

FOOD MANAGEMENT PUBLICATION SERIES

# RESEARCH PAPER #4

What does the future of  
personalized nutrition look like?



□ Baden-Wuerttemberg Corporate State University (Publisher)

Authors

Kathrin Friedrichs, Isabella Bauer, Cornelia Klug,  
Günter Käßer-Pawelka und Katja Lotz

Prologues by Hannelore Daniel and Jan Wirsam

## **Results of a Delphi study**

Closing report of the Delphi study, carried out as part of the research project “Personalized Nutrition”  
Heilbronn, 15th November 2022

The research project “Personalized Nutrition” was funded by the Dieter Schwarz Foundation.

Many thanks to Prof. Dr. Hilmar Sturm and the students of the study program BWL-Food Management at DHBW Heilbronn FM 19 B2 for the support in conducting part 1 of the Delphi study:

Jennifer Barthelmäs, Michael Behr, Natalie Bendl, Clara Bobbert, Aurelia Bruno Di Stefano, Vera Christina Bruns, Marcel Eberhardt, Svenja Flügger, Emily Frank, Aron Valentino Grillo, Felix Heinerich, Ina Hobbie, Lisa Knüppel, Anna Leidig, Yvonne Leitzbach, Hannah Mast, Melissa Sarrwat Mettry, Nils Tomkowiak, Jannik Weiß, Meike Winter

Layout and graphic design: Cathrina Priem-Sroder

Photo credits cover and back cover:

AdobeStock\_465082463, AdobeStock\_302605502, AdobeStock\_187579190,  
AdobeStock\_229153686, AdobeStock\_308894666, clause-2546124\_1920

## **Prolog by Prof. em. Dr. Hannelore Daniel, former chair of nutritional physiology at the Technical University of Munich (TUM)**

This report represents a valuable contribution to the assessment of the future of PERSONALIZED NUTRITION (PN). Based on a Delphi survey with expert interviews, the DHBW Heilbronn team has written a publication that is well worth reading. All facets of the topic are addressed, and the future viability of PN is evaluated. Sincere thanks to the dedicated authorship and the entire team for this publication.

PN may be considered by many to be something new; however, it already has had more than 20 years of quite an eventful history. Although the first ideas about personalization can be found as early as in the 1970s, it was only after the decoding of the human in 2001, when PN gained a strong momentum – and, of course, a particular emphasis on the genetic differences that make us as individual as we are. Already in 2003, there was a first company offering a nutrition program based on genotyping. Since then companies have come and gone. Scientific programs that tested, to what extent such PE approaches are more effective in achieving sustainable changes in dietary behavior or lifestyle, however, reported only modest effects. While individual targeting was a success factor for compliance, inclusion of gene variants and communication of associated risks was of no additional benefit. Recently, analysis of the gut microbiota has become part of commercial PN services. Whether this offers an additional benefit is not scientifically clarified. This past era of PN was driven by the developments of life sciences and focused one-sidedly on health aspects. The offers were/are used primarily by “early adopters” and persons who do not necessarily need them. PN was thus an elite diet without effect on the population level or on public health improvement.

There can be no doubt that the digital environment will give PE a new orientation in terms of both technology and content. Not only that the digital recording of location, time, environment and type of food intake and other lifestyle factors is possible as never before, but also the communication back to the consumer opens up a wide range of new approaches. Due to the enormous dissemination of digital devices it is possible to reach almost every population group and offer assistance in decision-making just in time and on the spot. PN of the future is digital, close and more social. Artificial intelligence, avatars, chatbots and other tools will bring PE into everyday life, of every social class and age group in every language. This also applies to older people. We already have the first generation of “digital seniors”; they are familiar with devices and technologies. At the same time, they are particularly at risk of poor nutrition status due to progressive loss of sense, smell, taste and appetite, and chewing and swallowing difficulties. They would thus benefit particularly from PN interventions.

Decisions regarding the purchase and consumption of food are based on an individual value system and are more difficult today than ever before. Here, too, PN opens up new suitable possibilities of support and, in addition to health, can also incorporate environmental and other factors such as animal welfare, fairness and social responsibility into the decision-making process. The key to the success of PN is and will remain, trust in the provider, the security of personal data and the quality of determinants of the program. The next era of PN can and must deliver greater benefits for people and the environment.

**Prof. em. Dr. Hannelore Daniel, 15th November 2022**

*Member of the Leopoldina Academy of Sciences and laureate of a number of important prizes, including the PRO MERITIS SCIENTIAE ET LITTERARUM as well as the Constitutional Medal and the Medal of Merit of the Free State of Bavaria*

## Prolog by Prof. Dr. Jan Wirsam, HTW Berlin, University of Applied Sciences

“Google: what should I eat?” leads to 20 meal suggestions that I could follow, including dishes that can be prepared within 35 minutes. Unfortunately this is not the result I was actually looking for. Numerous cooking recommendations are repeating, which are far from the personal needs and are even further away from the approaches of personalized nutrition.

The look into the future by the research team at DHBW Heilbronn using a Delphi Study, explores the question of what the future of personalized nutrition might look like. The core statements emphasize the interdisciplinarity of the personalized nutrition, the diversity in application, possible points of care, medical challenges, relevant technologies, preventive aspects, data protection aspects, privacy issues, and acceptance and communication.

The ease of use is what has made Google so successful. It remains exciting to observe how personalized nutrition can be made easily accessible to individuals, easy to understand and yet evidence-based. The Delphi study certainly helps to focus on the main priorities. Digitization and AI will definitely play an important role and the hunger for data of the big tech companies may then also lead to meaningful nutritional recommendations.

Stay hungry for data and healthy food!

**Prof. Dr. Jan Wirsam, HTW Berlin, 31st October 2022**

*Teaching and research area: innovation management, production management, operations management, digitalization, plant-based value creation*

# Table of contents

- 1. Introduction ..... 7**
- 2. Key statements at a glance ..... 10**
- 3. Methodology: structure of the Delphi study and procedure ..... 11**
  - 3.1 Delphi study part 1 ..... 11
  - 3.2 Delphi study part 2 ..... 13
- 4. Study results and interpretation ..... 15**
  - 4.1 Basis of personalized nutrition ..... 15
  - 4.2 Personalized nutrition digitally ..... 24
  - 4.3 Personalized nutrition from the consumer's perspective ..... 31
  - 4.4 Personalized nutrition in the focus of consumer policy ..... 34
  - 4.5 Personalized nutrition in retail ..... 39
- 5. Conclusion ..... 41**
- 6. References ..... 43**
- 7. List of figures ..... 46**
- 8. Appendix/data table ..... 49**
- Authors and contact details ..... 60**



## 1. Introduction

The increase in civilization diseases, the aging society, and population growth pose major challenges to the health care system and will require greater self-responsible health literacy of individuals (PwC 2022; EU 2022). It is already known to many consumers that nutrition directly influences health. However, there is much uncertainty due to the flood of advertised, sometimes contradictory diets and nutrition recommendations (DLG 2019).

The digital transformation of the healthcare system is expected to progress in the coming years. WHO and on EU and state levels this development is promoted and demanded (BMG 2022, WHO 2021, EU 2022). In the guidelines of federal health research, personalization and digitalization are seen as the key to implementing the goals of prevention and therapy (BMBF 2022). This development has already impacted nutrition in prevention, counseling and therapy and will continue to intensify.

At the same time, it is becoming increasingly clear that the official group-specific recommendations are not representing the best strategy for improving the health of the individual. The large interindividual variability is now being taken into account in research. First results from the PREDICT studies, a large-scale nutrition research program, show that the metabolic response to food is highly individual (Zoe 2020).

Health, digitalization and individualization are three of twelve so-called megatrends and are drivers for social transformation (Zukunftsinstitut 2022). Personalized nutrition is located at the interface of these three megatrends.

So far, there is no generally accepted definition of personalized nutrition. The research group of the DHBW Heilbronn has established the following definition of personalized nutrition as a basis for its work in 2021:

*Personalized nutrition is a diet that exceeds general nutritional recommendations; it is an individualized nutrition that optimizes a person's health status and well-being in the long term. Individual factors like personal, anthropometric, clinical, metabolomic, genetic, and epigenetic factors, as well as the composition of the gut microbiota may be taken into account (Lotz et al. 2022).*

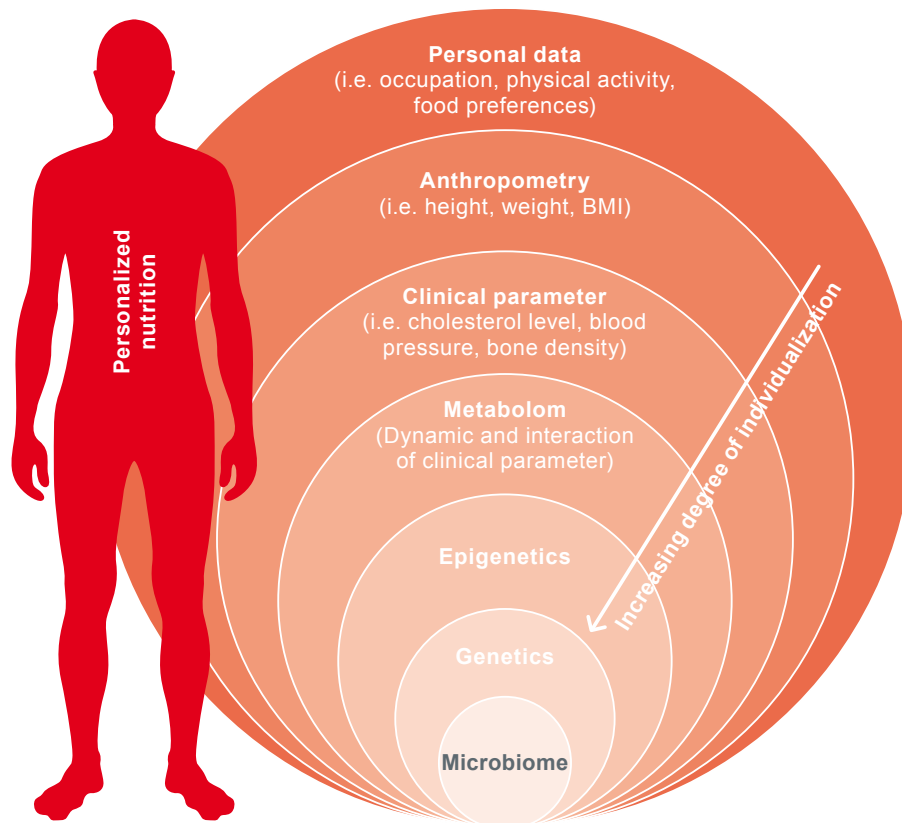


Figure 1: The shell model of personalized nutrition considering the degree of individualization (DHBW 2021).

The shell model depicts the factors which are influencing individual nutrition. These factors are interconnected and influence each other. The degree of individualization increases from the outer to the inner shells. Nevertheless, the personalization is possible at any level of the model, regardless of the use of previous or following shells.

Personalized nutrition, as understood by the DHBW research group, has the aim to support each individual in achieving a healthier diet in order to prevent from or stop the development of civilization diseases in order to stay healthy in older age for as long as possible.

So far, business models for personalized nutrition have not yet made it into the mass market with lasting success (Kirk-Mechtel 2022).

The personalized nutrition research group at DHBW Heilbronn has been working since 2020 to compile and structure the findings on personalized nutrition. Among other objectives, the aim is to examine the future viability of personalized nutrition. One important question forms the methodological starting point of the research:

How do experts envision the future of personalized nutrition?

To answer this question and to derive aspects for a future-oriented application of personalized nutrition, a Delphi study was conducted.



The Delphi study is a recognized method in social research, which is now used as in other disciplines such as technology, science and politics as a forecasting method as well. It is used, for example, when initial forecasts about possible trends and developments are needed. There is not the one approach, but rather various variants of application (Cuhls 2019). The following features are characteristic for the Delphi method. (Häder et al. 2000):

- the consultation of experts
- the anonymity of the participants among each other
- the controlled feedback
- the use of a formalized questionnaire
- the determination of statistical group answers
- the (multiple) repetition of the survey

The present Delphi study was developed in two stages: After a qualitative survey in the form of expert interviews in the first stage, a quantitative survey using a standardized questionnaire was carried out.

The limitations of a Delphi study are partly of a methodological nature. Among other things, the literature lists the difficulty of measuring validity and reliability. In addition, high dropout rates are often observed. A bias by experts and researchers, for example through misinterpretation of statements, can also occur. Last but not least, the results reflect opinions and assessments that do not necessarily develop in this way in the future (Landeta 2016).

## 2. Key statements at a glance

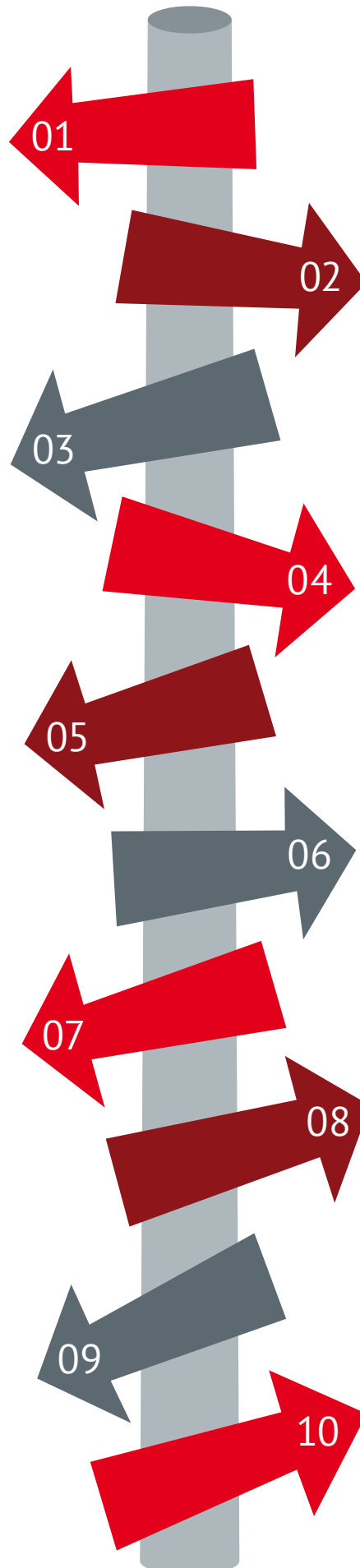
The cooperation across adjacent disciplines such as technology, nutritional science, communication, consumer protection, medicine, trade and industry, is becoming an important factor in setting the right course for personalized nutrition.

Personalized nutrition takes place mainly in the household, within the family. Retail, delivery services and community catering also represent important supply systems and offer further potential for personalized nutrition.

Technology plays an important role and will play a key role in the measurement and processing of data, as well as in the delivery of individual recommendations to consumers.

To be effective as a preventive measure, concepts of personalized nutrition must be accessible, usable and affordable for everyone. The development of personalized nutrition on a digital level is not yet reaching all population groups.

To promote acceptance and trust of users, it will be important to convey accessible and affordable concepts of personalized nutrition. Targeted communication will raise awareness in all population groups for the relevance, benefits and implementation of personalized nutrition.



The diversity of application areas as in preventive and therapeutic measures as well as in professional sports, results in a relevance of personalized nutrition for all age groups of the population.

For genome, epigenome and microbiota as a basis for individual nutritional recommendations scientific evidence is still too limited to make reliable recommendations. Rather, the phenotype and factors of lifestyle have to be considered.

Concepts of personalized nutrition in digital form should go hand in hand with personal consultation.

Trust in data protection will be crucial for the acceptance of personalized nutrition.

Personalized nutrition will not take place directly in stationary retail, but the digitization of retail will simplify access to data for personalized nutrition concepts.

### 3. Methodology: structure of the Delphi study and procedure

This Delphi study was designed in two survey rounds, expert interviews in the first round (Delphi study part 1) and a subsequent questionnaire round (Delphi study part 2).

#### 3.1 Delphi study part 1

In the preparation phase of the Delphi study, the following topics related to personalized nutrition were identified by reviewing publications, group discussions and expert talks:

- genome and metabolism
- microbiota and metabolism
- consumer behavior/motivation/acceptance
- technology and applications
- politics and consumer protection
- market and commerce

Guideline-based expert interviews were performed on these topics via Zoom. For each topic, three to six interviews with a duration of 30-45 minutes were conducted by Food Management bachelor's degree students from DHBW Heilbronn. To standardize the interview procedure, the students were trained in advance and had the possibility to get familiar with the questionnaire. A total of 41 experts from the DACH region who had already dealt with personalized nutrition in connection with their respective field of expertise, representing science, education, business, politics, were invited. Thereof 28 experts accepted the invitation and were interviewed. The distribution of the experts per topic is shown in *Figure 2*.

The aim of the first round was to generate theses from the statements and present them in a second round to an extended group of experts for evaluation. The interviews were transcribed and analyzed by means of a qualitative content analysis using MAXQDA. The standardized guideline provided orientation for building main categories.

Quality criteria of qualitative content analysis are inter- and intra-coder agreement and provide an indication of the stability and objectivity of the method (Mayring 2012). The basis of these quality criteria are multiple analyses of the interviews, preferably performed by different persons. Given the number and extent of the interviews, the quality criteria were not tested for, to comply with research efficacy.

The statements from the interviews were reformulated into 107 theses for the questionnaire and combined with rating scales. These theses reflect prototypical statements on the respective topic. Since it was important to the researchers to pass on the statements as faithfully as possible, it was sometimes inevitable to depict

several facts in one question. An example is the following thesis: It will be important to improve the marketing of accessible and affordable concepts of personalized nutrition.

During categorizing the statements, the initial topic areas were complemented by a further category “Cross-thematic theses”.

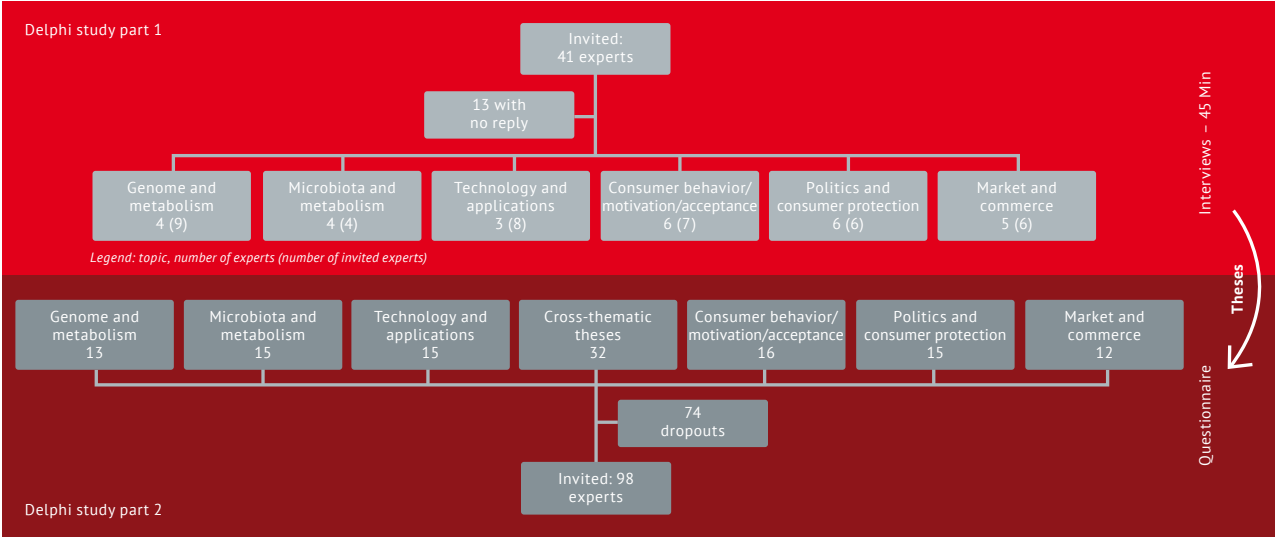
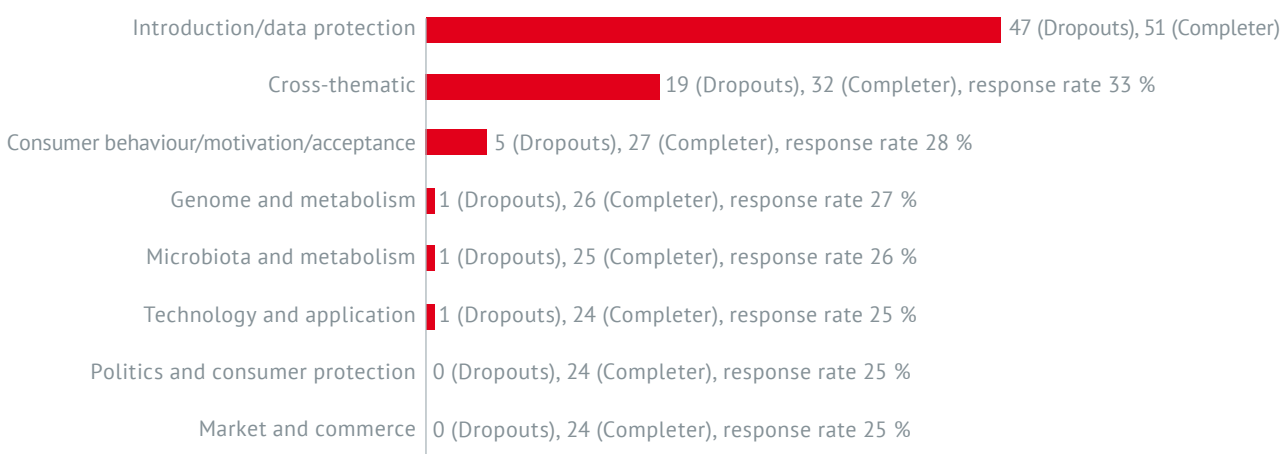


Figure 2: Structure of the Delphi study on personalized nutrition with topics and number of (invited) experts (Delphi study part 1), and participants, who stated that they had at least good or very good knowledge of the topic area (Delphi study part 2), respectively.

### 3.2 Delphi study part 2

The expert group of part 1 was expanded for the second round of the Delphi study. 94 experts were invited by e-mail to fill in an anonymous questionnaire, of which two experts declined in writing. A total of 98 people participated in part 2. This can either be explained by the fact that the participation link was shared with colleagues or that the invitation link was used by some experts several times from different devices. 24 experts completed the questionnaire, 74 participants dropped out gradually during the course of the questionnaire (dropouts). *Figure 3* displays the dropouts per topic block, the number of participants who completed the topic area (completers) and the corresponding response rate.



*Figure 3: Dropouts, completers and response rate per topic area in the 2nd round of the Delphi study.*

On a five-point Likert scale, the experts were asked to indicate their degree of agreement or disagreement with the theses. The following response options were given: “completely agree”, “rather agree”, “undecided”, “rather disagree”, and “completely disagree”.

While the experts were interviewed on their specific field of expertise in the Delphi study part 1, experts in the Delphi study part 2 were invited to evaluate the theses of all topic areas. For this reason, in addition to the five evaluation levels, there was also an option “no evaluation possible”. In some cases the option “other” enabled the entry of free text.

At the end of each topic area, the experts were asked to rate their expertise using a five-point response scale (1 = “I have no expertise” to 5 = “very good - I am an expert”). Participants were defined as experts and included in the analysis, if they stated that they had at least good or very good knowledge of the respective topic area. In the first block cross-topic theses were given for evaluation. Here, the answers of all participants who completed this block of questions were included in the analysis.

Descriptive analysis was performed using SPSS. Two methods of analysis were used to assess and interpret the level of agreement with each statement.

In a first step, the proportional distribution of all response options was determined, including the category “no evaluation possible”. These data were used to display the results graphically. Due to rounding, the sum of individual percentages may deviate from 100 percent. For clearness in the text and in graphs, the response categories “completely agree” and “rather agree” have been combined and displayed as “agreement”.

In a further step, the scale values were transformed into point values, where “completely agree” was given a score of 5 and “completely disagree” was given a score of 1. Mean values were calculated from these transformed scores; the option “no evaluation possible” was not included. The transformed mean values allow an initial assessment of the degree of agreement with the statements. Values greater than 3 rather indicate agreement, values less than 3 rather indicate disagreement. Mean values around 3 indicate an unspecific opinion. For a better overview, the mean values and further theses are listed in the data table in the appendix.

During the analysis of the data it became clear that, due to the complexity and the interaction of statements, new topic categories emerged which form the headings of the results section:

- Basis of personalized nutrition
- Personalized nutrition digitally
- Personalized nutrition from a consumer’s perspective
- Personalized nutrition in the focus of consumer policy
- Personalized nutrition in retail

Although the classical quality criteria of reliability, validity and objectivity can only be applied to a limited extent (Kuckartz 2005), there are criteria that are indicative of quality in this study.

The selection of participants for interviews and questionnaires is not arbitrary: Experts who had already dealt with the issue of personalized nutrition in connection with their respective areas of expertise were specifically selected. Both the consideration of the opinion of several experts from one topic area in the interviews and the stepwise structure of the method, by which the theses from the first round were evaluated by further experts, increase the reliability of the results. These are estimations of the experts that reflect their current state of knowledge. The guide-line based interviews and the semi-standardized questionnaire create a high degree of objectivity in the results. Furthermore, the method and procedure were presented in a transparent and comprehensible way.

Detailed information on the data material, such as interview guide, questionnaire and further data analysis, may be obtained from the authors.

## 4. Study results and interpretation

The 28 expert interviews resulted in 107 items for the standardized questionnaire in Delphi Study part 2. The results of the questionnaire round are described below.

### 4.1 Basis of personalized nutrition

#### ***The key to success: interdisciplinary collaboration***

It already became evident during the interviews in the first phase of the Delphi study that the topics are strongly interrelated and mutually dependent.

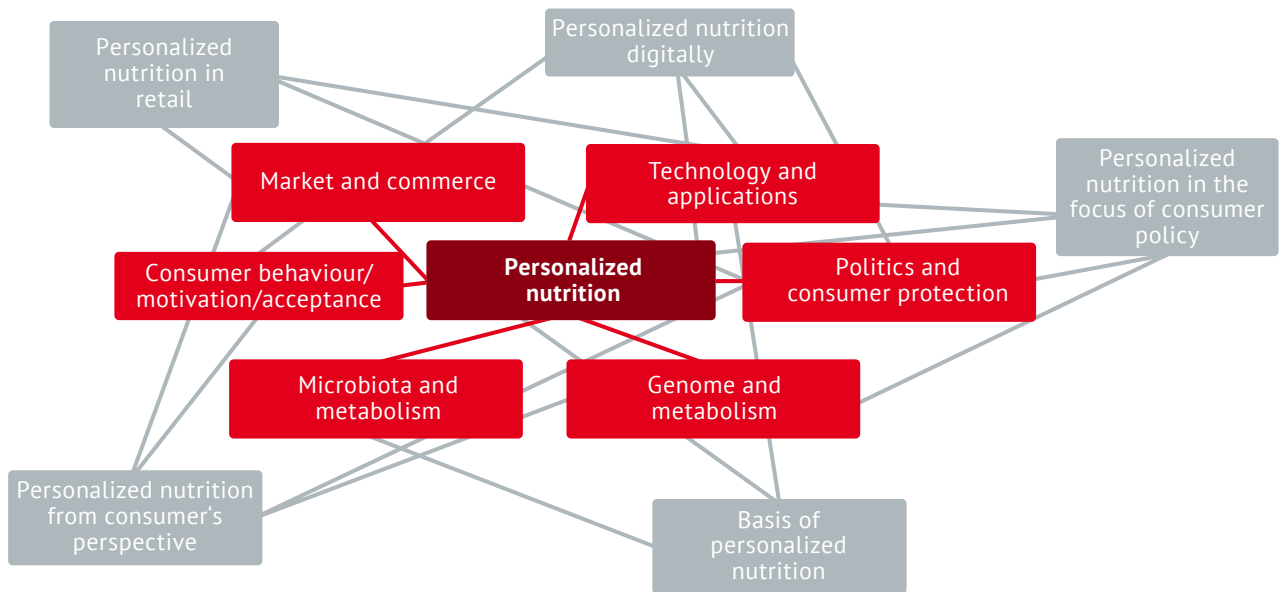


Figure 4: Complexity and interaction of the topics. Original topic areas (light red) and new topic complexes clustered after the analysis (gray).

It became obvious that the disciplines shown above need to interlock and the stakeholders involved must work closely together to advance personalized nutrition. Collaboration across adjacent disciplines, such as technology, nutrition, communication, consumer protection, medicine, trade and industry, will be an important factor in setting the right course.

#### ***Personalized nutrition: relevant in many areas of life***

Experts predict that personalized nutrition will play a role in the areas of professional sports (75%), therapy of diseases (72%) and prevention (63%).

## Personalized nutrition will ...



Figure 5: Application areas of personalized nutrition. Proportion of experts who completely or rather agree (data in %, n=32).

Personalized nutrition as a therapeutic intervention is not new. The nutritional counseling by specialists in dietary assistance, ecotrophology and nutritional science is basically the classic form of personalized nutrition. It is applied as a therapeutic measure in the case of special life circumstances, such as pregnancy or diseases like diabetes mellitus, for example. It acts on the basis of medical diagnoses and aims to help people in need of therapy regarding the individually appropriate food and beverage selection and the practical implementation of nutrition therapy (Lotz 2022). Therapeutic support continues to evolve on the digital level and is already partly available as a digital health application (abbreviation in German: DiGA) on prescription. Verified by the German Federal Institute for Drugs and Medical Devices (abbreviation in German: BfArM), these digital products are marketed as certified, reimbursable medical devices (BfArM 2022). According to a report by the consulting Ernst&Young, DiGAs are already available in 10 out of 17 indications (according to the WHO ICD 10, as of May 2022). It is expected that the range of application areas will continue to further expand and that DiGAs will be established as part of healthcare. According to a representative survey, conducted in January 2022, approximately 10.5 million people with public health insurance are willing to use DiGAs (EY 2022).

With the role of personalized nutrition as a method of prevention, it is reaching the general population. The megatrend health is contributing to a high interest in support for implementing a healthy lifestyle. According to the Zukunftsinstitut, health is a fundamental value and has become a synonym for quality of life. Health care or „Preventive Health“ is one factor in the megatrend health and focuses on maintaining one's individual state of health (Zukunftsinstitut 2022).



If personalized nutrition is used in prevention, it has to be accessible to everyone (66 % agreement) and guaranteed as a permanent diet (58 % agreement) in order to be effective.

**In order to be effective as a preventive measure, personalized nutrition has to be ...**

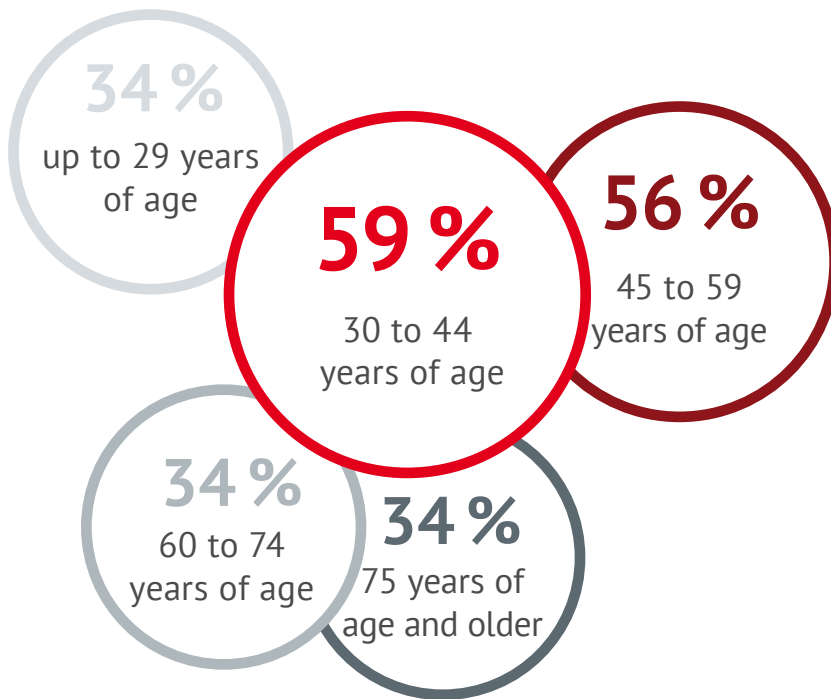


*Figure 6: In order to be effective as a preventive measure, personalized nutrition has to be ... accessible to everyone (left) ... guaranteed as a permanent diet (right). Proportion of experts who completely or rather agree (data in %, n=32).*

Personalized nutrition has long been used in professional sports. Besides healthy nutrition, it is mainly about self-optimization and performance enhancement. A personalized approach helps to address the individual needs of each athlete in terms of health, nutritional requirements, performance goals, physical characteristics and dietary preferences. In addition to individual needs, there are both sport-specific needs but also different approaches, depending on the training and competition phases of the athletes. (Nutrition and Athletic Performance 2016).

The diverse application areas in therapy, prevention, and professional sports create relevance for personalized nutrition in all age groups of the population. From the experts' perspective, this is particularly relevant for the age group 30-59 years.

**For these age groups personalized nutrition will become particularly interesting in the next few years:**



*Figure 7: For which of the age groups do you think personalized nutrition will be particularly interesting in the next few years? (data in %, n=32, multiple answers possible).*

Since personalized nutrition is strongly associated with the use of digital end devices and products, the lower rate of 60-75-year-olds and >75-year-olds may be due to the lower digital literacy of older people (see also 4.2 Personalized nutrition digital). However, today's 30-59 year olds are tomorrow's seniors and will have significantly better digital literacy skills. Higher ratings for the age group 30-59 years are on the one hand certainly linked to the higher digital literacy of Generation X, Y and the baby boomers, but possibly also because of first illnesses increase the level of suffering. For example, the prevalence of diabetes mellitus type 2 increases from the age of 40 in the German population (DDG 2022). For those the age group 29-year-olds and younger, the pressure of suffering is probably not yet in the spotlight, but possibly the desire for health and self-optimization (see also 4.3 Personalized nutrition from the consumer's perspective). Within the megatrend health, the two aforementioned topics, health and self-optimization, are becoming increasingly interrelated in searching for an increase of well-being and performance (Zukunftsinstitut 2022).

But where will personalized nutrition take place? In communal catering, at home or in the supermarket? The experts agree that personalized nutrition will primarily take place at home, within the family (78%). Supermarkets (38%), delivery services, and community catering (34% each) will rather play a secondary role.

Nonetheless, it is estimated that 16 million people eat every day in a community food facility such as company canteens, dining halls in schools, daycare centers, universities and hospitals (Pfefferle et al. 2021). Also the use of delivery services has increased steadily over the past few years. In 2021, around 8.14 million people ordered meals from a delivery service several times a month (Statista 2022). This results in a potential for preventive measures in mass catering and delivery services.

**In which of the following areas do you think personalized nutrition will mainly take place?**

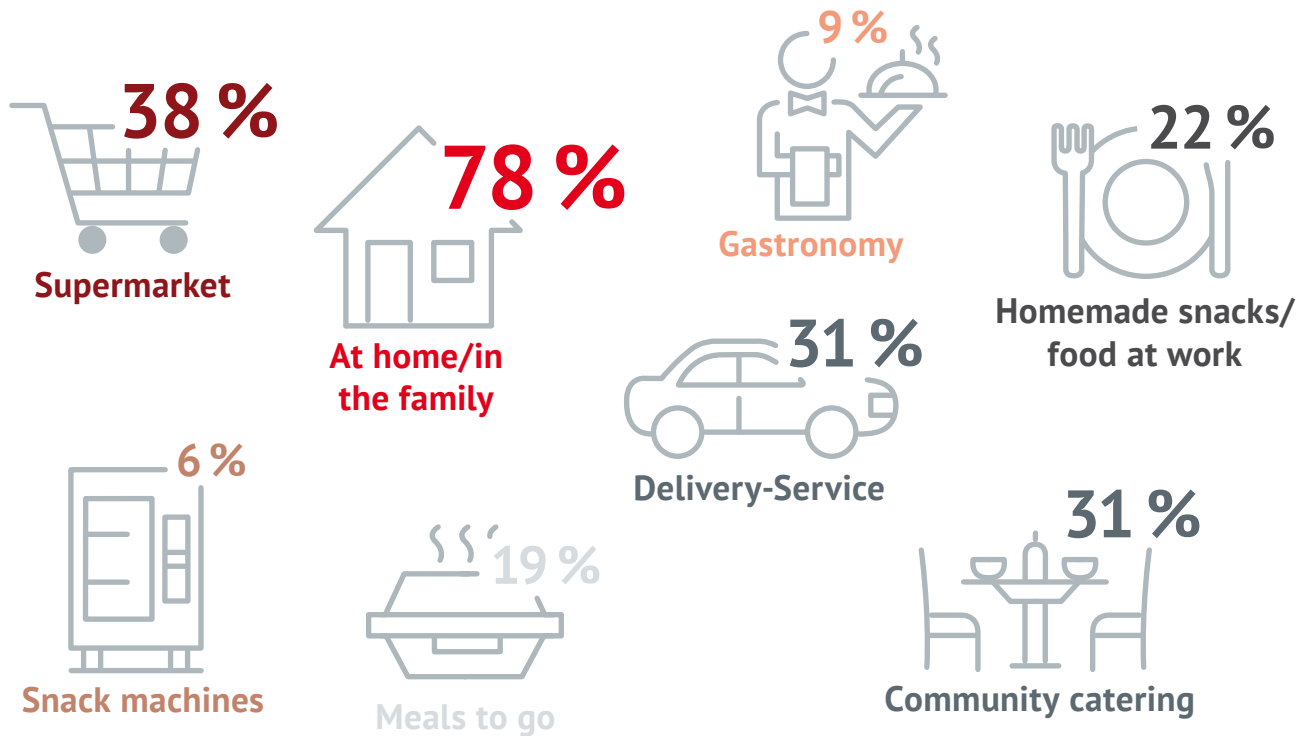


Figure 8: In which areas do you think personalized nutrition will mainly take place? (data in %, n=32, multiple answers possible).

An example for personalized nutrition in hospital catering was presented at the VEÖ Congress in Vienna 2022. A new supply system offers patients at the Franziskus hospital in Vienna the possibility to individually compose their meals from menu components and to order them à la carte, independent of predefined mealtimes. In addition to patient satisfaction, this system can save resources and avoid food waste without additional costs (Ronge 2022).

However, can a concept which takes into account individual preferences and, if necessary, intolerances, already be called a personalized nutrition?

**Phenotype and life circumstances are more relevant than (epi-)genome and microbiome**

In the context of personalized nutrition, the term holistic approach is often used. At best, it means individualizing the diet by taking into account all possible factors. 72% of the experts in the Delphi study agreed that a holistic approach that considers all factors is necessary to make nutrition individually healthier. Which factors are of particular relevance?

#### At a glance – of the 32 respondents, ...

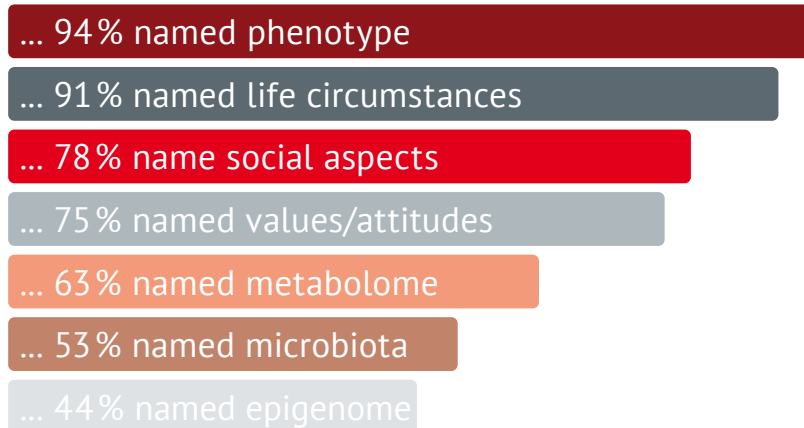


Figure 9: Frequency of mentioning relevant factors for a holistic approach to personalized nutrition. (data in %, n=32, multiple answers possible). Additional free responses: actual nutritional behavior, genetics, other omics approaches, existing diseases, physical anamnesis, special needs, physiological limitations - not all to be included under metabolome, phenotype.

The results show that phenotyping as a component of personalized nutrition is particularly emphasized: 94% of the participants were in favor of phenotype, closely followed by life circumstances with 91%. Also social aspects (78%) and values/attitudes (75%) are relevant factors for experts. Physiological and genetic factors, such as the metabolome, the microbiota and the (epi-)genome, play currently a rather minor role in a holistic approach to personalized nutrition. Rather, the phenotype and factors of life situation should be taken into account. When comparing this information with the shell model of the DHBW research group, these factors are primarily represented in the outer three shells as life circumstances, anthropometry and clinical parameters. Among other things, food preferences (and possibly intolerances) are also part of these factors, as reflected in the concept of the Franziskus hospital in Vienna in its form of Personalized nutrition. Thus, consideration of just one or two levels is already a good start to support individuals in achieving a healthier diet. If necessary and/or available, it can be expanded to include further factors. Basically, “holistic” means that biomedical parameters are no longer considered in isolation, but instead psychological factors, behavioral patterns, lifestyle, habits, social integration, working conditions and the environment are integrated (Zukunftsinstitut 2022).

Consumers still tend to associate personalized nutrition with DNA-tailored recommendations; the request for such recommendations is increasing, according to

the Trend Report Nutrition 2022 (BZfE and Nutrition Hub 2022). A market analysis on digital products for personalized nutrition conducted by the working group at the DHBW revealed that genome analyses were used in 36% of personalized nutrition concepts, foods and dietary supplements (Lotz et al. 2022). 53% of the Delphi study experts agree that the results of basic research is still too limited as for the (epi-) genome to provide a sound basis for personalized nutrition in the near future.

According to 69% of the experts, personalized nutrition based on the genome will remain a niche product.

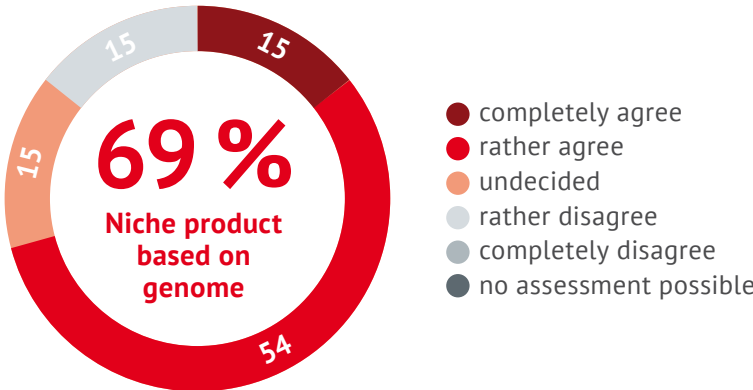


Figure 10: Personalized nutrition based on the genome will remain a niche product (data in %, n=13).

Nevertheless, some experts believe that further research into the genome and the epigenome is promising. However, according to 47% of the experts looking at single genes does not make sense anymore In the future, so-called gene scores would be used, which are several genes and allowing more reliable predictions to be made.

Evidence-based findings are also still lacking in the field of microbiota and metabolism. The relationships between microbiome, health and disease are complex. The foundation of the gut microbiome is already established at birth and during the first years of life. It is also scientific consensus that the composition of the gut microbiome is highly individual and resembles a fingerprint (Simon 2020, Bechthold 2021, Kviatcovsky 2021). There are still many uncertainties about, for example, what does a so-called good or healthy microbiome look like? Is the alteration of the microbiome a cause or consequence of disease?

Nevertheless, the interview results suggest that dietary recommendations based on microbiota analyses, compared to those based on DNA analyses, are more likely to be regarded as suitable for the mass market. However, this statement is only supported by 33% of the experts in the questionnaire.

On the contrary, 53% of the experts in this topic area agreed with the statement that personalized nutrition based on the microbiome will remain a niche product.

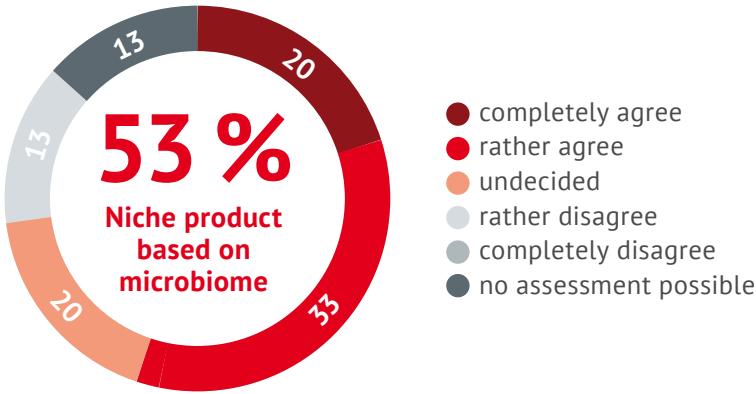


Figure 11: Personalized nutrition based on the microbiome will remain a niche product (data in %, n=15).

When assessing the microbiota, not only its composition, but also the functions and metabolic products of the microorganisms, the alteration of the microbiota due to lifestyle factors, diet and metabolic products of the host, as well as intestinal permeability and transit time are additional factors mentioned.

This holistic view of multiple parameters is not limited to the microbiota and the genome with the consideration of gene scores. According to the experts of the Delphi study, biomarker signatures (combinations of various biomarkers) will support personalized nutrition. In addition, stratified nutritional analyses can be used to develop metabolic and nutrient types.

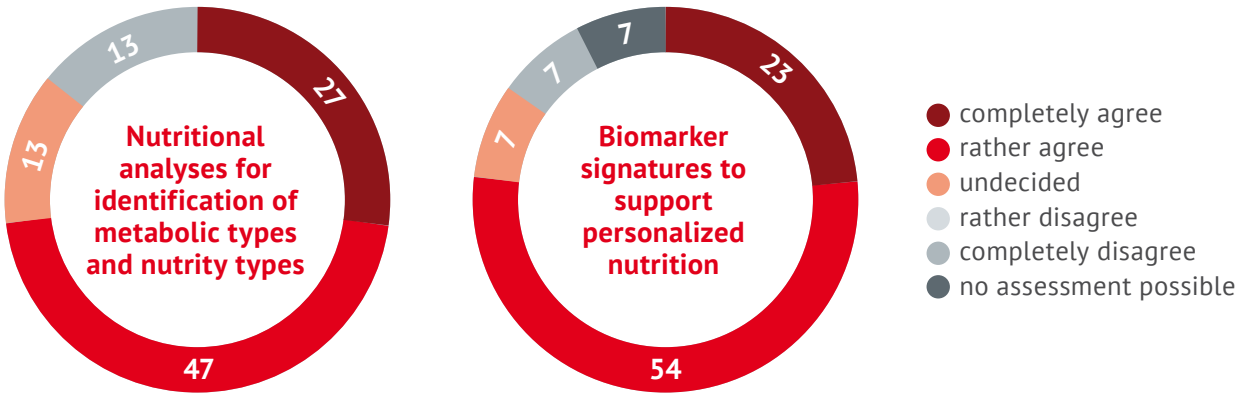


Figure 12: Left: Stratified nutritional analyses for identification of metabolic types and nutritive types will be developed in the future (data in %, n=15). Right: In the future, biomarker signatures will support personalized nutrition (data in %, n=13).

Consumers are still rather skeptical about the analysis of genome and microbiota as a basis for personalized nutrition recommendations. In a 2019 DLG study, 1000 consumers were asked about their willingness to use various analytical tools. 38% of respondents indicated their willingness to use genome and microbiome analyses. 58% declared their willingness to fill out a questionnaire regarding lifestyle, food preferences, anthropometry. The temporary wearing of a blood glucose monitor is imaginable for 28% of the respondents (DLG e.V. 2019).

Genome, epigenome and microbiota as a basis for individual nutritional recommendations are discussed very controversially and are not considered by some experts as a basis for personalized nutrition in the future. In the shell model, these factors are located on the inner shells and show a higher degree of individualization. The scientific evidence is still too limited to allow serious recommendations to be made. This is possibly due to the fact that the collection of these parameters is more complex and considerably more expensive compared with questioning or measuring the parameters of the outer shells.

Technological progress will reduce the cost of collecting the data, as illustrated by the cost development of gene sequencing. While in 2001 the cost of sequencing a human genome was still more than 10 million USD, today the analysis of the entire genome can be ordered for less than 1000 USD (National Human Genome Institute 2021). The majority of experts agree that as soon as technologies become available at a lower cost, these will drive the development of personalized nutrition. Another important development seen by 60% of the experts is the the standardization of technologies (for example, omics technologies and gene sequencing), so that data can be reproduced and used to gain insights, even if they are from different sources.

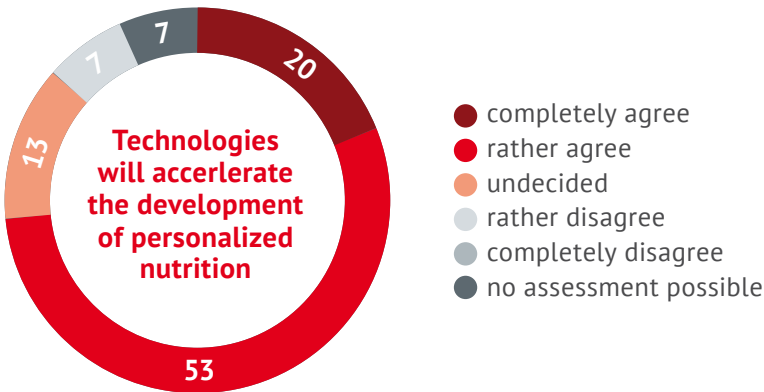


Figure 13: As soon as technologies become available at lower costs, these will accelerate the development of personalized nutrition (data in %, n=15).

## 4.2 Personalized nutrition digitally

The experts of the Delphi study agree that the technology in personalized nutrition will play an important role, in measuring the data required (sensors, wearables, electronic sales slips, etc.) and in the processing of data (using AI/algorithms/Big Data) as well as in the provision of individualized recommendations (apps/apps/wearables). Technology has become indispensable in the healthcare sector: “Health is digital” according to the Zukunftsinstitut (Zukunftsinstitut 2022).

### Technology will play an important role in personalized nutrition, especially with respect to ...

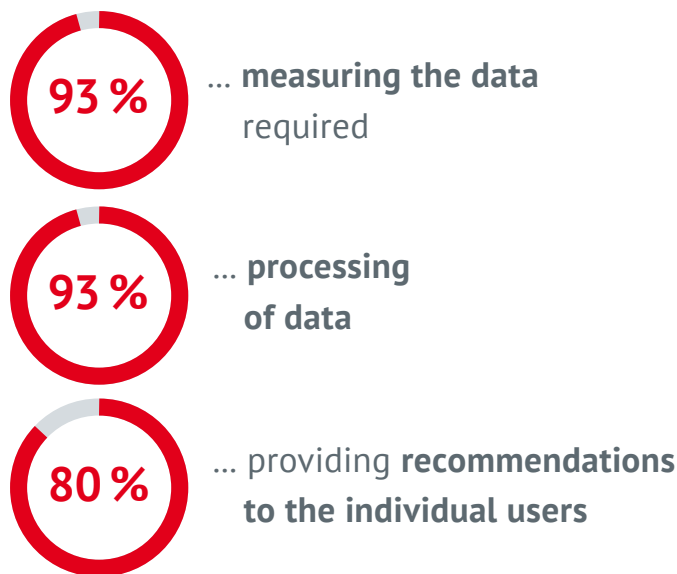


Figure 14: Application areas of technologies in personalized nutrition. Proportion of experts who completely or rather agree (data in %, n=15).

### Real World data collected discreetly by sensors

Sensors are predicted to play a major role in the measurement of data. Experts are forecasting that the collection of data relevant to health will be simplified in the future using sensors. Sensors would increasingly enable the collection and combination of large amounts of health-related data (67 % agreement).



Figure 15: The collection of health-related data will be simplified in the future using sensors. Proportion of experts who completely or rather agree (data in %, n=15).



Wearables from various providers that can, among other things, measure movement, pulse and blood pressure, and can even record an ECG are already available today. Experts believe that the use of so-called “real world data” will advance personalized nutrition. Real World data originate from everyday care, instead of being collected in randomized clinical trials (RCTs), and can stem from a variety of sources, such as electronic health records or personal mobile devices (Land der Gesundheit 2022).

More than 50 % of Delphi experts agree that real world data should be collected on an independent platform. These agreeing experts were asked to whom this data should be provided:

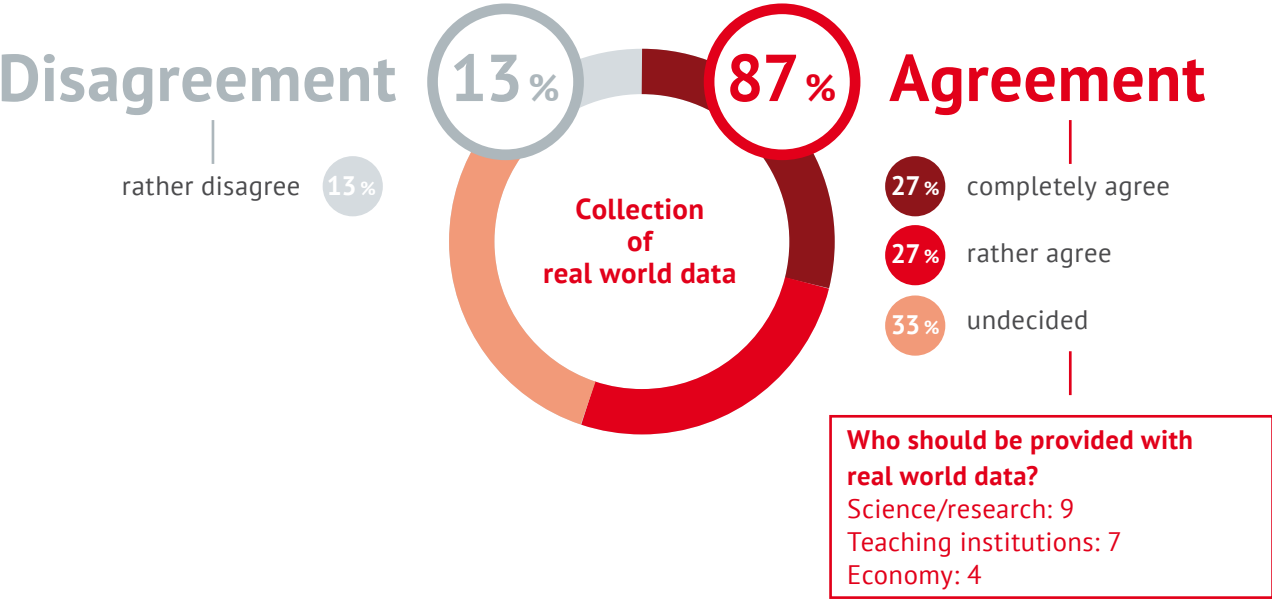


Figure 16: Real world data are to be collected on a platform by higher-level institutions in the future (data in %, n=15). Filter question: Who should be provided with the data? (responses, n=10, multiple answers possible).

Accordingly, science and research as well as teaching institutions in particular should be allowed to use this data.

**AI and algorithms - drivers in personalized nutrition**

Technologies will also be in focus with respect to the processing of the data. Artificial intelligence (AI) will enable reliable analysis of large amounts of data in this context. Big data analysis will result in algorithms that allow more accurate predictions of individual biomedical responses. By providing the option to process lots of data, technology will contribute to the more reliable implementation of the holistic approach described above, which takes many factors into account.

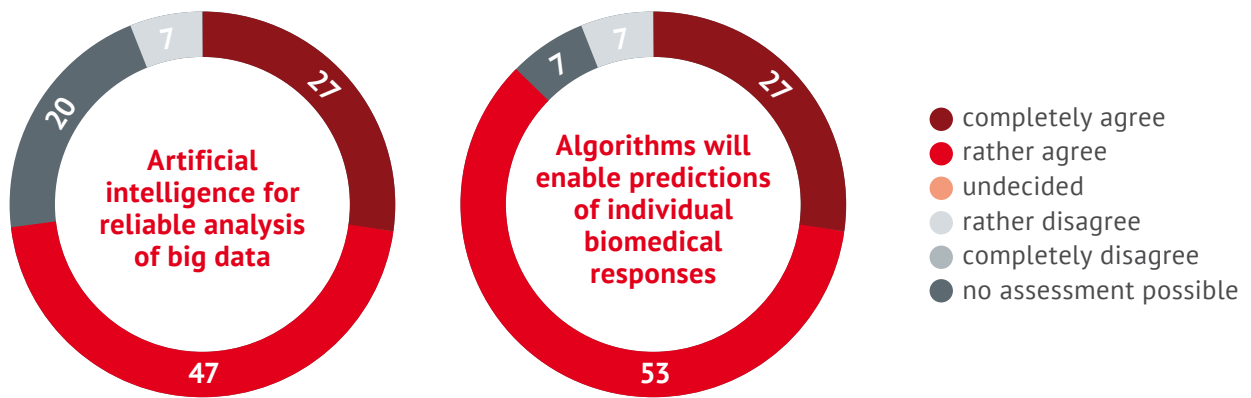


Figure 17: Left: Artificial intelligence will enable reliable analysis of big data (data in %, n=15). Right: Algorithms will enable more accurate predictions of individual biomedical responses (data in %, n=15).

### Smartphones and apps: personalized nutrition for everyone?

Both sensors for measuring data and technologies such as smartphones, apps and wearables for the provision of individualized recommendations will make personalized nutrition more practical. The number of smartphone users in Germany continues to grow and reached around 62.6 million in 2021 (Statista 2022). Consequently, experts consider the smartphone to be the primary medium for personalized nutrition, and apps are seen as the most cost-effective solution suitable for mass-scale use.

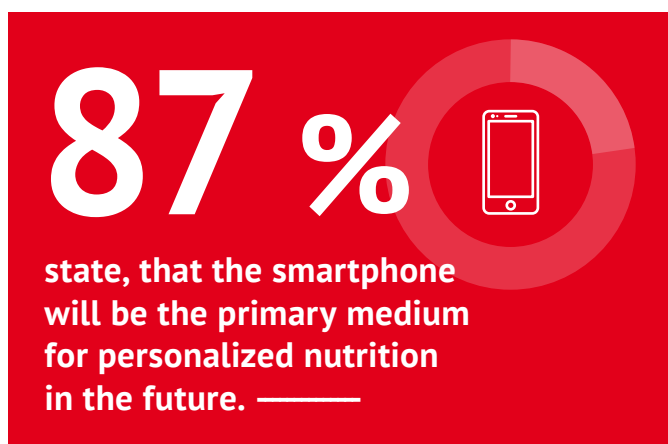


Figure 18: Due to availability and demand, the smartphone will be the primary medium for personalized nutrition in the future. Proportion of experts who completely or rather agree (data in %, n=15).

In combination with a wide range of apps, the smartphone has developed into a device with multiple functions. Apps on health topics such as fitness and nutrition are popular. According to a recent study by Initiative D21 38% of participants (n=2024) are already using digital health and fitness applications (Initiative D21 e.V. 2022). “Oviva - Your personal nutrition coach” for example, is an app that is gaining interest with over 100,000 downloads.

Nevertheless, some experts consider the development of personalized nutrition in the form of digital concepts for example, as an app, or by using wearables, as critical for health equity. The statements that the development of personalized nutrition on a digital level does not reach all social levels and age groups received great agreement.

### **The development of personalized nutrition on a digital level will not reach ...**



*Figure 19: With the development of personalized nutrition on a digital level, not all social levels (left) and not all age groups (right) are reached. Proportion of experts who completely or rather agree (data in %, n=16).*

Digitization in different population groups is not progressing at the same rate which leads to a so-called digital gap. Studies show, that while the gap continues to exist, it is narrowing. According to the German Ageing Survey, between 2017 and 2020, the proportion of 76-90 year old persons with access to the internet increased to 52% (of which 36% use mobile internet).

In the next younger age group, 61-75 years of age, 92% already have internet access (of which 63% use mobile internet). The most frequent purpose of use is searching for information (DZA 2021; Initiative D21 e.V. 2022).

Differences in usage can still be seen for different social levels, however, both the use of the internet in general and mobile internet are increasing especially in the group with a low level of education, which previously had a lower level of use. (Initiative D21 e.V. 2022). This initially doesn't suggest anything about the purposes of use initially, but it does show that there is at least a general possibility that digital concepts of personalized nutrition can be used.

The interviews in the first round of the Delphi study resulted in the statements that consumers are not motivated by personalized nutrition as a digital application, or at least that the motivation can not be maintained in the long term. Both statements were not supported by the second, larger panel of experts, although some experts still rather agree, that motivation is not maintained in the long term by digital applications.

## Personalized nutrition in the form of a digital application (e.g. a smartphone app) ...



Figure 20: Personalized nutrition in the form of a digital application (e.g. a smartphone app) ... will not motivate consumers (top), ... will not keep consumers motivated in the long term (middle), ... should be linked to personal advice (bottom). Proportion of experts who completely or rather agree (data in %, n=16).

On the contrary, studies show that the inclusion of gamification elements in digital applications can even promote motivation. In the area of health promotion, gamification can contribute to learning success, motivation and behavior change (Tolks et al. 2020).

However, the experts were predominantly in agreement with the statement that a digital application should be combined with personal counseling.

It is unclear how personal consulting is defined here, does personal consulting also include exchange via chat or video chat as well? This is particularly important if the digital application is supposed to be included in the list of digital health applications (DiGa) as a medical device and is thus to be reimbursed by health insurances. According to the criteria of the German Federal Institute for Drugs and Medical Devices (BfArm), the main function of a DiGa is based on the digital technology. Personal consultation in connection with this function can be offered, but is not taken into account for reimbursement by health insurances (BfArm 2022). One example is Zanadio, a digital health application for weight reduction. The application mainly focuses on digital technology, the content is based on the S3 guidelines and the therapy pillars of nutrition, exercise and behavior. If necessary, the support team can be contacted via chat.

If an application is offered as a DiGa, approved by the BfArm, it can be assumed that consumers have a high level of confidence in its safety and efficacy. The trust in a

digital application (for example smartphone app) in the context of personalized nutrition is essential for its success. The fact that it is primarily dependent on scientific conformity and the institutions involved, such as technology companies, institutes, physicians, medical professionals, DGE, nutritionists, etc., was highly agreed upon by the experts of the Delphi study. The degree of commercialization of the applications has rather less influence on trust.

**Trust in a digital application (e.g. smartphone app) in the context of personalized nutrition is essential for its success and depends on ...**

**50 %** ... institutions involved (technology companies, institutes)

**25 %** ... its degree of commercialization

**56 %** ... the scientific conformity

*Figure 21: Trust in a digital application (e.g. smartphone app) in the context of personalized nutrition is essential for its success and depends on ... Proportion of experts who completely or rather agree (data in %, n=16).*

### **Consumer trust in data protection is crucial to success**

According to the experts, data protection in particular is a hurdle for personalized nutrition and for the technologies behind the digital applications. A key challenge is the protection of sensitive, personal data during exchange and forwarding (93% agreement) and the necessary transparency in data processing (87% agreement).

**"The misuse of sensitive personal information is to be penalized and punished in the future." —**

*Expert statement from part 1 of the Delphi study*

The statement above that the misuse of personal information should be penalized and punished, was agreed to by 93% of the participants.

Data protection is especially important in centralized data management, if, for example, data is generated by wearables or measured by an omics technology transferred to a network for further processing or to a cloud for storage. Another possibility is the decentralized processing and storage of personal data, for example directly on the personal smart device (Reinfurth 2022). 53% of the experts in the Delphi study agree with the statement that smart technologies with decentralized data calculation will be available in the future for real-time recommendations.

Transparency for consumers about what their data is used for, where it is stored and who has access to this data plays an important role. The trust in data protection is recognized as critical to the success of personalized nutrition.



Figure 22: Trust in data privacy will be crucial to the success of personalized nutrition. Proportion of experts who completely or rather agree (data in %, n=15).

There was broad agreement with the statement that the interest of insurances (for example life insurance companies) and health insurance companies (private and statutory) will raise ethical concerns (86% agreement). The use of health data to incorporate them into bonus systems (73% agreement) or to adjust health care contributions (93% agreement), will put consumers under pressure. The issue of the de-solidarization of the health care system is not new, but it is fueled by the increasing use of digital health applications. The possibility of creating individual risk profiles with collected data, is regarded as critical by the German Ethics Council (Deutscher Ethikrat 2017). According to a study commissioned by the NRW Consumer Research Competence Center, people who already use health apps more likely endorse both premium reductions and risk surcharges compared to non-users (KVF NRW 2020).

### 4.3 Personalized nutrition from a consumer perspective

#### **Healthy nutrition and individuality - drivers of personalized nutrition**

What are the consumer motives for personalized nutrition in the first place? What is the motivation to implement personalized nutrition? The most frequent reason for the use of personalized nutrition is, according to experts, the desire for healthy nutrition. The trend of individualization is also a motivating factor. However, the pure pursuit of following a trend as a motive is only supported by a few experts. In addition, experts mentioned the desire for self-optimization, performance enhancement and well-being.

#### **Strongest motives for using personalized nutrition is the desire for ...**



Figure 23: Strongest motives for using personalized nutrition. Proportion of experts who completely or rather agree (data in %, n=16).

The graphic above describes the basic motivation of consumers to personalize nutrition.

What is ultimately leading to a change in behavior? Experts agree, that noticeable successes in terms of health and well-being is key. Noticeable success however can only occur if there is already a certain level of suffering or an existing self-awareness. According to some experts, this indicates that personalized nutrition requires personal exchange in order to motivate the consumers long term. As already described in the section on “Personalized nutrition - digital”, digital applications in combination with personal advice can have a supportive effect.

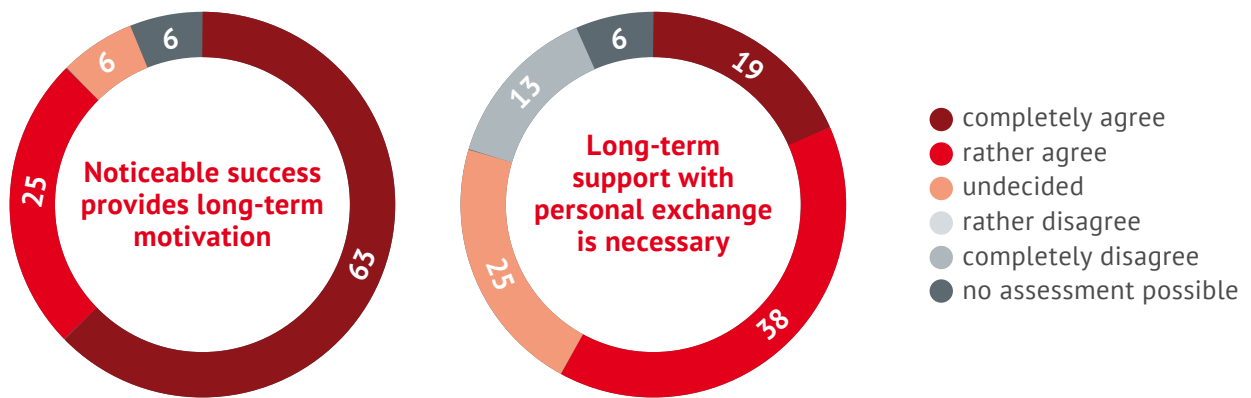


Figure 24: Left: Noticeable success through personalized nutrition, with regard to health and well-being, provides long-term motivation for users (data in %, n=16). Right: If personalized nutrition is used for health promotion, long-term support with personal exchange is necessary (data in %, n=16).

### Personalized nutrition: health, culinary delight and emotions

In addition to the above-mentioned motivations, the aspects of health, culinary delight and emotions play a special role. The aspect of culture, on the other hand, is given comparatively little importance.

The following aspects of personalized nutrition are considered important by the experts:

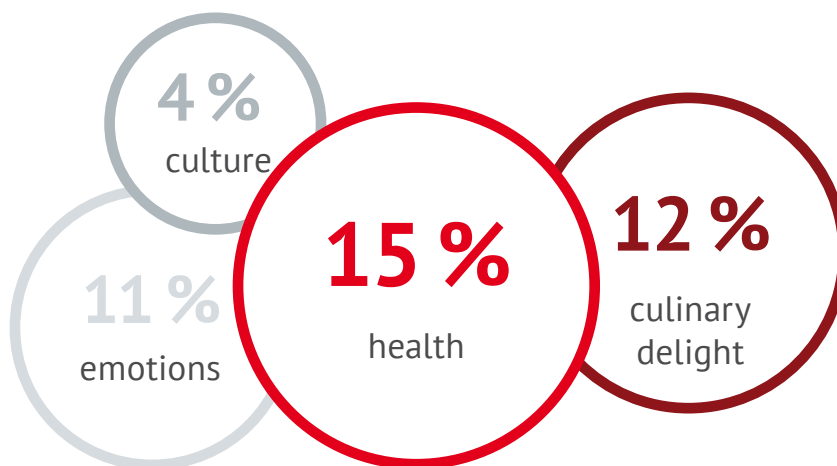


Figure 25: How important do you think are the following aspects of personalized nutrition? Proportion of experts, who consider these aspects to be very important or important (data in %, n=16).

Healthy nutrition therefore also has to taste good and appeal emotionally. This reflects the holistic approach of personalized nutrition.

The reference to health as a motivator indicates that individuals without knowledge of conscious nutrition are more difficult to reach through personalized nutrition than those who already deal with the topic of nutrition.





Figure 26: People with no knowledge of conscious nutrition are more difficult to reach through personalized nutrition than those who are already dealing with the topic of nutrition. Proportion of experts who completely or rather agree (data in %, n=16).

### Barriers to personalized nutrition among consumers

According to the experts, a lack of will and interest on the consumer's side can be higher obstacles to personalized nutrition than technology hostility and costs.

#### Barriers to personalized nutrition ...



Figure 27: Barriers to personalized nutrition among consumers. Proportion of experts who completely or rather agree (data in %, n=16).

In addition to the identification of obstacles, criticism of personalized nutrition was also raised. 29 % of the experts fear over-interpretation of the benefits of personalized nutrition and the creation of false expectations among consumers.

#### 4.4 Personalized nutrition in the focus of consumer policy

Awareness of the relevance, benefits and implementation of personalized nutrition can be stimulated through group-targeted information and communication to overcome consumer barriers.

**83 %** **"Awareness of the relevance, benefits and implementation must be stimulated through target-group-specific communication and information." —**

*Figure 28: Awareness of the relevance, benefits, and implementation of personalized nutrition must be stimulated through target-group-specific communication and information. Proportion of experts, who completely agree or rather agree (data in %, n=12).*

Politics holds a high level of responsibility here:



*Figure 29: It will be the task of politics to inform consumers transparently about the opportunities and risks of a personalized nutrition. Proportion of experts who completely or rather agree (data in %, n=15).*

In addition, it will be important to improve the marketing of accessible and affordable personalized nutrition concepts (67 % agreement).

#### ***Physicians and nutritionists as important source for personalized nutrition***

In the opinion of the experts, physicians and nutritionists are the primary sources for personalized nutrition followed by the DGE (German Nutrition Society), the health insurances and the BZfE (Federal Center for Nutrition).

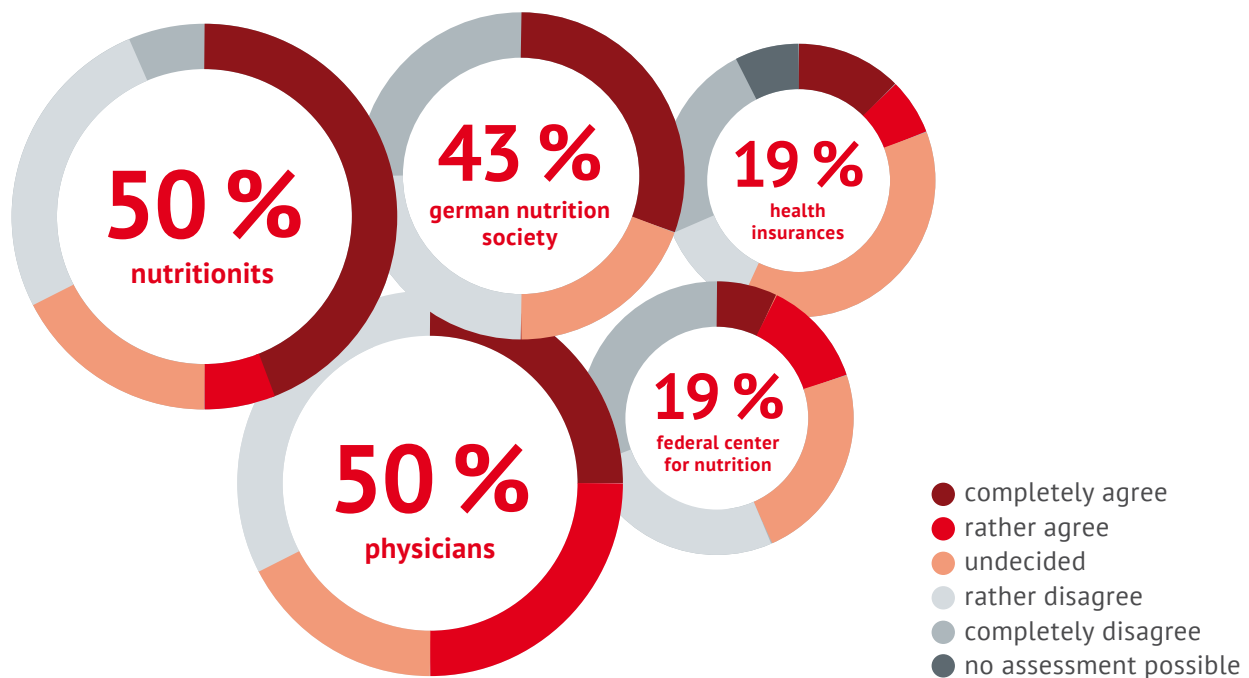


Figure 30: In your opinion, which of the following institutions/functions represent an important source for personalized nutrition? (data in %, n=16). Additional free responses: Professional associations (VDOe, DGG, DGEM), friends and acquaintances as well as media, start-ups in the field.

In addition, training of mediators of personalized nutrition is given importance.



Figure 31: Training of personalized nutrition mediators (e.g. physicians, health insurance companies) will be crucial for success. Proportion of experts who completely or rather agree ( data in %, n=16).

Particularly in the case of digital health applications, the authors of the EY white paper “Digital Health Applications” consider doctors’ offices to be the interface and most important sales channel for their prescription (EY 2022).

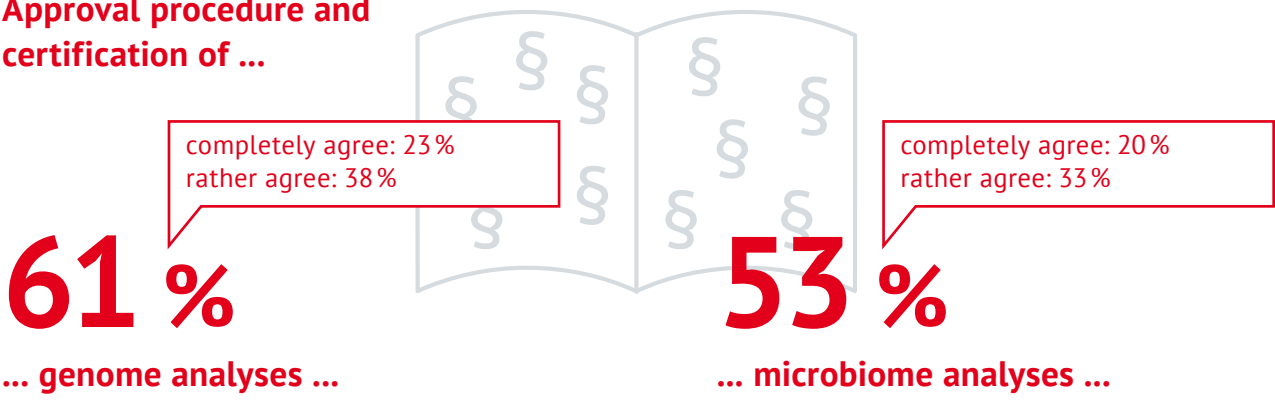
The German Federal Ministry of Health (BMG) is planning a nationwide network of kiosks, especially in socially disadvantaged regions and neighborhoods, to strengthen health advice and care as well as prevention (bvpg 2022). Personalized nutrition could be implemented here in a targeted manner. But how should Personalized Nutrition content be communicated to the public?

The most suitable methods are simple basic information (75% agreement) and easy-to-implement recommendations (75% agreement). However, 44% of the experts also supported the provision of scientific information. This assessment by the experts illustrates the aspect that the type of communication also has to be appropriate to the target group, and cannot follow a “one size fits all” principle.

**Microbiome and genome analyses: demand for legal approval procedures and certifications**

In addition to the accessibility of concepts for consumers, the validity of scientific bases is observed from a political point of view. More than 50% of experts are in favor of genome and microbiome analyses being made for personalized nutrition should be regulated by law through approval procedures and certification.

**Approval procedure and certification of ...**



... for personalized nutrition should be regulated by the legal system.

Figure 32: Approval procedure and certification of genome analyses (left, n=13) and microbiome analyses (right, n=15) for personalized nutrition should be regulated by the legal system. Proportion of experts who completely or rather agree (data in %).

In addition, more than 50% of the experts agree that quality criteria and consequences of biomedical analyses for personalized nutrition should be laid down in a framework of regulations. The creation of the regulations should primarily involve representatives from the fields of science, ethics, law, the German Nutrition Society and the public.

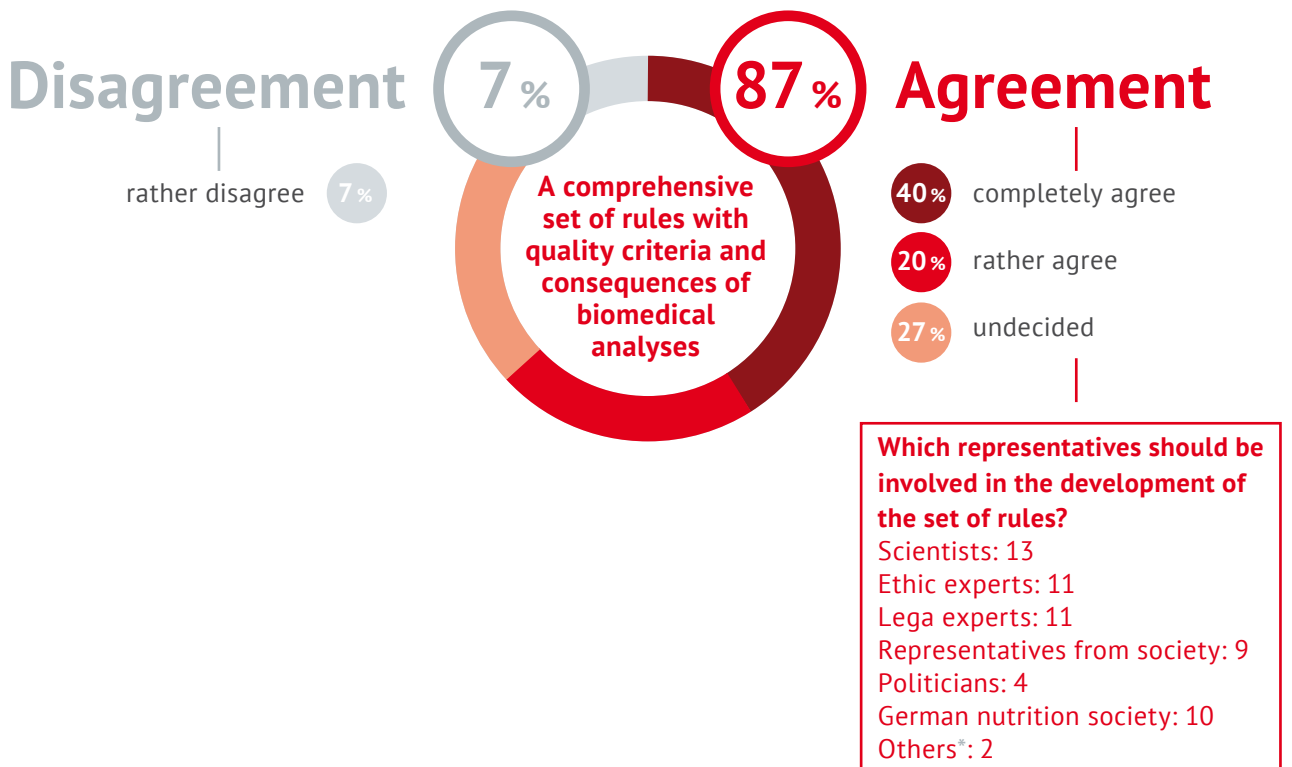


Figure 33: In the future, a comprehensive set of rules with quality criteria and consequences of biomedical analyses should underlie personalized nutrition (data in %, n=15). Filter question: The mentioned set of rules should be created by the participation of ... (responses, n=13, multiple answers possible).

In addition, the validity of the concepts of personalized nutrition should be communicated by independent institutions.

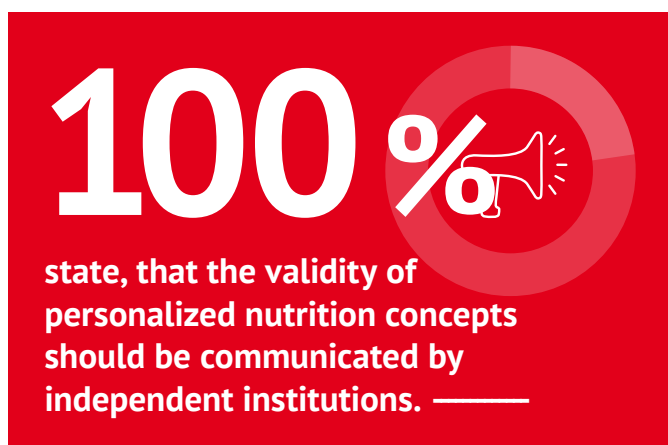


Figure 34: The validity of personalized nutrition concepts should be communicated by independent institutions. Proportion of experts who completely agree or rather agree (data in in %, n=12).

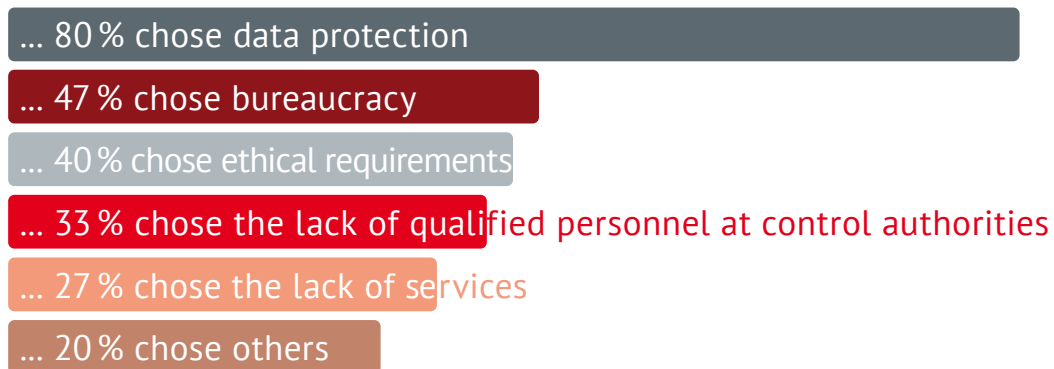
The validity of digital health applications in the therapeutic area is being tested by the Federal Institute for Drugs and Medical Devices (BfArM). The Prüfstelle für Prävention (PfP) certifies analog and digital programs on physical activity, nutrition, stress management and addiction. If validity is assured by the PfP, the programs will be

subsidized or covered by health insurances (PfP 2022). It remains unresolved which institution can validate concepts that are neither offered as a DiGa nor as a prevention program by health insurers, such as for example shopping aids or prescription apps.

### **Bureaucracy and data protection - system-side barriers to personalized nutrition**

The above-mentioned consumer barriers are accompanied by system-related hurdles which could hinder the establishment of personalized nutrition.

#### **Stated barriers: out of 15 experts of the thematic area ...**



*Figure 35: Barriers which will make it more difficult to establish personalized nutrition (data in %, n=15, multiple answers possible). Additional free responses: Lack of benefit vs. established approaches, lack of information and education, reasonable cost-benefit ratio, lack of expertise of health care professionals.*

Data protection is seen as the biggest hurdle, closely followed by bureaucracy, ethical requirements and a lack of qualified personnel.

#### 4.5 Personalized nutrition in retail

Personalized nutrition could also take place in the retail sector. However, when asked more specifically, experts do not expect personalized nutrition to become a reality in stationary retail, such as supermarkets. On the one hand, 42% of the experts recognize the potential of retail to take on a neutral mediating role in personalized nutrition through direct contact with consumers. On the other hand, 67% agree that a lack of trust in food retailers could be an obstacle to the establishment of personalized offers in retail.



Figure 36: Left: Personalized nutrition will take place locally in supermarkets. Middle: Retailers can take on a neutral mediating role in personalized nutrition through direct contact with consumers. Right: Lack of trust in food retailing can be an obstacle to the establishment of personalized offers in retail. Proportion of experts who completely or rather agree (data in %, n=12).

#### **Online retailing and grocery delivery services – Capture opportunities for Real World Data**

Sales of food products in online retailing in Germany are rising steadily. The past two pandemic years in particular have brought strong sales increases for online food retailing. Despite the increase, the market share of online retail in food sales was most recently around two percent (Statista 2022). Forecasts predict rising market shares in the coming years (IFH 2020). Online retail and food delivery services can facilitate the data access for personalized nutrition concepts.

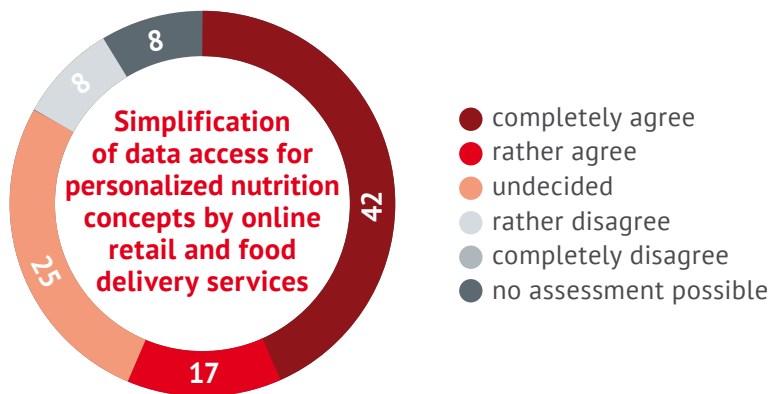


Figure 37: Online retail and food delivery services are new sales channels and will simplify data access for personalized nutrition concepts (data in %, n=12).

The path for personalized nutrition will be set in the next five years, 50% of the experts agree with this statement.

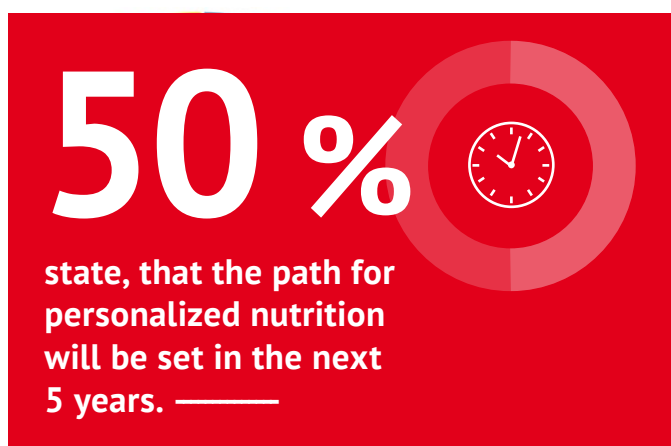


Figure 38: The path for personalized nutrition will be set in the next 5 years. Proportion of experts who completely or rather agree (data in %, n=12).



## 5. Conclusion

Personalized nutrition is a field of research with growing importance that is rapidly developing and was shown in the Delphi study to be very multifaceted. The collaboration of stakeholders from interdisciplinary fields beyond nutritional sciences such as technology, communication, data protection, consumer policy, medicine and commerce is of central importance for the further development of personalized nutrition.

The holistic approach, often mentioned in connection with personalized nutrition, is mainly reflected by the inclusion of individual living environments alongside biomedical parameters. For parameters with a high level of individualization, such as genome, epigenome and microbiota, the scientific evidence is still comparatively limited in order to make viable recommendations. Factors such as living environment, anthropometric data and clinical parameters are still the focus of nutritional recommendations. Through continued basic research of biomedical correlations, there is a potential for further development of personalized nutrition in the future.

Personalized nutrition has potential as a preventive and therapeutic measure, thus becoming interesting for the entire population. Personalized nutrition will initially take place in the home. Retail, delivery services and communal catering represent further supply channels presenting a wide reach for personalized nutrition concepts. Personalized nutrition is currently not yet widely accepted in stationary retail, such as supermarkets; but the digitization of retail will facilitate the collection of real world data and thus be able to promote personalized nutrition concepts.

Digitization plays a central role in personalized nutrition beyond the retail sector. Measurement with the aid of sensors and the processing of data by artificial intelligence and algorithms will enable real-time measurement of parameters and recommendations based on this in the future. Smartphones and wearables will become increasingly important as a medium for making individual recommendations to consumers. Here, the development of trustworthy data protection concepts plays a key role in convincing consumers of digital applications of personalized nutrition.

However, the development of personalized nutrition on a digital level does not yet reach all population groups. In particular, the population over 60 years of age and people from socially disadvantaged backgrounds are currently less accessible through digital concepts. Even if the development on a digital level is supported, the personal exchange remains significant. Whether contact in digital form, for example as a chat or video chat, is a possible alternative to face-to-face meetings remains unresolved.

For the use of personalized nutrition as a preventive measure, the development and offer of accessible, usable and affordable concepts for everyone in the population play a central role.

In addition to digitization, another key topic is communication. To promote acceptance of and trust in personalized nutrition, it will be important that the relevance, benefits, and implementation are communicated in a way that is appropriate according to the target group. Accessible and affordable concepts communicated by trustworthy multipliers lead to better acceptance. Political tools such as the validation of concepts and certified approval procedures for analytical methods are essential for their credibility.

Basic research, technology, digitization and data protection, as well as communication and marketing are topics that will continue to develop in the coming years with regard to personalized nutrition.

This leads to a need for further research for more intensive analysis of the areas of “private households”, “retail”, “communal catering”, “delivery services” and also the food industry, in order to open up possible applications for personalized nutrition and to develop criteria for the planning and implementation of personalized nutrition concepts in these areas.

## 6. References

- Bechthold A (2021): Das Mikrobiom im Darm – Ein ernährungsabhängiges Ökosystem. In: DGEwissen 9, S. 120-124
- Berry SE, Valdes AM, Drew DA et al. (2020): Human postprandial responses to food and potential for precision nutrition. Nat Med 26. S. 964-973
- BfArM – Bundesinstitut für Arzneimittel und Medizinprodukte (2022): Das Fast-Track-Verfahren für digitale Gesundheitsanwendungen (DiGA) nach § 139e SGB V. Ein Leitfaden für Hersteller, Leistungserbringer und Anwender. Version 3.1. [www.bfarm.de/diga](http://www.bfarm.de/diga) (eingesehen am 12.10.2022)
- Bundesministerium für Bildung und Forschung (o.D.): Unserer Gesundheit – Unsere Zukunft. Das Rahmenprogramm Gesundheitsforschung der Bundesregierung. <https://gf-bmbf.de/> (eingesehen am 14.09.2022)
- Bundesministerium für Gesundheit (2020): Ärzte sollen Apps verschreiben können. Gesetz für eine bessere Versorgung durch Digitalisierung und Innovation (Digitale-Versorgung-Gesetz - DVG). <https://www.bundesgesundheitsministerium.de/digitale-versorgung-gesetz.html> (eingesehen am 05.08.2022)
- Bvpg – Bundesvereinigung Prävention und Gesundheitsförderung e.V. (2022): Gesundheitskioske bundesweit geplant. <https://bvpraevention.de/cms/index.asp?inst=newbv&snr=13786> (eingesehen am 12.10.2022)
- BZfE und Nutrition Hub (2022): Trendreport Ernährung 2022 – Die 10 wichtigsten Ernährungstrends. <https://www.nutrition-hub.de/post/trendreport-ernaehrung-10-top-ernaehrungstrends-2022> (eingesehen am 21.06.2022)
- Cuhls K (2019): Die Delphi Methode – Eine Einführung. In: Delphi-Verfahren in Den Sozial- und Gesundheitswissenschaften: Konzept, Varianten und Anwendungsbeispiele, Springer Fachmedien Wiesbaden GmbH, S. 3-31
- DDG – Deutsche Diabetes Gesellschaft (2021): Deutscher Gesundheitsbericht – Diabetes 2022 Eine Bestandsaufnahme. Deutsche Diabetes Gesellschaft (DDG) und diabetesDE – Deutsche Diabetes-Hilfe (Hrsg.) [https://www.ddg.info/fileadmin/user\\_upload/Gesundheitsbericht\\_2022\\_final.pdf](https://www.ddg.info/fileadmin/user_upload/Gesundheitsbericht_2022_final.pdf) (eingesehen am 12.10.2022)
- Deutsche Landwirtschaftsgesellschaft (2019): Die Zukunft der Ernährung liegt in der Personalisierung – Individuelle Optimierungskonzepte. <https://www.dlg.org/de/lebensmittel/themen/publikationen/magazin-dlg-lebensmittel/personalisierte-ernaehrung> (eingesehen am 12.10.2022)
- Deutscher Ethikrat (2017): Big Data und Gesundheit – Datensouveränität als informationelle Freiheitsgestaltung: Stellungnahme. <https://www.ethikrat.org/fileadmin/Publikationen/Stellungnahmen/deutsch/stellungnahme-big-data-und-gesundheit.pdf> (eingesehen am 17.10.2022)
- Deutsches Zentrum für Altersfragen (2021): Deutscher Alterssurvey. DZA aktuell, Heft 5
- DLG e.V. Fachzentrum Lebensmittel (2019): My Food – Personalisierung und Ernährung. DLG-Studie Teil 2: Personalisierte Ernährung. [https://www.dlg.org/fileadmin/downloads/lebensmittel/themen/publikationen/studien/Studie\\_MyFood\\_Teil2\\_2019.pdf](https://www.dlg.org/fileadmin/downloads/lebensmittel/themen/publikationen/studien/Studie_MyFood_Teil2_2019.pdf) (eingesehen am 23.06.2022)
- Europäische Kommission (o.D.): Shaping Europes digital Future. <https://digital-strategy.ec.europa.eu/en/policies/ehealth> (eingesehen am 05.08.2022)
- EY Ernest&Young (2022): Digitale Gesundheitsanwendungen – Ausgebremst durch Höchstpreis oder jetzt auf der Überholspur? [https://www.ey.com/de\\_de/consulting/wachstumsmarkt-digitale-gesundheitsanwendungen](https://www.ey.com/de_de/consulting/wachstumsmarkt-digitale-gesundheitsanwendungen) (eingesehen am 21.07.2022)
- Häder M, Häder S (2000): Die Delphi-Methode als Gegenstand methodischer Forschung. In: Die Delphi-Technik in den Sozialwissenschaften. Häder, M/Häder, S (Hrsg.) Wiesbaden

IFH Köln (2020): Pressemitteilung IFH-Prognose: Onlinelebensmittelhandel steigt bis 2030 auf bis zu 9 Prozent. <https://www.ifhkoeln.de/ifh-prognose-onlinelebensmittelhandel-steigt-bis-2030-auf-bis-zu-9-prozent/> (eingesehen am 18.10.2022)

Initiative D21 e.V. (2022): D21 Digital Index 2021/2022. Jährliches Lagebild zur Digitalen Gesellschaft. <https://initiated21.de/d21index21-22/> (eingesehen am 21.08.2022)

Kirk-Mechtel M, Bundeszentrum für Ernährung (2022): Digitale Anwendungen unterstützen die Selbstoptimierung Personalisierte Ernährung und Biohacking <https://www.bzfe.de/service/news/aktuelle-meldungen/news-archiv/meldungen-2022/februar/personalisierte-ernaehrung-und-biohacking/> (eingesehen am 12.10.2022)

Kuckartz U, Rädiker S, Stefer C et al. (2005). Computergestützte Analyse qualitativer Daten – Tagungsband 2005: winMAX/MAXqda Anwenderkonferenz, Philipps-Universität Marburg, 10.-11. März 2005. <https://nbn-resolving.org/urn:nbn:de:0168-ssoar-9472> (eingesehen am 26.10.2022)

Kviatcovsky D, Zheng D, Elinav E (2021): Gut microbiome and its potential link to personalized nutrition. *Current Opinion in Physiology*, Vol. 23

Land der Gesundheit (o.D.): Real World Data: Das Potenzial besser nutzen. <https://www.landdergesundheit.de/fortschritt/real-world-data%20-potenzial-besser-nutzen> (eingesehen am 17.10.2022)

Landeta J (2006): Current validity of the Delphi method in social sciences, *Technological Forecasting and Social Change*. Volume 73, Issue 5, S. 467-482

Lotz K, Stoll-Hertrampf A, Antor S et al. (2022): Personalisierte Ernährung – State of the Art. *Ernährung im Fokus* 02, S. 74-79

Maier-Rigaud, R, & Böning, S-L (2020): Gesundheitsmonitoring mit Gesundheits-Apps und Wearables: Eine empirische Analyse der Nutzerinnen- und Nutzerprofile und ihrer Auswirkungen auf Selbstbestimmung und Solidaritätseinstellungen. *Working Papers des KVF NRW*, 13. [https://doi.org/10.15501/kvfw\\_13](https://doi.org/10.15501/kvfw_13) (eingesehen am 29.08.2022)

Mayring P (2012): *Qualitative Inhaltsanalyse – ein Beispiel für Mixed Methods*. In: *Mixed Methods in der empirischen Bildungsforschung*. Waxmann Verlag GmbH Münster

National Human Genome Institute (2021): DNA Sequencing Costs: Data. <https://www.genome.gov/about-genomics/fact-sheets/DNA-Sequencing-Costs-Data> (eingesehen am 24.06.2022)

Pfefferle H, Hagspihl S, Clausen K (2021): Gemeinschaftsverpflegung in Deutschland – Stellenwert und Strukturen. *ErnährungsUmschau* 8, S. 470-483

PwC (o.D.): Digitalisierung im Gesundheitswesen - Künstliche Intelligenz und Big Data sind die Schlüsseltechnologien der Zukunft. <https://www.pwc.de/de/gesundheitswesen-und-pharma/digitalisierung-im-gesundheitswesen.html> (eingesehen am 05.08.2022)

Reinfurth M, Qbeyond (2021): Die Vor- und Nachteile von zentraler und dezentraler Datenspeicherung. <https://blog.qbeyond.de/2021/06/die-vor-und-nachteile-von-zentraler-und-dezentraler-datenspeicherung/#:~:text=Was%20hei%C3%9Ft%20dezentrale%20Datenspeicherung%3F,%2DWarn%2DApp%20der%20Bundesregierung.> (eingesehen am 18.10.2022)

Ronge M, Ronge & Partner GmbH, GV-Austria (2022): Vortrag: À la carte im Krankenhaus? Individualisierung durch digitale Tools. *Verbands der Ernährungswissenschaften Österreichs: Personalisierte Ernährung auf dem Prüfstand – Forschung, Fortschritt, Grenzen. Jahrestagung des Verbands der Ernährungswissenschaften Österreichs am 19. und 20. Mai*

Simon MC, Seel W, Becks S (2020): Personalisierte Diät basierend auf dem Mikrobiom als Konzept der Zukunft? *Info Diabetologie* 14, S. 35-40

Statista (2021): Dossier: Smartphone Nutzung in Deutschland <https://de.statista.com/statistik/studie/id/71707/dokument/smartphone-nutzung-in-deutschland/> (eingesehen am 05.10.2022)

Statista (2022) Umsatz mit Lebensmitteln im Online-Handel in Deutschland von 2014 bis 2021. <https://de.statista.com/statistik/daten/studie/894997/umfrage/umsatz-mit-lebensmitteln-im-deutschen-online-handel> (eingesehen am 18.10.2022)

Statista (2022): Bevölkerung in Deutschland nach Häufigkeit der Nutzung von Lieferdiensten für fertige Mahlzeiten (Pizza etc.) in den Jahren 2018 bis 2021 <https://de.statista.com/statistik/daten/studie/290947/umfrage/umfrage-in-deutschland-zu-haeufigkeit-der-nutzung-von-pizza-lieferdiensten/> (eingesehen am 26.10.2022)

Tolks D, Lampert C, Dadaczynski K et al. (2020): Spielerische Ansätze in Prävention und Gesundheitsförderung: Serious Games und Gamification. Bundesgesundheitsbl. 63, S. 698-707. <https://doi.org/10.1007/s00103-020-03156-1> (eingesehen am 17.10.2022)

Thomas DT, Erdman KA, Burke LM (2016): Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and Athletic Performance. Journal of the Academy of Nutrition and Dietetics. Volume 116, Issue 3.

World Health Organisation (2021): Global strategy on digital health 2020-2025. <https://apps.who.int/iris/bitstream/handle/10665/344249/9789240020924-eng.pdf> (eingesehen am 05.08.2022)

Zanadio (o.D.): Deine digitale Adipositas-Therapie. <https://zanadio.de/> (eingesehen am 06.10.2022)

Zoe Science (2020): Whitepaper Rethinking the future of nutrition. Using large-scale biological data, AI and novel digital technologies to improve human health. <https://joinzoe.com/whitepapers/overview> (eingesehen am 29.08.2022)

ZPP Zentrale Prüfstelle für Prävention (o.D.): <https://www.zentrale-pruefstelle-praevention.de/> (eingesehen am 12.10.2022)

Zukunftsinstitut (2022): Megatrend Gesundheit <https://www.zukunftsinstitut.de/dossier/megatrend-gesundheit/> (eingesehen am 21.07.2022)

## 7. List of figures

<b>Figure 1</b> The shell model of personalized nutrition taking into account the degree of individualization (DHBW 2021). .....	8
<b>Figure 2</b> Structure of the Delphi study on personalized nutrition with topics and number of (invited) experts (Delphi study part 1), and participants, who stated that they were at least well or very well in the topic area (Delphi study part 2), respectively. ....	12
<b>Figure 3</b> Dropouts, completers and response rate per topic block in the 2nd round of the Delphi study. ....	13
<b>Figure 4</b> Complexity and interaction of the topics. Original topic areas (light red) and new topic complexes clustered after the analysis (gray). ....	15
<b>Figure 5</b> Application areas of personalized nutrition. Proportion of experts who completely or rather agree (data in %, n=32). ....	16
<b>Figure 6</b> In order to be effective as a preventive measure, personalized nutrition has to be ... accessible to everyone (left) ... guaranteed as a permanent diet (right). Proportion of experts who completely agree or rather agree (data in %, n=32). ....	17
<b>Figure 7</b> For which of the age groups do you think personalized nutrition will be particularly interesting in the next few years? (data in %, n=32, multiple answers possible). ....	18
<b>Figure 8</b> In which areas do you think personalized nutrition will mainly take place? (data in %, n=32, multiple answers possible). ....	19
<b>Figure 9</b> Frequency of mentioning relevant factors for a holistic approach to personalized nutrition. (data in %, n=32, multiple answers possible). Additional free responses: actual nutritional behavior, genetics, other omics approaches, existing diseases, physical anamnesis, special needs, physiological limitations - not all to be included under metabolom, phenotype. ....	20
<b>Figure 10</b> Personalized nutrition based on the genome will remain a niche product (data in %, n=13). ....	21
<b>Figure 11</b> Personalized nutrition based on the microbiome will remain a niche product (data in %, n=15). ....	22
<b>Figure 12</b> Left: Stratified nutritional analyses for identification of metabolic types and nutrity types will be developed in the future (data in %, n=15). Right: In the future, biomarker signatures will support personalized nutrition (data in %, n=13). ....	22
<b>Figure 13</b> As soon as technologies become available at lower costs, these will accelerate the development of personalized nutrition (data in %, n=15). ....	23
<b>Figure 14</b> Application areas of technologies in personalized nutrition. Proportion of experts who completely or rather agree (data in %, n=15). ....	24
<b>Figure 15</b> The collection of health-related data will be simplified in the future using sensors. Proportion of experts who completely or rather agree (data in %, n=15). ....	24

<b>Figure 16</b> Real world data are to be collected on a platform by higher-level institutions in the future. (data in %, n=15). Filter question: Who should be provided with the data? (responses, n=10, multiple answers possible). .....	25
<b>Figure 17</b> Left: Artificial intelligence will enable reliable analysis of big data. (data in %, n=15). Right: Algorithms will enable more accurate predictions of individual biomedical responses (data in %, n=15). .....	26
<b>Figure 18</b> Due to availability and demand, the smartphone will be the primary medium for personalized nutrition in the future. Proportion of experts who completely or rather agree. (data in %, n=15). .....	26
<b>Figure 19</b> With the development of personalized nutrition on a digital level, not all social levels (left) and not all age groups (right) are reached. Proportion of experts who completely or rather agree (data in %, n=16). .....	27
<b>Figure 20</b> Personalized nutrition in the form of a digital application (e.g. a smartphone app) ... will not motivate consumers (top), ... will not keep consumers motivated in the long term (middle), ... should be linked to personal advice (bottom). Proportion of experts who completely agree or rather agree (data in %, n=16). .....	28
<b>Figure 21</b> Trust in a digital application (e.g. smartphone app) in the context of personalized nutrition is essential for its success and depends on ... Proportion of experts who completely agree or rather agree (data in % n=16). .....	29
<b>Figure 22</b> Trust in data privacy will be crucial to the success of personalized nutrition. Proportion of experts who completely or rather agree (data in %, n=15). .....	30
<b>Figure 23</b> Strongest motives for using personalized nutrition. Proportion of experts who completely or rather agree (data in %, n=16). .....	31
<b>Figure 24</b> Left: Noticeable success through personalized nutrition, with regard to health and well-being, provides long-term motivation for users (data in %, n=16). Right: If personalized nutrition is used for health promotion, long-term support with personal exchange is necessary (data in %, n=16). .....	32
<b>Figure 25</b> How important do you think are the following aspects of personalized nutrition? Proportion of experts, who consider these aspects to be very important or important (data in %, n=16). .....	32
<b>Figure 26</b> People with no knowledge of conscious nutrition are more difficult to reach through personalized nutrition than those who are already dealing with the topic of nutrition. Proportion of experts who completely or rather agree (data in %, n=16). .....	33
<b>Figure 27</b> Barriers to personalized nutrition among consumers. Proportion of experts who completely or rather agree (data in %, n=16). .....	33
<b>Figure 28</b> Awareness of the relevance, benefits, and implementation of personalized nutrition must be stimulated through target-group-specific communication and information. Proportion of experts, who completely or rather agree (data in %, n=12). .....	34

<b>Figure 29</b> It will be the task of politics to inform consumers transparently about the opportunities and risks of a personalized nutrition. Proportion of experts who completely agree or rather agree. (data in %, n=15).	34
<b>Figure 30</b> In your opinion, which of the following institutions/functions represent an important source for personalized nutrition? (data in %, n=16). Additional free responses: Professional associations (VDOe, DGG, DGEM), friends and acquaintances as well as media, start-ups in the field.	35
<b>Figure 31</b> Training of personalized nutrition mediators (e.g. physicians, health insurance companies) will be crucial for success. Proportion of experts who completely or rather agree ( data in %, n=16).	35
<b>Figure 32</b> Approval procedure and certification of genome analyses (left, n=13) and microbiome analyses (right, n=15) for personalized nutrition should be regulated by the legal system. Proportion of experts who completely or rather agree (data in %).	36
<b>Figure 33</b> In the future, a comprehensive set of rules with quality criteria and consequences of biomedical analyses should underlie personalized nutrition (data in %, n=15). Filter question: The mentioned set of rules should be created by the participation of ... (responses, n=13, multiple answers possible).	37
<b>Figure 34</b> The validity of personalized nutrition concepts should be communicated by independent institutions. Proportion of experts who completely or rather agree (data in in %, n=12).	37
<b>Figure 35</b> Barriers that will make it more difficult to establish personalized nutrition (data in %, n=15, multiple responses possible). Additional free responses: Lack of benefit vs. established approaches, lack of information and education, reasonable cost-benefit ratio, lack of expertise of health care professionals.	38
<b>Figure 36</b> Left: Personalized nutrition will take place locally in supermarkets. Middle: Retailers can take on a neutral mediating role in personalized nutrition through direct contact with consumers. Right: Lack of trust in food retailing can be an obstacle to the establishment of personalized offers in retail. Proportion of of experts who completely or rather agree (data in %, n=12).	39
<b>Figure 37</b> Online retail and food delivery services are new sales channels and will simplify data access for personalized nutrition concepts (data in %, n=12).	40
<b>Figure 38</b> The path for personalized nutrition will be set in the next 5 years. Proportion of experts who completely or rather agree (data in %, n=12).	40



## 8. Appendix/data table

The following table lists all the theses questioned in the Delphi study. For a better overview, the theses used in the report are marked in bold. From the second column, the respective agreement values, given as a (1 = “completely disagree” to 5 “completely agree”) can be taken. The last column shows the topic area of the respective topic/item.

In particular, for question types that allow multiple answers, this is noted and the number of responses is given in %. In the case of the “other” responses, the associated free text answers is given in brackets.

The number of participating experts per topic area of the questionnaire can be taken from the list below.

- Cross-topic (32 experts) – **CT**
- Genome and metabolism (13 experts) – **G**
- Microbiota and metabolism (15 experts) – **M**
- Consumer behavior/ motivation/ acceptance (16 experts) – **C**
- Technology and applications (15 experts) – **TA**
- Politics and consumer protection (15 experts) – **PCP**
- Market and commerce (12 experts) – **MC**

### Basis of personalized nutrition

Target group/application area	Mean value	Topic area in survey
<b>For which of the age groups do you think personalized nutrition will be particularly interesting in the next few years?</b> <i>(Multiple answers possible)</i> <ul style="list-style-type: none"> <li>• Up to 29-year-olds (34 %)</li> <li>• 30-44-year-olds (59 %)</li> <li>• 45-59-year-olds (56 %)</li> <li>• 60-74-year-olds (34 %)</li> <li>• 75-year-olds and older (34 %)</li> </ul>		CT
<b>Personalized nutrition will...</b> <b>... find application especially in professional sports.</b> <b>... play a role particularly in prevention.</b> <b>... play a role in the therapy of diseases.</b>	4,14 3,90 4,17	CT
<b>In which of the following areas do you think personalized nutrition mainly take place?</b> <i>(Multiple answers possible)</i> <ul style="list-style-type: none"> <li>• Snack machines (6 %)</li> <li>• Gastronomy (9 %)</li> <li>• Meals to-go (19 %)</li> <li>• Homemade snacks at work (22 %)</li> <li>• Community catering (31 %)</li> </ul>		CT

Target group/application area	Mean value	Topic area in survey
<ul style="list-style-type: none"> <li>• Delivery service (31 %)</li> <li>• Supermarket (38 %)</li> <li>• At home / in the family (78 %)</li> </ul>		
Framework and evaluation criteria/ Potential of the personalized nutrition	Mean value	Topic area in survey
<p><b>In order to be effective as a preventive measure, personalized nutrition has to be...</b></p> <p><b>... guaranteed as a permanent diet.</b></p> <p><b>... be accessible for everyone.</b></p>	<p>3,76</p> <p>3,68</p>	CT
Personalized nutrition is being seriously implemented when it has the potential of a recognized consulting process.	3,54	
Personalized nutrition is seriously implemented when the success of conventional nutritional counseling is exceeded.	3,63	CT
Foundation Research	Mean value	Topic area in survey
Further findings in the area of basic research are needed before personalized nutrition is ready for the market.	3,87	CT
<p>Evidence-based results in basic research that can be used for personalized nutrition will be available in the next ...</p> <ul style="list-style-type: none"> <li>• 0-5 years (31 %)</li> <li>• 6-10 years (19 %)</li> <li>• 11-20 years (28 %)</li> <li>• Never (3 %)</li> <li>• No assessment possible (19 %)</li> </ul>		CT
Data measurement/diagnostics	Mean value	Topic area in survey
<b>Basic research technologies such as sequencing and omics technologies need to be standardized so that they are reproducible.</b>	4,27	T
<b>In the future, biomarker signatures will support personalized nutrition.</b>	3,92	G
<b>Stratified nutritional analyses to identify metabolite types and nutri types will be developed in the future.</b>	3,73	M
<b>Personalized nutrition based on the genome will remain a niche product.</b>	3,69	G
<b>Instead of monitoring individual genes, gene scores will be used in the future.</b>	3,30	G
<p>Genome sequencing as a standard in the context of clinical clinical trials will become established in the next</p> <ul style="list-style-type: none"> <li>• 6-10 years (1; 8 %)</li> <li>• 11-20 years (1, 8 %)</li> </ul>		G

Data measurement/diagnostics	Mean value	Topic area in survey
<ul style="list-style-type: none"> <li>• &gt; 30 years (1, 8 %)</li> <li>• Never (10, 76 %)</li> </ul>		
Personalized nutrition based on genome analysis will mainly be used in the therapeutic area.	2,31	G
Genome sequencing is essential for the optimal implementation of personalized nutrition for disease prevention.	1,77	G
The current state of research shows that the epigenome is will not be the basis for personalized nutrition in the near future.	3,38	G
Genome analysis will not play a role in personalized nutrition in the future.	3,33	G
<p><b>In addition to the composition of the microbiota, the following factors must be analyzed be analyzed</b>  <i>(multiple answers possible):</i></p> <ul style="list-style-type: none"> <li>• Function of the microorganisms (60 %)</li> <li>• Metabolic products produced (73 %)</li> <li>• No assessment possible (20 %)</li> </ul> <p>Other responses:</p> <ul style="list-style-type: none"> <li>• Change of microbiota due to lifestyle factors (1)</li> <li>• Blood sugar (1)</li> <li>• Diet, intestinal permeability, transit time (1)</li> <li>• Host metabolites (1)</li> </ul>		<b>M</b>
<b>Personalized nutrition based on the microbiome will remain a niche product.</b>	<b>3,69</b>	<b>M</b>
Microbiome analyses must be available at lower cost in the future.	3,29	M
The analysis and evaluation of the microbiota in general community medicine must be strengthened in the future.	3,00	M
<p>Personalized nutritional recommendations based on a microbiome analysis in the clinical setting will become standard in the next ...</p> <ul style="list-style-type: none"> <li>• 0-5 years (2; 13 %)</li> <li>• 6-10 years (2; 13 %)</li> <li>• 11-20 years (3; 20 %)</li> <li>• 21-30 years (1; 7%)</li> <li>• Never (5; 33 %)</li> <li>• No assessment possible (2; 13 %)</li> </ul>		M
In the future, methods for microbiome analyses must become easier to handle.	3,15	M
Personalized nutrition based on the microbiome will integrate discreetly into everyday life in the future.	2,08	M

<b>Data measurement/diagnostics</b>	<b>Mean value</b>	<b>Topic area in survey</b>
In the future, every person with health insurance should be entitled to a microbiome analysis once a year and corresponding nutritional counseling.	2,20	M
Personalized nutrition on the basis of the microbiome will be used especially in nutritional therapy.	2,86	M
In the future, microbiota analyses will be more suitable for the mass market than DNA analyses.	2,64	M
Daily nutritional recommendations based on the individual microbiome are more promising for health than general dietary recommendations for groups of people.	2,93	M
Personalized nutrition on the basis of the microbiome will establish first.	2,71	M
For phenotyping, the following technologies are important to collect as much data as quickly as possible: • Gene sequencing • Omics technology	2,90 3,90	T
<b>Factors</b>	<b>Mean value</b>	<b>Topic area in survey</b>
<b>A holistic (taking all factors into account) approach to personalized nutrition is necessary to make nutritional behavior healthier on an individual basis.</b>	<b>4,00</b>	<b>CT</b>
<b>In your opinion, what factors are relevant for a holistic approach to personalized nutrition?</b> <i>(Multiple answers possible)</i> • Phenotype (94 %) • Life circumstances (91 %) • Social aspects (78 %) • Values/attitudes (75 %) • Metabolome (63 %) • Microbiota (53 %) • Epigenome (44 %) Other responses (5): • Blood glucose (1) • Actual dietary behavior (1) • Genetics (1) • Other omics approaches (1) • Existing medical conditions (1) • Physical history, special needs, physiological limitations - not all to be classified under metabolome, phenotype (1)		<b>CT</b>

## Personalized nutrition digitally

Foundation Technology	Mean value	Topic area in survey
Until personalized nutrition is ready for the market, technical progress is key.	3,71	CT
<b>A holistic approach to personalized nutrition is more efficiently achieved through technological advances.</b>	<b>4,00</b>	<b>CT</b>
Current advances in digitization are standing in the way of the further development of personalized nutrition.	2,08	T
<b>Technological tools will make personalized nutrition more practical.</b>	<b>3,93</b>	<b>T</b>
<b>As soon as technologies become available at a lower price these will accelerate the development of personalized nutrition.</b>	<b>3,86</b>	<b>T</b>
Less expensive technologies have the potential to raise awareness of the of the topic of “personalized nutrition”.	3,27	T
The development of technologies for use in personalized nutrition will still take a long time.	3,07	T
Data measurement	Mean value	Topic area in survey
<b>Technology will play a significant role in personalized nutrition, especially with regard to the measurement of the data required.</b>	<b>4,71</b>	<b>T</b>
<b>In the future, the collection of health-related data will be simplified with the help of sensors.</b>	<b>4,00</b>	<b>T</b>
<b>Sensors will increasingly enable the collection of large volumes of health-related data and bring them together.</b>	<b>3,79</b>	<b>T</b>
In the future, we will no longer even notice the collection or measurement of data in everyday life.	3,13	T
Personalized nutrition on the basis of the genome will be discreetly integrated into everyday life in the future.	1,85	G
<b>The use of real-world data will drive the development of personalized nutrition.</b>	<b>4,00</b>	<b>T</b>
<b>In the future, real-world data will be collected on a platform by an independent superordinate institution.</b>	<b>3,74</b>	<b>T</b>
<b>Filter question: To whom should this data be provided?</b> (further consideration of experts who ticked “undecided,” “rather agree,” and “completely agree” – 10 experts) <ul style="list-style-type: none"> <li>• These data should be made available to science/research be made available to science/research (9; 90 %)</li> <li>• These data should be made available for teaching (7; 70 %)</li> </ul>		<b>T</b>

<b>Data measurement</b>	<b>Mean value</b>	<b>Topic area in survey</b>
<ul style="list-style-type: none"> <li>• These data should be made available to the economy (4; 40 %)</li> <li>• These data should not be made available to anyone (1; 10 %)</li> </ul>		
<b>Data processing</b>	<b>Mean value</b>	<b>Topic area in survey</b>
<b>Technology will play a significant role in personalized nutrition, especially with respect to processing of data.</b>	<b>4,57</b>	<b>T</b>
<b>Artificial intelligence will enable reliable evaluation of large volumes of data.</b>	<b>3,87</b>	<b>T</b>
In the future, cloud-based technologies will be more widely used in individualized microbiome analyses.	3,58	T
<b>Smart technologies with decentralized data calculation will be available in the future for daily updated recommendations.</b>	<b>3,64</b>	<b>T</b>
<b>Algorithms will enable more accurate predictions of individual biomedical responses.</b>	<b>4,00</b>	<b>T</b>
<b>Data output</b>	<b>Mean value</b>	<b>Topic area in survey</b>
<b>Technology will play a significant role in personalized nutrition, especially with regard to the recommendations to individual users.</b>	<b>4,29</b>	<b>T</b>
<b>Smart phone and apps</b>	<b>Mean value</b>	<b>Topic area in survey</b>
<b>Digital options such as apps are the most cost-effective for a mass-market solution for personalized nutrition.</b>	<b>3,86</b>	<b>T</b>
<b>Due to availability and demand, the Smartphone will be the primary medium for personalized nutrition.</b>	<b>3,93</b>	<b>T</b>
<b>Personalized nutrition in the form of a digital application (e.g. a smartphone app) ...</b>		<b>C</b>
... will not keep consumers motivated in the long term.	2,53	
... should be linked to personal advice.	3,88	
... will not motivate consumers.	1,80	
<b>Trust in a digital application (e.g., smartphone app) in the context of personalized nutrition is essential to its success and depends ...</b>		<b>C</b>
... on scientific compliance.	3,79	
... on its commercialization.	2,79	
... on the institutions involved (technology companies, institutes, physicians, DGE, nutritionists, etc.).	3,73	
<b>Challenges of personalized nutrition digitally</b>	<b>Mean value</b>	<b>Topic area in survey</b>
<b>With the development of personalized nutrition on a digital level ...</b>		<b>C</b>

<b>Challenges of personalized nutrition digitally</b>	<b>Mean value</b>	<b>Topic area in survey</b>
<b>... not all social classes are reached.</b> <b>... not all age groups are reached.</b>	<b>3,93</b> <b>4,07</b>	
<b>Data protection</b>	<b>Mean value</b>	<b>Topic area in survey</b>
<b>Transparency is an important criterion for users, when it comes to data collection and protection.</b>	<b>4,67</b>	<b>PC</b>
If data protection is guaranteed, consumers will share their data if they see a benefit for themselves.	3,47	PC
<b>Trust in data privacy will be crucial to the success of personalized nutrition.</b>	<b>4,21</b>	<b>PC</b>
<b>Protection of personal sensitive data becomes a challenge for technological systems when exchanging/forwarding the data.</b>	<b>4,53</b>	<b>T</b>
<b>Protection of personal sensitive data becomes a challenge for technological systems in terms of the transparency required to work with the data.</b>	<b>4,47</b>	<b>T</b>
<b>The misuse of sensitive personal information is to be criminalized and punished in the future.</b>	<b>4,79</b>	<b>PC</b>
In the future, the topic of data protection in connection with genome & metabolism will play an even greater role than today.	3,50	G

### **Personalized nutrition from consumer's perspective**

<b>Motivation/acceptance</b>	<b>Mean value</b>	<b>Topic area in survey</b>
<b>Individuals without a connection to conscious nutrition are more difficult to reach through personalized nutrition offers than those who already deal with the topic of nutrition.</b>	<b>4,31</b>	<b>C</b>
<b>The strongest motives for using personalized nutrition is the desire for ...</b> <b>... individuality</b> <b>... healthy nutrition</b> <b>... trend awareness</b> Others (3): • Performance enhancement/ -maintenance, self-optimization (1) • Improvement of sensation/performance enhancement (1) • Self-optimization (1)	<b>3,40</b> <b>4,25</b> <b>2,69</b>	<b>C</b>
The desire for climate-neutral and regional products will not be a driver of personalized nutrition.	3,09	MC

Motivation/acceptance	Mean value	Topic area in survey
<b>Noticeable success through personalized nutrition, in terms of health and well-being, ensures long-term motivation among users.</b>	4,60	C
<b>If personalized nutrition is used to promote health long-term support with personal exchange is necessary.</b>	3,53	C
<b>How important do you think the following aspects are for personalized nutrition?</b>		C
• health	4,93	
• culinary delight	4,20	
• emotions	3,80	
• culture	2,86	
<b>Education and information will promote confidence in personalized nutrition.</b>	3,93	C
Risks and consumer protection	Mean value	Topic area in survey
<b>The benefits of personalized nutrition are over-interpreted, creating false expectations among consumers.</b>	3,19	CT
Personalized nutrition has no advantages compared to conventional nutritional counseling and serves primarily to generate profits.	1,96	CT
The use of personalized nutrition could give the impression that preventive medical checkups are no longer necessary.	2,06	C
In the future, it should be up to each individual to decide whether to exercise the right to sequence his or her own genome and use this information to health issues and to achieve the personal optimum.	4,62	PC
Genotyping for personalized nutrition poses the risk of panicking people with the diagnosis of potential diseases.	3,00	G
Hurdles from consumer's perspective	Mean value	Topic area in survey
<b>Barriers to personalized nutrition will be ...</b>		C
... the lack of will	3,53	
... the lack of interest	3,56	
... the costs	2,75	
... hostility to technology	2,31	



## Personalized nutrition in the focus of consumer policy

Legal	Mean value	Topic area in survey
<b>Approval procedures and certification of genomic analyses for personalized nutrition should be regulated by the legislature.</b>	3,58	G
<b>Approval procedures and certification of microbiome analyses for personalized nutrition should be regulated by the legal system.</b>	3,14	M
Liability issues will become more important in the future in connection with genome analyses.	3,25	G
<b>In the future, a comprehensive set of rules with quality criteria and consequences of biomedical analyses should guide personalized nutrition.</b>	3,93	PC
<b>Filter question: The mentioned set of rules should be developed by the participation of...</b> ( <i>multiple answers possible</i> ) (further consideration of experts who selected, “undecided”, “rather agree” and “completely agree” - 13 experts) <ul style="list-style-type: none"> <li>• Scientists (13; 100 %)</li> <li>• Ethics experts (11; 73 %)</li> <li>• Legal experts (11; 73 %)</li> <li>• Representatives from society (9; 60 %)</li> <li>• Politicians (4; 27 %)</li> <li>• Representatives of the German Nutrition Society (10; 67 %)</li> <li>• Others (2; 13 %)</li> </ul>		PC
In order to lead personalized nutrition based on genetic diagnostic analyses out of the legal gray area in the future, a clear legal framework is necessary.	4,46	PC
Health monitoring	Mean value	Topic area in survey
<b>The interest of insurance companies (e.g., life insurance) and health insurers (private and statutory) in health data will raise ethical concerns.</b>	4,27	PC
<b>The use of data from personalized nutrition for bonus systems (e.g. repayment or premium reduction) will put users under pressure.</b>	4,07	PC
<b>The use of data from personalized nutrition for a possible increase in health insurance premiums will put users under pressure.</b>	4,40	PC
Marketing - Communication	Mean value	Topic area in survey
<b>Personalized nutrition services must be affordable for everyone.</b>	3,82	MC

Marketing - Communication	Mean value	Topic area in survey
It will come down to better marketing accessible and affordable personalized nutrition concepts.	4,00	MC
The validity of personalized nutrition concepts should be communicated by independent institutions.	4,42	MC
It will be the task of politicians to inform consumers transparently about the opportunities and risks of personalized nutrition.	3,60	PC
Training mediators of personalized nutrition (e.g. physicians, health insurers) will be critical to success.	3,94	C
Awareness of the relevance, benefits and implementation of personalized nutrition must be stimulated through target-group-specific communication and information.	4,17	MC
The focus should be on consumer information and education (transparency) rather than consumer protection.	2,87	PC
<b>For the communication of the contents of a personalized nutrition is best suitable ...</b> ... easy-to-implement recommendations. ... scientific information. ... easy to understand basic information.	4,47 3,38 4,27	C
<b>In your opinion, which of the following institutions/ functions represent an important source for personalized nutrition?</b> • physicians • health insurances • German Nutrition Society • nutritionists • Federal Center for Nutrition Others (3): • Professional associations/associations (VDOe, DGG, DGEM, ...) (1) • Friends and acquaintances as well as media (1) • Start-ups in the field (1)	3,37 2,67 2,87 3,56 2,38	C
<b>Organizational barriers</b>	Mean value	Topic area in survey
<b>The following barriers will make it more difficult to establish personalized nutrition (multiple answers possible):</b> • bureaucracy (47%) • data protection (80 %) • lack of qualified personnel at control authorities (33 %) • ethical requirements (40 %) • lack of services (27%) • no assessment possible (20 %) Others (3): • lack of benefit vs. established approaches (1)		PC

<b>Organizational barriers</b>	<b>Mean value</b>	<b>Topic area in survey</b>
<ul style="list-style-type: none"> <li>• lack of information and education (1)</li> <li>• reasonable cost-benefit ratio, lack of expertise of healthcare professionals (1)</li> </ul>		
An establishment of personalized nutrition in the general population is not in sight, since ethical questions are open.	2,38	PC
Personalized nutrition cannot yet be established in the mass market because of the lack of a legal framework.	3,33	PC

### **Personalized nutrition in retail**

	<b>Mean value</b>	<b>Topic area in survey</b>
<b>The path for personalized nutrition will be set over the next 5 years.</b>	<b>3,45</b>	<b>MC</b>
The increasing demand for health-oriented offerings will have a strong impact on the market success of personalized nutrition.	4,36	MC
<b>Through direct contact with consumers, retailers can take on a neutral mediating role in personalized nutrition.</b>	<b>2,83</b>	<b>MC</b>
<b>Personalized nutrition will take place locally in supermarkets.</b>	<b>2,17</b>	<b>MC</b>
Innovations such as 3D printing will make personalized nutrition a reality in food retailing.	2,27	MC
In order to be able to make an adequate and individual offer in food retailing in the future, a higher food supply is required.	1,67	MC
<b>Personalized recommendations will be facilitated by the digitization of the grocery business.</b>	<b>3,83</b>	<b>MC</b>
<b>In the future, personalized nutrition will lead to an expansion of competencies in the retail sector.</b>	<b>2,67</b>	<b>MC</b>
The retailers should detach themselves from political guidelines in order to actively validate the health of the consumers themselves.	2,25	MC
<b>Online retail and food delivery services are new distribution channels and will simplify data access for personalized nutrition concepts.</b>	<b>4,00</b>	<b>MC</b>
<b>Lack of trust in food retailing can be an obstacle to the establishment of personalized offers in retail.</b>	<b>3,42</b>	<b>MC</b>

## Authors and contact details



**Kathrin Friedrichs**

Researcher  
Research team personalized  
nutrition



**Isabella Bauer**

Scientific Assistant  
Research team personalized  
nutrition



**Dr. Cornelia Klug**

Research Center Lead  
Research team personalized  
nutrition



**Prof. Dr. Günter Käßer-Pawelka**

Research Leader  
Research team personalized  
nutrition



**Prof. Dr. Katja Lotz**

Project Lead  
Research team personalized  
nutrition

**Duale Hochschule Baden-  
Württemberg Heilbronn**  
Bildungscampus 4  
74076 Heilbronn  
<http://bit.ly/3EsHURQ>

“Together shaping the future of food” - this is the motto of the Business Administration-Food Management course at DHBW Heilbronn. Here, economics is combined with the content of nutritional sciences. In addition to classic business subjects (e.g. accounting, marketing or human resources), the focus is on lectures related to the food industry (e.g. “From-Farm-to-Fork”, merchandise science, flavor science or dietetics). A special highlight of the DHBW Heilbronn is our laboratory landscape, where practical experiments in the areas of sensory analysis, product development and market research make the studies even more lively.

At DHBW Heilbronn, we link research by integrating it into the dual study program. In this way, we ensure that the findings derived from research find their way into business practice and ultimately to consumers. The Personalized Nutrition research project was formed in 2020.

## BUSINESS ADMINISTRATION-FOOD MANAGEMENT



Online available from 16th November 2022

<https://www.food-management.online>

Suggested Citation:

Friedrichs K, Bauer I, Klug C, Käßer-Pawelka G, Lotz K (2022): Wie sieht die Zukunft der Personalisierten Ernährung aus? Ergebnisse einer Delphi-Studie. In: Schriftenreihe Food Management, Research Paper #4, Duale Hochschule Baden-Württemberg Heilbronn (DHBW) (Hrsg.)