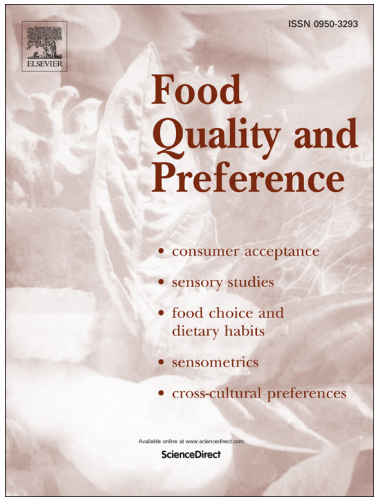

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PII: S0950-3293(18)30722-5
DOI: https://doi.org/10.1016/j.foodqual.2019.03.008
Reference: FQAP 3680

To appear in: *Food Quality and Preference*

Received Date: 3 September 2018
Revised Date: 19 February 2019
Accepted Date: 18 March 2019

Please cite this article as: Horvat, A., Granato, G., Fogliano, V., Luning, P.A., Understanding consumer data use in new product development and the product life cycle in European food firms – an empirical study, *Food Quality and Preference* (2019), doi: https://doi.org/10.1016/j.foodqual.2019.03.008

Understanding consumer data use in new product development and the product life cycle in European food firms – an empirical study

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Abstract

New food products have a high chance of market failure. To improve the chances of new product success, a consumer-oriented approach to product development has been recommended. The approach emphasizes the importance of an optimal fit between consumers' needs and the new product. To achieve this goal, food professionals generate and use various consumer data types and methods. However, very few studies address the extent to which the food industry uses consumer data in product development. This study investigated to what extent European food firms use various consumer data in different phases, i.e., new product development (NPD) and the product life cycle (PLC), and what data collection methods they employ. The current study classified consumer data into three types: consumer involvement, food trend, and environmental factor data. The results showed that more than 85% of the respondents use all three data types in NPD, while they rarely use consumer data in the PLC. Respondents most frequently use data collection methods such as focus groups, consumer surveys, and indirect data collection (e.g., internet, magazines). These methods are less effective in assuring product success and in developing new-to-the-world products. In fact, more than half of the respondents never or rarely worked on new-to-the-world projects. Increasing the use of consumer data in the PLC and adapting data collection methods to the type of the project and the phase of product development present opportunities for food firms to improve chances of new product success.

Keywords: new product development; product life cycle; consumer research; consumer involvement; consumer-oriented approach; food trends

1. Introduction

Failure of new food products is still a prevailing end-result of many firms' product development activities. Nielsen reported that between 2011 and 2013, 76% of the launched consumer goods did not survive one year on the market, while 45% remained on the market for less than half a year (Dijksterhuis, 2016). In the last few decades, firms have been applying a consumer-oriented, or consumer-led, approach to product development to design successful new food products. Busse and Siebert (2018) provided an extensive overview of definitions for consumer-oriented and consumer-led product development. Here, we adopt the description of consumer-oriented product development to achieve an optimal degree of fit between the new product and consumers' needs (Costa and Jongen, 2006).

To determine the optimal degree of fit between the new product and the needs of the target consumers, food firms use various methods to collect data about consumers' needs and preferences (Busse and Siebert, 2018; Nijssen and Lieshout, 1995). According to Moskowitz and Saguy (2013), a range of tests to obtain consumers' response to product ideas, concepts, and physical products to assess a product's acceptance level have been employed in the food industry (Moskowitz and Saguy, 2013). These tests have been useful for obtaining *consumer involvement data* (Janssen and Dankbaar, 2008). Other types of data can also be used to determine the optimal degree of fit, such as data on current *food trends* or aggregated data on *environmental factors* that affect consumers' needs and preferences, e.g., demographic, economic, socio-cultural, or technological (Janssen and Dankbaar, 2008; Stewart-Knox and Mitchell, 2003; Grunert et al., 1996). However, the majority of related scientific literature is focused on what consumer involvement data firms employ and what data collection methods they use, while the other two consumer data types, i.e., food trends and environmental factors, have rarely been studied (e.g., Busse and Siebert, 2018; Geyer et al., 2018; Creusen et al., 2013; Janssen and Dankbaar, 2008; Kaulio, 1998). Data obtained by direct consumer involvement in NPD, such as consumer co-creation, can be a source of product ideas and can have a positive effect on the financial performance of a company (Zaborek and Mazur, 2019; Martinez, 2014). However, it is also important to understand whether food firms use food trend and environmental factor data. Such data indicate future changes in consumers' needs and preferences, which can aid product success by developing products with longer product life cycles (PLC) (Fuller, 2005).

Moreover, past studies mainly focused on consumer involvement data obtained and used in the new product development (NPD) up to the launch of new products. However, consumers' needs and tastes change over time, and the degree of fit is not static, which is why firms often redesign and reformulate food products once they are already on the market (van Trijp and Steenkamp, 2005; Urban and Hauser, 1993). To successfully redesign and reformulate a product, it is essential to know what consumers like, or dislike, about the existing product (Otto and Wood, 2003). Therefore, it is necessary to understand whether food firms obtain and employ consumer data after the product is launched during the PLC as well. In this study, we define product development as the combination of NPD, which includes the development phases before a new product is launched on the market, and the PLC, which includes the phases after the new product is launched on the market. Lastly, previous studies analysed consumer data use of firms from various industries, not only food firms, except, for example, the study by Janssen and Dankbaar (2008).

Moskowitz and Saguy (2013) called for redefining the role of consumer research in food companies. They suggested that consumer research should move beyond mere product testing and become more involved in other business issues in product development. To achieve that, there is a need to increase scientific knowledge (Moskowitz and Saguy, 2013). The success of products in the PLC is one of the most important business issues since product sales substantially contribute to company growth (Barczak and Kahn, 2012). A potential way consumer research could become more involved in business issues could be by generating and using consumer data beyond product testing in NPD. Currently, it is not well known to what extent food firms use different types of consumer data in NPD or if they employ it after products are launched in various PLC phases. Therefore, there is a need to assess the current situation in the food industry and to identify knowledge gaps in consumer data use. This could facilitate the generation of scientific knowledge that would allow broader use of consumer research in assuring product success. Therefore, the aim of the current study is to contribute to the understanding of what consumer data types European food firms employ, in what phases of product development they use the data, and how they collect the data. Based on the study aims, the overall research question follows:

What consumer data types do people working in product development in European food firms use in NPD and the PLC, in what phases of NPD and the PLC do they use it, and what consumer data collection methods do they employ?

To answer this research question, we developed a conceptual framework containing the types of consumer data used in product development as the basis for the survey design, which we distributed among European NPD professionals working in food firms.

2. Conceptual framework

To analyse what consumer data types firms use during product development, we developed a conceptual framework (Figure 1). The framework displays three main data types, i.e., consumer involvement, food trend, and environmental factor data. In the context of this study, the three data types are independent of each other, and we differentiate them based on their specificity and time frame. Moreover, Figure 1 shows that we aim to determine whether the phase of product development, the type of product development project, and the firm size and function influence the types of consumer data used. We explain the framework elements in the following text.

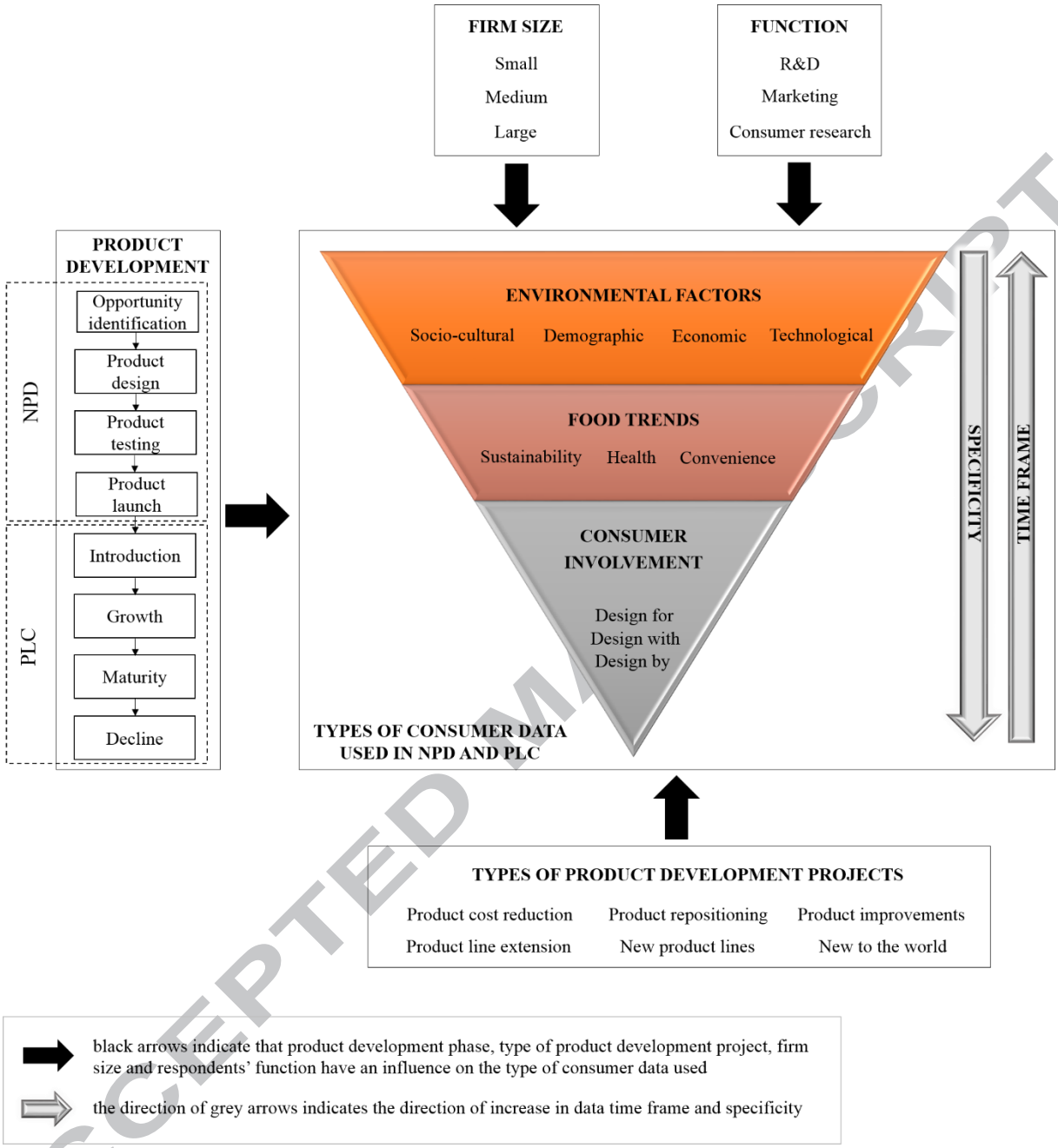

Figure 1: Conceptual framework for analysis of the use of three consumer data types, i.e., consumer involvement, food trends, and environmental factors. It is hypothesized that the type of consumer data used can vary based on the phase of product development, the type of product development project, the firm's size, and the function of the respondent.

2.1. Types of consumer data

2.1.1. Consumer involvement data

Interaction and collaboration with consumers are major aspects of consumer-oriented NPD that are important for understanding the fit of the product with consumers' needs (Costa and Jongen, 2006). The most straightforward way to assess the degree of fit between a new product and consumers' needs is to involve consumers directly in the NPD and the PLC. Here, we consider three major consumer involvement levels to obtain data: "design for", "design with", and "design by" (Janssen and Dankbaar, 2008; Kaulio, 1998). In the "design for" level, consumers' needs and preferences are determined based on general theories and models of consumer behaviour and on information obtained from the internet, magazines, marketing agencies, supermarkets, consumer surveys, and focus groups. In the "design with" level, consumers typically express their opinions on product concepts and physical products through sensory tests, concept testing, conjoint analysis, and category appraisal. In the "design by" level of involvement, consumers are strongly and actively involved and participate in the co-creation of the product, and methods such as lead user method, innovation templates, and consumer-idealized design are employed. Consumer involvement, such as with the "design by" level, is beneficial for the development of unique product ideas due to the use of methods that allow the discovery of consumer needs and values of which consumers themselves are not aware (Janssen and Dankbaar, 2008; Kristensson et al., 2003). However, "design by" methods can have certain limitations that hinder their more frequent use compared to "design for" and "design with" methods. For example, the lead-user method requires a dedicated team of 4 to 6 people with advanced interviewing skills for part-time work for six months to develop a product concept (Eisenberg, 2011). Likewise, consumer-idealised design, although similar to focus groups, requires skilful facilitators and more time investment by facilitators and participants (Ciccantelli and Magidson, 1993). While some studies show that employing "design by" methods, such as co-creation and lead user method, results in successful NPD (Zaborek and Mazur, 2019; Chang and Taylor, 2016), there is a lack of empirical evidence, which would show that the use of "design by" consumer involvement, instead of "design for" or "design with", will lead to more successful products.

2.1.2. Food trend data

To generate strong product ideas and to ensure that products remain competitive on the market, firms can monitor food trends to observe changing consumer needs (Stewart-Knox

and Mitchell, 2003; Davis, 1993). Consumer data collected at the beginning of the project can be years older in the moment of product launch, depending on the duration of NPD. Therefore, food professionals need to develop products for their future consumers (Fuller, 2005). Market research firms deliver information about future trends in food consumption to food firms. Food professionals can use such data throughout product development to eliminate short-lived fads and to invest in products that correspond to long-lasting trends (Fuller, 2005).

In the last few decades, three major food trends have been at the forefront of food innovations, which are included in the framework. First, the healthy food trend includes foods that support people's healthy food lifestyles, e.g., superfood, functional foods, the "free from" trend, clean label, sugar or calorie reduced, natural, and less processed foods (Asioli et al., 2017; Bugge, 2015). Second, convenience food products help consumers minimize the time and effort required for food preparation, consumption, and clean-up (Jackson and Viehoff, 2016; Brunner et al., 2010), e.g., food in small package units, ready-to-eat and ready-to-cook food. Third, sustainable products contribute to economic, social, and environmental goals in the food chain, e.g., vegetarian, vegan, ethical, local products, or those with a claim of special origin (Grunert et al., 2014; Vermeir and Verbeke, 2006).

2.1.3. Environmental factor data

On a more aggregated level, change in consumers' needs can be explained by 4 categories of environmental factor data: 1) socio-cultural; 2) demographic; 3) economic; and 4) technological (van Trijp and Steenkamp, 2005; Meulenberg and Viaene, 2001). In the following text, we explain the impact of some factors on changing consumer needs.

Socio-cultural factors include changes in consumers' attitudes, lifestyles, education, ethnicities, and buying patterns, which result from urbanisation and globalization. Urbanization has led to the emergence of lifestyles based on speed, movement, and convenience. Processed convenience foods have replaced raw products, and seasonal food consumption disappeared, leading to changes in buying patterns (Costa and Jongen, 2006; Meulenberg and Viaene, 2001). Furthermore, the level of education has increased, leading to the appearance of environmentally and nutrition-conscious consumers (Kearney, 2010; Brody and Lord, 2007; Costa and Jongen, 2006; Senauer et al., 1991). Furthermore, globalization has brought different cultures closer (Cwiertka, 2005; Ehrenfeld, 2003), causing changes in ethnic and religious composition in cities and changes in food habits of both local and new

populations (Wandel et al., 2008; Cwiertka, 2005). All of this has been playing a role in shaping consumers' attitudes by affecting their evaluation of a product over time (Solomon, 2008).

Demographic factors, such as population growth, age, sex distribution, household size, and regional migration, are also indicators of food demand (Hoek et al., 2004). For example, the ageing population tends to have a higher demand for healthy food (Costa and Jongen, 2010; Senauer et al., 1991), while primarily female consumers buy organic food (Padel and Foster, 2005; Davies et al., 1995). A decrease in the size of families and households led to demand for convenience food that can be prepared simply and quickly (Costa and Jongen, 2006; Meulenberg and Viaene, 2001; Senauer et al., 1991). Finally, increased mobility resulted in more regional migration, which led to increased food supply variety (Meulenberg and Viaene, 2001).

Economic factors, such as disposable income, unemployment levels, price fluctuations, and the macroeconomic situation, indicate consumers' buying behaviour (Senauer et al., 1991). Rising income can be an indicator of improvement in the quality of diets and food availability, but it can also lead to unhealthy diets high in fat (Kearney, 2010; Marmot, 2002), while lower income leads to limited consumption of fruits, vegetables, lean meat, and fresh fish (Drewnowski and Darmon, 2005; Nestle et al., 1998).

Technological advancement data relates to the technology used to produce a product. Although not directly obtained from consumers, this type of data is also an indicator of potential future change in consumer needs (Ronteltap, 2007). Past technological advancements, such as ready-to-eat meals, meat alternatives, advances in packaging methods, and more nutritious food, have led to multiple innovations that changed consumers' preferences (Neville et al., 2017; Elzerman et al., 2013; Falguera, 2012; Elzerman et al., 2011; Costa and Jongen, 2010; Ozdemir and Floros, 2004). By following technological advancements in and outside of the food industry, companies can innovate by recognizing unfulfilled consumers' needs on the market (Jongen and Meulenberg, 2005). Technological innovation can create added consumer value, which can have a positive effect on product success (Kock et al., 2011).

2.1.4. Differences among data types – time frame and specificity

Figure 1 includes two dimensions (time frame and specificity), which we used to differentiate consumer data types. The time frame represents the relative length of the period in which consumer data are obtained. Consumer involvement data represent the shortest time frame, as it usually involves data collection at one point in time, e.g., sensory tests (Delarue and Boutrolle, 2010; Poretta et al., 2010). Sensory tests can be designed as controlled laboratory studies that aim to measure consumer evaluation of sensory attributes of the product, or there can be an attempt to capture a realistic consumption setting, with the aim of measuring the overall consumer preference and acceptance of the product (Hemmerling and Spiller, 2016). Food trends indicate a change in attitudes over time, leading to a change in consumption patterns (Grunert, 2005). Determining consumption patterns requires data collection over a few weeks, months or years and includes food balance sheets, retail sales, and household budget surveys (Kearney, 2010). On the other hand, strategic environmental factors require the collection of data over many years to observe patterns of change. For example, projection of demographic data can be made up to 10 or 20 years (Senauer et al., 1991).

The second dimension of Figure 1 refers to data specificity. Here, we look at data specificity as relating to a particular product. In that sense, strategic environmental factors are the least specific because they provide general information not related to a specific product (e.g., Kearney, 2010; Lundahl, 2006; Fuller, 2005; Senauer et al., 1991). This type of data can be used for various product development projects. Food trend data are more specific since they contain detailed information about certain consumer groups and their interest in particular types of products (e.g., Mintel Ltd., 2018). Lastly, consumer involvement data offer the most specificity because they are usually obtained during the development of a specific product, which is tested or developed with consumers (e.g., Janssen and Dankbaar, 2008; Kaulio, 1998).

2.2. The product development phase, type of product development project, firm size and respondent's function can impact consumer data use

Figure 1 implies that various consumer data types can be used to a varying extent in different product development phases due to specific activities in each phase. NPD typically consists of four phases: opportunity identification, product design, product testing, and product launch

(van Kleef et al., 2005). Throughout those phases, consumer data are used to narrow down multiple product ideas and to develop and test new product concepts and formulations to assure product success (Luning and Marcelis, 2009; van Kleef et al., 2005). The PLC also typically consists of 4 phases: introduction, growth, maturity, and decline. Here, consumer data facilitate developing market strategy while the product goes from being unknown to consumers, to a product with a well-established consumer demand, until consumers stop buying it in favour of something newer (Fuller, 2005).

According to Earle et al. (2001), there are 6 six types of product development projects: product cost reduction, product repositioning, product improvements, product line extension, new product lines, and new-to-the-world products. The type of innovation project can dictate the consumer data type needed. For example, new-to-the-world projects can benefit from direct consumer involvement data to refine product concepts and physical products and to develop effective communication strategies when the product is unfamiliar to consumers (Janssen and Dankbaar, 2008; Earle et al., 2001). However, there is a lack of empirical evidence comparing the use of different consumer involvement data and their contribution to product success.

Finally, firm size and respondents' function could affect the type of data used. Small and medium firms exhibit financial constraints compared to large firms, which can lead to fewer resources available for obtaining consumer data (Beck and Demirguc-Kunt, 2006). Moreover, the difference in consumer data used can arise from respondents having different functions based on respondents' different tasks. Three functions are central to consumer-oriented product development. R&D, marketing, and consumer research (Costa and Jongen, 2006; van Trijp and Steenkamp, 2005). R&D's focus is on delivering superior technology to consumers, while marketing focuses on product positioning and image building (van Trijp and Steenkamp, 2005). Consumer research provides an in-depth understanding of consumers' needs, the translation of those needs into product requirements, and consumer product testing (Moskowitz and Saguy, 2013). The conceptual framework is the basis for the survey design.

3. Materials and methods

3.1. Online questionnaire

3.1.1. Questionnaire design

The questionnaire, consisting of three sections, was designed according to the principles laid out by Iarossi (2006). The first section included general questions aiming at typifying the respondents (e.g., if they work in food product development, their function, firm size), and the type of food innovation projects they are involved in. The second and the third section reflected the structure of the conceptual framework. Here, we aimed to collect answers on the data types that respondents use in NPD and the PLC and in which particular phases of NPD and the PLC. Finally, respondents indicated how data were collected by selecting various methods. The questionnaire (Supplementary material 1) was pretested by pilot administration, after which some minor changes were made. Cronbach's alpha value of 0.948 indicates that reliability was assured (Lance et al., 2006).

3.1.2. Respondents

Potential respondents were approached at the Anuga Food Fair (2017) in Cologne (Germany), via LinkedIn, and through the authors' personal networks. They were asked to complete an online survey via the SurveyMonkey platform. Eligible respondents needed to work in a European food producing firm and needed to be directly involved in the new product development process in that firm, i.e., as marketing, R&D, or consumer research personnel. The survey was open throughout October and November 2017. In total, 202 responses were collected. The final sample size consisted of 113 respondents, as 89 respondents did not reply to all mandatory questions. The final survey sample is described in Table 1.

Table 1: Description of the final survey sample

Category	Number of respondents	Percentage (%)
Firm size		
Small	19	16.8
Medium	25	22.1
Large	69	61.1
TOTAL	113	100
Respondent function		
R&D	73	64.6
Marketing	34	30.1
Consumer research	6	5.3
TOTAL	113	100

3.2. Data analysis

All statistical analyses were performed using IBM SPSS Statistics Version 23. Descriptive statistics were performed to determine the frequencies of respondents' replies regarding the use of consumer involvement, trends, and environmental factors and other collected data. McNemar's test was performed to assess the difference between percentages of different consumer data types used in NPD and the PLC. Pearson's chi-square test of independence was performed to examine the association between the size of the company and the type of consumer data used, the phase of NPD and the PLC in which data are used, and the data collection methods employed. Moreover, the association between the function of the respondent and the type of consumer data used, the phase of NPD and the PLC in which data are used, and the data collection methods employed were examined. Finally, the association between the project type and consumer data used in NPD and the PLC was tested. If a significant relationship was observed, a post hoc cellwise adjusted residual method was performed to examine independence between the categories of firm size, function, and projects. Bonferroni correction to the p-value of 0.05 was employed (MacDonald and Gardner, 2000).

4. Results

4.1. Consumer data types used in product development

Table 2: Frequency of use of various categories of consumer involvement, food trend, and environmental factor data in new product development (NPD) and the product life cycle (PLC), and results of McNemar's test to assess the difference between percentages of different consumer data types used in NPD and the PLC.

	Phase of product's life			
Type of consumer data used	**NPD (% respondents)**	**PLC (% respondents)**	χ^2	**p-value***
Consumer involvement	***85.8***	***50.4***	*33.33*	*<0.001*
"design for"	79.6	45.1	31.04	*<0.001*
"design with"	73.5	33.6	36.82	*<0.001*
"design by"	31.1	13.3	12.50	*<0.001*
Food trends	***87.6***	***54.9***	*31.84*	*<0.001*
healthy	74.0	41.6	30.42	*<0.001*
sustainable	61.0	33.6	24.50	*<0.001*
convenience	50.0	24.8	22.35	*<0.001*
Environmental factors	***89.4***	***63.7***	*21.78*	*<0.001*
socio-cultural	83.2	61.1	16.89	*<0.001*
demographic	73.5	48.7	21.78	*<0.001*
economic	66.4	46.0	16.03	*<0.001*
technological	63.7	40.7	18.78	*<0.001*

degrees of freedom = 1
*p-value significant below 0.05

Table 2 shows the frequency of use of different consumer data types during new product development (NPD) and the product life cycle (PLC). All three major data types are used to a similar extent in NPD, i.e., for direct consumer involvement, food trend, and environmental factor data frequency of use was 85.8%, 87.6%, and 89.4%, respectively. The results of McNemar's test suggest that all consumer data types are significantly less frequently used in the PLC than in NPD.

Respondents most frequently use consumer involvement data in NPD from the "design for" and "design with" category, while only 1/3 of the respondents employ the "design by" data. The use of all three categories of consumer involvement data is significantly lower in the PLC. Moreover, the trend towards healthy food is the most frequently incorporated trend in NPD (74%), followed by convenience (61%) and sustainable food (50%). In the PLC,

respondents most frequently use data on healthy food trends (41.6%), while sustainability and convenience trend data are less often used (33.6% and 24.8%, respectively).

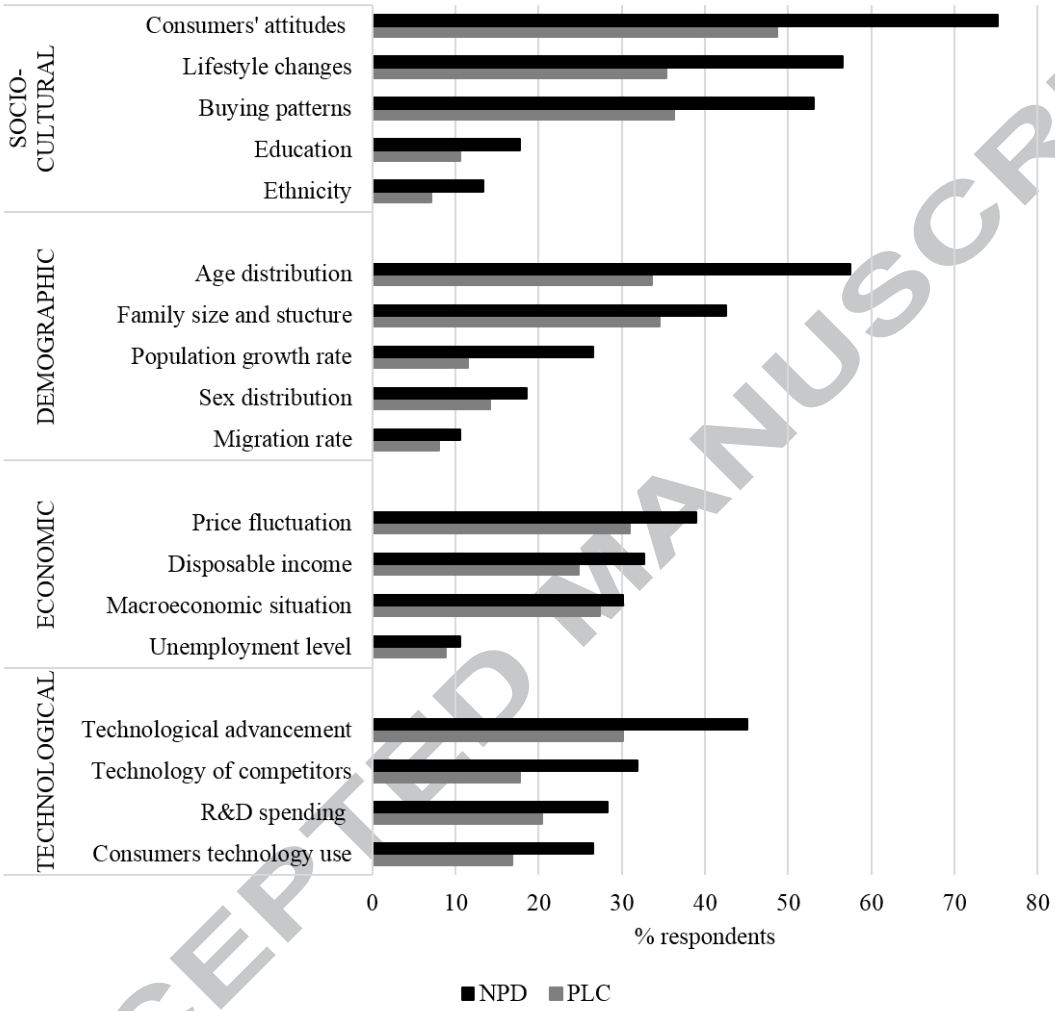

Figure 2: Frequency of use of various environmental factors (socio-cultural, demographic, economic, and technological) in new product development (NPD) and the product life cycle (PLC).

Figure 2 shows the frequency of the use of environmental factors, i.e., socio-cultural, demographic, economic, and technological, in NPD and the PLC. Overall, socio-cultural factors are the most widely used, followed by demographic, economic, and technological factors. In the category of socio-cultural factors, most respondents use information about consumers' attitudes towards product quality in NPD, as well as in the PLC (75% and 49%,

respectively). Within the demographic factors, the age distribution of the population and the family size and structure are the most commonly used factors. Among economic factors, 39% and 31% of respondents use price fluctuation data in NPD and the PLC, respectively. Within the group of technological factors, respondents most frequently use data about technological advancement in their field in NPD (45%) and the PLC (30%).

4.2. Use of consumer data in different phases of product development

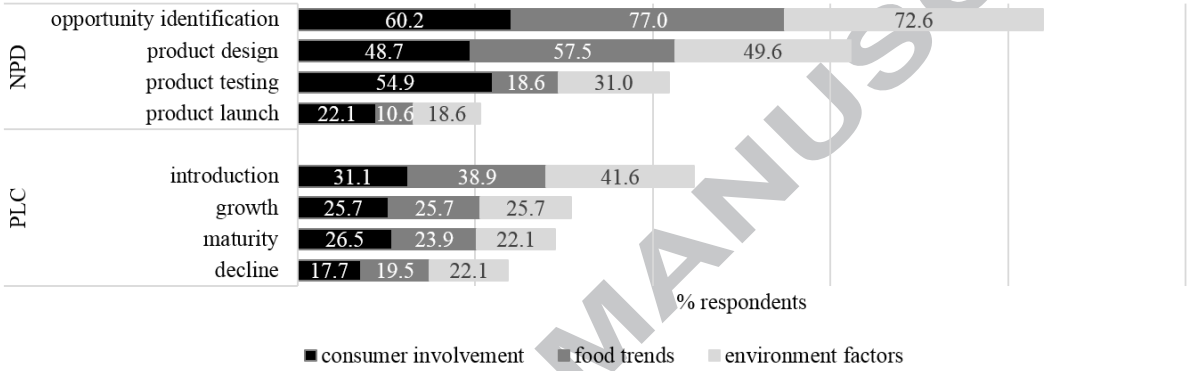

Figure 3: Frequency of use of the three data types in various phases of new product development (NPD) and the product life cycle (PLC).

Figure 3 shows that respondents use all three consumer data types the most frequently in the opportunity identification and product design phases of NPD. In the product testing phase, the use of consumer involvement data remains more prevalent than the other two data types. Figure 3 indicates that approximately a third of the respondents use consumer involvement, food trend, and environmental factor data in the introduction phase of the PLC, with environmental factors being the most frequently employed data type (41.6%). The utilization of consumer data further drops in the later phases of the PLC; approximately less than one quarter of the respondents use each of the three data types in the phases from growth to decline.

4.3. Utilization of different methods to collect consumer data

Respondents use various methods to acquire consumer involvement data. Figure 4 shows that respondents frequently collect "design for" data through external sources, such as supermarkets, marketing agencies, the internet, and magazines. Consumers are most often directly involved through focus groups, consumer surveys, and sensory and concept testing. Interestingly, Figure 4 shows that only 50% and 61% of the respondents obtain consumer involvement data by product concept and sensory testing, respectively, with consumers. Moreover, according to Figure 4, the respondents in our study rarely use "design by" methods, such as the lead-user method and consumer co-creation.

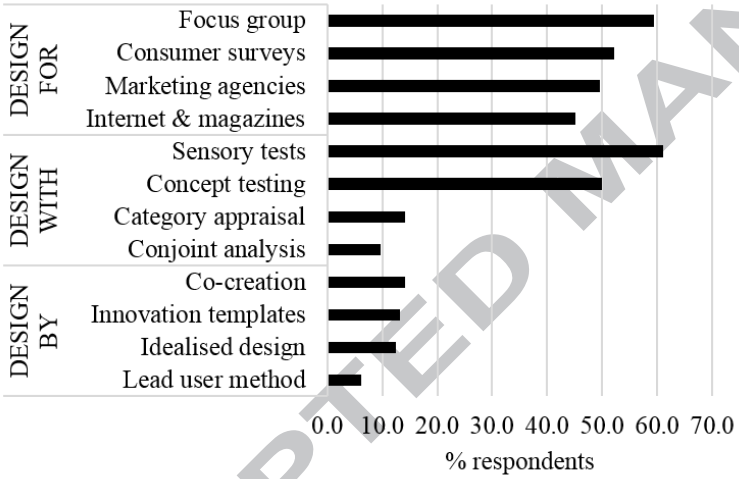

Figure 4: The use of the common "design for", "design with", and "design by" methods of consumer involvement in European food firms.

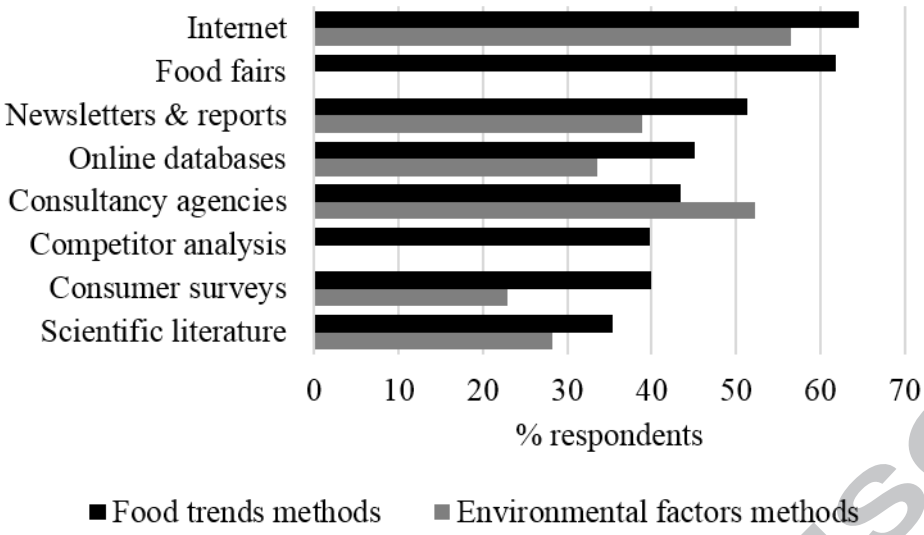

Figure 5: Methods respondents use most frequently to collect data on food trends and environmental factors.

Figure 5 shows the methods respondents use to collect food trend and environmental factor data. The internet (65%), e.g., specialized websites, and food fairs (62%) are the main channels of collecting food trend data. Furthermore, more than half of the respondents reported using newsletters and reports. The internet (57%) and consultancy firms (52%) represent the most commonly used sources of data on environmental factors. Moreover, most of the respondents do not use modelling and simulation methods during product development. The results showed that 70.8% of respondents use no modelling and simulation. Out of all the respondents who use some type of modelling, 84.8% employ statistical modelling, 5.3% use agent-based, 2.7% use system dynamics, and 1.8% employ discrete event modelling.

4.4. Types of product development projects and relationships between project type and consumer data used

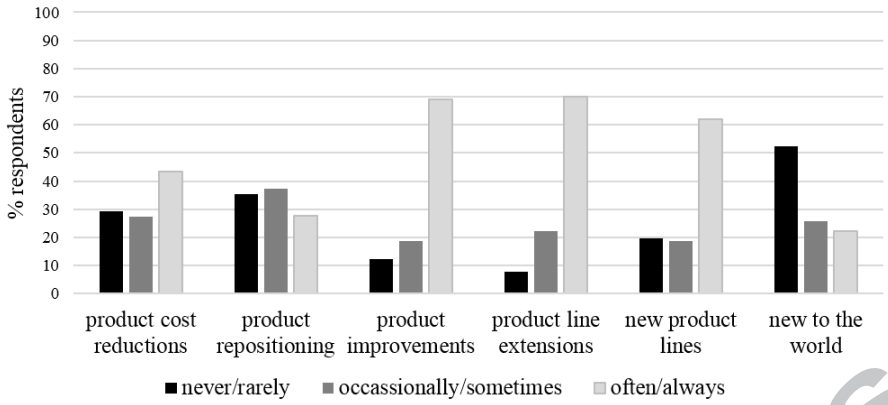

Figure 6: Frequency with which respondents work on the six major types of product development projects

Figure 6 shows the frequency with which respondents work on the six types of NPD projects: product cost reduction, product repositioning, product improvements, product line extension, new product lines, and new-to-the-world products. Product improvements and product line extension are the main types of product innovation projects among respondents, with 69.9% and 69% of respondents working on them often or always, respectively, followed by new product lines (62%) and product cost reduction (43%). Respondents engage the least frequently in new-to-the-world projects. Table 3 shows significant relationships between project types and consumer data used. A significant relationship was observed between the use of "design by" and healthy and convenience food trend data in NPD and participating in new-to-the-world projects. There is also a relationship between respondents who often participate in new product line projects and the use of economic and technological environmental factor data in NPD. Moreover, a relationship between always participating in product line extension projects and the use of economic factor data in the PLC was observed. Respondents who often participate in product improvements more often use consumer involvement and sustainable food trend data in NPD. Lastly, there is a relationship between sometimes participating in product repositioning and product cost reduction projects and the use of healthy and sustainable food trend data.

Table 3: Results of the cellwise adjusted residual method, showing the relationship between the project type and consumer data use in NPD and the PLC (only significant relationships are shown).

Association tested	**Adjusted Z-score**	**χ^2**	**p-value***
New-to-the-world projects			
Often participate in new-to-the-world projects x Use "design by" consumer involvement data in NPD	3.28	10.76	0.001
Rarely participate in new-to-the-world projects x Use "design by" consumer involvement data in NPD	3.64	13.25	<0.001
Always participate in new-to-the-world projects x Use healthy food trend data in NPD	3.08	9.49	0.002
Often participate in new-to-the-world projects x Use healthy food trend data in NPD	3.34	11.16	<0.001
Rarely participate in new-to-the-world projects x Use convenience food trend data in NPD	5.51	30.36	<0.001
New product lines			
Often participate in new product lines projects x Use economic environmental factor data in NPD	5.14	26.42	<0.001
Often participate in new product lines projects x Use technological environmental factor data in NPD	3.42	11.70	<0.001
Sometimes participate in new product lines projects x Use sustainable food trend data in the PLC	4.80	23.04	<0.001
Product line extension			
Always participate in product line extensions projects x Use environmental factor data in the PLC	4.37	19.10	<0.001
Always participate in product line extensions projects x Use economic environmental factor data in the PLC	4.72	22.28	<0.001
Product improvements			
Often participate in product improvements projects x Use consumer involvement data in NPD	3.06	9.36	0.002
Often participate in product improvements projects x Use sustainable food trend data in NPD	7.28	53.00	<0.001
Product repositioning			
Sometimes participate in product repositioning projects x Use healthy food trend data in NPD	4.78	22.85	<0.001
Product cost reduction			
Sometimes participate in product cost reduction projects x Use sustainable food trend data in the PLC	3.32	11.02	0.001

*Bonferroni corrected p-value significant below 0.004
degrees of freedom = 1

4.5. Relationship between firm size or function of the respondents and consumer data and methods used

Table 4: Results of the cellwise adjusted residual method, showing the relationship between the specific firm size categories (small, medium, large) and consumer data use in NPD and between methods used. The table only shows results where a significant relationship was observed.

Significant survey answer	**Adjusted Z-score**	**χ^2**	**p - value***
CONSUMER DATA USE IN NPD			
Small companies			
Do not use consumer involvement data in NPD	3.11	9.67	0.002
Do not use "design with" consumer involvement data in NPD	2.80	7.84	0.005
Do not use data on family size and structure (demographic environmental factor) in NPD	3.09	9.55	0.002
Do not use consumer involvement data in the testing phase of NPD	2.70	7.29	0.007
Large companies			
Use consumer involvement data in NPD	3.19	10.18	0.001
Use "design for" consumer involvement data in NPD	3.40	11.56	0.001
Use "design with" consumer involvement data in NPD	3.60	12.96	<0.001
Use consumer involvement data in the testing phase of NPD	3.90	15.21	<0.001
METHODS TO OBTAIN CONSUMER INVOLVEMENT DATA			
Small companies			
Do not use sensory tests to obtain consumer involvement data	2.89	8.35	0.004
Medium companies			
Use the focus group method to obtain consumer involvement data	3.15	9.92	0.002
Large companies			
Use the focus group method to obtain consumer involvement data	4.35	18.92	<0.001
Use survey methods to obtain consumer involvement data	2.69	7.24	0.007
Use concept testing to obtain consumer involvement data	2.95	8.70	0.003
Use sensory tests to obtain consumer involvement data	4.30	18.49	<0.001
METHODS TO OBTAIN FOOD TREND DATA			
Large companies			
Use consultancy and marketing agencies to obtain data on food trends	3.53	12.46	<0.001
METHODS TO OBTAIN ENVIRONMENTAL FACTOR DATA			
Small companies			
Do not use consultancy and marketing agencies to obtain data on environmental factors	2.98	8.88	0.003
Large companies			
Use consultancy and marketing agencies to obtain data on environmental factors	3.47	12.04	0.001

*Bonferroni corrected p-value significant below 0.008
degrees of freedom = 1

Table 5: Results of the cellwise adjusted residual method, showing the relationship between the respondents' function (R&D, marketing, consumer research) and consumer data use in NPD and the PLC and between methods used. The table only shows results where a significant relationship was observed.

Significant survey answer	**Function**	**Adjusted Z-score**	χ^2	**p-value***
CONSUMER DATA USE IN NPD				
Do not use data on convenience food trend in NPD	R&D	2.65	7.02	0.008
Use data on the economic environmental factor unemployment level in NPD	Consumer r.	3.22	10.37	0.001
Use environmental factor data in the introduction phase of the PLC	Marketing	2.85	8.12	0.004
METHODS TO OBTAIN CONSUMER DATA				
Use scientific literature to obtain data on food trends	R&D	2.95	8.70	0.003

*Bonferroni corrected p-value significant below 0.008
degrees of freedom = 1

Table 4 shows that respondents from large firms use consumer involvement data in NPD significantly more often, and specifically in the product testing phase, opposed to respondents from small companies. Respondents from large companies use consumer involvement methods, such as focus groups, consumer surveys, concept testing, and sensory tests significantly more frequently. Moreover, respondents from large companies use consultancy and marketing agencies to obtain trends and environmental factor data significantly more often. No significant association between the firm size and the data used in the PLC was observed. Table 5 shows that respondents with roles in marketing employ environmental factor data in the introduction phase of the PLC significantly more often. Furthermore, R&D personnel use scientific literature to obtain data on food trends more often.

5. Discussion

In this study, we aimed to increase the understanding of what types of consumer data European food firms employ, in what phases of product development they use the data, and how they collect the data. The results were used to discuss the opportunities for improvement of data use in product development.

5.1. Use of different consumer data types: opportunities for improvement

Respondents use all three types of consumer data in product development (Table 2). From the category of *consumer involvement data*, "design by" data are less frequently employed. The

lower frequency of use of "design by" consumer involvement data is in alignment with the observation that respondents rarely work on new-to-the-world projects (see Figure 6). "Design by" level of consumer involvement is more often used in the NPD of new-to-the-world projects, where it is important to discover unfulfilled consumer needs compared to existing products. "Design for" and "design with" data are more frequently used in NPD of incremental innovations, such as product improvement and product line extensions (Janssen and Dankbaar, 2008). Respondents rarely use "design for" and "design with" data in the PLC. Collecting consumer data in the PLC is essential to uncover the need to reposition a product or to start a new product line (Plewa, 2016; Earle et al., 2001; Urban and Hauser, 1993). The low use of consumer involvement data in the PLC (Table 2) may hinder firms' ability to uncover changes in consumers' needs and to recognize needs for product improvements and product line extensions.

Firms frequently use *data on food trends* in NPD (Table 2), which might be a successful strategy. Implementing insights from food trends into new products or product modifications could positively affect product success by fulfilling consumers' needs (Stewart-Knox and Mitchell, 2003; Davis, 1993). The high prevalence of the use of healthy food trend data could be an indication that firms are responding to consumers' health needs, which result from an increase in health issues, such as obesity and an ageing population (Yanovski, 2017; Nielsen, 2016). However, firms should not disregard the potential of other trends. For example, consumers are becoming increasingly aware of the impact food production has on the environment, leading to increasing demand for organic, natural, and local products (Rana and Paul, 2017; McGill, 2009; Aertsens et al., 2009; Vermeir and Verbeke, 2006). This could be an indication of the further growth of the sustainable food trend.

In the group of *environmental factor data*, only approximately half of the respondents use socio-cultural and demographic factor data in NPD, such as age distribution, lifestyle changes, and buying patterns, while other factors are used even less frequently, especially in the PLC (Figure 2, Table 2). This type of data can be valuable for distinguishing consumer segments and for developing product communication strategies, which can have a positive influence on a product's success (Nie and Zepeda, 2011; Lin, 2002). By understanding consumers' lifestyles, e.g., how people do things, behave and what their habits are, food firms can capture consumers' psychological profiles (Nie and Zepeda, 2011). Since not all respondents use such data, this is something firms could take into account when choosing what environmental factor data to collect.

Data such as the education level of a population, migration rate, and ethnicity of a population are less frequently used (Figure 2), and opportunities to develop successful products could lie in more frequent use of those environmental factor data. It can be especially beneficial to anticipate demographic transitions occurring in markets in developing countries, as they can be predictors of changes in lifestyles and attitudes (Ali et al., 2010). Since these factors do not change substantially over time, monitoring them can be an opportunity for firms to anticipate long-term changes (i.e., beyond the length of a life-cycle of a typical product) in consumers' attitudes, lifestyles, and buying patterns.

Respondents in the current study do not frequently take into account technological factors, such as technological advancement in the field or R&D spending (Figure 2). Monitoring technological advancements and becoming a technological leader by implementing new technologies can bring competitive advantage (Byun et al., 2018). Both technological leaders and followers need to monitor technological changes on the market and improve their strategy once changes occur (Doha et al., 2018; Aghion et al., 2001).

In the current study, respondents used information about environmental factors to a lesser extent in the PLC (Table 2, Figure 2). In the short term, this can be a problem with respect to economic factors such as price fluctuations, the current macro-economic situation, and the unemployment level. According to Steenkamp and Maydeu-Olivares (2015), negative macro-economic conditions and unemployment make people become more price sensitive and less quality sensitive, which affects their buying behaviour. Moreover, for products with very long life cycles, there can be an issue due to changes in the ageing of the population if this is not monitored. Ageing affects people's attitudes towards product quality, e.g., older people choose products of higher quality (Steenkamp and Maydeu-Olivares, 2015). Therefore, it is important to investigate and monitor the effect of age distribution on consumers' product acceptance to identify possible quality perception changes over longer times, which could affect product success.

5.2. Consumer data use in different product development phases: opportunities for improvement

In the first two NPD phases (i.e., *opportunity identification* and *product design*), firms frequently use food trend and environmental factor data (Figure 3). This can have a positive

impact on product success since it allows the discovery of promising product ideas by exploring multiple product ideas and increasing the understanding of consumers' needs (Poretta and Hartmann, 2010). However, the quality of collected consumer data, which can depend on how a particular method was applied, can also have an impact on the quality of ideas and future product success. Unfortunately, the results in Figure 3 do not reveal the quality of the data that respondents use. In the *product testing* phase, firms most frequently employ consumer involvement data (Figure 3). The number of new ideas drops as product development progresses, and the ideas that remain need to become more refined, which could explain the higher need for consumer involvement data and lower use of other data types (Barczak, 2009; Fuller, 2005). On the other hand, it is worrisome that only 54.9% of respondents include consumers directly in the product testing phase to assess consumers' acceptance of new products since this can have a positive impact on product success (Gruner and Homburg, 2000).

In the beginning of the PLC (i.e., *introduction* phase), firms most frequently use environmental factor data (Figure 3). This could result from the lack of data on product performance in this phase (e.g., sales data), while at the same time, firms need to invest strongly into promotion and provide attractive prices to compete in the market (Mohammadi and Saghaian, 2017). Using consumer involvement data is also relevant in this phase to compare firm predictions to real data to optimize the PLC management strategies (Urban and Hauser, 1993), but only 31.1% of respondents do so (Figure 3). The low utilization of all three data types after the introduction phase of the PLC could imply that the respondents in our study assess the degree of fit between the product and consumers' needs to a lesser extent once products are launched on the market and that they rarely base their PLC management decisions on consumer data. This can have an impact on product success if a change in consumers' needs goes unnoticed (Costa and Jongen, 2006). Unexpected changes in the economic, technological, competitive, and consumer environment can be noticed in a timely manner by systematic monitoring of the environment (Urban and Hauser, 1993). Firms should monitor data during the PLC to discern the forces that move the product from the introduction to the decline phase in the PLC, which can have positive effects on PLC management (e.g., Schmidt and Gary, 2002).

5.3. Possible implications of using different consumer data collection methods for product success

The most frequently used methods to obtain "design for" consumer involvement data by respondents are focus groups, consumer surveys, and the use of the internet and magazines (Figure 4). These methods often yield qualitative data on consumers' preferences and needs. Such data are beneficial in the opportunity identification phase to understand consumers' needs and to develop product ideas (Geyer et al., 2018; Creusen et al., 2013; van Trijp and Steenkamp, 2005). However, multiple researchers categorized these methods as passive consumer involvement methods that provide limited guarantees of product success and do not facilitate the development of truly innovative products (Geyer et al., 2018; Janssen and Dankbaar, 2008; Wind and Mahajan, 1997). By employing only these methods, firms will have less control over their product's success. "Design with" methods, i.e., sensory tests and concept testing are valuable for product development guidance, improvement, and maintenance (Resurreccion, 2007; van Trijp and Steenkamp, 2005). Moreover, the low use of methods to obtain "design by" data, such as the lead-user method and consumer co-creation (Figure 4), suggests that the firms in our study do not frequently involve consumers more actively and deeply throughout product development. Geyer et al. (2018) indicated that the use of the lead-user method in product development projects results in improved product performance forecasts. The use of "design by" methods can be especially useful in developing new-to-the-world products, as such methods uncover latent consumer needs and provide a better understanding of potential causes of product failure (Janssen and Dankbaar, 2008; Kristensson et al., 2008).

Figure 5 shows a lack of use of formal methods to obtain data on trends and environmental factors since only competitor analysis could formally be considered as a method. The most frequently used methods (e.g., internet, newsletters, and reports) usually do not provide data highly specific information to the food product under development. Respondents in our study most frequently employ low to moderately proactive methods (Figure 5), according to the classification by Kahn et al. (2006). More specifically, data on consumer needs are usually collected by passive consumer involvement (e.g., consumer surveys) or through secondary resources (e.g., internet, reports, food fairs) (Figure 5), which is in agreement with other studies (Kristensson et al., 2008; Kahn et al. 2006). A more proactive approach would include "continuous collection and assimilation of suitable information about the consumers' views and needs during product development" (Costa and Jongen, 2006, pg. 461) and could include

data collection based on retailers' check-out scanner data, household panels, and attitudinal market research (van Trijp and Steenkamp, 2005). According to Kristensson et al. (2008), for more sustainable success, firms need to use multiple methods for consumer data collection to discover both latent and existing consumer needs.

Our respondents rarely employ modelling methods in product development. Developing simulation computer models (e.g., system dynamics, agent-based) to facilitate product development can be a powerful approach, particularly when resources for testing a product in the real world are limited. By synthesising various types of consumer data in the form of a meaningful computer model, one can yield information about the expected success of a product during its PLC (e.g., Schmidt and Gary, 2002). Statistical methods cannot always support the generation of proper conclusions from data, especially when dealing with complex issues, such as food product success among consumers (Sterman, 2004). Complex "white box" modelling methods, such as system dynamics (e.g., Zhao and Zhong, 2015) and agent-based modelling (e.g., Sturley et al., 2017), allow for integration of knowledge and facilitate understanding of the relationships between data and product performance. This can ultimately lead to improved decision-making and to more successful new food products (Sterman, 2004). However, less than 10% of respondents employ these "white box" modelling methods.

5.4. The type of NPD project, firm size, and function have an impact on the type of consumer data used

In our study, respondents engage the least frequently in new-to-the-world types of projects and the most frequently in product improvement and product line extension projects (Figure 6). Likewise, Barczak et al. (2009) reported that in 2003, new-to-the-world projects were the least frequent among various firms, while product improvements and product line extensions were the most frequent projects. There are a few possible reasons for this. New-to-the-world products require 2 to 4 times more resources (Holahan et al. 2014; Ahmad et al., 2013; Barczak et al., 2009; Janssen and Dankbaar, 2008), and the food industry is an industry with relatively small R&D expenditures (Costa et al., 2016; Costa and Jongen, 2006). Moreover, Barczak et al. (2009) explained that new-to-the-world products require longer development times than incremental innovations. Interestingly, we found a relationship between undertaking new-to-the-world projects and the use of "design by" data (Table 3). Similarly, Janssen and Dankbaar (2008) reported that food firms developing truly new products more

often employ “design by” consumer involvement data. New-to-the-world products usually have a higher chance of success (Barczak et al., 2009). Costa and Jongen (2006) reported that truly new products fail 24% less often than incremental innovations. In the future, firms that participated in our study could consider using “design by” data more frequently and invest in the development of new-to-the-world products to increase chances of success.

Moreover, a significant relationship between firm size and the use of consumer involvement data has been observed (Table 4). Apparently, small firms less frequently use consumer involvement data or involve consumers in the product testing phase, whereas large firms more often use “design for” and “design with” data and undertake consumer surveys, concept testing, and sensory tests. Steffen (2018) suggested that small firms commonly base their strategy on intuition, which can have a negative impact on their product success. Limited use of sensory tests and concept testing may lead to lower product success, as this suggests that R&D professionals assume they know best what consumers want (Wind and Mahajan, 1997). Firms often do not include consumers to an appropriate extent due to limited resources (Dijksterhuis, 2016). In situations with limited resources, firms must wisely choose methods to generate consumer data (Sumberg, 2013). For example, conjoint analysis does not require intensive consumer involvement but provides data that can be used to assure a high likelihood of product success (Green et al., 2001; Wind and Mahajan, 1997).

Lastly, statistical analysis data suggest that the respondents’ function relates to the use of consumer data. We observed a relationship between belonging to the marketing function and using environmental factor data in the introduction phase of the PLC (Table 5). This could be explained by the nature of the activities in this phase, which are oriented at promotion of the product. Here, environmental factors could be used to understand changes among consumers to adjust promotion strategies (Mohammadi and Saghaian, 2017; Urban and Hauser, 1993).

5.5. Study limitations and recommendations for further research

Although the authors aimed at approaching diverse firms at the Anuga Food Fair and on LinkedIn (in terms of country, size, and product category), due to differences in firms’ visibility and approachability, there is the possibility of biased selection. Some bias could originate from contacting respondents from the authors’ personal network, which is particularly visible by the Netherlands being the most represented country in the study.

Moreover, respondents mainly belonged to large companies (61.1%), followed by medium (22.1%), and small firms (16.8%). Future research could focus more deeply on data use in medium and small firms. In the current conceptual framework, we initially considered the three data types independently, but there are likely interactions between them. Therefore, future research could examine the interconnections between the three consumer data types and the consequences for their use in product development of specific product categories.

6. Conclusions and implications for practitioners

The professionals in our study extensively use all three data types in NPD (consumer involvement, food trends, and environmental factors), while their use is significantly lower in the PLC. They use all three types of consumer data most frequently in the opportunity identification and product design phases of NPD. Only employment of consumer involvement data remains high in the product testing phase, which indicates respondents' awareness of the importance of consumer data for successful NPD. However, significantly lower use of all three data types in the PLC, especially after the introduction phase, indicates that the respondents in our study assess the degree of fit between a product and consumers' needs to a lesser extent once products are launched on the market. This can have an impact on product success if a change in the degree of fit goes unnoticed. Moreover, respondents frequently use methods such as focus groups, consumer surveys, and the internet and magazines. "Design by" methods, such as co-creation and lead user methods, are rarely used, and their use is associated with participating in "new-to-the-world" projects. Interestingly, most of the respondents do not work on new-to-the-world projects, and they mainly work on projects such as product improvements, product line extensions, and new product lines. Finally, there is an association between firm size and the type of data and methods employed in NPD. Respondents from small firms use consumer involvement data in NPD significantly less often, particularly in the testing phase, and they less often employ sensory tests, compared to respondents from large companies. Moreover, respondents from large companies use consultancy and marketing agencies to obtain trends and environmental factor data significantly more often than respondents from small firms.

Professionals in food product development could improve the chances of product success by strategically tailoring their data collection to the type of product innovation they are undertaking and to the phase of product development. Moreover, they could employ a higher

level of consumer involvement in product development, i.e., by using “design by” methods and using multiple methods to discover both latent and existing consumer needs, especially if they want to deliver new-to-the-world products. Furthermore, they could dedicate attention to establishing formal methods for collecting data on food trends and environmental factors. Currently, these types of data are the most frequently collected through secondary sources (e.g., newsletters, reports, food fairs, and the internet).

Lastly, to integrate various data and to improve understanding of the connection between collected consumer data and product performance, European firms could move towards the use of complex computer modelling and simulation, such as system dynamics or agent-based modelling. The scientific community could aid that effort by exploring the potential of the use of such modelling methods in managing food product development.

References

Aertsens, J., Verbeke, W., Mondelaers, K., and van Huylenbroeck, G. (2009). Personal determinants of organic food consumption: A review. *British Food Journal, 111*, 1140–1167.

Aghion, P., Harris, C., Howitt, P., and Vickers, J. (2001). Competition, Imitation, and Growth with Step-by-Step Innovation. *Review of Economic Studies, 68*, 467-492.

Ahmad, S., Mallick, D. N., and Schroeder, R. (2013). New Product Development: Impact of Project Characteristics and Development Practices on Performance. *Journal of Product Innovation Management, 30*(2), 331-348.

Ali, J., Kapoor, S., and Moorthy, J. (2010). Buying behaviour of consumers for food products in an emerging economy. *British Food Journal, 112*(2), 109-124.

Asioli, D., Aschemann-Witzel, J., Caputo, V., Vecchio, R., Annunziata, A., Naes, T., and Varela, P. (2017). Making sense of the "clean label" trends: A review of consumer food choice behavior and discussion of industry implications. *Food Research International, 99*, 58-71.

Barczak, G., Griffin, A., and Kahn, K. B. (2009). PERSPECTIVE: Trends and Drivers of Success in NPD Practices: Results of the 2003 PDMA Best Practices Study. *Journal of Product Innovation Management, 26*, 3-23.

Barczak, G., and Kahn, K. B. (2012). Identifying new product development best practice. Business Horizons, 55(3), 293-305.

Beck, T., and Demirguc-Kunt, A. (2006). Small and medium-size enterprises: Access to finance as a growth constraint. *Journal of Banking & Finance, 30*(11), 2931-2943.

Brody, A., and Lord, J. (2007). *Developing New Food Products for a Changing Marketplace* (2nd ed.). Hoboken: CRC Press.

Brunner, T. A., van der Horst, K., and Siegrist, M. (2010). Convenience food products. Drivers for consumption. *Appetite, 55*, 498-506.

Bugge, A. B. (2015). Why Are Alternative Diets Such as "Low Carb High Fat" and "Super Healthy Family" So Appealing to Norwegian Food Consumers? *Journal of Food Research, 4*(3), 89-102.

Busse, M., and Siebert, R. (2018). The role of consumers in food innovation processes. *European Journal of Innovation Management, 21*(1), 20-43.

Byun, J., Sung, T.-E., and Park, H.-W. (2018). Technological innovation strategy: how do technology life cycles change by technological area. *Technology Analysis & Strategic Management, 30*(1), 98-112.

Ciccantelli, S., and Magidson, J. (1993). FROM EXPERIENCE: Consumer Idealized Design: Involving Consumers in the Product Development Process. *Journal of Product Innovation Management, 10*, 341-347.

Costa, A. I. A., Greco, M., Grimaldi, M., Cricelli, L., and Corvello, V. (2016). Inter-organisational innovation processes in the European food and drink industry. *International Journal of Management and Enterprise Development, 15*(2/3), 191-208.

Costa, A. I. A., and Jongen, W. M. F. (2006). New insights into consumer-led food product development. *Trends in Food Science & Technology, 17*, 457–465.

Costa, A. I. A., and Jongen, W. M. F. (2010). Designing New Meals for an Ageing Population. *Critical Reviews in Food Science and Nutrition, 50*(6), 489-502.

Creusen, M., Hultink, E. J., and Eling, K. (2013). Choice of consumer research methods in the front end of new product development. *International Journal of Market Research, 55*(1), 81-104.

Cwiertka, K. J. (2005). From ethnic to hip: circuits of Japanese cuisine in Europe. *Food & Food Ways, 13*(4), 241-272.

Davies, A., Titterington, A. J., and Cochrane, C. (1995). Who buys organic food? A profile of the purchasers of organic food in Northern Ireland. *British Food Journal, 97*(10), 17-23.

Davis, R. (1993). From experience: The role of market research in the development of new consumer products. *Journal of Product Innovation Management, 10*(4), 309-317.

Delarue, J., and Boutrolle, I. (2010). The effects of context on liking: implications for hedonic measurements in new product development. In Jaeger, S. R. and MacFie, H. (Eds.), *Consumer-driven innovation in food and personal care products* (pp. 175-218). Great Abington, UK: Woodhead Publishing Limited.

Dijksterhuis, G. (2016). New product failure: Five potential sources discussed. *Trends in Food Science & Technology, 50*, 243-248.

Drewnowski, A., and Darmon, N. (2005). Food Choices and Diet Costs: an Economic Analysis. *Journal of Nutrition, 135*(4), 900-904.

Doha, A., Pagell, M., Swink, M., and Johnston, D. (2018). The Imitator's Dilemma: Why Imitators Should Break Out of Imitation. *Journal of Product Innovation Management*, 35(4), 543-564.

Earle, M., Earle, R., and Anderson, A. (2001). *Food product development*. Boca Raton: CRC Press.

Ehrenfeld, D. (2003). Globalisation: Effects on Biodiversity, Environment and Society. *Conservation & Society, 1*(1), 99-111.

Eisenberg, I. (2011). Lead-User Research for Breakthrough Innovation. *Research-Technology Management, 54*(1), 50-58.

Elzerman, J. E., Hoek, A. C., van Boekel, M. A. J. S., and Luning, P. A. (2011). Consumer acceptance and appropriateness of meat substitutes in a meal context. *Food Quality and Preference, 22*(3), 233-240.

Elzerman, J. E., van Boekel, M. A. J. S., and Luning, P. A. (2013). Exploring meat substitutes: consumer experiences and contextual factors. *British Food Journal, 115*(5), 700-710.

Falguera, V., Aliguer, N., and Falguera, M. (2012). An integrated approach to current trends in food consumption: Moving toward functional and organic products? *Food Control, 26*(2), 274-281.

Fuller, G. W. (2005). *New food product development: from concept to marketplace* (2nd ed.). Boca Raton, Florida: CRC Press LLC.

Geyer, F., Lehnen, J., and Herstatt, C. (2018). Customer Need Identification Methods in New Product Development: What Works "Best"? *International Journal of Innovation and Technology Management, 15*(1), 1-26.

Green, P. E., Krieger, A. M., and Wind, Y. (2001). Thirty Years of Conjoint Analysis: Reflections and Prospects. *Interfaces, 31*(3_supplement), 56-73.

Gruner, K. E., and Homburg, C. (2000). Does Customer Interaction Enhance New Product Success? *Journal of Business Research, 49*(1), 1-14.

Grunert, K. G. (2005). Consumer behaviour with regard to food innovations: quality perception and decision-making. In Jongen W. M. F., and Meulenberg, M. T. G. (Eds.), *Innovation in agri-food systems* (pp. 57-86). Wageningen: Wageningen Academic Publishers.

Grunert, K. G., Baadsgaard, A., Larsen, H. H, and Madsen T. K. (1996). *Market orientation in food and agriculture*. Boston, MA, USA: Kluwer.

Grunert, K. G., Hieke, S., and Wills, J. (2014). Sustainability labels on food products: Consumer motivation, understanding and use. *Food Policy, 44*(Supplement C), 177-189.

Grunert, K. G., and van Trijp, H. C. M. (2014). Consumer-oriented new product development. In van Alfen, N. K. (Ed.), *Encyclopedia of Agriculture and Food Systems* (pp. 375-386). San Diego, CA: Academic Press.

Hemmerling, S., and Spiller, A. (2016). Cross-National Sensory Segments in the Organic Market Based on Stated Preferences for the Five Basic Tastes. *Journal of food products marketing, 22*(7), 767-791.

Hoek, A.C., Luning, P.A., Stafleu A., and de Graaf, C. (2004). Food-related lifestyle and health attitudes of Dutch vegetarians, non-vegetarian consumers of meat substitutes, and meat consumers. *Appetite, 42*(3), 265-272.

Holahan, P. J., Sullivan, Z. Z., and Markham, S. K. (2014). Product Development as Core Competence: How Formal Product Development Practices Differ for Radical, More Innovative, and Incremental Product Innovations. *Journal of Product Innovation Management, 31*(2), 329-345.

Iarossi, G. (2006). *The Power of Survey Design: A User's Guide for Managing Surveys, Interpreting Results, and Influencing Respondents*. Washington, DC: World Bank.

Jackson, P., and Viehoff, V. (2016). Reframing convenience food. *Appetite, 98*, 1-11.

Janssen, K. L., and Dankbaar, B. (2008). Proactive involvement of consumers in innovation: selecting appropriate techniques. *International Journal of Innovation Management, 12*(3), 511–541.

Jongen W. M. F., and Meulenberg, M. T. G. (2005). *Innovation in agri-food systems*. Wageningen: Wageningen Academic Publishers.

Kahn, K. B., Barczak, G., and Moss, R. (2006). PERSPECTIVE: Establishing an NPD Best Practices Framework. *Journal of Product Innovation Management, 23*, 106-116.

Kaulio, M. A. (1998). Customer, consumer and user involvement in product development: A framework and a review of selected methods. *Total Quality Management, 9*(1), 141-149.

Kearney, J. (2010). Food consumption trends and drivers. *Philosophical Transactions of the Royal Society B: Biological Sciences, 365*(1554), 2793-2807.

Kock, A., Gemünden, H. G., Salomo, S., and Schultz, C. (2011). The Mixed Blessings of Technological Innovativeness for the Commercial Success of New Products. *Journal of Product Innovation Management, 28*(S1), 28-43.

Kristensson, P., Matthing, J., and Johansson, N. (2008). Key strategies for the successful involvement of customers in the co-creation of new technology-based services. *International Journal of Service Industry Management, 19*(4), 474-491.

Lance, C. E., Butts, M. M., & Michels, L. C. (2006). The Sources of Four Commonly Reported Cutoff Criteria: What Did They Really Say? *Organizational Research Methods, 9*(2), 202-220.

Lin, C.-F. (2002). Segmenting customer brand preference: demographic or psychographic. *Journal of Product & Brand Management, 11*(4), 249-268.

Lundahl, D. (2006). A holistic approach to product development. *Food Technology, 60*(11), 28-33.

Luning, P. A., and Marcelis, W. J. (2009). *Food quality management: technological and managerial principles and practices*. Wageningen: Wageningen Academic Publishers.

MacDonald, P. L., and Gardner, R. C. (2000). Type I Error Rate Comparisons of Post Hoc Procedures for I j Chi-Square Tables. *Educational and Psychological Measurement, 60*(5), 735-754.

Marmot, M. (2002). The Influence of Income on Health: Views of an Epidemiologist. *Health Affairs, 21*(2), 31-46.

Martinez, M. G. (2014). Co-creation of Value by Open Innovation: Unlocking New Sources of Competitive Advantage. *Agribusiness, 30*(2), 132-147.

McGill, A. E. (2009). The potential effects of demands for natural and safe foods on global food security. *Trends in food science & technology, 20*(9), 402-406.

Meulenberg, M. T. G., and Viaene, J. (2005). Changing agri-food systems in Western countries: a marketing approach. In Jongen W. M. F., and Meulenberg, M. T. G. (Eds.), *Innovation in agri-food systems* (pp. 87-124). Wageningen: Wageningen Academic Publishers.

Mintel Ltd. (2018). *Global Food & Drink Trends 2018*. Retrieved from: http://www.mintel.com/global-food-and-drink-trends/thank-you.php

Mohammadi, H., and Saghaian, S. H. (2017). Prioritization of expanded marketing mix in different stages of the product life cycle: The case of food industry. *Journal of Agricultural Science and Technology, 19*(5), 993-1003.

Moskowitz, H. R., and Saguy, I. S. (2013). Reinventing the Role of Consumer Research in Today's Open Innovation Ecosystem. *Critical Reviews in Food Science and Nutrition, 53*(7), 682-693.

Nestle, M., Wing, R., Birch, L., DiSogra, L., Drewnowski, A., Middleton, S., Sigman-Grant, M., Sobal, J., Winston, M., and Economos, C. (1998). Behavioral and Social Influences on Food Choice. *Nutrition Reviews, 56*(5), S50-S74.

Neville, M., Tarrega, A., Hewson, L., and Foster, T. (2017). Consumer-orientated development of hybrid beef burger and sausage analogues. *Food Science & Nutrition, 5*, 852–864.

Nie, C., and Zepeda, L. (2011). Lifestyle segmentation of US food shoppers to examine organic and local food consumption. *Appetite, 57*, 28-37.

Nielsen, K. A. (2016). Health beneficial consumer products – status and trends. In Osborn, S., and Morley, W. (Eds.), *Developing Food Products for Consumers with Specific Dietary Needs* (pp. 15-42). Woodhead Publishing (online book).

Nijssen, J., and Lieshout, K. F. M. (1995). Awareness, use and effectiveness of models and methods for new product development. *European Journal of Marketing, 29*(10), 27-44.

Otto, K. N., and Wood, K. L. (2003). *Product Design: Techniques in Reverse Engineering and New Product Development*. Beijing: Pearson Education Asia Limited and Tsinghua. University Press.

Ozdemir, M., and Floros, J. D. (2004). Active food packaging technologies. *Critical Reviews in Food Science and Nutrition, 44*(3), 185-193.

Padel, S., and Foster, C. (2005). Exploring the gap between attitudes and behaviour: Understanding why consumers buy or do not buy organic food. *British Food Journal, 107*(8), 606-625.

Plewa, M. (2016). Long-run dynamics between product life cycle length and innovation performance in manufacturing. *International Journal of Innovation Management, 20*(8), 1-20.

Poretta, S., Moskowitz, H. R., and Hartmann, J. (2010). Recent advances in commercial concept research for product development. In Jaeger, S. R. and MacFie, H. (Eds.), *Consumer-driven innovation in food and personal care products*. Great Abington, UK: Woodhead Publishing Limited.

Rana, J., and Paul, J. (2017). Consumer behavior and purchase intention for organic food: A review and research agenda. *Journal of Retailing and Consumer Services, 38*, 157-165.

Resurreccion, A. V. A. (2007). Consumer Sensory Testing for Food Product Development. In Brody, A. L., and Lord, J. B. (Eds.), *Developing New Food Products for a Changing Marketplace* (2nd ed., pp. 365-406). Boca Raton, Florida, USA: CRC Press.

Ronteltap, A., van Trijp, J. C. M., Renes, R. J., and Frewer, L. J. (2007). Consumer acceptance of technology-based food innovations: Lessons for the future of nutrigenomics. *Appetite*, 49(1), 1-17.

Schmidt, M. J., and Gary, M. S. (2002). Combining system dynamics and conjoint analysis for strategic decision making with an automotive high-tech SME. *System Dynamics Review, 18*(3), 359-379.

Senauer, B., Asp, E., and Kinsey, J. (1991). *Food Trends and the Changing Consumer*. St. Paul, Minnesota, USA: Eagan Press.

Solomon, M. R. (2008). Consumer behaviour: buying, having, and being (8th ed.). Upper Saddle River, NJ: Pearson Prentice Hall.

Steenkamp, J.-B. E. M., and Maydeu-Olivares, A. (2015). Stability and Change in Consumer Traits: Evidence from a 12-Year Longitudinal Study, 2002–2013. *American Marketing Association, LII*, 287-308.

Steffen, A. (2018). Exploring the Benefits of Employing Market Insights and Consumer Trends in Food Product Innovation: A Case Study from Germany. In Cavicchi, A., and Santini, C. (Eds.), *Case Studies in the Traditional Food Sector* (pp. 209-237). Kidlington, UK: Woodhead Publishing.

Sterman, J. D. (2004). *Business Dynamics: Systems Thinking and Modelling for a Complex World (International Edition)*. Singapore: McGraw-Hill.

Stewart-Knox, B., and Mitchell, P. (2003). What separates the winners from the losers in new food product development? *Trends in Food Science & Technology, 14*(1-2), 58-64.

Sturley, C., Newing, A., and Heppenstall, A. (2017). Evaluating the potential of agent-based modelling to capture consumer grocery retail store choice behaviours. *The International Review of Retail, Distribution and Consumer Research, 28*(1), 27-46.

Sumberg, J., Heirman, J., Raboanarielina, C., and Kaboré, A. (2013). From agricultural research to 'product development'. What role for user feedback and feedback loops? *Outlook on Agriculture, 42*(4), 233-242.

Urban, G. L., and Hauser, J. R. (1993). *Design and marketing of new products*. Englewood Cliffs, NJ: Prentice-Hall International, Inc.

van Kleef, E., van Trijp, H. C. M., and Luning, P. (2005). Consumer research in the early stages of new product development: a critical review of methods and techniques. *Food Quality and Preference, 16*, 181-201.

van Trijp, H. C. M., and Steenkamp, J. E. B. M. (2005). Consumer-oriented new product development: principles and practice. In Jongen W. M. F., and Meulenberg, M. T. G. (Eds.), *Innovation in agri-food systems* (pp. 87-124). Wageningen: Wageningen Academic Publishers.

Vermeir, I., and Verbeke, W. (2006). Sustainable Food Consumption: Exploring the Consumer "Attitude – Behavioral Intention" Gap. *Journal of Agriculture and Environmental Ethics, 19*(2), 69-194.

Wandel, M., Råberg, M., Kumar, B., and Holmboe-Ottesen, G. (2008). Changes in food habits after migration among South Asians settled in Oslo: the effect of demographic, socio-economic and integration factors. *Appetite, 50*(2), 376-385.

Wind, T., and Mahajan, V. (1997). Issues and Opportunities in New Product Development: An Introduction to the Special Issue. *Journal of Marketing Research, 34*(1), 1-12.

Yanovski, J. A. (2017). Obesity: Trends in underweight and obesity – scale of the problem. *Nature Reviews Endocrinology, 14*, 5-6.

Zaborek, P., Mazur, J. (2019). Enabling value co-creation with consumers as a driver of business performance: A dual perspective of Polish manufacturing and service SMEs. Journal of Business Research, in press.

Zhao, R., and Zhong, S. (2015). Carbon labelling influences on consumers' behaviour: A system dynamics approach. *Ecological Indicators, 51*, 98-1.

Supplementary material 1
Survey questionnaire

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For quality of life

The use of different data types in food industry

Introduction

Welcome to the survey about the use of different data types in food industry.

Food industry has been experiencing high failure rates of new products over the past decades.
This survey aims at learning what type of data food professionals use when making decisions in different stages of food product's life.

The survey consists of three parts:
1. General question about your work
2. Data use in new product development process (NPD)
3. Data use in product life cycle management (PLC)

It will take you up to 15 minutes to fill out the whole survey.

This survey is anonymous.
We want to assure you that your responses are completely anonymous and confidential. Responses to anonymous surveys cannot be traced back to the respondent. No personally identifiable information is captured unless you voluntarily offer personal or contact information in any of the comment fields. Additionally, your responses are combined with those of many others and summarized in a report to further protect your anonymity.

Thank you for starting the survey!

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The use of different data types in food industry

Part 1. General questions about your work

* 1. **Are you involved in new food product* development process in your company?**
*processed food products that are sold in supermarkets

- ◯ Yes
- ◯ No

* 2. Do you work on development of new food ingredients?

- ◯ Yes
- ◯ No

* 3. Which function description fits best your job title?

- ◯ **R&D**
  You design new food product recipes, which can be used as prototypes for consumer research and as test samples for (pilot) plant testing. You also work on product reformulations.
- ◯ **Marketing**
  You develop marketing strategies based on consumer and marketplace data, you prepare promotional and advertising materials and you manage the product during its product life cycle.
- ◯ **Consumer research**
  You perform research with consumers to study their response to product concepts and prototypes and/or collect information about consumers in any phase of product's life.
- ◯ None of the above

4. What is your current job title?

* 5. What country do you work in?

* 6. What is the size of the company where you work?

- ◯ Small (less than 50 employees)
- ◯ Medium (between 50 and 249 employees)
- ◯ Large (more than 249 employees)

* 7. How many years of experience in new product development jobs do you have?

8. What group of products are you developing (for example: dairy, confectionery, meat products, cereal products etc.)?

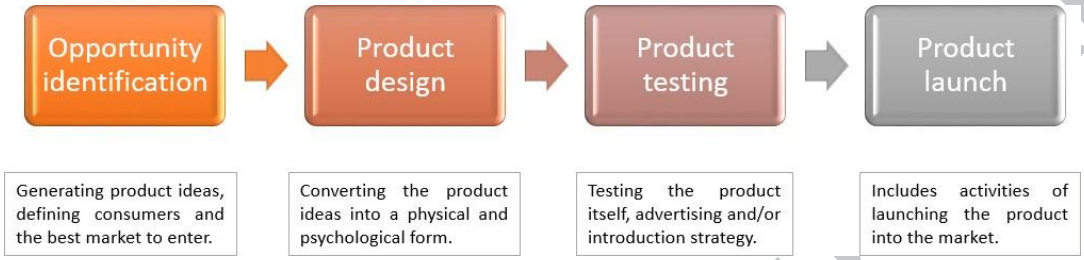
* 9. Indicate how often you worked on the following types of NPD projects in the past 3 years. Please read the descriptions carefully.

	Never	Rarely	Occasionally/Sometimes	Often	Always
Product cost reductions (re-positioned as a cheaper product, with similar	○	○	○	○	○
Product repositioning (products are targeted for a new use or application and usually a new market segment)	○	○	○	○	○
Product improvements (replacement of a present product with an improved	○	○	○	○	○
Product line extensions (additions to company's existing product lines)	○	○	○	○	○
New product lines (products are new to the	○	○	○	○	○
New-to-the-world (products are new to society, never seen before)	○	○	○	○	○

The use of different data types in food industry

Part 2. Questions about data use in new product development (NPD)

Please answer questions in part 2 with new product development process (NPD) in mind.
NPD typically consists of 4 phases.



* 10. Do you, in any way, use or collect data about consumers during NPD to make decisions about new products?

- ◯ Yes
- ◯ No

* 11. What consumer data collection methods have you used in NPD in the past 3 years? (more than one answer possible)

- ☐ Focus groups
- ☐ Consumer surveys
- ☐ External sources (supermarkets, marketing agencies)
- ☐ Internet and magazines
- ☐ Sensory tests
- ☐ Concept testing
- ☐ Category appraisal
- ☐ Conjoint analysis
- ☐ Lead-user method
- ☐ Consumer idealized design
- ☐ Innovation templates
- ☐ Consumer co-creation

Other (please specify)

* 12. In which phases of NPD do you use consumer data?
(more than one answer possible)

- [ ] In opportunity identification phase
- [ ] In product design phase
- [ ] In product testing phase
- [ ] In product launch phase

* 13. Do you, in any way, use or collect information about food trends during NPD?

- ( ) Yes
- ( ) No

* 14. Indicate which trends you incorporated in your products in NPD during the past 3 years?
(more than one answer possible)

- [ ] **Healthy food**
(superfood, functional food, "free from" trend, clean label, sugar or calorie reduction, natural, less processed)
- [ ] **Sustainable food**
(vegetarian, vegan, ethical, local, claim of food origin)
- [ ] **Convenience food**
(small package units, ready-to-eat, ready-to-cook)
- [ ] None of the above

Other (please specify)

* 15. In what NPD phases do you use information on trends?
(more than one answer possible)

- [ ] In opportunity identification phase
- [ ] In product design phase
- [ ] In product testing phase
- [ ] In product launch phase

* 16. How do you collect/obtain information about current food trends?
(more than one answer possible)

- [ ] marketing agencies, consultancy companies
- [ ] newsletters and reports
- [ ] online databases
- [ ] internet
- [ ] food fairs
- [ ] scientific literature
- [ ] consumer surveys
- [ ] competitors' analysis

Other (please specify)

* 17. Indicate which of the following socio-cultural and demographic data you used in NPD in the past 3 years.

There are two columns. In each column open the drop-down menu and choose one or more data types that you have used.
If you have not used any, choose "none of the above" (you only need to choose "none of the above" once for each column).

Socio-cultural changes in population	Demographic changes in population

Other (please specify)

* 18. Indicate which of the following economic and technological data you used in NPD in the past 3 years.

There are two columns. In each column open the drop-down menu and choose one or more data types that you have used. If you have not used any, choose "none of the above" (you only need to choose "none of the above" once for each column).

Economic changes in population	Technological changes in population

Other (please specify)

* 19. In what NPD phases do you use data on socio-cultural, demographic, economic and technological changes in population?
(more than one answer possible)

- [ ] In opportunity identification phase
- [ ] In product design phase
- [ ] In product testing phase
- [ ] In product launch phase
- [ ] I do not use it

* 20. How do you collect/obtain data on socio-cultural, demographic, economic and technical changes in population?
(more than one answer possible)

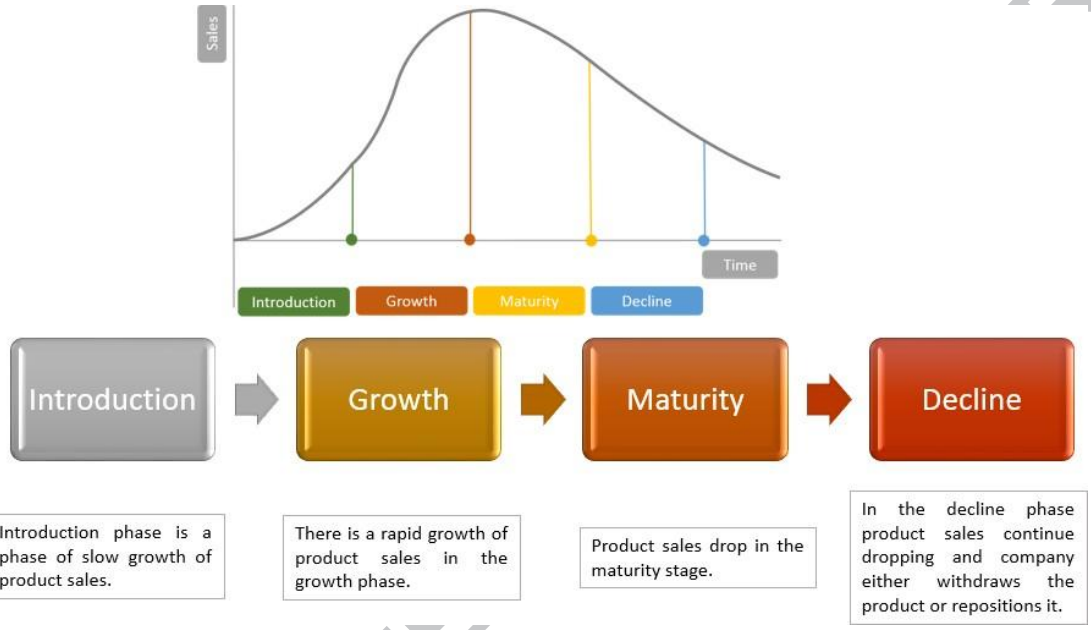
- [ ] From marketing agencies, consultancy companies
- [ ] From newsletters and reports
- [ ] From online databases
- [ ] From internet
- [ ] From scientific literature
- [ ] By undertaking surveys

Other (please specify)

Part 3. Questions about data use in product life cycle management (PLC)

In part 3 we will ask similar questions as in part 2.
Please answer the questions thinking of your products that are already on the market.

PLC typically consists of four phases.



* 21. Do you, in any way, use or collect data about consumers during PLC to make decisions about an existing food product?

- ◯ Yes
- ◯ No

* 22. What consumer data collection methods have you used in PLC in the past 3 years for products on the market?
(more than one answer possible)

- [ ] Focus groups
- [ ] Consumer surveys
- [ ] External sources (supermarkets, marketing agencies)
- [ ] Internet and magazines
- [ ] Sensory tests
- [ ] Concept testing
- [ ] Category appraisal
- [ ] Conjoint analysis
- [ ] Lead-user method
- [ ] Consumer idealized design
- [ ] Innovation templates
- [ ] Consumer co-creation

Other (please specify)

* 23. In which PLC phases do you use consumer data?
(more than one answer possible)

- [ ] In the introduction phase
- [ ] In the growth phase
- [ ] In the maturity phase
- [ ] In the decline phase

* 24. Do you, in any way, use or collect data about food trends during PLC to make decisions about existing products?

- ( ) Yes
- ( ) No

* 25. Indicate which food trends you used to change your existing products in PLC in the past 3 years.
(more than one answer possible)

- [ ] **Healthy food**
(superfood, functional food, "free from" trend, clean label, sugar or calorie reduction, natural, less processed etc.)
- [ ] **Sustainable food**
(vegetarian, vegan, ethical, local, claim of food origin etc.)
- [ ] **Convenience food**
(small package units, ready-to-eat, ready-to-cook etc.)
- [ ] I did not change existing products in the past 3 years

Other (please specify)

* 26. In which PLC phases do you use information about current food trends?
(more than one answer possible)

- [ ] In the introduction phase
- [ ] In the growth phase
- [ ] In the maturity phase
- [ ] In the decline phase

* 27. Indicate which of the following socio-cultural and demographic data you used in PLC in the past 3 years.

There are two columns. In each column open the drop-down menu and choose one or more data types that you have used.
If you have not used any, choose "none of the above" (you only need to choose "none of the above" once for each column).

Socio-cultural changes in population	Demographic changes in population

Other (please specify)

* 28. Indicate which of the following economic and technological data you used in PLC in the past 3 years.

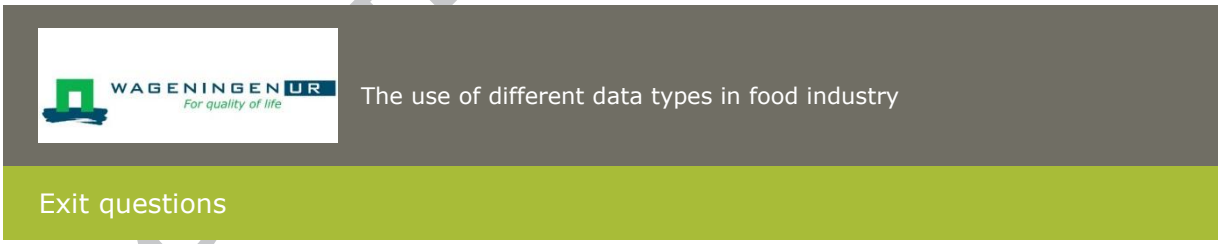
There are two columns. In each column open the drop-down menu and choose one or more data types that you have used. If you have not used any, choose "none of the above" (you only need to choose "none of the above" once for each column).

Economic changes in population	Technological changes in population

Other (please specify)

* 29. In what PLC phases do you use data on socio-cultural, demographic, economic and technological trends in population?
(more than one answer possible)

- [ ] In the introduction phase
- [ ] In the growth phase
- [ ] In the maturity phase
- [ ] In the decline phase
- [ ] I do not use it



* 30. Indicate which computer simulation methods you have used during NPD or PLC.
(more than one answer possible)

- [ ] Agent-based modeling
- [ ] Discreet event modeling
- [ ] System dynamics modeling
- [ ] Statistical models
- [ ] I have not used computer simulation

Other (please specify)

31. Please write your e-mail address if you don't mind being contacted in case we might have more questions.

32. Please write the name of the company where you work, if you wish. (optional)

The use of different data types in food industry

This is the end of the survey.

Thank you for participating in this survey!

To finish the survey click DONE.

If you have any questions, please contact us!

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Supplementary material 2

"Cellwise adjusted residual method" post-hoc test

This supplementary material demonstrates how to perform a "cellwise adjusted residual method" post-test of the Pearson's chi-square test of independence (MacDonald and Gardner, 2000). All statistical analyses were performed using IBM SPSS Statistics Version 23.

Firstly, Pearson's chi-square test of independence needs to be performed to examine if there is an association between the variable "size of the company" (options: small, medium, large) and the use of sensory tests (options: yes, no; variable name "method of sensory test"). Null hypothesis is that there is no association between the size of the company and the use of sensory tests.

To perform the Pearson's chi-square test of independence in IBM SPSS Statistics Version 23:

1. Analyze/Descriptive statistics/Crosstabs
2. In Crosstabs window
    a. Add the variable "size of the company" to the box "Row"
    b. Add the variable "method of sensory test" to the box "Column"
    c. Click on Statistics, and check the Chi-square box, click Continue
    d. To analyse click OK.

Figure 1 shows a significant result for the Pearson Chi-square test. However, a post-test is needed to determine the association between a particular size of the company (small, medium, large) and the particular use of sensory tests (yes, no).

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	18,809[a]	2	,000	,000		
Likelihood Ratio	18,992	2	,000	,000		
Fisher's Exact Test	18,676			,000		
Linear-by-Linear Association	17,163[b]	1	,000	,000	,000	,000
N of Valid Cases	113					

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.40.

b. The standardized statistic is -4.143.

Figure 1: Results of the Pearson's chi-square test of independence between the variable size of the company and the use of sensory tests.

"Cellwise adjusted residual method" post-hoc test

To perform the "Cellwise adjusted residual method" post-hoc test in IBM SPSS Statistics Version 23, first we need to obtain adjusted z-scores:

1. Analyze/Descriptive statistics/Crosstabs
2. In Crosstabs window
    a. Add the variable "size of the company" to the box "Row"
    b. Add the variable "method of sensory test" to the box "Column"
    c. Click on Cells, and check the Adjusted standardized residuals, click Continue
    d. To analyse click OK.

Results of adjusted standardized residuals can be seen in figure 2. Adjusted standardized residuals in figure 2 represent z-scores. Z-scores greater than 1.96 are statistically significant. But since we performed a series of analyses, a type 1 error could have been committed, which is why we need to calculate Bonferroni corrected p-values to determine which cells are statistically significant.

Size of the company * Method of sensory tests Crosstabulation

			Method of sensory tests		
			yes	no	Total
Size of the company	Small	Count	6,000	13,000	19
		Adjusted Residual	-2,890	2,890	
	Medium	Count	10,000	15,000	25
		Adjusted Residual	-2,447	2,447	
	Large	Count	53,000	16,000	69
		Adjusted Residual	4,300	-4,300	
Total		Count	69	44	113

Figure 2: Adjusted standardized residuals of the Pearson's chi-square test of independence n between the variable size of the company and the use of sensory tests. Adjusted residuals represent z-scores.

Firstly, to determine which cells are significant, we need to obtain adjusted p-value (Bonferroni corrected p-value) to control for the type 1 error. Since we performed six analyses, we need to adjust the p-value accordingly by dividing the p-value of 0.05 with 6 (0.05/6=0.008). Our Bonferroni corrected p-value is 0.008.

Secondly, the z-scores from figure 2 need to be transformed into chi-square values. First, we transfer all the z-scores from figure 2 into a new column in SPSS (see z_score column in table 1). To obtain chi_square values in table 1, we multiply z_score*z_score (in SPSS, go to Transform/Compute variable. In the "Compute variable" window write the Target variable: chi_square. In "Numeric expression" field insert "z_scores*z_scores". Click OK to calculate).

Thirdly, we need to obtain p-values of the chi-square values (go to Transform/Compute variable. In the "Compute variable" window write the Target variable: p_value. From "Function group" choose Significance. From "Functions and Special Variables" choose Sig.chisq. In "Numeric expression" filed, the following will appear: SIG.CHISQ(?). Instead of (?) insert (chi_square, 1). Number one specifies degrees of freedom. Click OK to calculate.).

Finally, compare the p_value column with the calculated Bonferroni corrected p-value (0.008). For each cell where p-value is 0.008 or lower, and where adjusted z-score is higher than 1.96, there is an association between the particular company size and the use of sensory tests. For example, there is an association between respondents from small companies and not using sensory tests (row 2 in table 1).

Table 1: Adjusted z-scores, chi-square values and Bonferroni corrected p-value of "Cellwise adjusted residual method" post- hoc test for the size of the company and the use of sensory tests

	adjusted_z_score	chi_square	p_value
1	-2,890	8,352	,004
2	2,890	8,352	,004
3	-2,450	6,003	,014
4	2,450	6,003	,014
5	4,300	18,490	,000
6	-4,300	18,490	,000

Reference:

MacDonald, P. L., and Gardner, R. C. (2000). Type I Error Rate Comparisons of Post Hoc Procedures for I j Chi-Square Tables. *Educational and Psychological Measurement*, *60*(5), 735-754.

Highlights

- Empirical study on consumer data use in product development in European food firms.
- Three consumer data types: consumer involvement, food trends, environment factors.
- More than 85% of respondents use all three data types in new product development.
- Respondents much rarely use consumer data in product life-cycle.
- Data collection methods do not optimally support development of truly new products.
-