

*Fibre4life: investigating older adults dietary fibre preferences and the role of targeted educational materials on modulating future dietary fibre intake*

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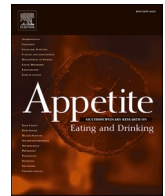
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# Fibre4life: Investigating older adults dietary fibre preferences and the role of targeted educational materials on modulating future dietary fibre intake

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## ABSTRACT

The UK has an ever-increasing ageing population; hence, promoting balanced nutrition can have fundamental health and cost benefits. In addition, the majority of older adults' dietary fibre intake is below recommendations and this is despite its well-cited benefits; therefore, more emphasis should be placed on identifying viable age-suitable strategies to overcome the associated dietary fibre-related knowledge gap. Accordingly, one hundred and seventy older adults (65–87 years) were recruited to partake in two survey related studies: (1) initial insights (e.g., dietary fibre-related knowledge, awareness, attitudes and behaviour as well as information preferences) were captured to inform the design of educational materials; and (2) the impact of two targeted educational materials on modulating older adults' future dietary fibre intake was tested. Older adults were willing to learn more about dietary fibre and requested additional information relating to its benefits, recommendations and food-based examples in a clear and accessible format. Therefore, two educational materials (factsheet and practical tips) were developed encompassing key themes. Overall, older adults engaged with the educational materials (regardless of topic and format); thus, demonstrating the potential benefits of this approach going forwards. There was strong agreement with all variables: learning something new, change future dietary fibre intake, format liking, content engaging and share with others as well as the overall experience being cited as useful/helpful. Going forwards, importance should be placed on measuring dietary fibre consumption post engaging with educational materials. In addition, utilising a holistic approach incorporating support from different sources (e.g., health professionals, government, food companies, supermarkets and community) could be fundamental in helping older adults to consume more dietary fibre and subsequently contributing to positive health outcomes.

## 1. Introduction

The UK has a growing ageing population; accordingly, there is increasing emphasis on the concept of healthy ageing to help preserve functional ability (ONS, 2019; World Health Organisation WHO, 2020). More broadly, ageing is considered a multidimensional process incorporating physical, psychological and social aspects that can contribute to disease risk and subsequently impact nutritional status (Armstrong et al., 2015; SACN, 2021). However, nutrition can have a strong influence on health and well-being in the ageing population (Volkert et al.,

2019). Despite well-cited evidence to support the benefits of a healthy diet; uptake is often insufficient relating to macro-and-micro-nutrients in this age group (Clegg et al., 2023; Dorrington et al., 2020; SACN, 2021). In addition, older adults are often unaware that nutritional requirements may modify with age; therefore, they need sufficient knowledge and understanding so that they can make more informed decisions (Doma et al., 2019a; Castro et al., 2021). This is particularly relevant for dietary fibre, a key macronutrient, where consumption is consistently below UK dietary recommendations, as evident in the recent Scientific Advisory Committee on Nutrition (SACN) report on

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older adults (SACN, 2021).

The recent National Diet and Nutrition Survey (NDNS) data noted that the mean dietary fibre intake of older adults (e.g., 65 years or over) in the UK is 18.3 g/d, which is substantially below the 30 g/d recommendations (SACN, 2015; Norton, Kaimila, et al., 2023; ONS, 2023). There is consistent evidence that dietary fibre-rich diets can reduce cardiovascular disease, coronary events, stroke, type 2 diabetes and cancer (colorectal) risk; leading to noteworthy public health benefits (SACN, 2015). However, older adults typically consume inadequate amounts of dietary fibre-rich foods which include: fruits, vegetables, breakfast cereals, wholemeal (bread, pasta and rice), pulses, peas, beans, nuts and seeds resulting in low overall dietary fibre intake (Kehoe et al., 2021; McKeown et al., 2022). This could be driven by a number of factors such as cost of dietary fibre-rich foods, cooking restraints, unappetising sensory properties, potential side effects (e.g., bloating), poor understanding of the health benefits, intake related confusion, inadequate on pack labelling as well as uncertainty associated with sufficient quantity and identification of dietary fibre-rich foods (Ipsos Mori, 2012; Barrett et al., 2020; Buttriss, 2015; Hooper et al., 2015; Kossioni, 2018; Lockyer et al., 2016; McKeown et al., 2022; Meynier et al., 2020; Robinson & Chambers, 2018; Tarrega et al., 2017). In addition, age-related changes (e.g., modulated appetite, sensory sensitivity, oral impairments, etc.) can impact older adults' eating experience (Methven et al., 2012; Morley, 2001; Norton, Lignou, Faka, & Methven, 2022; Vandenberghe-Descamps, et al., 2017; Volkert et al., 2019; Whitelock & Ensaif, 2018). Therefore, developing age-suitable targeted educational materials could be an ideal starting point to help nudge older adults to consume more dietary fibre.

Importantly, nutrition education related interventions in older adults can be effective in modulating intake, improving dietary habits, knowledge, behaviour and health literacy as well as encouraging label awareness (MacNab et al., 2017; Zhou et al., 2018; Neves et al., 2020; Barnett & Zeng, 2022; Alghamdi et al., 2023). However, more research is required as there are limited studies in older adults and specifically focusing on a particular nutrient. Accordingly, developing co-created and targeted dietary fibre specific educational materials (using older adults in the design stage) could be a viable approach to help promote dietary fibre intake in the ageing population; hence, this needs relevant investigation. Emphasis needs to be placed on utilising a targeted, innovative, simplistic, positive, enjoyable, practical and evidence-based approach which is easy to implement as well as resonating with the individual to maximise benefits (Appleton & Adams, 2023; Bhargava & Hays, 2004; Frieden, 2014; MacNab et al., 2017; Ruxton et al., 2023). Fundamentally, information needs to be communicated effectively to older adults so that they can overcome the associated dietary fibre-related knowledge gap and subsequently increase dietary fibre intake. Therefore, to address this our study aims to: (1) explore older adults' awareness, attitudes and expectations towards dietary fibre-rich foods as well as preferences for educational materials; (2) design age-suitable co-created targeted dietary fibre educational materials based on initial insights; and (3) test the subsequent impact of dietary fibre-specific educational materials on modulating older adults' future dietary fibre intake.

## 2. Materials and methods

### 2.1. Study outline

The Fibre4life project consisted of two studies coupled with a design element in between the studies as outlined in Fig. 1. One hundred and seventy older adults (defined as 65 years and above -  $72.0 \pm 5.5$  years; range: 65-87 years) were recruited to partake in the two studies over a five-month period (March 2023 to July 2023). The power calculation was based on Yamane's formula ( $n = \frac{N}{1 + Ne^2}$ , where  $n$  = sample size;  $N$  = population, and  $e$  = precision) applying a 0.1 precision factor and population size of 12 million; approximately 100 older adults would be sufficient to partake in the project (ONS 2019; Yamane, 1973). Older adults were recruited from across the UK (via University of Reading volunteer databases and social media) using minimal exclusion criteria (e.g., unable to access the project and no informed consent). Older adults were provided with the participant information sheet, an opportunity to ask any questions and subsequently gave informed consent if they agreed to take part in the project. In addition, older adults were notified that data would be pseudo-anonymised and they were free to withdraw at any point without giving notice. The Fibre4life project was conducted in accordance with the Declaration of Helsinki and was given a favourable opinion for conduct by the University of Reading School of Chemistry, Food and Pharmacy Research Ethics Committee (study number: 15/2023).

### 2.2. Study one: initial insights

This study focused on capturing insights relating to dietary fibre-related knowledge, awareness, attitudes and behaviour as well as, preferences for information dissemination, so that subsequent educational materials could be developed. The survey utilised five sections using different question types: (1) single selection via category scales (e.g., yes or no, correct vs incorrect, agreement: strongly disagree to strongly agree (five-point scale), willingness: not willing to willing (five-point scale), liking: dislike extremely to like extremely (five-point scale) and easiness to consume: very difficult to very easy (five-point scale)); (2), check-all-that-apply (CATA); (3) ranking; and (4) open-ended questions (Table S1). The first section aimed to understand initial nutritional related background as well as awareness and knowledge of dietary fibre recommendations by exploring key themes: (i) the role of nutritional information and key factors in food choice; (ii) willingness to improve nutritional intake and consume reformulated foods; (iii) awareness and knowledge of UK dietary fibre recommendations; and (iv) examples of dietary fibre-rich foods and possible benefits of sufficient dietary fibre intake. The second section focused on perception, attitudes and expectations towards dietary fibre-rich foods by determining: (i) key sensory properties; (ii) liking and easiness to consume; (iii) associated issues; and (iv) expectations. The third section briefly identified typical consumption habits via highlighting frequency, timing and commonly consumed dietary fibre-rich foods. The fourth section investigated dissemination preferences for learning more about dietary fibre such as: (i) willingness to learn more and strategies to encourage consumption; (ii) formats, topics and trustworthy sources; and (iii)



Fig. 1. Overview of the study approach (S1: study one – March to April and S2: study two – June to July).

opportunity to ask a question. The final section captured basic demographic information namely age, gender, living, education and employment status. The survey was available in both an online (via Compusense Cloud Software, Ontario, Canada) and paper format to ensure suitability for all older adults.

### 2.3. Design stage

This stage used key themes from the initial insights so that co-created tailored age-suitable information on dietary fibre was developed and subsequent impact tested in study two. Accordingly, two key themes were established: (1) dietary fibre recommendations and benefits and (2) nutritional labelling and dietary fibre-rich examples, in different formats (factsheet: text supplemented by images and practical tips: images with supporting text) to promote effectiveness and maximise impact for older adults. The design aimed to reflect older adults' needs as well as taking account of communication and cultural considerations.

### 2.4. Study two: impact analysis

This study aimed to understand the impact of two targeted educational materials on modulating older adults' future dietary fibre intake. The survey incorporated three sections utilising category scales (agreement and liking), preference and open-ended questions in both an online (via Compusense Cloud software) and paper format (Table S1). The first and second section used the same format, where older adults were presented with educational materials followed by seven questions focusing on: (1) learning something new; (2) changing future dietary fibre intake; (3) how you will incorporate changes; (4) format liking; (5) engaging content; (6) willingness to share; and (7) feedback. The third section determined overall educational materials preferences on theme, format and usefulness as well as suggested future materials.

### 2.5. Statistical analysis

All analysis was performed according to a pre-defined protocol using the following approaches: (1) Cochran's Q test for CATA data with the McNemar (Bonferroni) procedure for multiple comparisons (Meyners & Castura, 2014); (2) Friedman's test using ranked data with the Nemenyi's approach for multiple comparisons (Lawless & Heymann, 2010); (3) two-alternative forced choice test (via the guessing model) to establish differences between variables (e.g., yes vs no; incorrect vs correct) (Ennis & Jesionka, 2011); (4) tests for two proportions to determine differences between two groups within a single data set (e.g., top and bottom two boxes from agreement and liking data) (Norton, Alexi, et al., 2023); (5) Mann-Whitney test to enable comparisons between educational materials variables (e.g., learn something new, change behaviour, format liking, engaging content and share with others) (Norton, Lignou, Faka, & Methven, 2022); (6) Kruskal-Wallis test to identify differences between food categories from liking and easiness to consume data with Steel-Dwass-Critchlow-Fligner method for multiple comparisons (Norton, Lignou, & Methven, 2022), utilising XLSTAT (version 2022.3.2.1348, New York, USA) and  $p < 0.05$  was considered statistically significant. In brief, the open-ended questions data were tabulated by counting the frequencies of responses within a recurring theme (Ares & Deliza, 2010; Norton, Alexi, et al., 2023). The data from five-point category scales were grouped as follows: agreement (disagree: strongly disagree + disagree; neutral: neither agree nor disagree; agree: agree + strongly agree), liking (dislike: dislike extremely + dislike moderately; neutral: neither like nor dislike; like: like moderately + like extremely) and easiness to consume (difficult: very difficult + difficult; neutral: neither easy nor difficult; easy: easy + very easy), all presented in percentage format.

## 3. Results

### 3.1. Demographics

The older adult cohort were mainly living with a partner, retired, educated, considered nutritional information in food choice, willing to improve nutritional intake and consume reformulated foods as well as typically did not avoid hard to chew foods (Table 1 and Fig. 2). In addition, older adults' most common drivers in food choice were healthy, ingredients, price, sensory appeal and food quality ( $p < 0.0001$ ; Fig. 2).

### 3.2. Study one: dietary fibre knowledge, preferences and expectations

Older adults were typically unaware of the UK dietary fibre recommendations; however, this was unable to reach statistical significance ( $p = 0.95$ ; Fig. 3). Similarly, older adults struggled in some cases to identify the correct value relating to the UK dietary fibre recommendation ( $p = 0.93$ ; Fig. 3). Older adults were also asked to identify dietary fibre-rich foods demonstrating significant differences between food categories ( $p < 0.0001$ ; Fig. 3); there was high consensus for wholemeal/grain bread, breakfast cereals, peas/beans and vegetables being considered as dietary fibre-rich foods. In addition, older adults recognised dietary fibre-related benefits to varying extents ( $p < 0.0001$ ; Fig. 3). Nearly all older adults noted improved digestive function as the key function relating to dietary fibre; however, there was lower agreement for reduced disease risk. In addition, older adults most commonly associated no issues, negative side effects, no clear information, low sensory appeal with dietary fibre-rich foods ( $p < 0.0001$ ; Fig. 3).

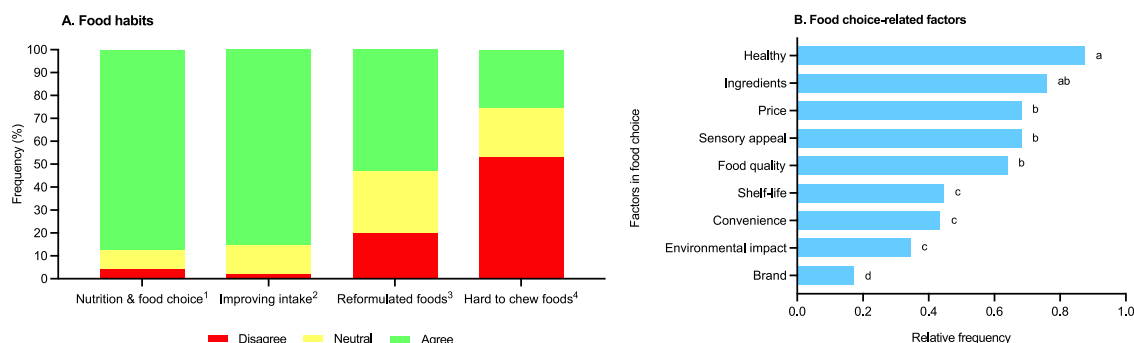
There were also significant differences ( $p < 0.0001$ ) relating to relevant sensory properties for dietary fibre-rich foods where taste/flavour was considered key whereas aftertaste was perceived as least important (Table S2). Overall, there were positive liking and easiness to consume scores of various dietary fibre-rich foods with significant differences between food categories ( $p < 0.0001$ ; Fig. S1). Fruits,

**Table 1**

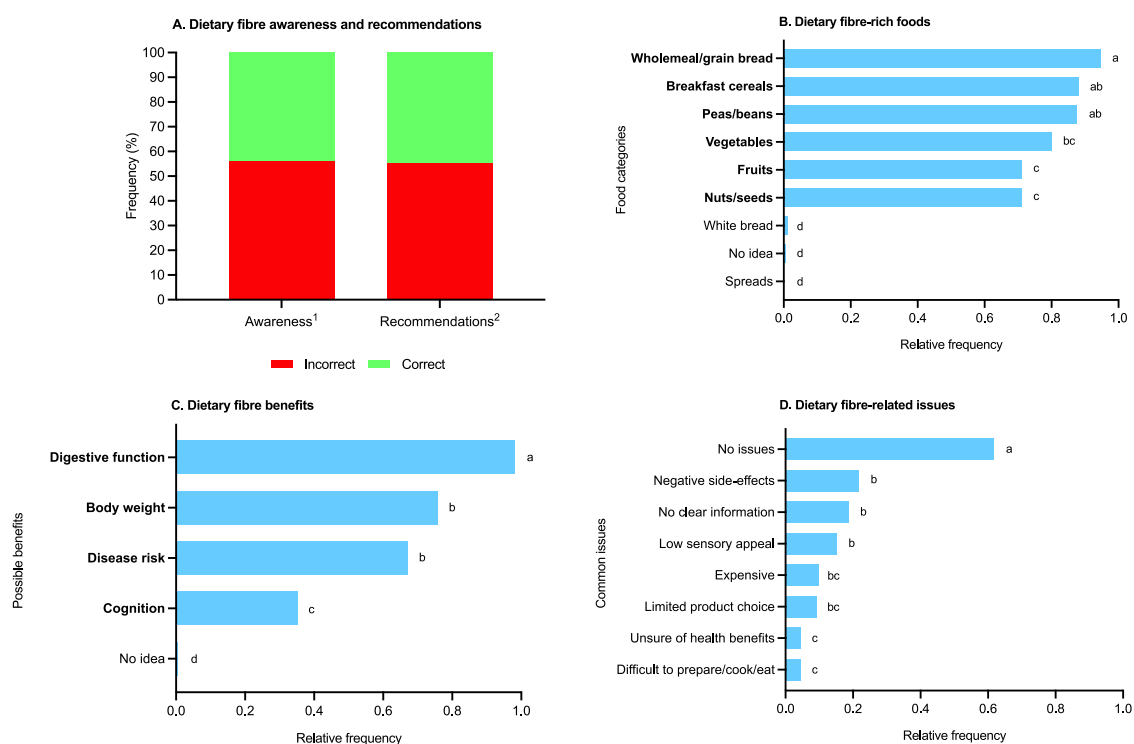
Summary of older adults' demographics in study one ( $n = 170$ ) and study two ( $n = 150$ ).

Demographic	Study one		Study two	
	n	%	n	%
<b>Age</b>				
65–69	70	41.2	61	40.7
70–74	46	27.1	41	27.3
75–79	33	19.4	30	20.0
80+	21	12.4	18	12.0
<b>Gender</b>				
Male	71	41.8	68	45.3
Female	99	58.2	82	54.7
<b>Living</b>				
Alone	39	22.9	32	21.3
Partner	119	70.0	108	72.0
Family	11	6.5	9	6.0
Tenant	1	0.6	1	0.7
<b>Education</b>				
Doctorate degree (PhD)	10	5.9	9	6.0
Graduate degree (MSc/MA)	23	13.5	21	14.0
Undergraduate degree (BSc/BA/BEEd)	57	33.5	46	30.7
Vocational/technical training	47	27.6	43	28.7
Secondary school	33	19.4	31	20.7
<b>Employment</b>				
Employed (full-time)	4	2.4	2	1.3
Employed (part-time)	18	10.6	15	10.0
Freelancer/contractor	3	1.8	3	2.0
Self-employed	7	4.1	5	3.3
Student	1	0.6	1	0.7
Retired	137	80.6	124	82.7

The same older adult cohort was used in both studies; however, some older adults were unavailable to partake in study two.



**Fig. 2.** Older adults' (n = 170) preferences by (A) food habits: <sup>1</sup>role of nutritional information in food choice; <sup>2</sup>interest in improving nutritional intake; <sup>3</sup>willingness to consume reformulated foods; and <sup>4</sup>avoid hard to chew foods (data reported as percentages) and (B) food choice factors (data expressed as relative frequency and differing letters reflect significance from multiple comparisons).



**Fig. 3.** Older adults' (n = 170) perceived knowledge of (A) dietary fibre recommendations: <sup>1</sup>awareness of UK dietary fibre recommendations; and <sup>2</sup>correct interpretation of UK dietary fibre recommendations (data reported as percentages) (B) dietary fibre-rich foods; (C) dietary fibre benefits; and (D) dietary fibre-related issues (data expressed as relative frequency and differing letters reflect significance from multiple comparisons with bold denoting correct response).

vegetables and bread (wholemeal/grain) were most liked whereas peas/beans and breakfast cereal least liked. Similarly, fruits and nuts/seeds were considered most and least easy to consume respectively. In terms of consumption habits, older adults were mainly consuming dietary fibre-rich foods daily (87.6%) at either breakfast (84.1%), lunch (61.2%) or evening meal (71.8%). The most commonly consumed dietary fibre-rich categories over the past seven days were vegetables (83.9%) and fruits (80.5%).

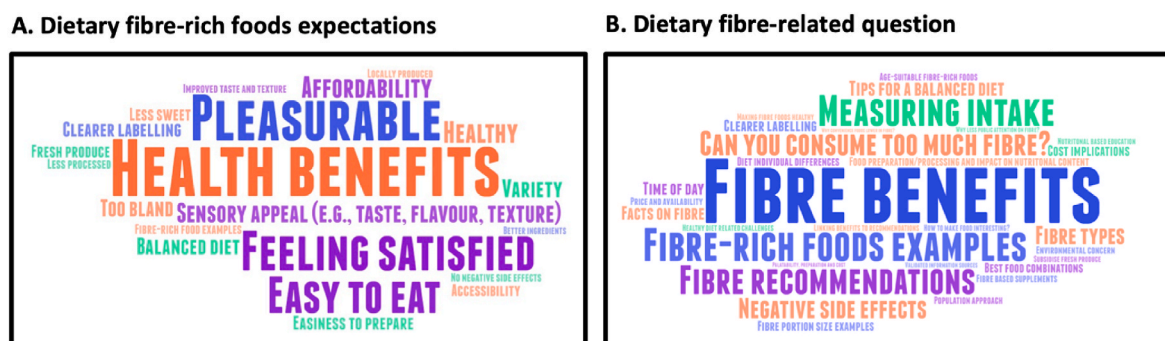
### 3.3. Design stage

The majority of older adults (87.6%) were willing to read information on dietary fibre ( $p < 0.0001$ ). It was apparent dietary fibre related benefits, dietary fibre-rich food examples, clear/accessible information and how it fits into daily routine would encourage older adults to

consume more dietary fibre-rich foods ( $p < 0.0001$ ; Table S3). There were significant format preferences ( $p < 0.0001$ ) relating to factsheets and understanding nutritional labelling in terms of learning more about dietary fibre (Table S3). Older adults noted evidence-based organisations, health professionals and scientists as main trustworthy sources ( $p < 0.0001$ ; Table S3). Dietary fibre related benefits, UK dietary fibre recommendation and recipe ideas were considered key topics by older adults ( $p < 0.0001$ ; Table S3). Similarly, key themes emerged from the open-ended questions such as dietary fibre benefits, dietary fibre-rich foods examples and sensory appeal (e.g., taste, flavour, texture) (Fig. 4).

The factsheet was the most preferred format consisting of text, supplemented with images-based design over two-pages (Table S3). There was no clear consensus on a second format per se; however, older adults were interested in practical aspects (such as in interpreting labelling and dietary guidelines). Hence, this design incorporated 'practical tips'





**Fig. 4.** Summary of older adults' ( $n = 170$ ) key themes from open-ended questions by (A) dietary fibre-rich foods expectations and (B) dietary fibre-related question (e.g., an opportunity to ask a question on the topic).

to help older adults incorporate dietary fibre into their everyday diet via images with supporting text approach over three-pages. Accordingly, two educational materials (as outlined in Fig. S2) were developed combining key themes (e.g., dietary fibre recommendations, benefits and examples) in clear and accessible formats.

### 3.4. Study two: impact analysis

Overall, the educational materials were well received with significantly more ( $p < 0.0001$ ) older adults selecting agree (or like) than disagree (or dislike) for learning something new, change future dietary fibre intake, format liking, content engaging and share with others (e.g., community, family and friends) (Fig. 5). However, there were no significant differences between educational materials (factsheet vs practical tips; learn something new:  $p = 0.94$ ; change future dietary fibre intake:  $p = 0.56$ ; format liking:  $p = 0.30$ ; content engaging:  $p = 0.66$ ; and share with others:  $p = 0.80$ ). In addition, no significance preference ( $p = 0.23$ ) was observed between educational materials (factsheet: 46.7% vs practical tips: 53.3%) in terms of format/topic. There was an element of perceived confidence towards adherence to the 30 g/d dietary fibre recommendation ( $p < 0.0001$ ) where more older adults selected 'yes' to consuming 30 g/d than 'no'. Positively, over 85% of older adults found the experience useful and helped with improving dietary fibre-related knowledge and understanding ( $p < 0.0001$ ).

Older adults expressed the intention of incorporating fruits, vegetables, nuts and wholegrains to help consume more dietary fibre in their everyday diet (Fig. 6). The feedback on the educational materials was very positive and key themes included: informative, meal ideas, easy to read and liked examples (Fig. 6). In terms of future education areas for focus, this mainly related to liking the current approach (e.g., fact-sheets/practical tips) coupled with emphasis on meal ideas and healthy eating (Fig. 6). Older adults noted if they did not adhere to current guidelines the main reason was not measuring intake and challenges with consuming 30 g/d, whereas older adults consumed fruits, vegetables, dietary fibre-based cereals, nuts and healthy eating to meet the recommendations (Fig. 6).

## 4. Discussion

### 4.1. Study one: general trends

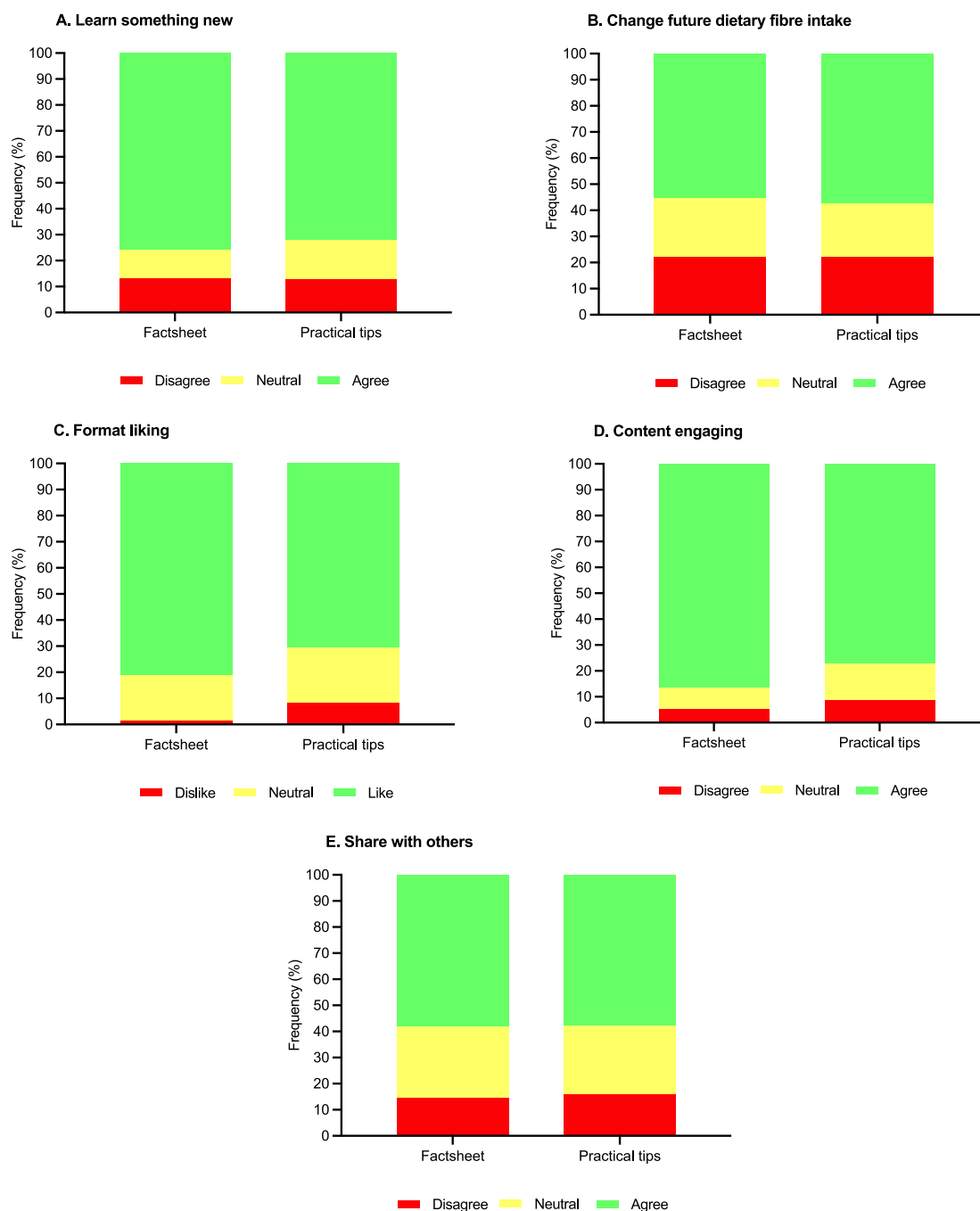
It was encouraging that the older adult cohort considered nutritional information in food choice-based decisions and demonstrated willingness to modulate nutritional intake. This is hugely relevant as nutritional knowledge and attitudes can have a key impact on an older adult's health status and quality of life (Jeruszka-Bielak et al., 2018). More specifically, older adults noted factors such as healthy, ingredients, price, sensory appeal and food quality being fundamental in food choice; accordingly, matching similar findings in the literature (Locher et al.,

2009; Kamphuis et al., 2015; Meynier et al., 2020). Such findings are likely to relate to age-related changes (e.g., modulated appetite, sensory sensitivity and oral impairments) subsequently impacting food acquisition, preparation and consumption, leading to a strong emphasis on the social, sensory and pleasurable aspects in food choice (Bailly et al., 2020; Methven et al., 2012; Morley, 2001; Norton, Lignou, Faka, & Methven, 2022; Terp et al., 2021; Van Wymelbeke et al., 2020; Vandenberghe-Descamps, et al., 2017; Volkert et al., 2019; Whitelock & Ensaff, 2018). Accordingly, this suggests ensuring adults have sufficient nutritional related knowledge prior to 'entering older age' could have notable benefits and implies a more life course approach to nutrition should be recommended.

### 4.2. Study one: dietary fibre knowledge, preferences and expectations

It was evident that at least 55% of older adults were unaware of the UK dietary fibre recommendations and its value (e.g., 30 g/d). This finding supports previous research demonstrating low awareness of the recommendations and/or benefits (Barrett et al., 2020; Foster et al., 2020; Hooper et al., 2015; Lockyer et al., 2016; Robinson & Chambers, 2018). This also explains the suboptimal dietary fibre intake evident from recent NDNS and global data in an ageing population (Kehoe et al., 2019; Norton, Kaimila, et al., 2023; SACN, 2021). In addition, lack of front-of-pack labelling for dietary fibre could be a contributing factor, as individuals need sufficient knowledge to know where to look for dietary fibre content on a pack (Hooper et al., 2015; Lockyer et al., 2016; McKeown et al., 2022). Another key challenge for older adults is correctly identifying dietary fibre-rich foods and to some extent this was demonstrated in our study for certain foods (Magalis et al., 2016; Barrett et al., 2020; Meynier et al., 2020; McKeown et al., 2022). For example, over 80% of older adults noted bread (wholemeal/grain), breakfast cereals, peas/beans and vegetables as dietary fibre-rich foods, whereas this dropped to 70% for fruits and nuts/seeds. In addition, older adults were very familiar (98%) with dietary fibre's benefit relating to digestive function; however, notably less older adults (67%) realised dietary fibre's role in disease risk reduction. This highlights that work still needs to be conducted in promoting dietary fibre-related awareness, especially relating to food categories and benefits.

Older adults noted taste/flavour as a key sensory modality for dietary fibre-rich foods, with similar findings demonstrated in older adults-based studies for other macronutrients (Norton, Lignou, & Methven, 2022). This suggests in order to promote consumption it is important that food 'delivers' on taste regardless of the particular nutrient. Liking of dietary fibre-rich foods was broadly very positive; although, peas and beans were considered least liked. This could be explained by bean related barriers in an ageing population such as potential side effects (flatulence and abdominal discomfort), preparation/cooking knowledge and how to utilise beans in meals (Doma et al., 2019b). Moreover, increasing peas and bean consumption could be an area of focus for



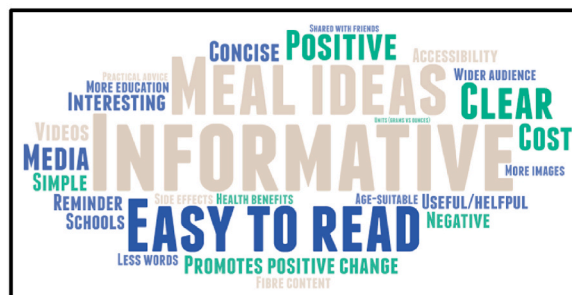
**Fig. 5.** Summary of older adult's ( $n = 150$ ) impact analysis on educational material by (A) learning something new; (B) change future dietary fibre intake; (C) format liking; (D) content engaging; and (E) share with others. All data expressed in percentage format (disagree: strongly disagree + disagree; neutral: neither agree nor disagree; agree: agree + strongly agree; and dislike: dislike extremely + dislike moderately; neutral: neither like nor dislike; like: like moderately + like extremely).

future work and subsequently help promote dietary fibre intake. In addition, oral health can be modified by age; accordingly, this can result in modulated food preferences for easy to chew foods, thereby impacting diet quality (Razak et al., 2014; Vandenberghe-Descamps et al., 2017; Walls & Steele, 2004). Interestingly, older adults in our study noted nuts/seeds as the least easy to consume in the dietary fibre-rich food category, despite 52% stating they did not avoid hard-to-chew foods; suggesting that oral health may have impacted food choice. Moreover, poor oral health can contribute to lower dietary fibre intake in an ageing population (Kiesswetter et al., 2018; Kossioni, 2018; Tada & Miura, 2014; Walls & Steele, 2004). In practice, this can lead to food

preparation changes (such as skin removal or overcooking) and food avoidance (Sheiham & Steele, 2001; Walls & Steele, 2004; Tada & Miura, 2014; Kossioni, 2018). Therefore, going forwards in order to overcome oral health and dietary fibre intake related barriers, more emphasis should be placed on: (1) tailored dietary fibre-rich foods and recipes to match older adults' needs and (2) relevant substitutions so that if an older adult avoids a particular food, they can replace it with a suitable equivalent.

Surprisingly, 60% of older adults cited no issues with dietary fibre; however, this could be explained by lack of knowledge associated with dietary fibre and/or its side effects (e.g., bloating or fluctuance) not



**A. Factsheet (incorporate changes)****B. Practical tips (incorporate changes)****C. Factsheet (feedback)****D. Practical tips (feedback)****E. 30 g/d adherence (no)****F. 30 g/d adherence (yes)****G. Future campaigns**

**Fig. 6.** Overview of older adults' ( $n = 150$ ) key themes from open-ended questions by (A) factsheet – incorporate changes into diet; (B) practical tips – incorporate changes into diet; (C) feedback on factsheet; (D) feedback on practical tips; (E) perceived reasons for non-adherence to 30 g/d guidelines; (F) perceived adherence to 30 g/d guidelines; and (G) future education ideas.

necessarily being perceived as negative. In addition, dietary fibre-related issues included negative side effects, no clear information and low sensory appeal; such findings have been identified previously in the literature and are associated with poor uptake (Doma et al., 2019b; Henn et al., 2022; Hooper et al., 2015; Lockyer et al., 2016; Meynier et al., 2020). Moreover, it should be noted that this generation are likely to associate meals in terms of meat and two vegetables; accordingly,

older adults may assume this would contain an appropriate dietary fibre content. However, in practice to reach the 30 g/d dietary fibre threshold a diet needs to consist of (1) fruits and vegetables (e.g., eight portions); (2) starchy foods (e.g., wholegrains, potatoes); and (3) high dietary fibre snacks (e.g., nuts, seeds) (Hooper et al., 2015). Positively, 88% of older adults consumed dietary fibre-rich foods daily; however, it is concerning that 12% either consumed daily fibre-rich foods only weekly or had no

idea whether they consumed them. Correspondingly, demonstrating the challenge older adults encounter in consuming sufficient dietary fibre intake. It was evident breakfast and evening meals were the main consumption moments; going forwards, this is an area for improvement, by adding a dietary fibre component to all meals across the day to help promote intake.

#### 4.3. Design stage

The vast majority of older adults (88%) were willing to engage with dietary fibre-related information, which is extremely encouraging. Three key themes (e.g., dietary fibre recommendations, benefits and examples) emerged which were subsequently incorporated into two educational materials. These findings are supportive of previous literature (e.g., poor awareness of benefits and recommendations as well as identification of dietary fibre-rich foods) (Barrett et al., 2020; Foster et al., 2020). In addition, it has been suggested that dietary fibre-related educational materials should focus on promoting the relevant benefits coupled with practical aspects (including food-based examples) to help overcome common misconceptions (Meynier et al., 2020; Barrett et al., 2020). Thus, two educational materials (factsheet and practical tips) were developed encompassing older adults' preferences covering: (1) dietary fibre-related key facts (including what is dietary fibre, recommendations and benefits); (2) interpreting nutritional labelling; and (3) practical aspects (e.g., meal ideas, dietary fibre-rich examples and tips), in an age-suitable design to subsequently promote engagement and relatability. It could be suggested that the older adults did not fully understand the question relating to information format preferences as videos and infographics were less selected; yet, were mentioned in the feedback. Accordingly, an image-based example may have been more useful rather than the text description provided for each format. Dietary fibre labelling is an ongoing issue as it is not required on front-of-pack but information is provided on the back-of-pack (e.g., ingredients list and table of nutrients) in some cases (Buttriss, 2015). However, the font size is often small making reading food labels challenging and adding complications for an ageing population. In addition, the names of specific dietary fibre ingredients (e.g., inulin, lignin) are not easily identifiable as dietary fibre by the general population.

Positively, older adults perceived evidence-based organisations (e.g., NHS, British Nutrition Foundation, WHO), health professionals (e.g., dietitians, nutritionists, GPs) and scientists as key trustworthy sources; therefore, utilising such groups in future educational material dissemination could be a feasible approach to promoting engagement. This implies having more infrastructure support such as readily available educational materials in commonly visited public places (e.g., GPs, supermarkets, community halls) as well as opportunities to ask questions and gain advice could help with practical application of increasing dietary fibre intake. In addition, key design cues such as targeted, innovative, simplistic, positive, enjoyable, practical and evidence-based were also incorporated in the design development (Appleton & Adams, 2023; Bhargava & Hays, 2004; Frieden, 2014; MacNab et al., 2017; Ruxton et al., 2023). As already alluded to older adults are typically unaware that nutritional requirements may modify with age; accordingly, this can result in confusion whether information is age-relevant or applicable (Castro et al., 2021). Moreover, co-creation enables a process that uses the target population (e.g., older adults) in design-related stages of research (Voorberg et al., 2015). For example, in our study older adults' input (via initial insights) directly informed the corresponding design which proved invaluable in stimulating and modulating interest as well as future intake as evident by the impact analysis (Section 4.4). In addition, co-creation has been suggested as a viable approach to promoting sustainable change for health behaviour-based interventions in an ageing population as well as being considered an evolving area (Leask et al., 2017; Terkelsen et al., 2022). Accordingly, this suggests capturing older adults' preferences could be a key step in promoting subsequent engagement in dietary fibre.

#### 4.4. Study two: impact analysis

The older adults engaged with the educational materials (regardless of topic and format); accordingly, this demonstrates potential efficacy in this approach going forwards. The results were very promising as there was strong agreement for all variables (e.g., learning something new, change future dietary fibre intake, format liking, content engaging and share with others) as well as the overall experience being cited as useful/helpful. However, it should be noted that there was an element of confusion towards meeting dietary fibre recommendations in this older adult cohort. For example, 67% of older adults believed they adhered to the current guidelines by following healthy eating practices and incorporating fruits, vegetables, dietary fibre-based cereals and nuts into their diet. Similarly, Magalis et al. (2016) demonstrated an overestimation of dietary fibre related consumption where consumers perceive they adhered to recommendations whereas in reality they were under-consuming. This suggests the need for appropriate education combined with easy ways to measure dietary fibre intake and more portion size support. Thus, an essential next step for this proof-of-concept project is to measure dietary fibre intake in an ageing population. However, selecting an appropriate dietary assessment method in an ageing population is not without its challenges (de Vries et al., 2009; Zuniga & McAuley, 2015). The novel online personalised dietary advice tool - eNutri could be a viable solution; it quantifies dietary intake via a validated, up-to-date food frequency questionnaire designed for older adults and then provides personalised food based dietary advice (Zenun Franco et al., 2018, 2022; Kelly et al., 2022). This has successfully changed dietary behaviour towards a healthier diet including increasing dietary fibre intake (Zenun Franco et al., 2018, 2022; Kelly et al., 2022).

It is evident that education can positively influence dietary fibre-related consumption; however, whether this translates into notable changes in subsequent intake represents an ongoing challenge (MacNab et al., 2017; Neves et al., 2020; Weingarten & Hartmann, 2023). It is important that the education provided utilises a co-creation component encompassing the target populations preferences; accordingly, our study addresses this limitation in previous studies (Weingarten & Hartmann, 2023). In addition, dietary fibre-related knowledge needs to reflect all aspects, including benefits, identification, purchase and cooking of such foods; therefore, highlighting the multiple elements required to promote awareness as well as an emphasis on different dietary fibre-rich sources since food variety can increase food intake (Magalis et al., 2016; Emling et al., 2021). This implies an emphasis on information dissemination via a public health related campaign could be hugely beneficial.

The cost-of-living crisis may impact older adults to a greater extent compared with other population groups (Age UK, 2022). It should be noted that socio-economic status (SES) was not a focus of this study; however, future research should investigate how best to capture this information in an ageing population, where a pension is typically the main income source. van Meurs et al. (2022) recent review highlighted nutrition-based interventions may be less effective in low SES groups citing key barriers (such as poor health literacy, insufficient social/economic resources and prioritising convenience). Positively, delivery of education can be provided both in person and online, demonstrating widespread reach, yet, this must aim to overcome common effectiveness barriers namely food preferences, motivation, cost, health literacy, trust and expectations (Alghamdi et al., 2023; Ruxton et al., 2023). Accordingly, the Fibre4life approach should be expanded to a broader and larger older adult cohort as well as across the adult life course (since low dietary fibre intake an issue regardless of age) in the future. In addition, capturing different demographics (e.g., low vs high SES, regional and country variation, living alone vs with others, etc.) coupled with measuring dietary fibre intake to maximise impact.

## 5. Conclusion

This study used older adult insights to co-create targeted educational materials for subsequent impact analysis. It was apparent that older adults were relatively uncertain and confused regarding dietary fibre recommendations and benefits as well as identifying dietary fibre-rich foods. Positively, most of the older adult cohort consumed dietary fibre-based foods daily; however, they would benefit from a more balanced distribution across the day. Older adults were willing to learn more about dietary fibre and would like additional information relating to its benefits, recommendations and food-based examples in a clear and accessible format. Accordingly, two educational materials encompassing key themes utilising older adults' preferred information format (e.g., factsheet and practical tips) were co-created. Importantly, the educational materials (regardless of format and topic) were perceived as helpful and were well received in terms of learning something new, changing future dietary fibre intake, format liking, content engaging and share with others. In addition, emphasis should be placed on measuring dietary fibre intake using accessible methods in both short- and long-term contexts, ideally reflecting ecological validity so that intake related confusion can be clarified. Going forwards, it is clear that older adults would like educational materials to include key facts and practical tips as well as meal ideas and a focus on healthy eating. More broadly, this suggests regular and consistent information could be useful in overcoming common dietary fibre-related misconceptions coupled with more infrastructure support (e.g., health professionals, government, food companies, supermarkets); therefore, suggesting a holistic approach to dietary fibre would be beneficial.

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## Ethical statement

The Fibre4life project was conducted in accordance with the Declaration of Helsinki and given a favourable opinion for conduct by the University of Reading School of Chemistry, Food and Pharmacy Research Ethics Committee (study number: 15/2023).

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Data will be made available on request.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.appet.2023.107109>.

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