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Design-led innovation for more plant-based food: An interdisciplinary approach to more consumer-centric product development

ABSTRACT

A more plant-based diet will contribute to food sustainability. Achieving this change requires collaboration across disciplines which is not easy to achieve. This article illustrates how interdisciplinary collaboration in a large research project can be facilitated through a design-led innovation process juxtaposing approaches from design and science. Consumer insights were used in creative workshops to ideate and develop packaging and product concepts for plant-based food focusing on 'environment', 'health' and 'Norwegian' design imperatives. Learning loops of alignment – creation – feedback were applied to design and test six packaging

KEYWORDS

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prototypes of two product categories (Pea Porridge, Faba Bean Drink). Qualitative feedback was collected from 147 consumers and a quantitative survey with 1102 Norwegian consumers tested product expected liking and product-concept match. Younger consumers and users of plant-based products exhibited a higher expected liking vs. non-users and older respondents. Packaging design adopted for specific consumer segments can positively contribute to a shift to more plant-based diets. We show how a dynamic interdisciplinary innovation approach can be powerful to creating new product ideas, getting consumers' input and fostering collaboration and learning among disciplines. We offer other researchers and the food industry actionable opportunity areas and design imperatives for their innovation activities around plant-based food.

INTRODUCTION AND THEORETICAL BACKGROUND

We need to change the way we produce and consume food to create more sustainable food systems (Hinrichs 2014; Fanzo et al. 2020). One effort in that direction is to increase the amount of plant-based proteins in our diet and reduce proteins of animal origin (Willett et al. 2019; Schiermeier 2019). This is challenging as geographic and climatic conditions determine which crops can be grown profitably in each region (Alandia et al. 2020) and consumers may be reluctant to change or simply not be interested in eating more plant-based foods (Graça et al. 2015). The high complexity of these necessary changes requires interdisciplinary approaches, which are currently not developed or implemented (Atkins and Michie 2013; Gonera et al. 2021). This article illustrates how an interdisciplinary design-led innovation process involving designers and scientists facilitates alignment, creation and learning across disciplinary boundaries, leading to an integrated research and product development approach – in this case, for the development of plant-based foods.

Interdisciplinary approaches are necessary for addressing the most critical global socio-technological challenges (Borrego and Cutler 2010), such as the transition to more sustainable food production and consumption. Public funding organizations encourage such collaborations to achieve sustainability goals and solve grand challenges (EU Horizon Europe, Mazzucato 2018). Our research is contextually anchored in a research and innovation consortium (RIC) which is a large publicly funded and academically led research project aiming at the increased production and consumption of plant-based proteins in Norway. Traditionally researchers in these types of projects are motivated by personal productivity and academic peer recognition (Simons et al. 2011; Pabst et al. 2020). This can lead to working and thinking in silos and not utilizing the full potential that such multi-disciplinary projects may provide to jointly generate insights relevant for users (consumers, companies and other researchers). In recent years, the design discipline has evolved to play an important role for solving such complex challenges when users, researchers and designers engage in a co-creative and collaborative process (Sanders and Stappers 2008). We believe design can bring huge advantages to research and innovation projects, such as increased user focus and insight generation, facilitation of collaboration, better visualization, making research results tangible, increasing the focus on solutions and innovations (Ben Mahmoud-Jouini et al. 2016, Gonera and Pabst 2019: Micheli et al. 2019; Secundo et al. 2020). Applying design in innovation projects has also been shown to lead to product concepts with higher feasibility, relevance and specificity compared to traditional approaches (Meinel et al. 2020). However, this is not an easy endeavour and Laursen and Haase (2019) question whether design can be applied by non-designers or whether a designer is needed to guide the process. Therefore, designers often act as translational developers (Norman 2010) or design innovation catalysts (Price et al. 2018), facilitating a process that translates insights from research into tangible prototypes and concrete innovation. This approach helps creating reusable knowledge through a generative process and artefacts (Hodges et al. 2017) and has been shown to be successful also in research projects where several research disciplines work on solving complex societal problems (Simeone et al. 2017; Gonera and Pabst 2019). Like scientists, designers often conduct surveys and apply ethnographic research, and the results are even subjected to statistical data analyses. However, it is more difficult to link the activity of design with a scientific task of a scholarly nature. In science, one searches for general principles that can explain phenomena by applying either inductive or deductive logic. A design project, on the other hand, can be contextually specific or situational (Hodges 2017).

Design as practice has evolved from arts and crafts and as a discipline it is continuously being formalized in various contexts (Whitney and Nogueira 2020). Design has many branches such as product design, service design, strategy, graphic design and systems design and areas of application, i.e. health, food, education and transportation (Buchanan 2001). There are various processes, roles and content models applied by both design practitioners and researchers depending on the respective context and challenge to be solved (Bobbe et al. 2016; Tan 2012; Wynn and Clarkson 2018). In this research, the authors relied on several process models; one central process model is design thinking. Design thinking is an integrated toolset and mindset with an iterative, experimental, non-linear approach to development, emphasizing the importance of human-centricity, visualization and collaboration by combining what is technologically feasible with what is desirable and economically viable (Brown and Katz 2011; Liedtka 2015; Micheli et al. 2019). It can be described as a series of iterative diverging and converging processes and activities with strong focus on understanding the context, defining a specific problem, ideating possible solutions and then testing and implementing the most successful solutions (British Design Council 2019). Design and the important role of creating tangible prototypes has also lately gained attention in food product development and is found to spur creativity as well as collaboration towards innovative solutions (Grimsby and Kure 2019; Veflen Olsen 2014, Rothe and Dunn 2021). Prototypes can be drawings, simple cardboard models, packaging mock-ups, wireframes or in the case of food, edible products that will be tested with users/consumers for learning and further improvement (Curedale 2019). Physical prototypes and visual communication approaches can have various purposes. One purpose in a research project can be described as bringing an intangible idea, or two-dimensional sketch, into a tangible, three-dimensional artefact. This allows for better testing with project stakeholders (e.g. users, project partners, industry partners) and it can spark discussions about the various aspects for consumer understanding and implementation of research results (Capjon 2004, 2005). Informal knowledge can be deep and is often tacit, however it takes much more time to convey and is much harder for people from other fields to understand (Whitney and Nogueira 2020). It is important to consider that design-related teamwork differs from other types of teamwork that research teams might be used to, it is an experiential learning process on both team and individual level (Hölzle and Rhinow 2019). Therefore, design facilitation has emerged as a practice that contributes to better interdisciplinary collaboration by providing for example core design competencies, a creative process and collaborative conditions (Aguirre et al. 2017; Mosely et al. 2021; Tan 2012). Also, the innovation process in academically managed projects can be described as incomplete at both ends – user needs are hesitantly included in the innovation process and there is often little interest in market commercialization (Gonera and Pabst 2019). At the same time these are the underexplored areas which should complement each other eventually (Hölzle and Rhinow 2019).

Consumer-centric approaches (such as design) in research and innovation are gaining popularity, as they help researchers not only to understand patterns and behaviours but also to develop solutions that can improve people's lives (Fenko and van Rompay 2018; Schifferstein 2015). Consumer-driven product development and customer-centred design are therefore necessary to ensure both competitiveness of companies but also the change to more sustainable diets at consumer level (Linnemann et al. 2006; Kumar and Whitney 2007). Complementary to design as an act of reflection on action (Schön 1992), our research highlights the potentials of using both qualitative and quantitative consumer surveys as feedback and learning mechanisms to allow for further product development. In situations where a food product cannot be tasted, consumers base their decisions on extrinsic attributes (e.g. brand, packaging, price, labels and claims) in the absence of intrinsic product knowledge (sensory aspects). They draw information about product quality, health and nutritional aspects, social responsibility, etc., from the on-pack communication (Symmank 2019). Packaging and its design are key in the marketing mix of food companies, including health and nutrition claims and sustainability messages, which can differentiate products in the market, but also potentially help consumers to make healthier and more sustainable choices (Nocella and Kennedy 2012). There has been extensive research on the importance of the study of extrinsic cues in consumer decision making; for an overview of methods in sensory and consumer science see Asioli et al. (2017). Positioning healthy products in a more exciting way should theoretically increase consumers' likelihood to consume these products according to Bublitz and Peracchio (2015). However, Beckman et al. (2021) point out the difficulty of establishing design imperatives that communicate intrinsic attributes related to health, sustainability and local origin. These are challenging to define as they both change over time and with the consumer's individual 'food system'. We address this issue with our interdisciplinary and consumer-centric approach to develop communicative qualities and design imperatives related to Norwegian plant-based food for packaging prototypes. While concept testing has been widely used in food consumer research, qualitative consumer insights, generative problem solving and prototyping as in the designerly approach are less common. Prototypes in food science are mostly limited to experimental foods by chefs; a more holistic approach can only be attained by combining perspectives in an interdisciplinary way (Schifferstein 2015; Veflen Olsen 2014). Design is described as a useful tool in product development towards changing consumer behaviour for plant-based foods where Rothe and Dunn (2021) point out a clear opportunity to combine design-based insight and problem definition process with quantitative methods from other disciplines.

CONSUMERS AND PLANT-BASED FOOD

For better understanding the context of the research project, the next chapter provides a short overview of the state of the literature regarding consumers' motivations and barriers towards the transition to a more plant-based diet.

Consumers are primarily motivated to eat more plant-based foods and reduce meat consumption by their awareness of lower environmental impact (sustainability), aspects of animal welfare, positive personal health, perceived ease of cooking and easy access (Reipurth et al. 2019; Beacom 2021; Gonera et al. 2021). Using these motivations to communicate product attributes and characteristics towards consumers may facilitate the transition to more plant-based food. Previous research has, however, identified barriers to the consumption of novel plant-based foods, including the perceived inadequacy of its nutritional value and the association to unnaturalness (Corrin and Papadopoulos 2017; Tuorila and Hartmann 2020). Many consumers are not willing to make such a transition because of attachment to meat and unwillingness to change habits (Graça et al. 2015; de Boer et al., 2016; Hielkema and Lund 2021). Other barriers impeding increased consumption of plant-based food are established eating routines, fear of protein deficiency, lack of vegetarian options and difficulties in preparing grain legumes and other vegetarian foods, in particular lack of practical knowledge (Pohjolainen et al. 2015; Jallinoja et al. 2016; Melendrez-Ruiz et al. 2019, 2020). Consumers can be segmented into different groups according to their eating behaviour and food attitudes (Scarborough et al. 2014; van Loo et al. 2017). Products and the related communication and packaging designs need to target specific segments, i.e. vegans and vegetarians require a different communication compared to those reluctant to change from animal to plant proteins (Szejda et al. 2020; Gonera et al. 2021). Even if in recent years, consumer attitudes to health and sustainability have been shown to diverge (i.e. driven by egoistic vs. altruistic motivations) (Rosenfeld and Burrow 2017), consequences of the COVID-19 crisis are showing that environmental and health concerns may be converging in consumers' minds, opening new opportunities to drive the green shift by combining both (Gilchrist et al. 2020). Our research builds on the above-mentioned drivers and barriers, creates new consumer insights for the context of Norway and seeks to translate these into innovation opportunities by applying an interdisciplinary and a design-led process.

RESEARCH GAP AND AIM OF THE STUDY

The aim of this article is to illustrate how design-led innovation and prototyping were applied in an interdisciplinary effort to contribute to consumers' transition to healthier, more sustainable diets, in a case study on plant-based foods. By interdisciplinary we mean an interactive approach across diverse disciplinary perspectives in a collaborative research process. This leads to new levels of thinking where the research is conducted mutually and draws on theories and methods across disciplinary boundaries (Fawcett 2013). The case project described here included natural science, social sciences and design represented by food technologists, designers, chefs, innovation researchers, economists and consumer scientists.

Based on the previous chapter we have identified the following research gaps which we would like to address with our study:

1. How can interdisciplinary collaboration in a large research project be facilitated through a design-led consumer-centric innovation process (the design-led innovation process section)?
2. How can design imperatives for communicating sustainability and testing packaging prototypes with consumers be developed to aid the shift to more plant-based diet (development of prototypes and testing with consumers section)?
3. How can rigorous feedback loops from consumer insights into design processes of new consumer products be combined with the focus on product development and innovation (the juxtaposition of design and science section)?

RESEARCH APPROACH, CASE DESCRIPTION AND DESIGN-LED INNOVATION PROCESS

Given the lack of previous research on the contemporary topics of using design-led innovation methodologies in interdisciplinary RIC, we choose an inductive, mixed method approach using case study design as a research strategy (Eisenhardt and Graebner 2007; Yin 2017). This explorative study was embedded in the interdisciplinary research project FoodProFuture, which aims at increased production and utilization of domestically produced plant-protein bioresources, leading to a desirable shift to more plant-based diets. We have gathered rich information and insights through interdisciplinary and co-creative workshops, reflection of the design-led innovation process and qualitative and quantitative consumer testing.

The consumer-focused and design-led innovation activities in the case project followed an iterative design thinking process model through the four phases of discover–define–develop–deliver (British Design Council 2019). The activities are illustrated in Figure 1. Marked by the circular arrows, iterations occurred during each phase of the design process and between phases. Figure 1 describes the activities during the entire project period starting with the *discover* and *define* phases. These delivered rich data sources based on consumer insights (focus groups, market analysis, expert interviews and consumer survey) leading to the development and testing of prototypes in the *develop* phase. The activities in the *develop* phase highlighted in green are the main data source for this study. The *deliver* phase though illustrated in Figure 1 is not part of the research project as the goal (of the case project) is to deliver relevant and actionable insights, not finished products. Thus, the project is about learning, knowledge generation and sharing with relevant food industry stakeholders. In this case, the implementation is not up to the researchers but the individual food companies.

Discover and *define phase*. Market and consumer insights regarding plant-based food were collected in the early phases of the case project (focus groups [Varela et al. 2022], market analysis [Gonera and Milford 2018], consumer survey [Bugge and Alfnes 2018] and future scenarios [Prexl and Gonera 2020]). Results were summarized and synthesized in several interdisciplinary workshops.

Develop phase. In this phase of the project, multiple interdisciplinary workshops were held to ideate, prioritize and prototype. From eighteen ideas for plant-protein rich food products, three packaging prototypes for two product categories are portrayed in this article. Packaging prototypes and product

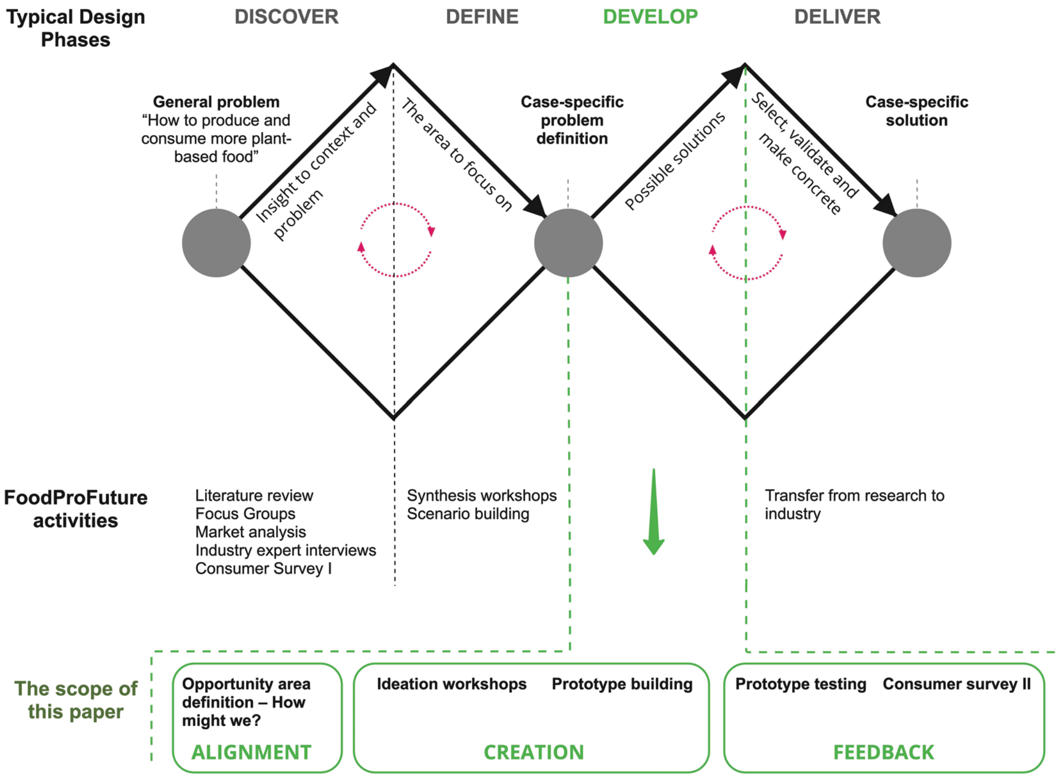

Figure 1: Illustration of the design-led innovation process in FoodProFuture in a double diamond model and the scope of this article (highlighted in green with the different activities of the develop phase).

concepts for Pea Porridge and Faba Bean Drink were designed. The detailed approach is described below and contains observations and learnings addressing the two main aims of the study: facilitating interdisciplinary collaboration through a design-led consumer-centric innovation process and developing design imperatives for communicating sustainability and testing packaging prototypes with consumers.

Develop phase: alignment. Based on insights from the *discover* and *define phases* and known consumer barriers to change to a more plant-based diet, innovation opportunity areas were developed by formulating 'How might we…?' (HMW) questions (Curedale 2019; von Thienen et al. 2014). The HMW questions illustrated in Figure 2 represent the consumer needs and barriers from literature and those identified in the case project. The opportunity areas were structured along five themes representing the stages where consumers make food choices and have food experiences. They were used as starting points for ideation and prototyping in the *develop* phase.

An initial interdisciplinary workshop was held in May 2019. The objective was to first obtain a common understanding on the research of each discipline and create a plan for how to develop and test prototypes and concepts for more plant-based food consumption. Specific plant crops, ingredients and related products and processes are in scope for the research project. The food technologists and agronomists shared their research results centred on technology development and raw material and ingredient availability while consumer and innovation scientists shared market and consumer insights during the workshop. The lengthy written project description, divided into tasks by discipline, was illustrated by a jointly created graphical format which enabled the researchers to see the full picture and think beyond their own discipline towards more consumer-centric innovation. This alignment process was essential for further work (trust building, common understanding and common objectives).

Develop phase: creation. After aligning the interdisciplinary team, the designers and innovation researchers made detailed plans for the next interdisciplinary workshop. That included being clear in the overall objective of the workshop and developing different activities towards achieving that objective and subsequently preparing the materials (worksheets, presentations, props, etc.). A full day prototype ideation workshop was held in fall 2019 to develop innovation ideas in a multi-disciplinary group of researchers (food technologists, designers, chefs, innovation researchers and consumer scientists). The aim was ultimately to develop testable prototypes that can be used for learning purposes with consumers and for knowledge transfer to the food industry. The workshop was led by a designer and an innovation researcher. Observations, photos and field notes were documented by a second innovation researcher and a master student. A second designer supported the process by drawing the ideas. The entire workshop centred on the questions 'What to make?', 'What to learn?' and 'How to test?' developed in the previous workshop. After a warm-up exercise, consumer insights and HMW questions were presented by a consumer researcher and innovation researcher respectively as starting points. The workshop focused first on short-term ideas (producible right away) to make it easier to come up with ideas immediately. We then performed individual brainstorming for ideas and wrote them on post-its. The post its were discussed in groups of two to three and ideas were clustered into thematic groups. After this initial exercise we handed out idea cards for short-term ideas. The ideas were described, a conceptual drawing and notes on how the prototype should be tested were made. In a second part we repeated the same exercises for long-term ideas (possible in five+ years) to challenge traditional thinking and increase creativity. Figure 3 illustrates results from the process (left image). In total, 21 ideas along the consumer journey were developed (sixteen products, three educational interventions, one behavioural intervention and one service), addressing different HMW questions. Some of the ideas were either similar or could be combined to an improved idea and we thus ended up with eighteen specific ideas (see lower part of illustration in Figure 2).

The group of fourteen researchers and designers prioritized six ideas by voting on expected consumer desirability, easy to make, commercial potential, sustainability and then discussing the highest-rated results' alignment with the case project's objective for further work in the project. These six ideas were further refined into six product concepts to develop a more specific understanding of the actual idea, target group, point of sales, presentation/visualization, possible producers leading to a more refined view on which prototypes to make, what the learning objective is and how to test these concepts with consumers (Figure 3, right image).

The two innovation researchers analysed the materials from the workshop and synthesized it to make a digital version of the workshop results available for the rest of the team. This is an important follow up addressing the

Themes	Food attitudes	Planning meals	Shopping/choosing food	Preparing meals	Eating meals
How might we questions	HMW make a product that is perceived natural/low processed so that consumers scepticism about processed plant food will be reduced?	HMW help consumers to use more plant-based ingredients so that they are supported in their wish to live a healthier life?	HMW increase the awareness to plant-based products in restaurants/canteens so that it is easy for consumers to choose more plant-based options?	HMW enable people to cook a meal with plant-based foods as main component so they can increase their intake of plant protein and decrease meat?	HMW create products with familiar taste and texture so that consumers find it less difficult to change their food habits?
	HMW reach out to the majority of people who do not care about increasing plant-based food so that they also start changing their food habits?		HMW increase the awareness to plant-based products in-store so that it is easy for consumers to choose plant-based options?	HMW enable people to get familiar with cooking meat-free diets so that they do not perceive it as difficult and time consuming?	HMW encourage consumers to try new tastes and textures to make them change their diet?
				HMW inspire consumers to prepare plant-based food so that they feel comfortable to experiment with different ingredients in every-day life w/o spending too much time?	
Ideas	Bean education	Plant stock	Product label	Weekend pulses	Outdoor meal
	New process	Personalized food	Online shopping experience	Meat replacer	**Pea Porridge**
	Plant food blogger		Meat monday		**Bean drink**
	Cooking class		Store layout		Healthy snack
					Textured layers
					Pea meal kit

Figure 2: Innovation opportunity areas along the consumer journey formulated as HMW questions (upper part) and overview of eighteen ideas from the interdisciplinary workshop (lower part).

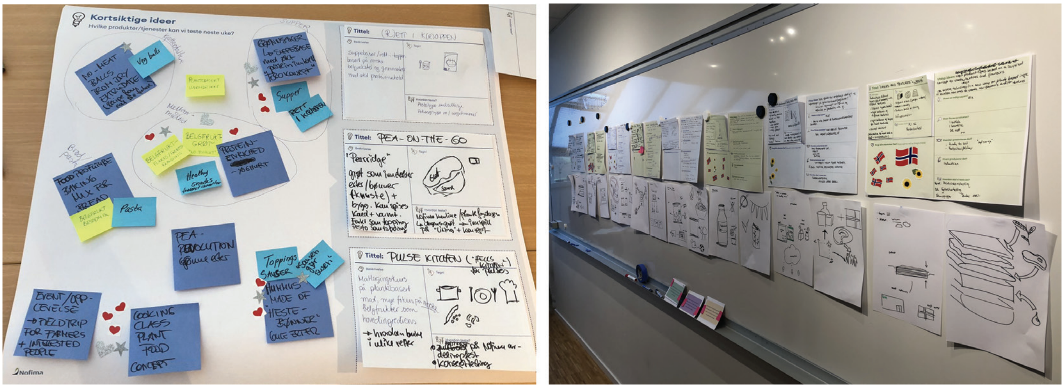

Figure 3: Illustrations and prioritization of prototype ideas in one of the interdisciplinary workshops: short-term ideas from brainstorming (left) and detailing and drawing of prioritized ideas (right).

scepticism to creative work among researchers who often doubt the value of these activities when they are not being followed up thoroughly (Gonera and Pabst 2019).

Faba Bean Drink and Pea Porridge were chosen as case study prototypes for further testing and investigation as they showed to be commercially interesting and are based on two of the plant-protein cultivars that can be grown in the Norwegian climate (Abrahamsen et al. 2019). The following HMW questions are addressed: HMW create products with familiar taste and texture so that consumers find it less difficult to change their food habits? How might we encourage consumers to try new tastes and textures to change their diet? To validate the commercial interest, an e-mail survey with four food companies participating in the project was performed including the following questions: which plant-based ingredients are you most interested in? Which plant-based products/product types are you most interested in? Which consumer insights are you most interested in? New plant-based milk, snacks/small meals as well as beans and peas were high on the industry's priority list together with a knowledge need on how to communicate new plant-based products to consumers. Edible products from Norwegian raw materials were not available at the time of testing. We therefore decided to test packaging illustrations and prototypes together with a product concept.

The design activities centred on 'learning through design' (Resnick and Ocko 1990) to understand how to communicate Norwegian plant-based food to consumers. A prototype design guideline description of functional goals and aesthetical attributes expressed through a mood board were developed jointly by designers and researchers (food science, consumer science, innovation and nutrition). HMW questions, target group, user benefit, unmet user need, product awareness, use situation and disposal situation were described in the design description to enable the designer's work. The initial concept for the Pea Porridge is a 'ready-to-eat savoury porridge for breakfast or snack in the daytime after sport, in-between meals or as a substitute for lunch or dinner'. The Faba Bean Drink is a 'beverage made from faba bean – a healthy plant-based drink, rich in proteins made in Norway from Norwegian ingredients'.

Prior to developing the product packaging designs, we aligned the objective of the prototype tests based on previous consumer insights from the *discover* phase and existing literature. Consumer motivations for choosing plant-based products often centre on aspects of health and environment (Reipurth et al. 2019; Stubbs et al. 2018; Beacom et al. 2021; Varela et al. 2022). Many people in Norway prefer domestically produced food (Kvakkestad et al. 2018) and local origin is an important driver for choosing both plant-based products (Vandenbroeck 2021; Milford et al. 2021) and the corresponding animal product (Haas et al. 2019). Based on these insights, we designed and developed packaging prototype variants communicating *environmental friendliness*, *healthiness* and *Norwegian origin* for the two product categories. We were interested in answering: 'What communicative qualities related to Norwegian plant-based food products will consumers find most attractive and why?' This addresses one of the research gaps: the difficulty of establishing design imperatives that communicate intrinsic attributes (Beckman et al. 2021). A design description was used to develop product names, packaging designs, graphics, emotional triggers, concept messages and related nutritional information in a multi-disciplinary team. Two-dimensional prototypes in the form of illustrations and three-dimensional prototypes in real product size and supersize were built (three workshops with several prototype iterations).

Individual designs with different packaging cues were developed along the three archetypes: structural, graphical and verbal (Magnier and Crié 2015; Underwood 2003). For the design that communicates environment motives symbolizing earth-friendliness and harmony with nature and messages about low carbon footprint were employed. The health-variants incorporated modern design with messages about protein and mineral content, low sugar content, organic and vegan messages. The Norwegian designs played on traditional knitting patterns or a farm scenery with clear messages about Norwegian origin. Concepts were developed according to the desired product attributes and communication intention. Figure 4 provides an overview over the six prototypes and concepts.

Develop phase: feedback. To learn quickly and provide valuable input for the project, the packaging prototypes were tested at three events in fall 2019 with approximately 200 participants ('Eat the Future' were two immersive knowledge-sharing events and 'Change by Design' was a design-centred conference related to sustainability). Respondents were participants at the events and not recruited according to any selection criteria and thus do not represent a certain consumer or demographic segment. We presented the prototypes as packaging mock-ups and posters including the concept description at a stand. At 'Eat the Future' the mock-ups were real size and at 'Change by Design' the mock-ups were supersized to catch more attention. A feedback sheet for input on preference, reason for preference (health, sustainability, local production) and verbatim feedback were collected ($N = 147$). We asked the following questions in two events: 'Which of these three protypes would you chose? Which aspect is most important for you when choosing such a product (Norwegian, Health, Environment)?' and in one event: 'If you had to choose, which one would you chose and why?' (answers on post-its put on the supersized prototypes). The information from consumers was transcribed to electronic format and feedback for each prototype was evaluated by thematic analysis (Braun and Clarke 2012) and compared within one product category and between product categories.

We found that there was a somewhat even distribution across all products with the Norwegian Faba Bean Drink being most preferred for the drinks with approximately twice as many consumers preferring this variant compared

	Environment	*Health*	*Norwegian*
Faba Bean Drink	 As beans in the pod, we must come together -ZEM is a tasty Norwegian-produced bean drink that is healthy for you and the planet and gives you what you need when you eat plant-based.	 FAB DRINK is a healthy plant-based drink made from Norwegian faba beans. The drink has a high content of protein and soluble fibre. Eat healthy and live healthy.	 Beandrink is our contribution to change, from the Norwegian soil to the set table. This drink is made from a selected blend of beans from farms near you. Lactose-free, gluten-free, rich in fibre and Norwegian from A to Z.
Pea Porridge	 Do something good and feel good, GREEN PEAS is one step in the right direction. Made from 100% organic plant-based ingredients to create food enjoyment. Big changes start with small bites.	 P3 is exactly what you need to perform: Plant Protein Porridge is a tasty, vegan, organic fuel for body and soul with a high fibre and protein content.	 Porridge is one of our beloved and traditional meals, and has a soft, velvety taste. Norwegian Pea Porridge is made with 100% Norwegian plant-based ingredients, filled with green power from peas and the care for our traditions.

Figure 4: Faba Bean Drink and Pea Porridge packaging prototypes and concepts.

to the health and environmental design. The Norwegian version of the Pea Porridge was slightly more preferred among the porridges. A thematic analysis of the reason for choosing a particular product design showed that the intended communication messages were clearly perceived by the respondents (see Table 1). For both Norwegian designs, opinions were polarized. On one hand, consumers who preferred traditional design and values considered the product feasible for a broad range of consumers as it looks familiar and does not scare people who are sceptical to untraditional vegan foods. On the other hand, there were some respondents who considered the product design old fashioned. Many also associated it with self-sufficiency, local production and employment, as well as food safety. Other comments referred to the feelings evoked by the design, such as claims that it 'calls for celebration of heritage and cultural values: it speaks to me about togetherness & tradition' and it 'appeals to my Norwegian heart'. Many of the comments to the health and environment designs praised the simplicity and how it is easy to understand what the product contains. Some of the comments about the health design mention the protein contents as a positive attribute, whereas the environment design was typically positively received 'because it feels mostly connected to the planet

Table 1: Overview over reasons for product preferences and other comments (N = *147).*

Product category	Design		
	Environment	**Health**	**Norwegian**
Faba Bean Drink	• Sustainability clearly communicated • Trustworthy • Clean and modern design • Looks like Oatly	• Health focus is clearly communicated • Informative and fun • Clear protein message • Simple visual message • Too much like Oatly	• Clearly communicates Norwegian production • Traditional design • A milk for everyone (does not scare people who are sceptical of vegan food) • Reflects national culture • Familiar look • Looks old fashioned
Pea Porridge	• Looks sustainable • Locally produced • Peas are clearly communicated • Clean and easy to understand design • For everyone (not only for particularly interested people)	• Informative and new design • Link to training (protein) • Creates curiosity • Looks chemical/ technical • Too much dietary information	• Norwegian means sustainable • Locally produced • Suggests tradition, familiarity and food safety • Fits best in Norwegian market • Vegan message not clear enough • Too national-romantic

and a low CO_2 footprint' or because it 'appeals to my wish to do less harm'. We found that the three attributes 'Norwegian', 'Health' and 'Environment' were not clearly separable by respondents and that the comments reflected personal values and preferences. For example, Norwegian-ness symbolizes sustainability, local production and safe food for many, which can also be associated with both environment and health.

Consumer survey: Triangulating with quantitative data

In addition to the qualitative consumer data, we tested the packaging prototypes and product concepts with a larger number of consumers. Combining quantitative and qualitative methods as well as design and consumer-research-based methods in product development is described as a need by other scholars (Symmank 2019; Rothe and Dunn 2021). A quantitative consumer survey was conducted in June 2020 to explore expected liking and product-concept match of the concepts and prototypes developed in previous steps, as well as the relation to consumers' attitudes and food habits. Consumers were recruited ($N = 1102$), and data were collected by the market research company Kantar.

Consumer sample. The questions for this study were part of a weekly so-called 'omnibus' online survey containing questions from various institutions. The respondent selection was approximately representative of the Norwegian population, and the data were weighted for gender, age and region to correct for sample deviation.

Socio-demographics. Average age of respondents was 55.1 years (sd = 16.5), 49.6% were females, 34.6% were users of plant-based drinks or ready-to-eat

Table 2: Demographic information of survey respondents for users and non-users of plant-based drinks or ready-to-eat meals.

	Users				Non-users			
Age	**<30**	**30–44**	**45–59**	**60+**	**<30**	**30–44**	**45–59**	**60+**
Female	63	70	82	140	8	24	63	94
Male	39	60	97	156	7	19	69	97

meals and 79% were omnivores (the rest either flexitarian, vegetarian, vegan or other), $N = 1102$.

Questionnaire. Product prototype questions: there were two blocks of questions, one corresponding to each product category (Pea Porridge and Faba Bean Drink), that were randomized among respondents. For each block, respondents were shown images of the three different prototypes (in balanced, rotated order). For each image they rated their expected liking, using a seven-point hedonic scale ('Do not like at all' to 'Like very much'). This was followed by a preference ranking of the three images for each product category, from the most to least liked. Next, respondents were presented with a concept description (see Figure 4), together with the same images and rated the fit of the concept to each product image, using a seven-point scale ('Fits very poorly' to 'Fits very well'). Consumer-related questions for segmentation were also asked in a second section of the questionnaire (food habits and attitudes underlying food choices related to health, environment and product origin based on previous literature [Lindeman and Väänänen 2000; Steptoe et al. 1995]). Lastly the respondents were presented with eight different statements related to food consumption and production. The related results from the second part of the questionnaire are not presented in this article. All data analyses were performed using R version 4.0.4 (R-Core Team 2020). Graphics were created using ggplot (Wickham 2016).

Overall liking and concept fit: the average values for predicted product liking are between 2.8 and 3.5, which means that most respondents did not expect to like the products. The results of the survey showed that overall, the prototype Norwegian Pea Porridge (PN) had best rating for fit to concept and highest expected liking. The least-liked product was Norwegian Faba Bean Drink (DN), whereas Health Pea Porridge (PH) had lowest rating on concept fit (Figure 5). This somewhat contradicts the qualitative results where the Norwegian Faba Bean Drink was best liked.

Regarding age and gender we found that females are generally more positive than males to the prototypes for concept fit ($p = 0.007$), but not for liking ($p = 0.6$). However, the three-way interaction between prototype, gender and age is significant ($p = 0.002$ for liking, $p < 0.001$ for concept fit). For both measures, there is an age effect, with the younger respondents (age < 30) clearly being more positive than the older. For the concept fit, the younger respondents tend to discriminate more between the products than the older age groups. Men below 30 have a significantly higher liking scores for all products than older male consumers.

Expected product liking depends on whether the people consume plant-based products or not. User/non-users are significantly different for both concepts fit and expected liking ($p < 0.0001$). In general, non-users (who report never using plant-based drinks or ready-to-eat meals) are less positive

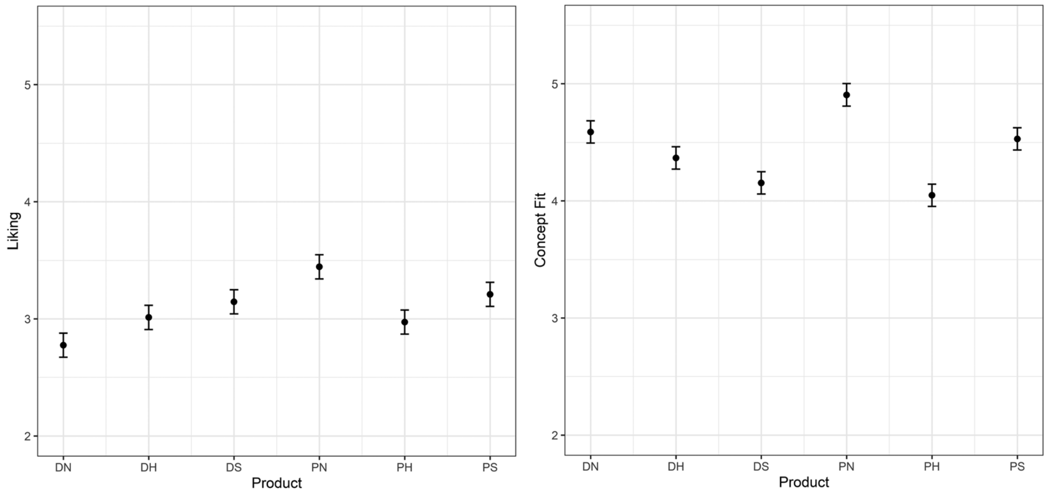

Figure 5: Overall expected liking (left) and concept fit (right) for the six prototypes. D, drink; P, porridge; N, Norwegian; H, health; S, environment.

about the products (for concept fit and liking) than users. The differences between users/non-users are smaller for porridges than drinks possibly because porridge is naturally plant based whereas the drink category is still dominated by cow milk. Users also have higher correlation between average concept fit and average liking than non-users (0.42 for users, 0.34 for non-users), indicating that design may be more important if the goal is to recruit new consumer groups to plant-based products. Food attitudes determine and predict both product liking and product/concept fit (data not presented).

These insights can be used as inputs for further product development and for redesigning the packaging. For example, the products may be targeted more directly to non-users who might be difficult to reach because they are not looking to change their diet or to young females who are more likely to change to plant-based diets (Gonera et al. 2021). Ideally, the designers would have carried out a new iteration of designs, based on these learnings. However, unfortunately the project's time limitations made it difficult to iterate on these findings in our case. This is an illustration of the 'milestone dilemma' as described by Hölzle and Rhinow (2019) who point out that unknown learning objectives are hard to plan according to milestones and that we had to stick to the project plan and budget rather than continuing with a new learning loop.

DISCUSSION

The aim of this article is to explore how an interdisciplinary collaboration between designers and scientist may support innovation processes. Combining processes of alignment of actors, creation of prototypes and classical consumer-research methodologies our research case exemplifies how such blends may contribute to the consumers' transition to healthier, more sustainable diets. At the same time, we discuss and share our learnings from the back-and-forth dynamics of such interdisciplinary collaborations involving designers and scientists. The discussion is structured along the three aspects of the research gap.

The design-led innovation process

We included researchers from different disciplines in a design-led innovation process by applying tools and mindsets of designers (British Design Council 2019; Micheli et al. 2019). The inclusive approach with a focus on integrating and learning between multiple disciplines is valuable but not easy to implement as it combines many different backgrounds and ways of thinking in a complex context (Gonera and Pabst 2019). Throughout the project, we experienced some scepticism towards the value of using this methodology. It was pivotal to reflect, adopt the methodologies and keep a strong focus on both interaction, learning and solutions that are desirable, viable and feasible. Laursen and Haase (2019) question whether design practices and processes can be applied by non-designers or whether a designer is needed to guide the process. Our case study project would not have been possible without designers and other project members with design skills. Designers facilitate for alignment across disciplines to reach conceptual frameworks that may lead to the creation of prototypes (Aguirre et al. 2017). These processes are often experienced as chaotic and based on sensemaking processes combining insights and ideas from different actors (Kolko 2010). This may create tensions among scientists that tend to gravitate towards their fields of expertise preoccupied with nuance and precision. Applying a facilitation learning cycle as described by Pabst et al. (2020) might support in this dilemma.

From observations and field notes during the workshops we learned that some of the participants were originally sceptical to the process and creative tasks such as ideation and drawing. The more immersed and engaged participants became to the tasks the more they also embraced and enjoyed it. One participant started out with saying 'oh my god, I cannot do this!', 'I am not good in this…' and ended up concluding 'I am a great drawer!' towards the end of the workshop.

There was generally high interest and curiosity about the design-led process with its elements of ideation, concept description and making things tangible by drawing and prototypes. After the workshops we received specific feedback about the usefulness of this type of activities illustrated by the two quotes from food technologists: 'I think that is a very good idea and a great approach I would like to join also in next sessions'. There was even an element of surprise that this way of working actually delivers concrete results, illustrating that the unfamiliarity with designerly ways of working causes low expectations but can be overcome by good facilitation and by creating tangible results: 'This workshop delivered much more specific results than I expected'.

Natural scientists and technologists in research projects spend a lot of time in the lab running quantitative experiments being far away from the market and consumer. Some of the participants were very sceptical about testing products or prototypes so early in the project before they had finished their lab work or concluded on some of the research hypotheses. They expressed this by saying 'We really can do that? – Now?' and 'Can we test and prove something?' during the prototype workshop. This illustrates that thinking about consumer testing and prototype testing is not a natural part in RIC projects and natural scientific disciplines' research approach. After introducing some conceptual thoughts about what prototypes are and how they can used and after making some drawing and discussing possible ways of testing

Figure 6: Word cloud representing spontaneous association of researchers in the project with the way we worked with design-led innovation.

prototypes, the same researchers were surprised that testing prototypes can indeed happen at this stage of the project and stated that 'We are so ready to test something immediately that I still cannot believe it'.

To understand spontaneous associations of researchers to 'the way we worked with innovation in this project' we performed a word association exercise individually with fourteen researchers from different disciplines participating in the various design-led activities throughout the project. The words were translated to English and grouped into categories and a word cloud was generated (Figure 6). Many of the researchers experienced the way we work as user-driven, collaborative, engaging and innovative but also novel. These are all elements of a design-led approach, and it seems that the intention of using this new way of working was well perceived and understood by the team members and they engaged in a learning journey.

Engaging in design activities (i.e. drawing, prototyping, conceptualizing) lead to higher engagement in the group and contributed to learning through negotiating different design proposals, in accordance with Capjon (2004). We also learned that it is essential to have good facilitation skills and a dedicated role translating insights into action/prototypes in line with Price et al. (2018) and Gonera and Pabst (2019). The design methodologies used in the case project had to be specifically tailored and adapted according to the learning or co-creation objective and the stakeholders. Within the *develop* phase of the design thinking model, the learning loops in the project could be structured as 'alignment–creation–feedback' with insights from different disciplines feeding into the process together with learnings from various testing activities.

Development of prototypes and testing with consumers

Six packaging prototypes (three per product) and their extrinsic attributes were designed collaboratively to be tested with consumers. The developed designs represented 'Norwegian', 'Health' and 'Environment' themes and design imperatives. The qualitative data provided rich feedback on the design elements and why consumers liked the respective packaging designs and whether we met the design imperatives. As we have not collected demographic data, food habits and attitudes we cannot derive any segment specific information.

The quantitative survey showed a low average expected liking score for all the prototypes, and only a small segment of the respondents gave high expected liking scores. This is in line with previous literature showing that consumers generally have low sensory expectations with regards to plant-based, vegan and vegetarian products, particularly if novel and unfamiliar (Aschemann-Witzel et al. 2019; Tuorila and Hartmann 2020). This also illustrates the challenge of facilitating a sustainable food transition by penetrating the market with new, healthy, plant-based products. In our study, we found that no single parameter may determine liking; thus, graphic design preferences may play a strong role in product acceptance and choice. The difference in results between the drink and porridge products can be related to design, descriptions or products themselves. Porridge is a traditional meal and peas are an ingredient that everyone is familiar with. Peas have been cultivated and eaten in Norway since the thirteenth century (Nilsen 2021), and several traditional Norwegian dishes contain peas. On the contrary, a Faba Bean Drink at the time of the survey did not exist (to our knowledge). Consumers might not be familiar with faba beans, as they are mainly cultivated as animal feed, and rarely sold for food consumption. Previous literature showed that different proteins would not be equally accepted by consumers in different product carriers, but there is an interaction of product, claim and category, and acceptance depends on familiarity (Verbeke et al. 2009).

Getting consumers to make the transition towards healthy and sustainable diets can be challenging and requires strategies and efforts in many different areas (Gonera et al. 2021). Creating appealing designs for new plant-based products is an important part of this. Some consumer groups are already convinced that eating more plant-based is beneficial, and for them, the design is less important in a purchasing decision. The challenge is to create products and designs that get people who normally do not eat plant-based food to try such products. Our study finds that consumers that do not eat products from the respective categories (non-users) are less positive to the products than users, and older people are less positive than younger people, which is in line with results from previous studies (Hielkema and Lund 2021; Lemken et al. 2019). This points to the importance of developing marketing strategies tailored towards specific consumer clusters (Lemken et al. 2019), particularly product development targeted at non-users and older consumers. These consumer groups can be characterized as late majority/laggards regarding adoption to plant-based food (Rogers 2010), which means that they are not interested in changing their food habits and may not be looking for new cues or products but rather are attracted by familiarity and tradition in the design cues or recognizable graphics from the same product category. Our results indicate that using food products that already exist as inspiration for new products and clearly communicating that the product is based on local ingredients are two ways that may increase consumer willingness to try a new product.

The juxtaposition of design and science

Two of the recognized weaknesses of academically managed RIC and underexplored areas are that user needs are hesitantly included in the innovation process and that there is often little interest in innovation and market commercialization (Gonera and Pabst 2019; Hölzle and Rhinow 2019). Our explorations highlight the potential (and need) to better integrate design into large scientific research consortia. We argue that there is a potential for exploring new applied research designs that integrate designerly approaches and the design discipline more thoughtfully to capture 'the best from both worlds'. For example, using the HMW questions as a generative approach to translating barriers into opportunities/ideas are a valuable extension to consumer-research methods and answer the call to develop solutions that can improve people's lives (Fenko and van Rompay 2018; Schifferstein 2015). With increasing complexity, we face a demand for more creative solutions and extension of classical consumer-research methodologies, highlighting the need for open and collaborative practices that involve non-scientific actors such as citizens, companies and policy-makers, as well as scientists from a range of institutions and disciplinary backgrounds (Jones et al. 2008; Van Noorden 2015). This research also addresses the need for more extensive method combination, qualitative and quantitative, particularly during product development processes (Symmank 2019).

The facilitated interdisciplinary interactions helped the involved participants to form a more comprehensive picture about plant-based food. Research teams may benefit from using design to bring forward tangible artefacts and representations of their joint efforts while designers may get rigour and detailed feedback to further iterate on their designs or to challenge their basic conceptual frames. For example, it became obvious during the process of developing the packaging prototypes that expert knowledge from nutritionists and food chemists was needed to assure realistic prototypes with correct information on plant species names, nutritional content and label information.

Looking forward, some structural dilemmas and barriers to using design thinking in RIC need to be addressed when trying to introduce our described approach. Design thinking should be clearly communicated as learning format (Hölzle and Rhinow 2019), tools and formats need to be tailored to the case, a change agent or advocate for design in the project or core organization is needed, team reflexivity needs to be prioritized, good experiences need to be created (Gonera and Pabst 2019) and the alignment process towards common understanding across disciplines requires significant attention.

CONCLUSION

The study shows how design-led innovation and prototyping can be applied in an interdisciplinary effort to contribute to the consumers' transition to healthier, more sustainable diets, illustrated by a case study on plant-based foods. We addressed three identified research gaps:

How can interdisciplinary collaboration in a large research project be facilitated through a design-led consumer-centric innovation process? Here we thoroughly describe and exemplify the design-led innovation process we applied in our case project so that others can replicate it and adapt to their own context. We showed that design and design-led innovation provide valuable tools to foster interdisciplinary collaboration and extending the skillset and mindset of participants (through learning by doing). The opportunity to broaden the project scope in research projects from understanding a phenomenon to generatively developing solutions is highlighted.

How can design imperatives for communicating sustainability and testing packaging prototypes with consumers be developed to aid the shift to more plant-based diet? To address this research gap, we co-creatively developed specific packaging prototypes and tested them with consumers both qualitatively (the designerly way) and quantitatively (the consumer researcher way). This process is dependent on both areas of expertise (the designer and the scientist), however the question remains whether the design intention was communicated clearly and distinctly enough to achieve the learning objective of the consumer studies. There is no 'one size fits all' packaging design for communicating the attributes of plant-based foods. Depending on a consumer segment's food habits and attitudes, different designs might have to be developed for different target groups. Our findings are particularly valuable for the food industry, who are developing more and more plant-based products in high growth categories such as plant-based drinks and small meals (i.e. porridge). Further research should also focus on the correlation between consumers' food habits and attitudes in the relation to the respective designs and design imperatives.

How can rigorous feedback loops from consumer insights into design processes of new consumer products be combined with the focus on product development and innovation? By juxtaposing design and science, we expanded consumer-research methods with creative techniques to understand consumer preferences and strengthen the design work by research-based data. An active learning process with even more iterations and learning loops would have been advantageous and opens avenues for further research. The developed HMW question may serve as springboard for other researchers and innovators to further ideate and develop solutions for the transition to more plant-based food.

Based on our learnings and experiences we highly encourage the use of design-led innovation processes and designerly ways of working in complex interdisciplinary research projects such as RICs. The presented approach is transferable to other cases but needs to be adapted in terms of the specific context and project objectives. The research represents a single case study designed to learn as much as possible about applying a design-lead collaborative approach. Prototype designs from only two product categories were exposed to Norwegian consumers and purchase intent was not tested. Future work should combine packaging prototypes with product tasting and purchase intent testing. Forthcoming research should continue to test the usefulness for design-led innovation processes in consumer research and large research and innovation projects.

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