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# Innovative pLAnt Protein fibre and Physical activity solutions to address poor appEtite and prevent undernUTrITion in oldEr adults – APPETITE

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## Abstract

Older adults with poor appetite are at higher risk of undernutrition due to the role of appetite as a key driver of food intake. Dietary protein and fibre are critical nutrients in this population, and enhancing their intake is vital to preventing undernutrition and maintaining organ function and health. In *APPETITE*, a transdisciplinary consortium of experts from eight institutions in six European countries will collaborate to design potentially effective interventions to enhance protein and fibre consumption of community-dwelling older adults with poor appetite, thereby addressing undernutrition through a targeted nutrition- and physical activity-based strategy. Older adults with poor appetite will first be evaluated using a mixed-methods approach to gain insights into their nutritional and behavioural preferences. Working with this target group, innovative, acceptable and affordable food products will be developed that combine several domestic plant proteins and dietary fibres. Mechanistic insights will be gained by examining the impact of selected products and physical activity on digestibility, amino acid bioavailability and whole-body protein metabolism. In a multi-country, randomised controlled intervention trial, the impact of two new food products, provided as part of a personalised diet, a physical activity programme, and their combination will be determined. *APPETITE* will improve our understanding about plant-based protein and fibre products and their metabolic and clinical effects. It will create

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new knowledge about how these products can be combined in a whole-diet approach, together with physical activity and regular social contacts, to overcome undernutrition and to contribute to a better quality of life for older Europeans.

**KEYWORDS**

appetite, fibre, malnutrition, older adults, personalised nutrition, plant protein, undernutrition

## INTRODUCTION

Older people have a higher risk of undernutrition, which leads to serious adverse health outcomes. However, effective preventive strategies are lacking. New strategies should focus on the aetiology of undernutrition and directly address potential causes and underlying mechanisms (Cox et al., 2020; Volkert et al., 2019).

A key aetiological factor directly affecting food intake is poor appetite (Cox et al., 2020; Landi et al., 2017), which is reported by about one in four community-dwelling older adults (Hung et al., 2019; van der Meij et al., 2015, 2017), and is independently related to adverse health outcomes, such as impaired physical performance, sarcopenia, frailty, disability and mortality (Landi et al., 2016). Reduced food intake and restricted dietary diversity have been linked to poor appetite (Cox et al., 2020). Lower intakes of protein and dietary fibres have been described in older persons with poor appetite, alongside lower intake of several nutrient-rich food groups (e.g. meat, fish, wholegrains, vegetables), and a higher consumption of food groups low in micronutrients (e.g. fats, oils, sweets and sugar-sweetened beverages), compared to those with good appetite (van der Meij et al., 2017).

Interventions designed to increase appetite, or increase dietary intake despite a poor appetite, should therefore be key to preventing undernutrition (i.e. protein-energy malnutrition as well as nutrient deficiencies). However, treatment strategies for poor appetite are not well-established, and the evidence regarding the effectiveness of interventions to address anorexia in older people is currently very limited (Cox et al., 2019).

Enhancing dietary protein and fibre intake in older Europeans is a key objective because sub-optimal intakes of both nutrients are common, not only in those older adults with poor appetite (ter Borg et al., 2015; Kehoe et al., 2019; Tieland et al., 2012). Adequate protein intake can prevent excessive decline in muscle mass and function (sarcopenia), a widespread health-issue in older adults, intensified by undernutrition (Deer & Volpi, 2015). Adequate dietary fibre intake prevents constipation and can slow down the development of many chronic diseases prevalent in older people (Stephen et al., 2017). Thus, targeting adequate protein and fibre intakes may be particularly beneficial in this vulnerable population. Potential satiating effects

of protein are acknowledged in the general adult population (Paddon-Jones et al., 2008), but are not necessarily relevant for the older population (Clegg & Williams, 2018). A recent systematic review addressing this topic came to the conclusion that protein supplementation did not compromise energy intake in healthy older adults and may represent an effective solution to tackle protein deficiencies in this population group (Ben-Harchache et al., 2021). Also, satiating effects of fibre are discussed in the adult population, mainly in relation to weight reduction in overweight people. However, a systematic review of 107 treatments with 38 different fibre sources, summarised that acute fibre interventions mostly did not reduce appetite or food intake (78%) or enhance satiety (61%). Neither fibre type nor fibre dose was related to satiety response or food intake (Clark & Slavin, 2013). In older adults, no appetite suppression was observed in a recent 10-week, randomised, blinded, crossover study to test the effects of consuming snacks fortified with pea hull fibre. The authors conclude that this fibre may be appropriate for older adults at nutritional risk (Alyousif et al., 2020). Accordingly, addition of protein and fibre to the usual diet of older persons with poor appetite seems a promising strategy to improve intake of these nutrients.

However, prevention of undernutrition cannot be achieved by solely offering specific nutrients or a specific food product, given the observed heterogeneity in eating patterns across older populations and established lifelong dietary habits. Beneficial long-term effects can only be expected with a more comprehensive approach, considering individual dietary habits and food preferences, which are, however, currently largely unknown in the high-risk population of older adults with poor appetite. In addition, non-dietary factors, such as, physical activity, social and health aspects, need to be considered as these are relevant factors in the aetiology of poor appetite (Cox et al., 2020). Furthermore, to be successful, intervention strategies need to be participatory, involving older people from the concept-planning stages onwards (Robinson, 2018).

When considering the role of protein in the maintenance of muscle strength and function, not only the amount of protein but also the type and quality are important, since digestibility and bioavailability of amino acids (AA) and whole-body protein metabolism are affected by these aspects (Dardevet et al., 2021; Deutz et al., 2014). Previous research on this topic has

focussed on animal protein sources, particularly whey protein, which has been shown to be better digested and have greater anabolic properties compared to plant proteins (Boirie & Guillet, 2018). However, plant proteins are more affordable and environmentally sustainable, and various domestic plant-protein sources are available. In older adults, good acceptance of plant protein sources, similar to meat, is reported (Grasso et al., 2019). In view of these advantages, and in light of the huge environmental impact of human nutrition, strategies to improve digestibility and anabolic properties of plant proteins are urgently required.

It is well known that digestibility of proteins and subsequent AA bioavailability are greatly affected by food structure and matrix, particle morphology and cooking procedures (Barbe et al., 2013; Buffiere et al., 2017; Nyemb et al., 2014). In addition, particle morphology, particle size, as well as physicochemical properties (i.e. water binding, viscosity) of dietary fibres are known to affect digestibility either directly or indirectly via the microbiome (David-Birman et al., 2013; Mandalari et al., 2018; de Marco Castro et al., 2021). Knowledge on the impact of particle morphology in relation to the digestibility of different plant proteins and combinations of plant proteins with dietary fibres is however scarce.

Anabolic properties of plant proteins can be improved by fortification with specific essential AA or by combining several plant-protein sources to achieve a more favourable AA profile (Dardevet et al., 2012; Jarzaguet et al., 2018; Walrand et al., 2016). These strategies, in particular the addition of specific essential AAs, may affect taste, texture and palatability, which are highly relevant for consumer acceptance, and thus, need to be considered. Consumers need to be involved at very early stages of development in order to generate acceptable products. Anabolic properties of dietary protein may also be enhanced by physical activity (Gorissen & Witard, 2018). As well as the expected improvements in lean body mass and muscle function following 12 weeks of exercise in healthy older adults, adjustments in skeletal muscle signalling were detected, favouring protein synthesis pathways (Krause et al., 2019). These anabolic effects are well studied for animal protein (Boirie & Guillet, 2018), but little is known about the effects of plant proteins on digestion and protein metabolism. Physical activity also enhances energy expenditure and may increase appetite in some circumstances, but evidence for this in older adults and an understanding of underlying mechanisms is currently very limited (Clegg & Godfrey, 2018; Grannell et al., 2019).

Thus, understanding how nutritional interventions, namely the addition of plant-based proteins and fibre as part of a personalised diet, alone or in combination with physical activity, may impact on clinical outcomes (i.e. appetite, dietary intake, nutritional and functional status) as well as the underlying physiological

mechanisms (i.e. AA bioavailability and protein metabolism) would be a huge step forward and an important milestone in developing new approaches to combat undernutrition in older adults.

## OBJECTIVE OF APPETITE

The overall objective of *APPETITE* is to prevent undernutrition in community-dwelling older adults by enhancing appetite through targeted nutrition and physical activity. This objective will be pursued firstly by developing innovative, acceptable, accessible, and affordable food products based on combinations of several plant proteins and dietary fibres for and together with older adults with poor appetite. Subsequently, the effects of selected products as part of personalised diet—with and without physical activity—on digestibility, AA bioavailability and whole-body protein metabolism, appetite, incidence of undernutrition and other nutritional and functional outcomes will be examined in older adults with poor appetite who are at higher risk of undernutrition.

## FEATURES AND DESIGN OF APPETITE

*APPETITE* is a transnational research project in the framework of the Strategic Research Agenda of the Joint Programming Initiative (JPI) 'A Healthy Diet for a Healthy Life' (HDHL), proposed and granted in the call *Development of targeted nutrition for prevention of undernutrition for older adults (PREVNUT)*. The project started officially on 1 April 2021 and is planned for a period of 3 years with a total funding of €1.2 million from national funding authorities and additional €0.5 million in kind contribution.

A transdisciplinary consortium of experts from eight institutions in six European countries (Table 1) will collaborate in six work packages (WP) which are closely interrelated (Figure 1) and described below. An overview of the objectives and responsible partners for each WP is given in Table 2, and related tasks with the rough timeline are listed in Table 3.

Figure 1 illustrates the project design as a balance between physical activity and the personalised intervention diet, including the newly developed plant-based protein and fibre food products, which will be examined at biochemical and at clinical levels (Figure 2).

The target population of *APPETITE* is older persons aged 70 years or older with poor appetite according to the Simplified Nutritional Appetite Questionnaire (SNAQ, score < 14; Wilson et al., 2005), at high risk of undernutrition (BMI 22–24 kg/m<sup>2</sup> or involuntary weight loss <5% in past 6 months) and being inactive (<150 minutes physical activity per week and no regular resistance training, Bull et al., 2020).

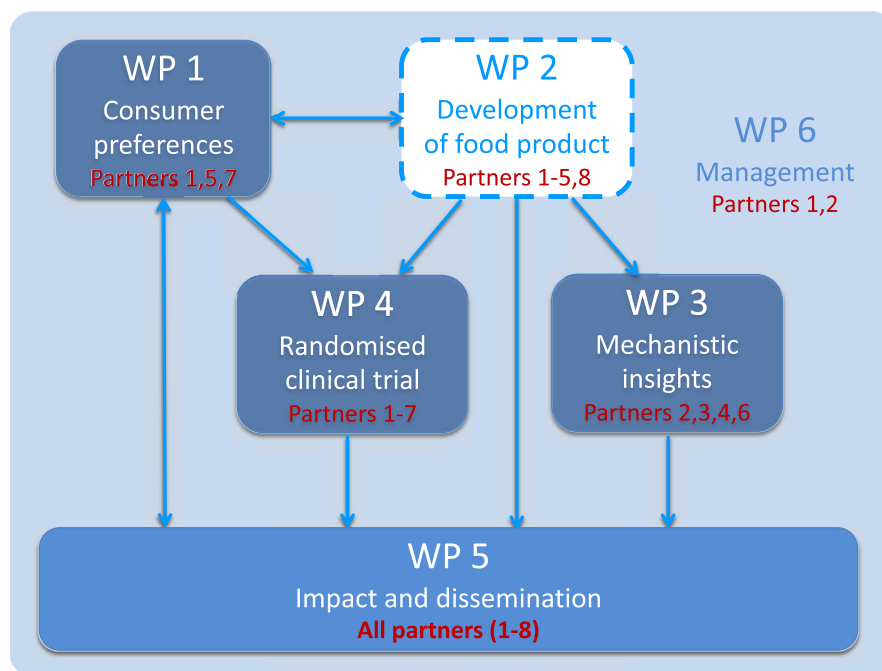
**TABLE 1** Members of the APPETITE Consortium

1-FAU <sup>a</sup>	Friedrich-Alexander-Universität Erlangen-Nürnberg <i>Institute for Biomedicine of Aging</i>	Germany
2-UCD	University College Dublin <i>School of Public Health, Physiotherapy and Sports Science</i>	Ireland
3-INRAE	Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement <i>INRAE Centre de Theix, Unité de Nutrition Humaine</i>	France
4-IVV	Fraunhofer Institute for Process Engineering and Packaging	Germany
5-NU	Newcastle University <i>NIHR Newcastle Biomedical Research Centre</i>	UK
6-UNIPD	University of Padua <i>Department of Biomedical Science, Neuromuscular Physiology Laboratory</i>	Italy
7-VU <sup>b</sup>	Vrije Universiteit Amsterdam <i>Faculty of Science, Department of Health Sciences</i>	The Netherlands
8-B2F <sup>b</sup>	Bridge2Food	The Netherlands

<sup>a</sup>Project Coordinator.

<sup>b</sup>Project Collaborators.

**FIGURE 1** APPETITE work packages (WPs) with involved partners and their interrelation



## WP1: Understanding the older consumer with poor appetite

As a basis for the other WP and activities, WP1 aims to achieve a better understanding of community-dwelling older adults with poor appetite. Characteristics and preferences of this target group will be evaluated by taking a mixed-methods approach based on qualitative interviews (Task 1.1) and quantitative data analyses (Task 1.2).

In Task 1.1, a consumer panel of 6–10 older adults from VOICE ([www.voice-global.org](http://www.voice-global.org)) will be established at the start of the project to discuss and guide further work. Supported by the panel, qualitative interviews will be performed with community-dwelling older adults with poor appetite or at risk of undernutrition to develop understanding of the determinants of poor appetite and gain insights into nutritional and behavioural preferences, including helpful strategies to maintain and/or increase food intake.



**TABLE 2** The APPETITE objectives per work package (WP)

WP number	Title and objective	Partners responsible
1	<i>Understanding the older consumer with poor appetite</i> To gain detailed insight into characteristics and preferences of community-dwelling older persons with poor appetite to support development of consumer-centered food products, inform shaping of the intervention, and facilitate screening and recruitment of older persons to participate in the mechanistic and in the clinical trial	5-NU, 7-VU
2	<i>Innovative, sensorily attractive plant protein fibre products</i> To develop innovative plant-protein fibre (PPF) products with attractive sensory properties and balanced amino acid profiles in cooperation with older adults with a poor appetite, elucidate product characteristics and their effect on <i>in-vitro</i> digestibility, and provide products for WP3 and WP4	4-IVV, 1-FAU
3	<i>Mechanistic insights</i> To gain mechanistic insights by examining the impact of innovative PPF products, physical activity and probiotic interventions on digestibility, amino acid bioavailability and whole-body protein metabolism in older persons with poor appetite	3-INRAE, 6-UNIPD
4	<i>A randomised controlled trial to prevent undernutrition in older adults with a poor appetite</i> To determine the impact of innovative PPF products as part of a personalised optimised diet, a physical activity program, and their combination on appetite, incidence of undernutrition and other nutritional, functional and clinical outcomes in older persons with a poor appetite and at high risk of undernutrition in a multi-country randomised controlled intervention trial	2-UCD, 7-VU
5	<i>Impact and dissemination</i> To provide accurate information from the APPETITE project background, objectives, approaches and results to a wide audience of stakeholders in order to rise awareness, share knowledge and improve dialogue between researchers, healthcare providers, policy-makers, industry and the older population.	2-UCD, 1-FAU
6	<i>Management</i> To organise an efficient project structure and manage legal, administrative and data management issues appropriately	1-FAU, 2-UCD

FAU, Friedrich-Alexander-Universität Erlangen-Nürnberg; INRAE, Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement; IVV, Fraunhofer Institute for Process Engineering and Packaging; NU, Newcastle University; UCD, University College Dublin; UNIPD, University of Padua; VU2, Vrije Universiteit Amsterdam.

In Task 1.2, existing data on dietary intake and appetite from a large dataset of older participants from the *Longitudinal Aging Study Amsterdam (LASA)* will be used to compare older adults with a poor versus a normal appetite with respect to physical, emotional, cognitive and social factors as well as regarding nutrient and food group intakes. Information on appetite assessed in two consecutive LASA waves will be used to distinguish acute from chronic poor appetite, and to clarify whether older adults with acute and those with chronic poor appetite differ with respect to subject and dietary characteristics.

Integrated findings from both tasks will inform consumer-centred product development in WP2, facilitate screening and recruitment of older adults to participate in the mechanistic trials (WP3) and in the clinical trial (WP4), and allow shaping of the two intervention strategies in WP4.

## WP2: Innovative, sensorily attractive plant protein fibre products

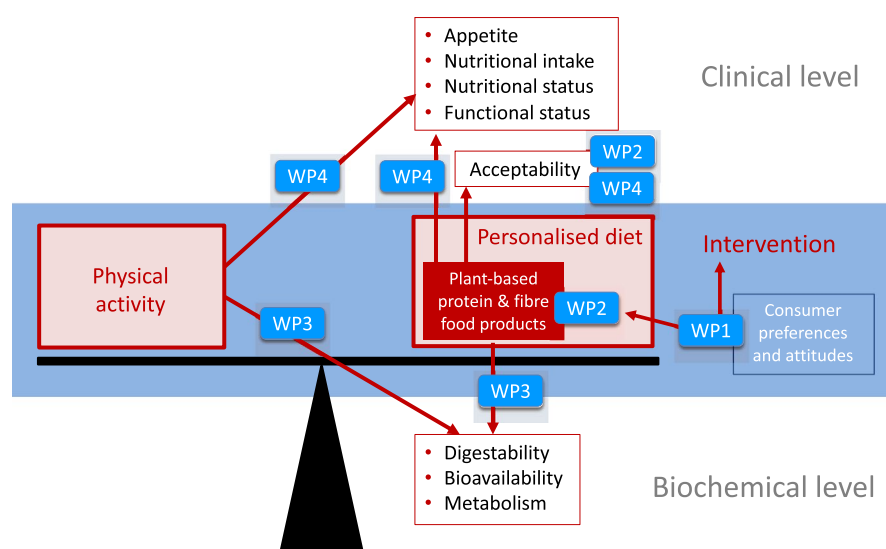
WP2 is dedicated to the development, characterisation and provision of innovative plant-protein fibre (PPF)

products with attractive sensory properties and balanced AA profiles, which are at the same time well-digested, sustainable, affordable and easily usable. Different domestic plant proteins will be combined to optimally balance AA profiles, mimicking whey protein. Based on the AA profiles of commercially available plant protein isolates, analysed after hydrolysis by chromatography, AA ratios will be calculated and ideal combinations determined. Dietary fibres of the same sources (e.g. wheat, corn, pea fibres) will be added (Task 2.1).

Besides a trained panel of product testers at the Fraunhofer Institute for Process Engineering and Packaging (IVV), older adults with a poor appetite will be involved from the beginning to give feedback on sensory properties and liking of the new products, which will then be adapted accordingly in further development steps. Up to six PPF mixtures will be tested in two different model foods, one sweet (e.g. porridge) and one savoury (e.g. soup), typically eaten by older adults in the participating APPETITE partner countries. In parallel with the product development, possibilities for application of the PPF products and tips on their incorporation into a daily diet will be developed and tested together with older adults with poor appetite (Task 2.2).

**TABLE 3** The APPETITE work packages and related tasks

No	Title	Months
<b>1</b>	<b>Understanding the older consumer with poor appetite</b>	<b>1–18</b>
1.1	Working in partnership with older adults and elucidate consumer perspective	1–18
1.2	Phenotyping the older adult with a poor appetite	1–18
<b>2</b>	<b>Innovative, sensorily attractive plant-protein fibre products</b>	<b>1–36</b>
2.1	Product development and provision for WP3 and WP4	1–18
2.2	Sensory and applicability testing by older persons with poor appetite	4–20
2.3	Characterisation of particle morphology and <i>in-vitro</i> digestibility	4–36
<b>3</b>	<b>Mechanistic insights</b>	<b>1–36</b>
3.1	Determination of <i>in-vivo</i> plasma amino acid (AA) appearance from plant-protein fibre products	6–16
3.2	Determination of effective AA bioavailability, splanchnic extraction and protein utilisation from a plant-based protein fibre product in comparison to whey protein	18–36
3.3	Establishing the impact of physical activity on dietary AA bioavailability, splanchnic extraction and utilisation from a plant-based protein-fibre mixture in comparison to whey protein	18–36
3.4	Examine the effects of probiotics on metabolism and appetite	1–18
<b>4.</b>	<b>A randomised controlled trial to prevent undernutrition in older adults with a poor appetite</b>	<b>1–36</b>
4.1	Preparation of the personalised nutrition and physical activity trial	1–18
4.2	Recruitment, execution of the trial and data entry	12–24
4.3	Data analyses to determine the effectiveness of the interventions	24–36
<b>5.</b>	<b>Impact and dissemination</b>	<b>1–36</b>
5.1	Develop a quality plan for creating effective use and dissemination	1–6
5.2	Install stakeholder advisory board	1–3
5.3	Targeted actions to address a wide range of stakeholders	1–36
<b>6.</b>	<b>Management</b>	<b>1–36</b>
6.1	Project management	1–36
6.2	Data management	1–36



**FIGURE 2** APPETITE project design: Balance between physical activity and nutrition at clinical and biochemical level

Furthermore, PPF products will be characterised regarding particle morphology, for example size (using a MasterSizer), porosity (using a Malvern Morphologi 4 system) and visual appearance (using scanning electron microscopy), and the impact of different PPF mixtures and their particle morphology on *in-vitro* digestibility will be determined. An *in-vitro* digestion model established at IVV will be used to determine digestibility of up to 10 sensorily attractive PPF products in comparison to an *in-vitro* protein digestibility-corrected AA score (PDCAAS) test (Megazyme K-PDCAAS 12/19; Task 2.3).

Based on the findings of this work package, a number of PPF mixtures with attractive sensory properties, optimal AA profiles and high *in-vitro* digestibility will be selected and provided for the examination of *in-vivo* digestibility and metabolic effects in WP3 and for use in the clinical intervention study in WP4.

### WP3: Mechanistic insights

WP3 aims to gain insights into the metabolic effects of the new PPF products with and without physical activity. More precisely, the effects of the new PPF products on splanchnic extraction (*i.e.* the retention of dietary AA by the gut and liver for their own needs), peripheral AA bioavailability and utilisation (protein retention), and on muscle signalling markers will be investigated before and after a physical activity programme in older adults with a poor appetite.

First, in a preparatory short-term study with 10 healthy older adults, AA bioavailability will be determined by measuring net peripheral plasma AA appearance after consumption of three selected PPF products compared to the reference of 30 g whey protein (Task 3.1). This will allow comparison of *in-vitro* (WP2 Task 2.3) and *in-vivo* digestibility of several PPF mixtures and identify the product with both optimal AA composition and sensory properties as well as optimal postprandial plasma AA profile to be tested.

In Task 3.2, selected PPF products will be compared to whey protein when included in a complete meal in a randomised cross-over study in 12 inactive older adults with poor appetite (a subgroup of persons participating in WP4 with physical activity but without nutritional intervention). Throughout a test day, with either a PPF or a whey protein test meal, splanchnic extraction, dietary AA bioavailability and whole body protein metabolism (protein synthesis, protein breakdown, AA oxidation and net balance) will be evaluated using stable isotope tracers ([U-15N] spirulina added to test meal and [1-13C] leucine or [13C] bicarbonate administered intravenously). All measurements, including blood sampling and indirect calorimetry, will be performed before the meal and postprandially at regular intervals for 420 minutes. In addition, postprandial

appetite biomarkers (ghrelin, GLP-1, PYY) will be determined in all blood samples, and a muscle biopsy will be collected postprandially following the PPF meal for examination of signalling markers of muscle plasticity (atrogin1, MURF1, LC3, BNIP3, Akt-dependent mTOR and FxO), metabolic adaptations (AMPK and PGC1alpha) and denervation (AChR subunits expression, agrin/MuSK/Lrp4, NCAM, and Myog).

After finishing the 12-week physical activity programme described in WP4, all measurements from Task 3.2 will be repeated after separate consumption of both test meals on two more test days using the same procedures. The effects of the physical activity programme and PPF meal on AA bioavailability, splanchnic extraction, protein utilisation, and also on appetite biomarkers will be investigated in comparison to the effects of the physical activity programme and the whey protein meal. Muscle signalling markers following the PPF meal before and after the physical activity programme will be compared (Task 3.3).

An additional task will be to elucidate the effects of a previous probiotic intervention together with dietary plant-based proteins on the peripheral bioavailability of AA and on appetite in inactive older adults at risk of undernutrition. Twelve older adults consuming a standardised plant-based diet previously completed a randomised, placebo-controlled crossover-trial at University College Dublin (UCD) with 8 weeks of probiotic supplementation versus control with an 8-week wash-out period. Appetite was assessed pre- and post-intervention using SNAQ and daily visual analogue scale (VAS) ratings. In *APPETITE*, biological indicators of appetite will be assessed in the postprandial state, wherein appetite-related gut peptides (*e.g.* ghrelin, GLP-1, PYY) in response to a plant-based meal will be determined. From the metabolic perspective, plasma and faecal water metabolomic profiles and gut microbiome diversity (16S) will be determined using untargeted and targeted (AA, short chain fatty acids) approaches to give greater mechanistic insight into potential effects of probiotic supplementation on metabolites associated with appetite (Task 3.4).

### WP4: A randomised controlled trial to prevent undernutrition in older adults with a poor appetite

In WP4, the impact of innovative PPF products as part of a personalised optimised diet, a physical activity programme, and their combination will be determined in community-dwelling older adults with a poor appetite and at high risk of undernutrition in a multi-country randomised controlled intervention trial. In each of four study centres—in Ireland, France, Germany and Italy—60 community-dwelling adults aged 70 years or older with poor appetite, at high risk of undernutrition



and who are inactive will be recruited by established methods and contacts at each centre (e.g. newspaper advertisement, local senior centers and meeting places, participants of previous studies) and randomly allocated to one of the following four groups, stratified by sex at each site: (1) personalised diet plus physical activity programme, (2) usual diet plus physical activity, (3) personalised diet and no physical activity, and (4) control (usual diet, no physical activity). Persons with major cognitive impairment, clinical depression or other current medical conditions affecting appetite or currently taking medications affecting appetite will be excluded.

A personalised diet will be developed by a dietitian based on usual dietary habits and applied with individual counselling and PPF recipes. Two PPF product variants (one sweet, one savoury) with the best AA blend, taste, and bioavailability—as determined in WP2 and WP3—will be used with the aim to increase daily intake of protein by 40 g and daily intake of fibre by 10 g. The new products will be incorporated into individuals' habitual diets to enhance dietary intake despite self-reported poor appetite. The physical activity intervention will be a structured exercise programme based on the successful and safe *Lifestyle Interventions and Independence for Elders (LIFE)* trial, incorporating aerobic, strength, flexibility and balance training, and consisting of two group sessions and three home sessions per week (Pahor et al., 2014).

At baseline and after 12 weeks, important participant characteristics and outcome variables will be assessed. Fasting blood and faecal samples will be collected in a random sub-sample of participants across sites. The primary endpoint is the change in appetite determined by a subjective rating (VAS) and an objective measurement (*ad libitum* test meal energy intake). Furthermore, intervention effects on daily protein, fibre and energy intakes (3-day diet records), incidence of undernutrition (loss of bodyweight and lean body mass assessed using BIA [all sites] and DXA [three sites]), hedonic responses (validated questionnaire), endurance capacity (400 m walk test), muscle strength (isometric handgrip and leg strength), muscle motor unit recruitment (high density electromyography) and motor unit number (motor unit number estimates technique) and quality of life (EQ-5D) as well as consumer rating of the interventions and new products will be assessed.

The three tasks in this work package deal with trial preparation, including development of questionnaires and standard operating procedures, staff training and ethical approvals (Task 4.1), recruitment, trial execution and data entry (Task 4.2), and finally, data analyses to determine the effectiveness of the interventions (Task 4.3), using approaches employed in other European multi-centre dietary intervention studies (Shaw et al., 2009; Tierney et al., 2011).

## WP5: Impact and dissemination

WP5 includes a range of activities to ensure broad dissemination and far-reaching impact of the project. Information about *APPETITE* will be provided to a wide audience of stakeholders in order to raise awareness, share knowledge and improve dialogue between researchers, healthcare providers, policy-makers, industry and older adults themselves.

As a first task, a quality plan for effective use and dissemination to all critical stakeholders will be developed jointly by all partners (Task 5.1).

A stakeholder advisory board was established at the start of the project (Task 5.2). International experts in the field who are also well connected to relevant European professional societies were identified and asked to advise the *APPETITE* management team. Advisory board members will be kept informed about the project progress and will be invited to participate in project meetings. They will be involved in relevant decision-making and are asked to promote dissemination of *APPETITE* outputs nationally and internationally.

In Task 5.3, targeted actions will be taken and all relevant stakeholder groups addressed according to the dissemination plan developed in Task 5.1. For example, a wide audience will be reached by internet (JPI and partner institutions' websites) and press releases, older adults and their families will be informed by information from the *APPETITE* consortium which will be circulated widely through healthcare and nutrition-related websites and be available for download. Healthcare professionals, scientific communities and industry will be reached by *APPETITE* presentations and stands at (inter)national conferences. Project protocols and results will be published in high-impact, peer-reviewed open access international scientific journals. Industry will be invited to a workshop addressing specific food product development issues. Policy- and decision-makers will be informed by proactive strategies, for example policy reports and briefings.

## WP6: Management

WP6 is dedicated to the management of the *APPETITE* project in order to organise an efficient project structure and manage legal and administrative issues appropriately (Task 6.1). Progress in the WPs will be actively monitored and aligned between WPs, and dissemination activities and communication with stakeholders will be coordinated.

In Task 6.2, data management within the project will be organised, supervised and coordinated. A data management plan has already been developed together with all partners, including all WPs and all data used, assessed and analysed during the project.

The data management plan will ensure that data handling complies with the FAIR guidelines of Findability, Accessibility, Interoperability, and Reusability (Wilkinson et al., 2016). All data from which published results are derived will be available for other researchers on request.

## DISCUSSION

In *APPETITE*, eight institutions from six European countries are collaborating to develop new approaches to enhance the protein and fibre consumption of older adults with poor appetite to overcome undernutrition, which is a widespread, and still yet unsolved problem.

Thus, *APPETITE* is addressing the highly relevant topic of undernutrition in older adults by tackling a key cause, poor appetite, and offering attractive food products as part of a comprehensive intervention approach. The project aims to create new knowledge in three important areas: (1) how affordable, accessible and sustainable plant-based protein and dietary fibre can be combined to produce sensorily attractive food products, (2) the mechanisms that explain how these products are digested, absorbed and metabolised and (3) how these food products, in the context of generally improved nutrition, together with physical activity and regular social contacts during regular group training sessions and individual dietary counselling meetings may contribute to overcoming undernutrition. A better understanding of the role of physical activity and the balance between nutrition and physical activity will result, which is required to inform public health measures and also provides the basis for future research projects building on this new knowledge.

The consortium teams include experienced scientists in the fields of nutrition science and dietetics, epidemiology, geriatric medicine, food processing and technology, sports medicine and physical activity, physiology, biochemistry and metabolic research, sensory sciences, and qualitative research. These different competences and longstanding expertise complement each other and cover all fields required for the successful completion of the ambitious *APPETITE* project.

Our transnational collaboration is partly based on successful cooperation within the MaNuEL Knowledge Hub (Visser et al., 2017; Volkert et al., 2020) which has been extended to additional new partners with complementary expertise. It enables translational research from the development of food products in cooperation with the target group, and testing of the newly developed products at experimental levels to clinical application using harmonised methods and technologies in shared samples. Clinical research facilities in four countries allow the conduct of a multi-centre study in different European regions with varying dietary habits and environments. Collaboration with *Bridge2Food*

([www.bridge2food.com](http://www.bridge2food.com)) allows extensive exchange between researchers and the food industry and paves the way for further developments and future use of the products at large-scale industrial level.

Importantly, it is one of *APPETITE*'s main objectives to provide comprehensive and accurate information about the project, its background, approaches and results to a wide audience of stakeholders in order to raise awareness, share knowledge and improve dialogue between researchers, healthcare providers, policy-makers, industry and older adults. Thus, we anticipate that the research will have a significant impact on future product developments and policy decisions to reduce the prevalence of undernutrition in older adults in Europe and a special WP of *APPETITE* is dedicated to impact and dissemination (WP5) to meet this aim.

Effective dissemination of the project approaches and findings to a wide audience will increase awareness and debate about the topic among relevant target groups including older adults themselves, policy-makers, healthcare providers and industry. Based on the real-life, person-centred interventions in *APPETITE*, older adults will be empowered to engage in strategies to optimise a health-promoting lifestyle and reduce undernutrition. *APPETITE* strategies and results will be useful to guide policy and revise and improve recommendations and guidelines regarding nutrition, physical activity and prevention of undernutrition in close cooperation with older adults themselves and relevant international and national stakeholders across Europe. Moreover, the wider learnings from this research could be exploited by other population groups, for example, vegetarians, many of whom may benefit from the incorporation of plant-based protein products and physical activity into their lifestyle behaviours.

In summary, *APPETITE* will improve our understanding about plant-based protein and fibre products and their metabolic and clinical effects. It will create new knowledge on how these products can be used in a whole-diet approach together with physical activity and regular social contacts to overcome undernutrition and to contribute to a better quality of life for older Europeans.

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## CONFLICT OF INTEREST

The authors have no conflicts of interest to disclose.

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