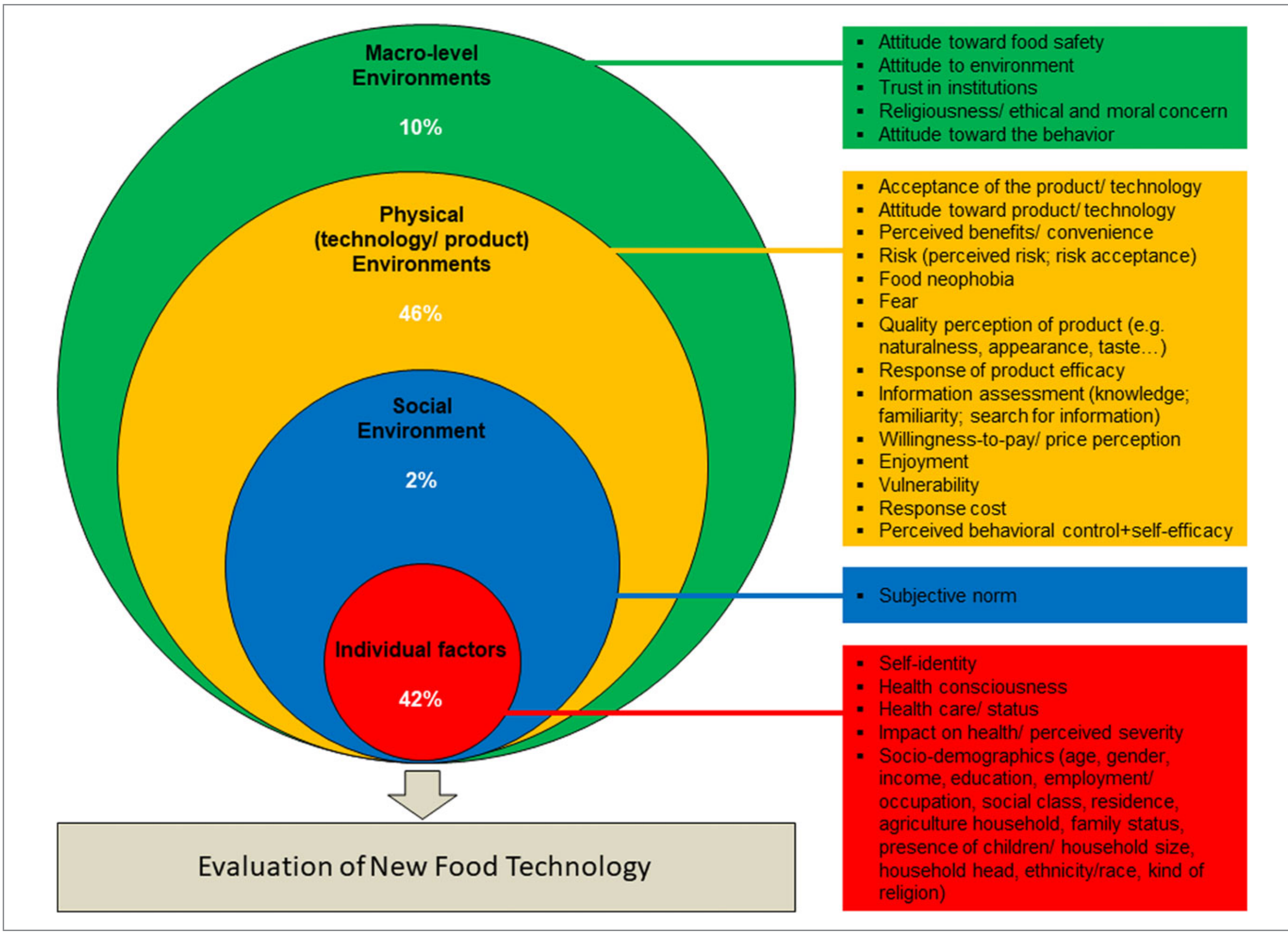

Figure 3–An ecological framework depicting the multiple influences on peoples' evaluation of new food technologies.

To identify the most often reported significant relationships between variables, a cutoff level of 4% was applied to avoid overload of less established constructs. The share of the specific relationship (for example, 63 relationships of perceived benefits) in the total number of significant relationships ($N = 769$) was calculated ($63/769 = 0.08$). In addition, factors from qualitative studies are used to justify outcomes from the quantitative research findings.

Results of the Review

Description of included studies

Based on 183 studies from which data were extracted, genetic modification was the most common food technology, followed by food fortified with nutritional ingredients (functional food), processing technologies, and non-GM biofortification (Table 1). Nearly 75% of included studies were conducted in developed countries, and only one-quarter in developing countries. Europe covered 45% of selected studies, America 22% (North America 19% and South America 3%), Asia 18%, Africa 9% (mainly from East Africa), and Oceania 6%.

About 95% of included studies used primary data obtained from surveys. Thereby, 76% of all selected studies conducted online, face-to-face, postal, or telephone interviews, 13% applied experimental designs (for example, willingness to pay auctions and choice experiments), and 6% carried out qualitative approaches such as means-end chain laddering techniques or in-depth interviews. The remaining 5% of the studies used secondary data, all of them based on the Eurobarometer[1] (European Commission, 2018). Concerning supply chain actors, studies mainly focused on consumers' evaluation (169 studies), a few on farmers' behavior (13 studies), and only two studies targeted processors.

With regard to variables used to describe chain actors' food technology evaluation, 1,986 variables were extracted. The majority of these variables was obtained from quantitative research, especially consumer studies, but also a few studies on farmers or processors. For qualitative studies, 228 latent variables were extracted and used for further analysis.

Frequency of factors in chain actors' evaluation behavior studies

By employing the procedure of inductive category development adapted from Mayring (2000), variables were grouped by consumer (quantitative approaches: 24 latent, 14 descriptive; qualitative approaches: 12 latent) and farmer studies (two latent, 10 descriptive). Only two studies at processor level could be identified, hence no convergence of factors could be reached.

Following the ecological model by Story et al. (2008), more than 40% of the variables were related to the physical (technology/product) or individual environment, while far fewer

[1]Used data: Eurobarometer 52.1 analyzed by Simon (2010); Gaskell et al. (2004); Costa-Font and Mossialos (2005); Eurobarometer 58.0 analyzed by Olofsson, Öhman, and Rashid (2006); Costa-Font and Gil (2008); Costa-Font and Gil (2009); Eurobarometer 73.1 analyzed by Hudson, Caplanova, and Novak (2015); Kim and Kim (2015).

variables were categorized as macrolevel (Figure 3). Strikingly, only 2% of the variables belonged to the social environment category.

Consumer: Quantitative studies. Five categories of *dependent* variables were identified for consumer studies (Table 2). These are as follows: likelihood/intention to adoption/acceptance, willingness to pay, attitude to food or technology, acceptance, and perceived risks and benefits.

When testing the various outcomes of variables and relationships according to the different dependent variables (Appendix A), as well as across included technologies (Appendix B), high similarities were obtained. Therefore, findings were aggregated for all proxy indicators of chain actors' evaluation.

In describing the dependent variables, *latent* factors of well-known theories such as Theory of Planned Behavior and Protection Motivation Theory as well as the Food (Technology) Neophobia Scale were applied. These included: subjective norm, perceived behavioral control, self-efficacy, response of product efficacy, vulnerability, response cost, and food neophobia. Those variable groups had a small share compared to other variable groups. It was observed that models used in studies are to a lesser extent based on well-established, rather tend of use, other factors independent of theories. For the latter, the two most often applied latent variables were information assessment (knowledge, familiarity, and search for information) and level of trust in institutions. These were followed by attitude toward product or technology/innovation, as well as perceived benefit/convenience, risk (perceived risk and risk acceptance), and quality perception of product.

Individual *descriptive* factors, such as age, gender, education, income, and health care/ status, as well as presence of children/ household size, were most often used as influencing factors to dependent variables.

Consumer: Qualitative studies. The factor that was most often mentioned in qualitative studies in the context of evaluating new food technologies was related to the product itself (perceived characteristics of product), followed by individual factors, namely, impact on health and perceived quality of life.

The comparison of results between the quantitative and qualitative studies showed that variables were similar but the order was different. Main differences included: characteristics of product and impact on health were more often mentioned in qualitative compared to quantitative studies. The factors risk and benefits were similar to that of quantitative studies. However, enjoyment was more and information assessment was less often stated in qualitative consumer studies. In addition, the variable trust in institutions was the second most often used variable in quantitative consumer studies, but it turned out to be less interesting in qualitative consumer studies (second least used variable).

Farmer studies. *Dependent* variables of farmer studies can be summarized into three categories, that is, likelihood/ probability of adoption/acceptance, adoption, and perceived risks and benefits.

Farmer studies focused more on farmer and farming characteristics but not on *latent* variables. Only two latent variable groups could be identified, that is, perceived risks or benefits of product/ seeds and source of information.

Included farmer studies also focused on *descriptive* farmer and farming characteristics. Thereby, farming practices (for example, experiences, livestock, soil quality, and waiting period), farm size, education as well as financial benefits (for example, saving of pesticides, yield advantages) and age were often included in models.

Significant relationships to measure chain actors' evaluation behavior

In the above section, the percentages of variables were presented. The relationships between variables were analyzed using the following structure:

- Consumer evaluation studies:
  - Quantitative approaches, analyzing relationships between following variables:
    - □ latent → latent → dependent (Figure 4, and Figure C1 in Appendix)
    - □ descriptive → dependent (Figure 5)
  - Qualitative approaches, analyzing relationships between following variables:
    - □ latent → latent (Figure 6)
- Farmer evaluation studies, analyzing relationships between following variables:
  - □ latent, descriptive → dependent (Figure 7).

Consumer: quantitative studies. Within quantitative consumer studies, eight *latent* factors met the 4% cutoff level, that is, showed the most often significant relationships toward the dependent variable: (1) information assessment, (2) perceived benefits/convenience and risk, (3) trust in institutions as well as (4) attitudes toward product or technology/innovation, (5) quality perception of the product, (6) impact on health, and (7) perceived behavioral control. The specific relationships are explained in more detail in the following paragraphs.

(1) Information assessment: There is a tendency for a positive relationship toward evaluation of new food technologies, that is, the more knowledge a consumer has about, or the more familiar a consumer is with the new technology, the better and more positive is the food evaluation (with respect to GM: Amin, Othman, Lip, Jusoff, & Jusoff, 2011; Baker & Burnham, 2001; Lusk et al., 2004; fortification: Annunziata, Vecchio, & Kraus, 2016; Brečić, Gorton, & Barjolle, 2014; and nanotechnology: Kim & Kim, 2015). For example, an experimental auction by La Barbera, Amato, and Sannino (2016) demonstrated the positive effect of level of (subjective) knowledge about lycopene[2] on willingness to pay for functionalized healthy food in both auctions condition (hypothetical compared with real). However, a survey with male consumers by Henson, Masakure, and Cranfield (2008) revealed a negative influence of (subjective) knowledge[3] on intention to buy lycopene-enriched functional food as a means to reduce the risk of prostate cancer. They assumed that consumers might be skeptical about the efficacy of this product to reduce the risk of prostate cancer (Henson et al., 2008).

(2) Perceived benefits and risks: Both are important factors for the evaluation of new food technologies. Perceived benefits are defined both as useful, needed/necessary (Henson, Annou, Cranfield, & Ryks, 2008), and healthy (Labrecque, Doyon, Bellavance, & Kolodinsky, 2006; Verbeke, 2005) as well as advantageous for the environment (Chen, 2008).

[2]Measurement of knowledge: "How much are you aware of the therapeutic properties of lycopene?" (scale 1—not much to 7—a lot) by La Barbera, Amato, & Sannino, 2016.

[3]Measurement of knowledge: "Do you have expertise related to medicine, nutrition, and health care or are you employed in the food or nutrition industry?" (Yes/No) by Henson, Masakure, & Cranfield (2008).

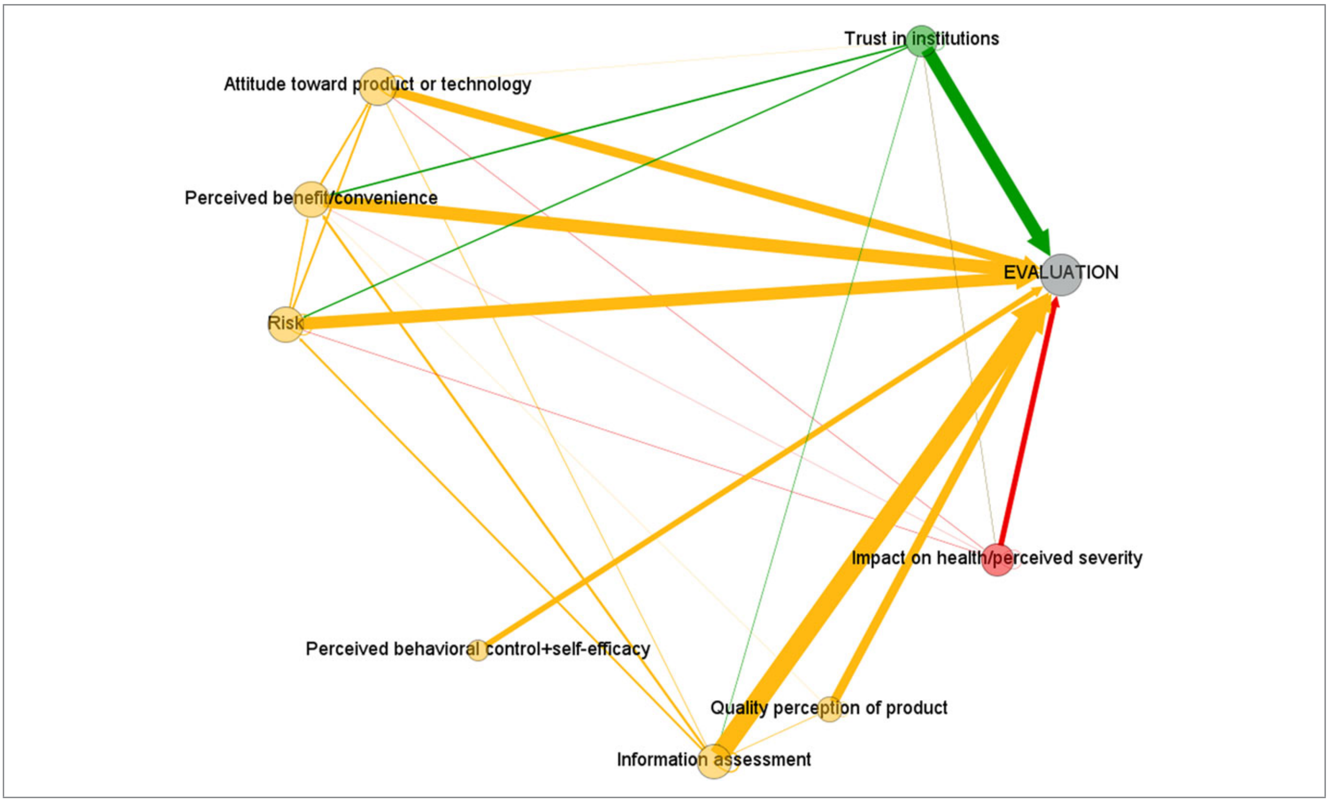

Figure 4–Significant relationships between latent and dependent variables (quantitative consumer studies) with a cutoff level of 4% (and its interrelations).
Remark: red = individual factors; blue = social environments; yellow = physical environments; green = macro-level environments; edge thickness, or weight, represents association strength between nodes.

Thereby, consumers who perceived a food technology innovation as beneficial exhibit positive evaluations (Prati, Pietrantoni, & Zani, 2012; Steenis & Fischer, 2016). Perceived risk, which is associated with impact on health, being harmful/dangerous, negative impact on environment, and cause for concern/worry, unknown/uncertain (Henson et al., 2008), had a negative influence on food evaluation among consumers (for example, Coppola, Verneau, & Caracciolo, 2014; Rodríguez-Entrena & Salazar-Ordóñez, 2013). Perceived benefits and risks mediate information assessment and trust in institutions, but both have an additional significant direct effect on evaluation of new food technologies.

(3) Trust in institutions: Overall, trust in institutions and stakeholders, for example, government, food industry, farmers, scientists, and the media, increases the positive evaluation of new food technologies (with respect to GM: Gutteling, Hanssen, Van Der Veet, & Seydel, 2006; Kimenju & De Groote, 2008; Marques, Critchley, & Walshe, 2015; fortification: Siegrist, Stampfli, & Kastenholz, 2008; Vecchio, van Loo, & Annunziata, 2016; and processing technologies: Sapp & Downing-Matibag, 2009; Siegrist, Stampfli, Kastenholz, & Keller, 2008). For example, respondents who hold a skeptical view of biotechnology companies were less likely to consume nutritionally enhanced GM cereals than those who trusted biotechnology companies (Onyango & Nayga, 2004).

(4) Attitude toward product or technology: Several studies found evidence that general attitude toward product or technology (innovation) is the most important explanatory attitudinal factor for novel food technology evaluations. This relationship was primarily positive (for example, with respect to GM: Costa-Font & Gil, 2012; Laros & Steenkamp, 2004; Spence & Townsend, 2006; fortification: Carrillo, Prado-Gascó, Fiszman, & Varela, 2013; Cranfield, Henson, & Masakure, 2011; Krutulyte et al., 2011; and nanotechnology: Cook & Fairweather, 2007; Kim & Kim, 2015; Sodano, Gorgitano, Verneau, & Vitale, 2016). As illustrated in Figure 4, attitude toward product or technology (innovation) is significantly influenced by information assessment. Even though surveys showed that consumers have little knowledge about new food technologies (Siegrist, 2008), a majority of the people develop a view/an attitude toward this subject based on their preexisting knowledge and values as suggested by Lyndhurst (2009).

(5) Quality perception of the product: In the actual purchase decision, various factors are shown to be taken into account, for example, appearance, taste, naturalness, and healthiness, all categorized as quality perception of the product. The intrinsic attribute product appearance[4] was the most important factor influencing the decision to purchase irradiated papaya for Brazilian consumers (Deliza,

[4]Measurement of appearance: In an experimental design by Deliza, Rosenthal, Hedderley, & Jaeger (2010), the appearance of the fruit in terms of degree of blemishing varied (from free of blemishes [good appearance] to few blemishes [regular appearance]), but size and the color were kept constant throughout the experiment.

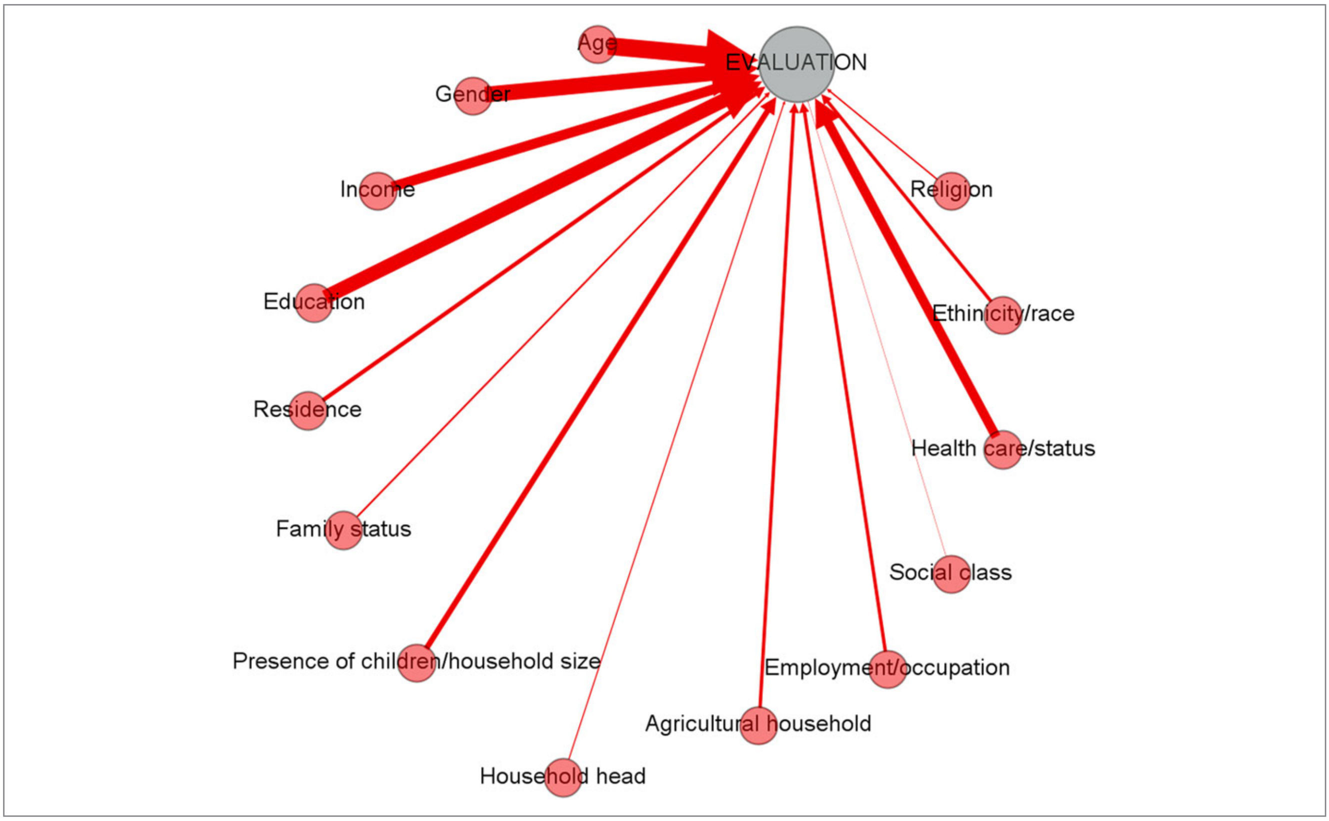

Figure 5–Significant relationships between descriptive and dependent variables (quantitative consumer studies). Remark: red = individual factors; edge thickness, or weight, represents association strength between nodes.

Rosenthal, Hedderley, & Jaeger, 2010). For Italian consumers, appearance[5] negatively affected the willingness to pay a premium price for functional snacks before tasting (nonsignificant after tasting) as consumer do not believe that these products are appealing (Pappalardo & Lusk, 2016). Naturalness[6] appeared to be an important and positive technology feature for consumers with regards to GM foods (Hudson, Caplanova, & Novak, 2015; Ronteltap et al., 2016). Technologies that were seen as more natural and newer were perceived less risky and more beneficial (Hudson et al., 2015). In terms of direct effects on dispositions to biotechnology, motivation to find natural foods[7] had a very strong negative effect (Lockie, Lawrence, Lyons, & Grice, 2005). Respondents for whom naturalness of food was important perceived more risks to be associated with nanotechnology compared to respondents who considered naturalness of foods to be less important (Siegrist et al., 2008). Concerning perceived healthiness, this attribute had a positive influence on purchase intention for functional food (Dobrenova, Grabner-Kräuter, & Terlutter, 2015), GM food (Hu, Adamowicz, & Veeman, 2009), and food nanotechnology (Sodano et al., 2016). Figure 4 shows that quality perception of the product mediates information assessment.

(6) Impact on health: Regarding impact on health, studies can be distinguished based on how a variable was conceptualized. Some studies measured perceived health impact of the product or the applied technology. Others measured perceived severity of a health threat. Depending on the conceptualization used, the influence on the evaluation of new food technologies was positive or negative. Measuring perceived negative health concern toward GM food had a negative effect on consumers' willingness to purchase GM food (Amin et al., 2011), as was perceived severity of eating irradiated meat (Crowley, Marquette, Reddy, & Fleming, 2013). Nevertheless, for the case of severity of a health threat (for example, frightened of the possibility getting cancer or memory loss), the intention to choose fortified or functional food increased (Cox & Bastiaans, 2007; Cox, Koster, & Russell, 2004; Henson, Cranfield, & Herath, 2010).

(7) Perceived behavioral control: This factor is part of the Theory of Planned Behavior (Ajzen, 1991) and comprises components that reflect beliefs about controllability and about self-efficacy (Ajzen, 2002). The latter also belongs to the Protection Motivation Theory by Rogers (1975) and refers to the individual's belief that they can cope with the health threat by a recommended behavior, for example, buying a new food product. In line with previous investigations on the construct perceived behavioral control

[5]Measurement of appearance: "Extent to which food looks appealing." using a best-worst scale approach by Pappalardo and Lusk (2016).

[6]Measurement of naturalness: "Apple Cisgenesis: Attitudes to artificially introducing a gene that exists naturally in wild/crab apples which provides resistance to mildew and scab" (scale 1—totally agree that it is fundamentally unnatural to 4—totally disagree) by Hudson et al. (2015); "This (GM) bread is unnatural" (scale 1—totally disagree to 5—totally agree) by Ronteltap et al. (2016).

[7]Measurement of natural content: Ratings of several statements (contains no additives; contains natural ingredients; contains no artificial ingredients; certified free of chemical and hormone residues; is as unprocessed as possible; is prepared in a way that preserves its natural goodness; scale 1—strongly agree to 5—strongly disagree) by Lockie, Lawrence, Lyons, & Grice (2005).

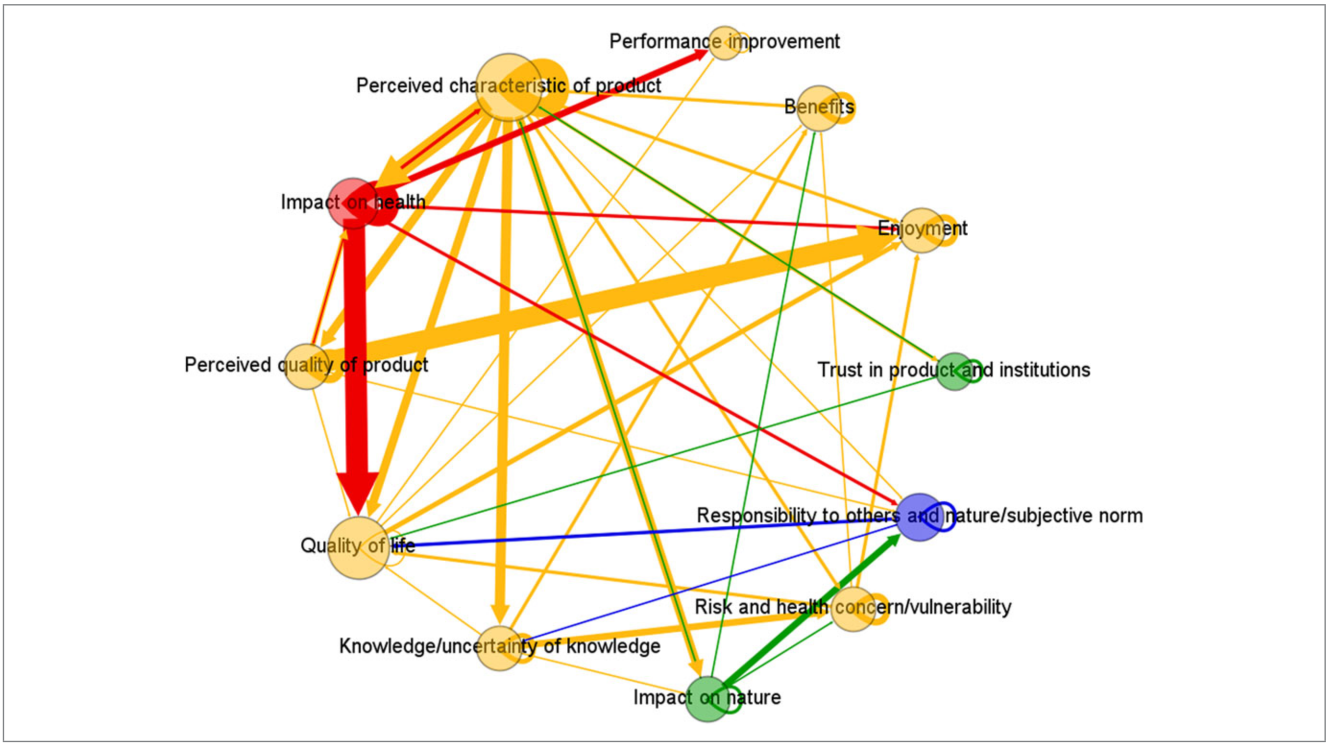

Figure 6–Relationships between variables of qualitative consumer studies.
Remark: red = individual factors; blue = social environments; yellow = physical environments; green = macro-level environments; edge thickness, or weight, represents association strength between nodes.

(Ajzen, 2002; Povey, Conner, Sparks, James, & Shepherd, 2000), self-efficacy was more often significantly influencing consumers' new food technology evaluation than controllability. A positive influence of self-efficacy on consumers' evaluation of new food technologies was demonstrated with respect to GM (Cox, Evans, & Lease, 2008), biofortification (De Steur, Mogendi, Wesana, Makokha, & Gellynck, 2015; Mogendi et al., 2016a), and fortification (Cox et al., 2004; Henson et al., 2010; Henson et al., 2008; Tudoran, Scholderer, & Brunso, 2012). This was also highlighted in the context of Australian consumers' intentions to consume conventional and novel sources of long-chain mega-3 fatty acids (for example, GM food), where self-efficacy (confidence to consume) was the most important predictor (Cox et al., 2008).

Many quantitative research studies at consumer levels test hypotheses about the effect of sociodemographic characteristics (individual factors) on food technology evaluation (Figure 5). Findings indicate inconsistency. *Descriptive* factors that were most often reported as significant are as follows: (1) age, (2) gender, (3) educational and income level, (4) health care/status, (5) household size and presence of children, (6) residence, and (7) religion and ethnicity, and those are analyzed below in more detail.

(1) Age: For age, we observe positive and negative relationships. On the one hand, studies demonstrated that older people were less willing to use or buy functional food (Brečić et al., 2014; Cranfield et al., 2011; Verneau, Caracciolo, Coppola, & Lombardi, 2014) or GM food (Canavari & Nayga, 2009; Hudson et al., 2015), were less accepting nanotechnology for food production (Kim & Kim, 2015), or were less willing to pay for GM food (Lusk et al., 2004). But, on the other hand, there are studies that show older people who were willing to pay more for innovative food (with respect to GM: Lusk & Rozan, 2008; non-GM biofortification: Oparinde, Banerji, Birol, & Ilona, 2016; fortification: Kavoosi-Kalashami et al., 2017; Siegrist et al., 2008; Vecchio et al., 2016), had less fear toward GM foods (González, Johnson, & Qaim, 2009; Laros & Steenkamp, 2004; Sjöberg, 2008; Titchener & Sapp, 2002), or had higher intention to buy functional food or nutraceutical products (Henson et al., 2008).

(2) Gender: Results of gender influences on food evaluation seem to be more consistent. Overall, compared to men, women evaluated GM foods (Chen, 2011b; Govindasamy, Onyango, Hallman, Jang, & Puduri, 2008; Lusk & Rozan, 2008; Napier, Tucker, Henry, & Whaley, 2004; Zepeda, Douthitt, & You, 2003) as well as food produced by nanotechnology more negatively (Sodano et al., 2016; Spence & Townsend, 2007) but were more attentive to healthy life including healthy food and more willing to try functional food (Annunziata et al., 2016; Chen, 2011a; Coppola et al., 2014). There are also a few studies that have demonstrated that men were more reluctant toward new food than women (Cranfield et al., 2011; Nayga, Fisher, & Onyango, 2006; Sjöberg, 2008).

(3) Education and income: In terms of education and income level, different studies find varied effects on food evaluation. Thereby, a higher education and/or higher income resulted in higher positive evaluation of novel food technologies (with respect to GM: Abdulkadri, Pinnock, & Tennant, 2007; Laros & Steenkamp, 2004; Pardo, Midden, & Miller, 2002; fortification: Brečić et al., 2014; Kavoosi-Kalashami et al., 2017; Landstrom, Hursti, Becker, & Magnusson,

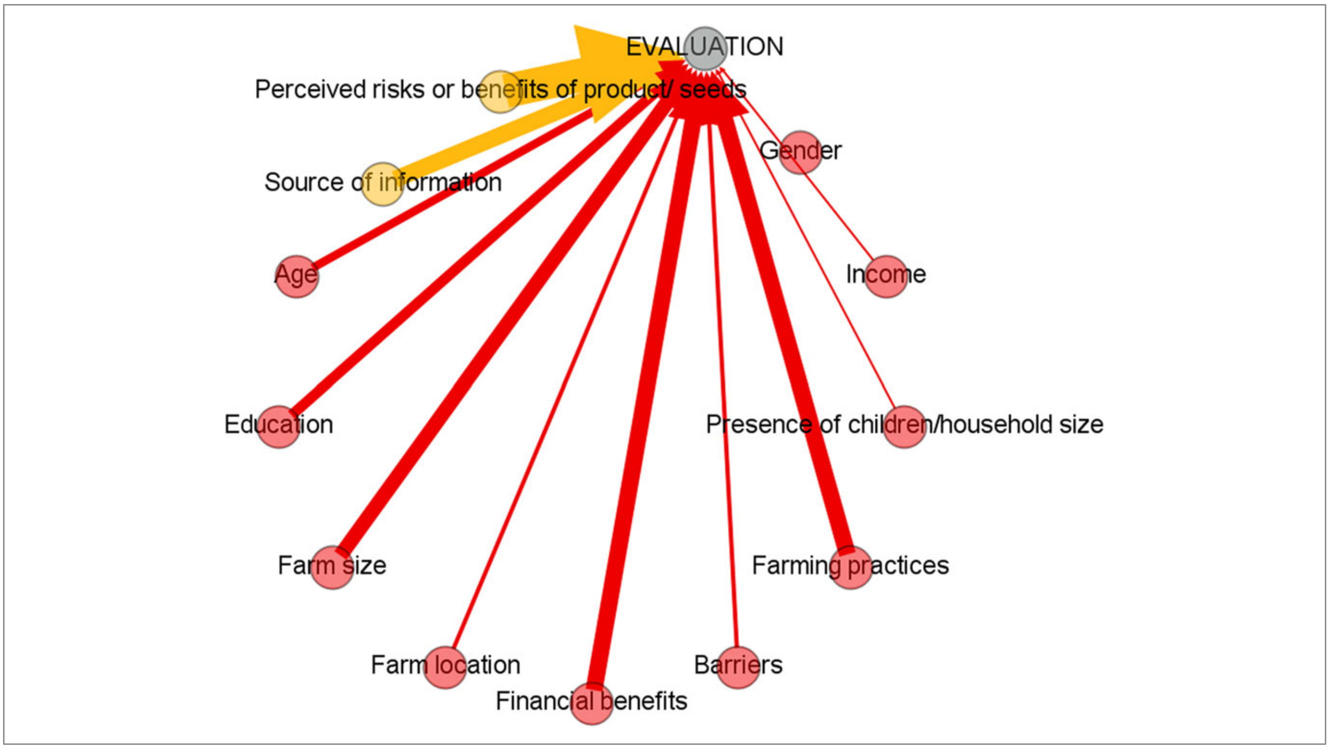

Figure 7–Significant relationships between latent, descriptive and dependent variables (farmer studies).
Remark: red = individual factors; yellow = physical environments; edge thickness, or weight, represents association strength between nodes; gender had no significant relationship.

2007; and nanotechnology: Matin et al., 2012; Sodano et al., 2016). Other studies showed that consumers with higher education and/or income had a negative perception toward new food technologies (Chen, Liu, Nanseki, Li, & Chen, 2016; Giamalva, Bailey, & Redfern, 1997; Poortinga, 2005; Zhang, Chen, Hu, Chen, & Zhan, 2016; Zheng, Gao, Zhang, & Henneberry, 2017).

(4) Health care/ status: Both terms are often used with GM and functional food studies and results tend to show positive influences. We observed a positively perceived health status increased the likelihood to use a functional food ingredient (Cranfield et al., 2011). It is also reported that physical exercise and a higher body mass index positively affected evaluation of GM and functional food, respectively (Brečić et al., 2014; Cox et al., 2008). It seems consumers who are health-conscious more often used functional foods or contrarily those consumers who are willing to compensate for an unhealthy lifestyle (De Jong, Ocké, Branderhorst, & Friele, 2003). Furthermore, the health status of significant others (for example, sickness, overweight of a family member) had a positive impact on functional food evaluation (Kavoosi-Kalashami et al., 2017; Verbeke, 2005), but a negative influence on GM food evaluation (Cox et al., 2008; Zepeda et al., 2003).

(5) Household size: The larger the number of household members, the higher the consumption of functional food (Brečić et al., 2014) as well as their willingness to pay for it (Kavoosi-Kalashami et al., 2017). However, when there were young children in a household, willingness to consume or pay more for GM food was lower (Chen et al., 2016; Thorne, Fox, Mullins, & Wallace, 2017). This is similar for functional food in a study by Annunziata et al. (2016), but different for Vecchio et al. (2016) who showed a higher willingness to pay for functional food.

(6) Residence: Living in urban or rural areas also affects consumers' food technology evaluation that are rather mixed (Canavari & Nayga, 2009; Olofsson, Öhman, & Rashid, 2006; Onyango & Nayga, 2004). There were also a few studies that reported a higher willingness to try or pay by urban people for functional food (Coppola et al., 2014) or GM food (Ali, Rahut, & Imtiaz, 2016), while others reported a negative influence for GM food (Govindasamy et al., 2008). Belonging to an agricultural household negatively influenced functional food consumption (Brečić et al., 2014) as well as the willingness to pay for GM food (Thorne et al., 2017).

(7) Religion and ethnicity: Both influence consumers' food technology evaluation, with a tendency to negative relationships. Religious consumers showed a negative effect in support for biotechnology (Costa-Font & Mossialos, 2005). For ethnicity, Blacks had more moral opposition to GM of plants than Whites (Knight, 2007a, 2007b), but Hispanics demonstrated more support than Whites (Knight, 2007b).[8]

Consumer: Qualitative studies. Given that means-end-chain analysis uses a laddering technique, a dependent variable could not be identified, though the focus is on the relationships between factors. Therefore, data from qualitative studies were interpreted through comparison of most often mentioned relationships between latent variables, as derived from the quantitative studies. First of all, Figure 6 shows that knowledge is related to perceived risks and benefits (Barrena, García, & Sánchez, 2017; Grunert

[8]Results are based on a causal model examining the intervening effects of knowledge, morality, trust, and benefits.

et al., 2001; Krutulyte et al., 2008), and also that perceived risks are related to perceived benefits (Krutulyte et al., 2008) as has been observed in a number of quantitative consumer studies. In addition, qualitative studies demonstrated the mutual relationship between perceived characteristics of product and trust in product/institutions, on the one hand, or perceived benefits on the other (Hagemann & Scholderer, 2009). Furthermore, the perception of the quality and characteristics of the product were related to impact on health (Bredahl, 1999; Sonne et al., 2012). These are potential factors that may have an (mediated) effect on the evaluation of new food technologies by consumers.

Farmer studies. Model-based studies at farmer level focused on descriptive factors. Only two *latent* factors could be categorized based on extracted data (Figure 7), that is, (1) perceived risks or benefits of product and (2) source of information.

(1) Perceived risks and benefits: Regarding perceived risks and benefits of the product, a high level of ambiguity aversion (Barham, Chavas, Fitz, Salas, & Schechter, 2014) or the perceived advantages of disease-resistant and flavor-enhancing crops (Luh, Jiang, & Chien, 2014) positively influence GM food evaluation.
(2) Source of information: Empirical results by a GM seed evaluation study in Taiwan by Luh et al. (2014) indicated that information acquired through social networking increased the probability of adoption. If government reports with scientifically underpinned information about GM seed were provided to farmers, the risk perception toward the use of GM seeds among U.S. farmers' decreased and hence adoption was more likely (Guehlstorf, 2008). U.S. farmers were also more likely to be influenced by their first-hand or local experiences than by state or expert observations (Kaup, 2008).

Three groups of significant *descriptive* factors can be identified as follows: (1) financial benefits and barriers, (2) farming practices and farm size, and (3) education and age on new food technology evaluation.

(1) Financial benefits and barriers: Both can be linked with perceived risks and benefits as latent variables. For example, having yield advantages, and insecticide or herbicide savings, positively influenced evaluation of GM crops (Useche, Barham, & Foltz, 2009). Farmers facing credit constraints, however, had a lower willingness to pay for GM crops (Basu & Qaim, 2007). Regarding time commitment, full-time farmers were less likely to adopt a new technology when there is a greater income-related uncertainty vis-á-vis the earnings from farming activities (Luh et al., 2014).
(2) Farm size: Farm size is another key factor. The bigger the land area owned, the higher the probability of GM crop adoption (Basu & Qaim, 2007; Useche et al., 2009). For farming practices and experiences, mixed results are reported. Although the evaluation of GM banana was positively affected by the extent of farming experiences[9] in East African highlands (Edmeades & Smale, 2006), the opposite was found for banana farmers in Taiwan (Luh et al., 2014)[10].
(3) Education and age: Various demographic factors were found to be significant, for example, older farmers were less likely to adopt GM crops (Breustedt, Müller-Scheeßel, & Latacz-Lohmann, 2008; Oparinde, Abdoulaye, Mignouna, & Bamire, 2017; Zhang, Cui, & Yu, 2017) than less educated ones (Edmeades & Smale, 2006; Tudoran et al., 2012).

Discussion

Main outcomes and future research

This systematic review provides a comprehensive overview of studies determining key factors that influence new food technology evaluation among supply chain actors. Our findings indicate that most studies dealt with GM foods, instead of other food innovation like processing technologies (for example, PEF) or non-GM biofortification (for example, conventional and agronomic approaches). It is possibly a consequence of associated public controversy (Frewer et al., 2011; Gupta et al., 2012). There is also an imbalance in terms of study location and supply chain actor, with most studies targeting consumers in developed countries.

In our study, we analyzed 1,986 variables from 94% quantitative and 6% qualitative studies. For quantitative consumer studies, we grouped the variables to 24 factors by applying inductive category development. Out of these 24 factors, eight factors account for about 72% of all factors mentioned across the samples and 55% of significant relationships, that is, trust in institutions, information assessment, perceived risks, perceived benefits, attitudes toward product or technology, quality perception of the product, perceived behavioral control (including self-efficacy), and impact on health. Their impact on explanation of consumers' food evaluation shows positive and negative relationships depending on the technology, study setting, and type of measurement. Especially the importance of trust, knowledge, and perceived risks and benefits in the context of consumer evaluation behavior by various technologies (Gupta et al., 2012), but also particularly in the food context (Frewer et al., 2013; Lusk et al., 2014; Rollin et al., 2011; Ronteltap et al., 2007), is supported by earlier reviews. Following the results of various reviews, including our systematic overview, the factors that were found to influence consumer evaluation of one technology contribute in shaping the evaluation of other technologies (Gupta et al., 2012). Nevertheless, some factors (for example, ethical and moral concern, subjective norm, and enjoyment) have been less frequently studied throughout different chain actors' technology evaluations as shown in the ecological framework (Figure 3).

Although quantitative studies are often depending on well-established theories and models, which lead to a "path-dependent development," qualitative studies may open avenues for future (quantitative) research through in-depth exploration and identification of emerging relationships. Accordingly, this review also embraces qualitative research studies in addition to quantitative studies. Thereby, qualitative research supports the identified factors by quantitative studies, with the exception of trust. Trust is less often stated in qualitative research than in quantitative research. This might be caused by the difference of trust to other variables that are related to the influence of individual factors, social environment, as well as the perception toward the product/technology, whereas trust is on a higher abstracted level and might be processed subconsciously. But trust in institutions and also in information reduces complexity, as not all pros and cons of a new food technology can be assessed in everyday life decision situations (Lusk et al., 2014), especially when consumers have little knowledge about a technology (Siegrist & Cvetkovich, 2000).

[9]Measurement of farming experience: Ratio of years of experience to age of person in charge of banana production by Edmeades and Smale (2006).
[10]Measurement of farming experience: Experience with planting bananas (in months) by Luh, Jiang, & Chien (2014).

The results of this systematic review open avenues for future research. First, in terms of the scope of studies, there is a need for research in developing regions, at farmer or processor levels, and non-GM innovations (for example, processing technologies). As shown in this review, GM evaluation research is dominating in developed countries, but most GM crops are cultivated nowadays in developing regions (ISAAA, 2016), demonstrating the gap of chain actor evaluation research. Although the importance of GM foods still increases (ISAAA, 2016), other food technologies, such as the utilization of food waste, for example, to gain high-added value ingredients (Galanakis, 2012); alternative sources of proteins, such as seaweeds and insects (Tian, Bryksa, & Yada, 2016); but also synthetic biology, CRISPR/Cas (Katz et al., 2018), and 3-D printers (Dankar, Haddarah, Omar, Sepulcre, & Pujolà, 2018), are also advancing.

Second, while a standardized approach to define and measure food consumer evaluation and its proxy indicators (like information assessment or attitude toward product or technology) in a consistent way will improve consumer food research and its comparability (Hess et al., 2016; Mogendi et al., 2016b), it requires insights into the effect of operationalization of variables, and the methods that are used to collect information on those variables. Nevertheless, based on a large database of consumer studies, one could develop a food technology evaluation model that consists of the most frequently reported variables/constructs and significant relationships, and validate and apply it to specific contexts. Such a unifying theory of food technology evaluation seems to be lacking and has also been stated by other scientists (Bredahl, Grunert, & Frewer, 1998; Hess et al., 2016; Lusk et al., 2014; Mogendi et al., 2016b). Although there are researchers criticizing such theory building for controversial food technologies (Lusk et al., 2014), the important predictors in this study have been confirmed across various food technologies (Frewer et al., 2013; Gupta et al., 2012; Ronteltap et al., 2007) and lend support for an overall explanatory model that does not rule out context-specific variables, similar to those found in the Theory of Planned Behavior.

Third, food innovation adoption literature on farmers and processors is quite limited. There is a need to investigate in more detail factors influencing farmers' and processors' evaluation behavior toward new food technologies. This is important as the understanding of the evaluation behavior of all food supply chain actors is important in order to develop a successful innovation diffusion (Bigliardi & Galati, 2013; Bröring, 2008; Grunert et al., 2005). Thereby, factors from other research contexts can give important additional adoption factors that can be adapted to the food context. For farmers, it is literature on the adoption of precision agriculture (for example, Adrian, Norwood, & Mask, 2005) or information technology (for example, Aleke, Ojiako, & Wainwright, 2011); and for processors, future research can adapt factors from the research area of information technology (for example, Kinsey & Ashman, 2000), organic food products (for example, Shanahan, Hooker, & Sporleder, 2008), or environmental management systems (for example, Massoud, Fayad, El-Fadel, & Kamleh, 2010). These factors will help to develop a supply chain evaluation research approach in the future.

Reflection on strengths and limitations

According to the broad scope of this systematic review, both strengths and limitations must be considered. On the one hand, it synthesizes the results of food technology evaluation studies throughout different technologies and supply chain actors and, thereby, improves the understanding of the key factors driving chain actors' evaluation behavior. Due to the comprehensive scope, we mainly focus on findings across technologies, rather than between. Nevertheless, Table A1 in the appendix provides significant relationships between latent variables and food evaluation for each technology category in quantitative consumer studies. On the other hand, the heterogeneity of this systematic review does not allow to conduct a reliable meta-analysis. Furthermore, when interpreting the results, one needs to take into account the occurrence of publication bias as well as the discussion about overestimating *P*-values and missing presentation of effect sizes (Hirschauer et al., 2016) as well as missing information on construct measurements. Due to the publication bias, which assumes that research reports often present only significant relationships (Petticrew & Roberts, 2006), a calculation of the share of significant to nonsignificant evaluation relationships was not advisable. To enhance the transparency of research, researchers should further invest in providing information on the concepts they measure. Even though we consider this systematic review to be the first to analyze significant effects of targeted factors of food technology, our results are interpreted using the statistical thresholds of significance.

Implications and Conclusions

By providing a comprehensive understanding of the critical factors for new food technology evaluation, this review provides factors to build a framework for future studies related to chain actors' food evaluation, specifically by helping to clarify how the factors of different groups can vary. Thereby, this review has identified research gaps in the current research landscape, for example, limited research on farmer and processor evaluation behavior, on non-GM technologies, in developing countries, and the inconsistency of variable measurements. These research gaps merit consideration in future research in order to better understand the adoption of new food technologies along the supply chain and, in turn, to develop successful implementation strategies. From a policy-related perspective, insights of the consolidated factors influencing consumers' evaluation behavior can serve as the basis for the development of public outreach strategies, for instance, through identifying crucial building blocks for communicating research results.

Author Contributions

Carolin Kamrath researched prior studies, prepared figures and tables, drafted the manuscript, and revised it. Joshua Wesana researched prior studies, drafted the manuscript, and revised it. Stefanie Bröring and Hans De Steur contributed to the conceptualization of the study and revised the manuscript.

Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

A list of the included studies within this literature review is provided as supplementary material.

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Appendix A

Table A1–Extent of significant relationships between latent variables and food evaluation for each technology category in quantitative consumer studies.

Latent	Technology							
Code name	Genetic modification		Non-GM biofortification		Fortification		Processing technology	
	absolute	*in %*	*absolute*	*in %*	*absolute*	*in %*	*absolute*	*in %*
Acceptance of the product/ technology	5	3%	0	0%	0	0%	0	0%
Willingness to pay/ price perception	6	4%	0	0%	0	0%	0	0%
Attitude towards the behavior	2	1%	0	0%	2	4%	2	3%
Attitude towards food safety	4	2%	0	0%	0	0%	2	3%
Attitude towards product/ technology	10	6%	0	0%	12	21%	12	19%
Attitude to environment	1	1%	0	0%	0	0%	0	0%
Perceived benefit/ convenience	11	7%	0	0%	6	11%	6	10%
Risk (perceived risk; risk acceptance)	19	12%	0	0%	3	5%	4	6%
Fear	0	0%	0	0%	0	0%	1	2%
Food neophobia	0	0%	0	0%	2	4%	2	3%
Impact on health/ perceived severity	11	7%	0	0%	5	9%	6	10%
Health consciousness	0	0%	0	0%	5	9%	5	8%
Response cost	0	0%	1	33%	1	2%	1	2%
Response of product efficacy	1	1%	0	0%	7	13%	7	11%
Perceived behvavioral control+self-efficacy	8	5%	1	33%	5	9%	5	8%
Subjective norm	2	1%	0	0%	1	2%	1	2%
Self-identity	1	1%	0	0%	0	0%	0	0%
Trust in institutions	26	16%	0	0%	0	0%	2	3%
Religiousness/ ethical and moral concern	5	3%	0	0%	0	0%	0	0%
Information Assessment	38	23%	1	33%	1	2%	1	2%
Quality perception of product	11	7%	0	0%	1	2%	2	3%
Vulnerability	1	1%	0	0%	4	7%	4	6%
Enjoyment	0	0%	0	0%	1	2%	0	0%
Total number (without excluded)	*162*	*100%*	*3*	*100%*	*56*	*100%*	*63*	*100%*

Appendix B

Table B1–Extent of significant relationships between latent variables and the specific dependent variable in quantitative consumer studies.

Latent	Dependent											
Code name	Acceptance		Willingness to pay		Intention/likelihood		Attitude tow prod/tech		Perc. benefits & risks		all dependent variables	
	absolute	*in %*	*absolute*	*in %*	*absolute*	*in %*	*absolute*	*in %*	*absolute*	*in %*	*absolute*	*in %*
Acceptance of the product/ technology	0	0%	3	11%	2	2%	0	0%	0	0%	5	2%
Willingness to pay/ price perception	0	0%	1	4%	2	2%	2	4%	1	5%	6	3%
Attitude towards the behavior	0	0%	1	4%	4	3%	0	0%	0	0%	5	2%
Attitude towards food safety	1	6%	0	0%	4	3%	1	2%	0	0%	6	3%
Attitude towards product/ technology	3	18%	3	11%	14	11%	1	2%	1	5%	22	9%
Attitude to environment	0	0%	0	0%	1	1%	0	0%	0	0%	1	0%
Perceived benefit/ convenience	1	6%	2	7%	7	6%	4	8%	3	16%	17	7%
Risk (perceived risk; risk acceptance)	4	24%	5	18%	8	7%	4	8%	3	16%	24	10%
Fear	0	0%	0	0%	1	1%	0	0%	0	0%	1	0%
Food neophobia	0	0%	0	0%	2	2%	0	0%	0	0%	2	1%
Impact on health/ perceived severity	0	0%	0	0%	15	12%	0	0%	2	11%	17	7%
Health consciousness	2	12%	0	0%	3	2%	0	0%	0	0%	5	2%
Response cost	0	0%	0	0%	2	2%	0	0%	0	0%	2	1%
Response of product efficacy	0	0%	0	0%	7	6%	0	0%	1	5%	8	3%
Perceived behavioral control+self-efficacy	0	0%	0	0%	13	11%	0	0%	1	5%	14	6%
Subjective norm	0	0%	0	0%	3	2%	0	0%	0	0%	3	1%
Self-identity	0	0%	0	0%	0	0%	1	2%	0	0%	1	0%
Trust in institutions	3	18%	0	0%	12	10%	11	23%	2	11%	28	12%
Religiousness/ ethical and moral concern	0	0%	0	0%	3	2%	2	4%	0	0%	5	2%
Information Assessment	1	6%	13	46%	7	6%	19	40%	3	16%	43	18%
Quality perception of product	0	0%	0	0%	9	7%	3	6%	1	5%	13	6%
Vulnerability	2	12%	0	0%	2	2%	0	0%	1	5%	5	2%
Enjoyment	0	0%	0	0%	1	1%	0	0%	0	0%	1	0%
Total number (without excluded)	*17*	*100%*	*28*	*100%*	*122*	*100%*	*48*	*100%*	*19*	*100%*	*234*	*100%*

Appendix C

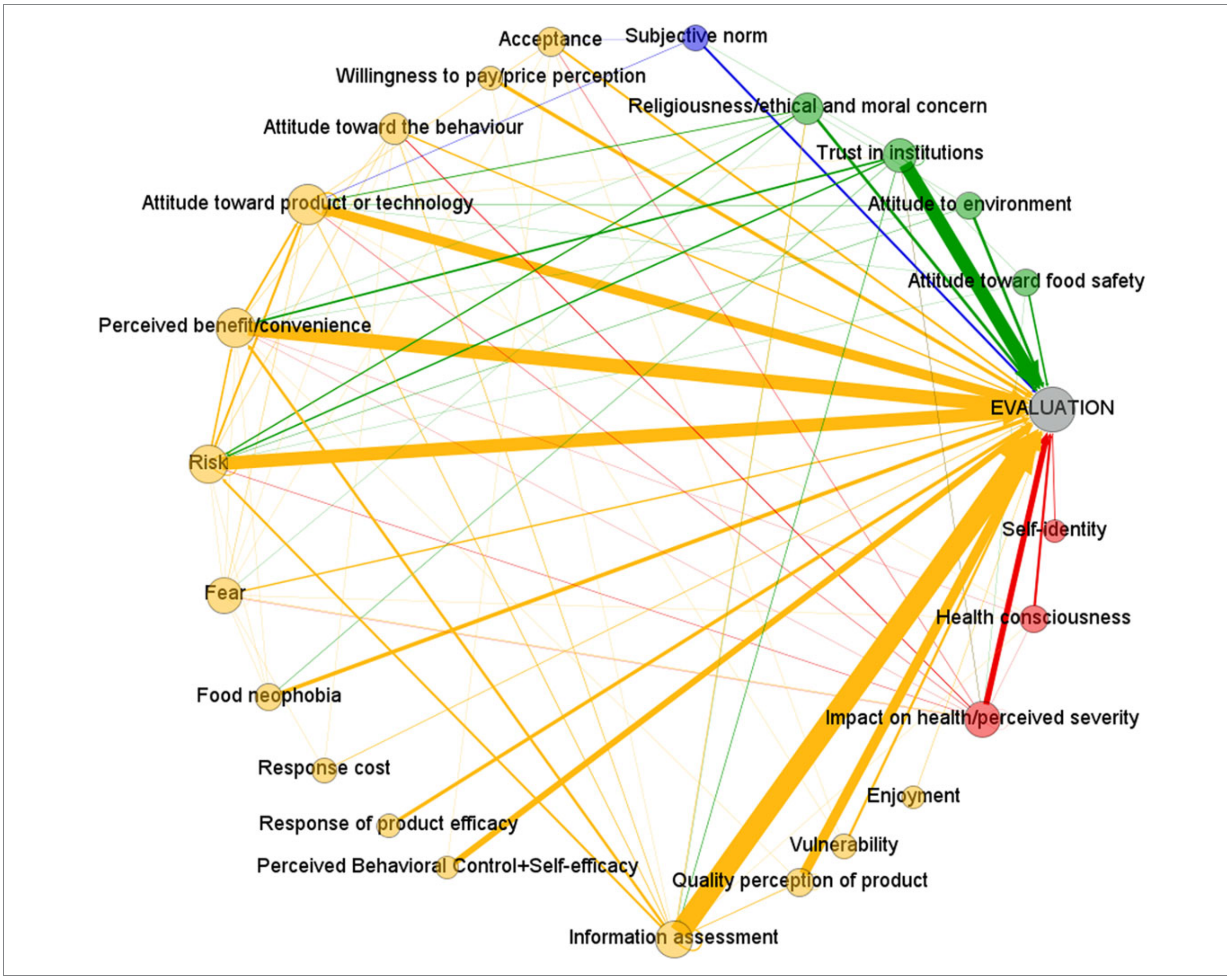

Figure C1–All significant relationships between latent and dependent variables (quantitative consumer studies).
Remark: red = individual factors; blue = social environments; yellow = physical environments; green = macro-level environments; edge thickness, or weight, represents association strength between nodes.