Examining Stakeholder Preferences for High Fibre White Wheat Bread: Evidence from the UK Wheat Supply Chain

Abstract:

The transformation of food systems requires collective and careful collaborative efforts among relevant stakeholders. Against this background, this study examines stakeholders' preferences for high fibre white wheat bread, considering economic, environmental, and social (public health) factors. A discrete choice experiment (DCE) was conducted to understand UK wheat stakeholder attitudes to adopting new high fibre white wheat varieties for producing high fibre white wheat bread. We used representative samples of stakeholders along the UK wheat supply chain (WSC) with data collection focusing on preferences and perceptions of individuals who are decision-makers in the chain. We found evidence of correlation between risk attitudes and perceptions of sustainability factors as well as risk attitudes and preferences for high fibre wheat attributes. The results of a binary probit model show that improvements in economic, environmental, and social (public health) are positively associated with the satisfaction (utility) of high fibre wheat bread but negatively associated with increasing prices. Additionally, stakeholders are willing to pay 4p, 32p and 44p for the improvement of economic, environmental, and social (public health) and £0.95 for 800g high fibre white wheat bread. The policy implications of the study are discussed. The transformation of the wheat economy should focus on the sustainability factors as well as high fibre wheat attributes.

1.0   Introduction

Concern for public health has made the transformation of the food systems more important for development partners and policy makers. Wheat is an important global food security crop suggesting sustainable wheat production will have significant impact on economic development due to its economic contributions as a top three cereal crop in the world. Its relevance is not only for food security but also for economic stability (Lombardozzi & Djanibekov, 2021). Wheat provides more than 20 per cent of the calories and protein needs by the world population but faced with challenges such as low yield (average yield per hectare for wheat is estimated at 3 tonne/ha), which is exceptionally low when compared to maize and rice (Hawkesford *et al.*, 2013). The challenges are not limited to low yield alone but also how to achieve sustainable yield and resource use efficiency (Hawkesford *et al.*, 2013). This low yield trend and other impediments are still to be solved. Therefore, a multidisciplinary multistakeholder approach is needed to reverse this trend and tackle the challenges to ensure sustainable wheat economy for public health benefits.

Strutt and Parker described wheat as "the biggest commercial crop in the world"[1]. Beside economic and market values, the health benefits of wheat are many (Ciudad-Mulero *et al.*, 2020), while its versatility in terms of usage is second to none (Peña, 2002). Wheat is noted to be more popular among cereal crops due to its high adaptability, agro-ecological spread, its storability as well as complex chemical composition (Pena, 2007). Wheat is also known for its richness in starch and gluten protein. These attributes put wheat on top ranking in the class of cereal crops for achieving food security and sustainable economic development. It is often argued that effective stakeholder engagement is needed to achieve a sustainable wheat economy (Deng *et al.*, 2021). Such engagement requires collaborative research that should account for the different components of food systems and sustainability.

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[1]Wheat is not a crop but an economic enterprise known for its many benefits for human and animals. More information about the importance of wheat can be found at https://www.struttandparker.com/knowledge-and-research/what-about-wheat-look-our-most-important-crop. Report Q4 2015.

The United Kingdom currently producing around 80% of the wheat consume in the country, filling the 20% gap from importation from Canada, France, and Germany. [2]Available statistics suggest wheat flour is an important bedrock for UK diet with this single ingredient providing about 33% of all grocery products on supermarket shelves; 20% of the energy and protein consumed by the UK population. Wheat flour also makes a significant contribution to vitamin and mineral intake supplying much of the fibre, calcium and iron consumed in the UK. Approximately 12 million loaves of bread, 2 million pizzas, and 10 million cakes and biscuits are made in Britain every day from the wheat flour. Bread is bought by more UK households than any other product. To meet the demand of the growing population, the UK flour milling industry processes 6.2 million tonnes of wheat to produce almost 5 million tonnes of flour every year, making the industry the largest single processor of British wheat. Approximately 85% of wheat processed by the UK flour mills are grown locally. In terms of the flour type/usage, white bread flour constitutes over 50% of the flour produced in the UK since 1991/92. This is distantly followed by biscuit and starch. Other uses of flour include food ingredients, wholemeal breadmaking, pre-packed household flour, brown breadmaking and cake, in order of proportional importance, respectively. From the foregoing, it is important to examine the attitudes of relevant stakeholders to the adoption of innovation such as willingness to change production and purchase practices.

In this study, we are interested in understanding which factors play a role in stakeholders in the UK wheat supply chain (WSC) adopting a new experimental white wheat flour variety which is likely to support increases in daily fibre intake. We posit that the transformation of WSC requires more than breeding improved seed varieties or cultivars. In other words, there is the need to examine the preferences of all relevant stakeholders in the WSC to aid the identification of the barriers as well as willingness to adopt innovation in the food transformation system for sustainable economic development. It is important to make a clear distinction between high fibre bread and high fibre white wheat bread. The former is the currently available fibre-reach bread such as brown bread while the latter is a new type of wheat under development and relate to the development of hybrid white wheat variety or cultivar by the UK scientists in collaboration with the concerned academic disciplines (social science, food science and technology, environmental science and mathematical modelling) as well as industry experts along the entire wheat supply chain.

Sustainable development connects with economic development and environmental sustainability with three main components at the focal point: social, economic, and environment (Mitlin, 1992). The social part includes public health as its tenet, but this factor is often ignored in policy research. For development to be sustainable, there must be a change in thinking and improvement in the ways businesses are conducted globally, especially in the agricultural and food sector. This is also important for the actualisation of sustainable development goals (SDGs). It is a reversal issue that agriculture has negative impact on the environment, yet the environment affects agricultural production activities in diverse ways. A

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[2] Information about the statistics on wheat and wheat flour in the UK is sourced from Flour Milling in the UK: Facts and Figures. Available at https://www.ukflourmillers.org/_files/ugd/329f2f_969c4be808074547b9ede30ac93d125f.pdf

good example is the impact of greenhouse gas (GHG) emissions on wheat production (Röder *et al.*, 2014). Like many crops, wheat production is vulnerable to climatic variability (Cho *et al.*, 2012). The quality as well as the quantity of food consumed by the world population are driven by the quality of nutrients in the soil, the quality and amount of water absorbed by crops in/from the soil, the availability or quality or the amount of rainfall, as well as other chemical and physical components of the environment. It follows that a healthy environment is important for sustainable food production with healthy population outcomes. This partly makes the resilience of the food system to the environmental shock an indispensable research issue (Davis *et al.*, 2021). Building resilient food system requires comprehensive approach that must consider all the activities involved in the FSC which may give a new definition to the food policy. Sustainability should therefore top the agenda in the transformation of food system.

Circular economy has been singled out as one of the best ways to ensure a sustained wheat supply in the UK (Dossa *et al.*, 2022). Reduction in grain losses along the supply chain without necessarily increasing the genetic yields of grain cultivars also holds great promises for the sustainability of the grain food systems (Mesterházy *et al.*, 2020). Like in many agricultural sub-sectors, the UK wheat economy requires systemic approach that would capture all the components of the supply chain. Additionally, all the dimensions of sustainable development are needed for full assessment of sustainability. Research linking the components of sustainability to an important economic outcome (health) is limited. Moreover, behavioural insights into the preferences of important economic players along the wheat supply chain has not been a subject of debate in the economic literature. This study bridges this gap by examining the social, economic, environmental, and public health preferences of randomly selected relevant stakeholders toward the high fibre wheat in the UK. Specifically, risk attitudes and preferences of individuals and policy makers who may influence economic policy were taken into consideration. It is hypothesised that a risk averse person may show less willingness toward the social, economic, health and environmental outcomes associated with the high fibre white wheat.

The high fibre white wheat flour upon which our studied is focused, is an experimental white flour being developed at Rothamsted Research in the UK, in collaboration with industry. Cross breeding of selected wheat varieties has led to increased arabinoxylan content, the major dietary fibre part of white flour. Given around 76% of bread sold in the UK is white, these new varieties offer an opportunity to improve dietary fibre intake, whilst avoiding the new to dramatically alter individual dietary bread preferences. Similarly, the new varieties are not expected to require changes to growth or production processes, thus enabling the new high fibre loaves to be produced at a similar cost to standard white bread loaves. We note here the distinction of our new bread variety with high fibre bread – fibre-rich bread, such as brown bread.

Our interest here is understanding the attitude and willingness of key decision makers in the UK wheat supply chain to adopting the new high fibre white wheat and flour. This study thus wants to figure out what factors may influence whether stakeholders within the WSC adopt

the new product. The results from this study are expected to help in addressing important policy issues relating to nutrition and health in the UK and beyond. Answers to the following questions are used to inform our overall goal. What are the risk attitudes of stakeholders in the WSC? What factors may drive stakeholders within the UK WSC towards deciding whether to grow, process and utilise high fibre white wheat and flour to produce high fibre white wheat bread? What are the attributes of high fibre wheat bread that are important for policy considerations? How much are stakeholders within the WSC willing to pay for a new 800g high fibre white bread?

The reminder of this article is organised as follows. Section 2 summarises the research methods. The results and discussion are presented in Section 3 whilst Section 4 summarises our findings and reflects upon how they may inform policy recommendations.

2.0   Research methods

This study used primary data collected across the UK wheat supply chain and suggested the data to both descriptive and inferential statistical analytical methods.

2.1   The data source

This study used risk attitudes, a discrete choice experiment and socio-economic data collected through online and in-person questionnaires. Representative samples of 69 relevant stakeholders along the wheat supply chain were interviewed. A copy of the questionnaire is provided in Appendix B. Respondents' risk attitudes were first examined using a 11-point Likert scale. This was followed by the discrete choice experiment which presented participants with three policy options framed around economic (contribution of agriculture to GDP), environmental (environmental performance index), nutrition (fibre content in 800g of bread) as well as the variation in the price of an 800g of bread. The data collected were analysed using different descriptive and inferential statistical methods. Lastly, respondents' socio-economic factors were examined. Further detail on the DCE is given in Section 2.0.1.

This study used risk attitudes, discrete choice experiment and socio-economic data collected through online and in-person to analyses sustainability issues and preferences for high fibre white wheat bread in the UK. Representative samples of 69 relevant stakeholders along the wheat supply chain were interviewed. A copy of the questionnaire is provided in **Appendix 2**. Respondents' risk attitudes were first examined using a 11-point Likert scale (part 1 of the questionnaire). This was followed by the discrete choice experiment which presented participants with three policy options framed around economic (contribution of agriculture to GDP), environmental (environmental performance index), nutrition (fibre content in 800g of bread) as well as the variation in the price of 800g of white wheat bread. Respondents' perceptions of sustainability factors as well as preferences for high fibre wheat attributes were first examined in part 3A of the questionnaire. Lastly, respondents' socio-economic factors were examined (Part 3B of the questionnaire).

2.0.1 The risk attitudes

The risk attitude elicitation methods first used by Dohmen *et al.* (2011) was adopted in this study. Respondents were asked to rank their attitudes to risk using a 11-point Likert scale ranging from 0 to 10 within four risk domains (general, environmental, economic, and social). More details can be found in Part 1 of the questionnaire under **Appendix 2**.

2.0.2 The discrete choice experiment (DCE) design

Our design is based on the efficient design. Respondents were presented with a set of hypothetical scenarios and three policy options which reflect the economic, environmental, nutrition and price factors. The economic is based on the potential contributions of the agriculture (wheat) to the GDP. Agriculture currently contributes approximately 0.51% to GDP in the UK with the projection that this contribution may be increased to 1% and 2% respectively in the medium and long term. The environment is captured using the environmental performance index (EPI)[3] which is an index estimated for 180 countries based on their performance in environmental sustainability as it affects food production. This index accounts for 11 factors including the health impact, climate change impacts, water resources, habitat diversity, and ecosystem vitality. The current UK EPI is 77.7. We projected that this number may increase to 87.7 and 97.7 in the medium and long terms period. Note that the higher the index, the better the performance. Thus, the associated high, medium, and low attribute for EPI is 97.7, 87.7 and 77.7, respectively. On the nutritional benefit, we assume the UK dietary fibre intake as well as average fibre from 800g loaf of white bread may increase from the current value of 19g to 25g in the medium term and 30g government recommendation or target in the long term. These values are therefore included in our DCE to reflect the respective high (30g), medium (25g) and low (19g) attribute for nutrition. Lastly, the average price 800g loaf of white bread in the UK is included as £0.90, £0.95, and £1.00, respectively for attribute for low, medium, and high values. These attributes are alternatively mixed up through the D-efficiency design in our choice experiment. Therefore, respondents faced with eight (8) rows from which they are to choose one (1) from three (3) alternative options (**Table 1**). Mor details on the DCE can be found in the Part 2 of the questionnaire under **Appendix 2**.

Table 1: Attributes Description and Attribute Levels

Attributes	Attributes description	Attributes Levels		
Economics (GDP)	Economic benefit, by increasing the contribution of agriculture (wheat) to GDP	High (H) (2.0%)	Medium (M) (1.0%)	Low (L) (0.51%)

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[3] The EPI developed by Yale University is based on 40 performance indicators across 11 issue categories. It is sourced from https://epi.yale.edu/epi-results/2022/component/epi.

		High (H)	Medium (M)	Low (L)
Environment (EPI)	Environmental impact associated with food production, in line with the environmental performance index (EPI) which reflect the health impact, climate change impacts, water resources, habitat diversity, and ecosystem vitality	High (H) (97.7)	Medium (M) (87.7)	Low (L) (77.70)
Nutrition (fibre content of bread)	Nutritional benefit of the hi-fi wheat (increased fibre contents) which will promote good health. This value stands for the average fibre content of 800g of white bread	High (H) (30g)	Medium (M) (25g)	Low (L) (19g)
Price (£)	Cost of 800g loaf of white bread	£1.00	£0.95	£0.90

Note: The EPI is an index that reflects the environmental performance of 180 countries.

2.0.3 Perceptions, preferences, and socio-economic variables

Respondents were asked about their perceptions of sustainability factors related to high fibre white wheat. It is premised that this question is important for sustainable economic development since policies must be seen to have a sustainable impact. A 5-point Likert scale of qualitative questions was asked on the following sustainability dimensions: social, economic, environmental, and public health. The question reads: "Kindly rank your preferences for the following attributes on a 5-point scale of importance, where 1 = not at all important and 5 = extremely important". More details can be found in the Part 3A of the questionnaire under **Appendix 2**.

In considering the new high fibre white bread wheat, respondents were also asked to rank eight different attributes using a 9-point score with equal number of rankings allowed., i.e. the same number may be assigned to different attributes. The question asked was "What attributes/factors/reasons would make you prefer high fibre white wheat to your existing wheat cultivars/grains/flour? Please rank from 1-9, the same number can be assigned to different attributes". More details can be found in the Part 3A of the questionnaire under **Appendix 2**.

2.2 Data analytical methods

The data collected were analysed using different descriptive and inferential statistical methods. Data on the risk attitudes, socio-economic variables, including sustainability factors as well as perceptions on high fibre wheat attributes were analysed using descriptive statistics such as frequency, percentage, and graphs. Furthermore, data on perception of high fibre wheat attributes were subjected to factor analysis to know the principal components. Lastly, probit and logit regression models were applied to examine the determinants of choice of high fibre white wheat bread as well as the willingness to pay for the relative sustainability attributes of high fibre bread (economy, environmental and nutrition).

3.0 Results and Discussion

The results of the data analyses are presented in this section. This is followed by the discussion as well as recommendations emanating from the study. First, the results of the risk attitudes are presented in Section 4.1. The results of the distribution of risk attitudes of stakeholders are presented and discussed in Section 4.1.1. In Section 4.2, the socio-demographic and economic variables are presented and discussed. Here perceptions about sustainability attributes, rankings of preferences for wheat attributes as well as socio-demographic variables are discussed. This is followed by factor analysis of high fibre white wheat attributes in Section 4.3 and lastly the results about relative willingness to pay for high fibre white wheat bread are discussed in Section 4.4.

3.1 Socio-economic variables

The description of other socio-demographic and economic variables is presented in **Table 2** and **Table 3**. First, we present the results of the various categories of the sampled respondents. As showed in **Table 2**, sampled stakeholders in the UK wheat supply chain varied in their roles from farming to management as well as advisory roles. The majority (62.3%) of the sampled respondents are wheat farmers or growers, although some reported they perform other roles such as managers or farm business owners. Others varied from seed breeders (7.2%) to grain merchants (7.2%), quality compliance authority (1.4) as well as those performing other functions along the wheat supply chain.

As shown in **Table 2**, 66.7% of the respondents claimed they were aware of the health benefits of high fibre white wheat bread. This level of awareness although relatively high, requires more efforts in the publicity through the mainstream and social media so that public will not only be more aware of the health benefits of high fibre white wheat bread but also be convinced about changing their preferences. Around 85.5% of respondents are willing to change their existing purchase or business practice to more healthy and sustainable practices along the UK wheat supply chain. This figure is relatively high and may improve significantly with increasing level of awareness about the benefits associated with consuming high fibre white wheat bread. Respondents were also asked about their efforts to obtain information about high fibre wheat/flour/bread. This question was asked to assess the efforts of individual stakeholders from the perspective that every business owner and stakeholder is motivated to act based on the information they receive or have. The response shows 49.3% of the sample made little effort in obtaining the necessary information on high fibre wheat/white wheat bread and related products.

Assessment of the likely impact of an innovation is a right think is the right direction for researchers and policy makers. While a comprehensive impact assessment may be necessary for a robust result, perception about such impact may give some useful direction as preliminary guide for future impact assessment of technological innovation. In terms of the potential impact of high fibre white wheat bread, about half (47.8%) of the sampled respondents agreed high fibre white wheat will have a positive impact on public health. Similarly, stakeholders were asked to give their views about the benefits of consuming high fibre white wheat bread. About 46.4% of the sample agreed there are lots of benefits associated with the consumption of high fibre white wheat bread. This support the earlier

expressed views that a relatively high number of respondents are aware of the benefits offered by this innovative product especially health related benefits.

Table 2: Description of Socio-Economic Variables

Variables	Frequency	Percentage
Stakeholders' categories		
Breeders-grain/seed producers	5	7.2
Wheat farmers	43	62.3
Wheat grain merchants	5	7.2
Wheat millers	-	-
Wheat bakers	2	2.9
Grain quality compliance authority	1	1.4
Other categories	13	18.8
Aware of health benefits		
No	23	33.3
Yes	46	66.7
Willingness to change		
Yes	59	85.5
No	10	14.5
Efforts on Information on High Fibre		
No Effort	28	40.6
Little Effort	34	49.3
Much Effort	7	10.1
Potential Impact of Available HiFi bread		
Very positive	10	14.5
Positive	33	47.8
Neutral	25	36.2
Very Negative	1	1.4
Benefit in consuming HiFi bread		
Strongly agree	22	31.9
Agree	32	46.4
Neutral	14	20.3
Disagree	1	1.4
Age range		
20-29	10	14.5
30-39	10	14.5
40-49	14	20.3
50-59	23	33.3
>60	12	1.4
Dummy for Aged 39 or less		
Less than 40 years	20	29
40 years and above	49	71

Source: Data Analysis, 2023

Furthermore, about 33.3% of the respondents are within the age bracket of 50-59 years with approximately 71% of the samples aged 40 and above. This is a sign of relatively old samples but still economically active.

As shown in **Table 3**, approximately (42%) of the respondents had university degree with 58% holding at least first degree (the highest reported degree is masters). Moreover, around 78% of the sampled respondents are males while the remaining are either females or show they prefer not to reveal their gender. Approximately 71% of the samples have more than 15 years of work and business experience. This shows some prominent level of experience which is necessary for business innovation as well as adoption of new business technological innovation such as high yielding varieties and food processing machines and methods.

Table 3: Description of socio-economic variables continue.

Variables	Frequency	Percentage
Educational level		
Secondary School Completed	6	8.7
Further/Vocational Education	23	33.3
University degree	29	42
Postgraduate degree	11	15.9
Dummy for At least University Degree		
At least university degree	40	58
Others	29	42
Male	54	78.3
Female	13	18.8
Prefer Not to Say	2	2.9
Business Experience		
<=5	4	5.8
6-10	7	10.1
11-15	9	13
>15	49	71
Membership of professional association		
Yes	36	52.2
No	33	47.8
Source of Information		
Radio	13	18.8
Television	7	10.1
Newspaper or Magazine	29	42.0
Professional association/society	13	18.8
Events (C/W/S)	2	2.9
Others	5	7.2
Annual Turnover		
Less than £100,000	5	7.5
£100,100-£200,000	6	8.7
£200,100-£300,000	7	10.1

£300,100-£400,000	4	5.8
£400,100-£500,000	7	10.1
More than £500,000	38	55.1

Source: Data Analysis, 2023

Approximately 52% of the sampled stakeholders belong to one or more professional associations. The main source of information for the respondents with respect to high fibre wheat grains and wheat products are newspaper/magazine (42%), radio (19%), professional association/society publications (19%) as shown in **Table 3**. In terms of income, approximately 55% of the sampled stakeholders reported an annual turnover of more than £500,000 showing most sampled businesses are medium to large scale enterprises. The scale of operation of a business is a necessary condition for the assessment of staff strengths, economic returns, and overall economic impact.

3.2   Sustainability factors and high fibre wheat attributes

Analysis of the data collected with respect to perceptions around sustainability factors as well as rankings for high fibre white wheat attributes are summarised using descriptive statistics in **Table 4**. We are firstly interested in the price respondents are willing to pay for an 800g high fibre white wheat loaf of bread. It is estimated all the sampled respondents are willing to pay up to £1.00 when asked a closed question with a yes or no response. The question reads "Are you willing to pay 90p, 95p or £1.00 for 800g high fibre white wheat bread?" However, when asked in an open question "How much are you willing to pay for an 800g loaf of high fibre bread"? The average amount the respondents are willing to pay is £1.31 with a standard deviation of 0.38p.

Table 4: Descriptive Statistics of Sustainability Dimensions and Wheat Attributes

Variables	Mean	SD	Min range	Max range
Amount willing to pay for 800g high fibre bread (£) **N=62**	1.31	0.38	0.90	2.50
Perceptions on Sustainability Dimensions (N=69)				
Social	3.16	0.92	1	5
Economics	4.06	0.92	1	5
Environmental	3.83	0.96	1	5
Public Health	4.06	0.91	2	5
Ranking of High Fibre Wheat Attributes (N=69)				
Taste	6.28	2.64	1	9
Demand	4.55	2.17	1	9
Income	2.94	2.44	1	9
Cost/Price	4.51	2.53	1	9
Yield/Output	3.83	1.94	1	9
Weather resistance	5.09	2.18	1	9

Grain colour	7.78	2.09	1	9
Protein level	5.57	1.86	2	9
Disease resistance	4.46	2.11	1	9

Source: Data Analysis, 2023

The minimum and maximum prices are 90p and £2.50, respectively. The variation in the responses could be attributed to the differences between the open and closed survey questions. Notwithstanding, the results give a sign as whether our sampled respondents are willing to pay a higher price for the newly developed high fibre white wheat bread. This is a relatively cheaper price when compared to existing related products in the economy. This may thus lead to a higher chance of consumer acceptance and uptake of the new loaf. While willingness to pay for premium is important, the study participants prioritize affordability with some selecting the lower bound of 90p.

3.2.1 Sustainability perception variables in relation to high fibre white wheat

The results (**Table 4** and **Figure 1**) show an estimated average value (standard deviation in parentheses) of 3.16 (0.92), 4.06 (0.92), 3.83 (0.96) and 4.06 (0.91) respectively for social, economic, environmental, and public health dimensions. Most of the respondents (49.3%) chose somewhat important (3) for the social dimension, 44.9% chose very important (4) for the economic dimension, 40.6% chose very important (4) for the environmental dimension while 37.7% chose extremely important (5) for the public health dimension. These findings suggest that economic and public health dimensions are more prioritised or ranked higher compared with environmental and social ones. The results are further illustrated in **Figure 1** where economic and public health attributes top the ranking for the average values with approximately 27% of the total mean values respectively versus 20.92% and 25.36% percentage mean shares for social and environmental dimensions, respectively. The frequency distribution of the respondents is further illustrated in **Figure 2**. The result proves that respondents attach more value to the economic and public health dimensions/factors, stressing their importance in economic policy relevance to the UK wheat supply chain as well as sustainable economic development.
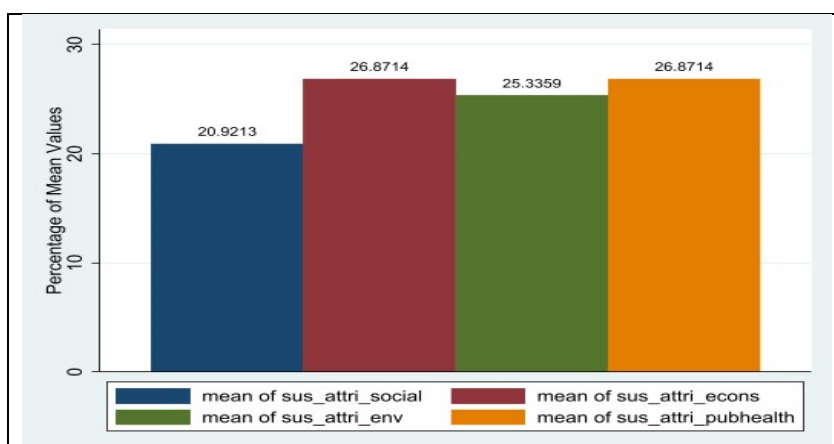

Figure 1: Bar Charts for the Percentage Perceived Share of Average Values of Sustainability Factors

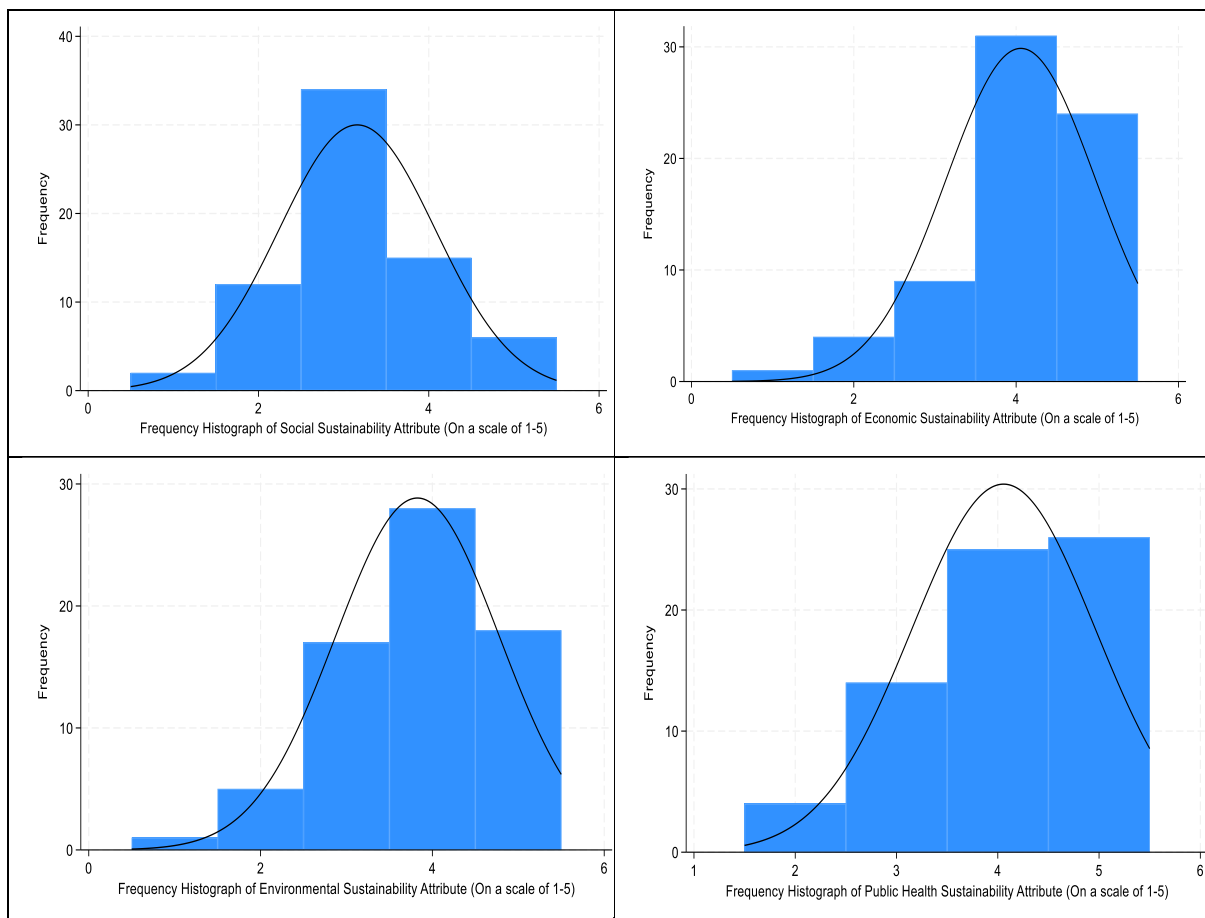Note: perception questions varied from not at all important (1) to extremely important (5)

Figure 2: Frequency Distribution of the Perceptions of Stakeholders toward Sustainability Factors of High Fibre Wheat

Source: Data Analysis, 2023

3.2.2   Ranking of wheat attribute preferences

The results, as shown in **Table 4** indicate that the mean values of ranking (standard deviation in parentheses) are estimated at 6.28 (2.64), 4.55 (2.11), 2.94 (2.44), 4.51 (2.53), 3.83 (1.94), 5.09 (2.18), 7.78 (2.09), 5.37 (1.86) and 4.46 (2.11), respectively for taste, demand, income, cost/price, yield (output), weather resistance, grain colour, protein level and disease resistance. This suggests grain colour is most important, followed by taste, protein level, weather resistance, demand, cost/price, disease resistance, yield/output whilst income is least important when considering the new wheat variety. The corresponding percentage average values are illustrated in **Figure 3**. These findings suggest the respondents are more likely to be concerned about the wheat grain colour which depict appearance, chemical composition like protein level which relate to healthy diet, the environmental variables such as the weather condition that affect the production of wheat. Thus, sustainability factors are important in the food system and should top the debate agenda in the wheat supply chain management.
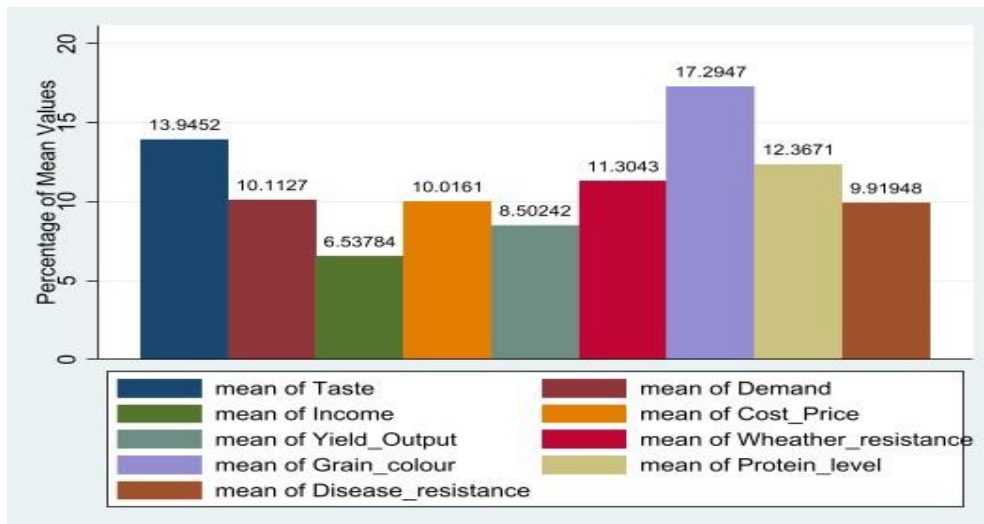
Figure 3: Percentage Bar Chart for Mean Values of Wheat Attributes

Source: Data Analysis, 2023

3.3   Principal components of high fibre white wheat attributes

Factor analysis was conducted on the ranked variables responded to by the sampled stakeholders within the UK wheat supply chain. This relates to the 9 different attributes using the 9-point scoring/ranking system with equal number of rankings allowed (that is, respondents can assign an equal number between 1 and 9 to different attributes). Three components are found in line with a Eugen value greater than 1 as shown in **Table 5**. Approximately 59.96% of the variance can be described as economically related (economic, environment and nutrition), grain (chemical) composition and purchasing power (price matter). The first component (category) are those stakeholders who have strong preferences for factors deciding their level of purchase such as demand (quantity) and income. It also includes those who attached high value to the roles of weather tolerance and protein level of wheat. They may see innovation beyond the technology traits to include the economic/environmental/nutritional benefits associated with the technology. A good proportion of this first category of stakeholders shown the weather or climatic conditions for their reasons in changing to high fibre white wheat. Such stakeholders can be seen to be environmental supporters who may prioritize sustainable food production for the overall benefits of sustainable economic development. The second category of stakeholders can be described as individuals who prioritise biological and chemical attributes of food (wheat in this context) in reaching their decision to take on a new product. In this respect, the stakeholders have preferences for taste, yield (output), grain colour and disease resistance. It can be inferred that these stakeholders may look beyond economic gains, simultaneously prioritizing food quantity and quality for healthy living. Thus, they can be seen as those who put public health above cost and price. The last stand-alone category is described as purchasing power (price matters). These are the stakeholders who prefer or have preferences for cost (price) above any other attributes. They are therefore likely to be interested in not only in the attractiveness of grains and the chemical/biological composition of wheat but also the associated prices.

Table 5: Principal Components and Related Attributes

Factors and Related Attributes	Factor Loadings (Raw)	Factor Loadings (Rescale)
1. Economy **(Economic, Environment, Nutrition)**		
Demand	-1.262	-0.583
Income	-1.895	-0.778
Weather resistance	1.139	0.522
Protein level	1.012	0.544
2. Grain Composition		
Taste	-2.316	-0.877
Yield/Output	0.481	0.248
Grain colour	-1.260	-0.602
Disease resistance	0.921	0.436
3. Purchasing Power		
Cost/Price	-2.434	-0.962

Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy = 0.43, ranking ranges between 1-9
Bartlett's Test of Sphericity (Chi-Squared = 73.53, DF = 36, Sig level= 0.001)
Source: Data Analysis, 2023

3.4 Stakeholders attitudes to risk

Sampled stakeholders' risk attitudes were examined and the results presented in **Table 6**. The average ranking values are reported in the table. For general risk, the respondents' average value of 6.44 suggests most of the sampled stakeholders are risk-loving. The median value of 7.00 further attests to this claim, which implies majority of the sampled stakeholders ranked their risk attitudes at 7 out of a possible 10. Similar trends were recorded for the environmental, economic, and social risks with an average rank of 6.04, 5.84 and 5.68, respectively. It can also be argued that the risk attitudes of the stakeholders tended to be neutral with respect to economics and social risks since 5.00 is the mid-point between 0 and 10. In other words, judging from the median values, respondents can be said to be risk-loving (7.00) for general risk, tend towards risk-loving (6.00) for environmental and economic risks but risk neutral (5.00) for social risk. The correspondence percentage bar chart is presented alongside the average values (**Figure 4**), with the general risk, environmental risk, economic risk, and social risk having a shared proportion of 26.83%, 25.15%, 24.34% and 23.68% respectively of the mean values. This confirms the order of risk preferences by the stakeholders.

Table 6: Risk Attitudes of the Respondents

Categories of Sustainability Related Risks	Mean	Median	SD	Min	Max
General Risk	6.44	7.00	1.81	2	10
Environmental Risk	6.04	6.00	1.93	2	10
Economics Risk	5.84	6.00	1.94	1	10

| Social Risk | 5.68 | 5.00 | 2.25 | 0 | 10 |

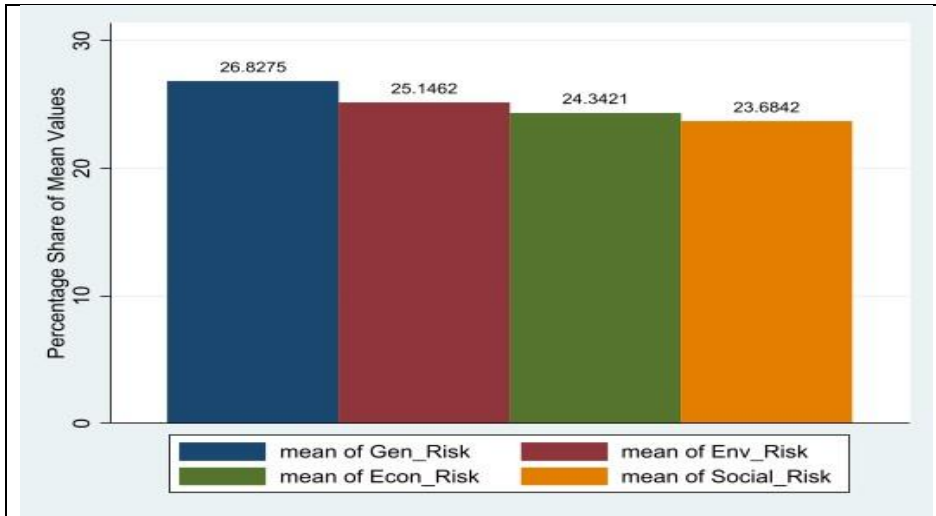Source: Data Analysis, 2023

Figure 4: Percentage Share of Average Values of Risk Attitudes of the Respondents

Source: Data Analysis, 2023

3.4.1 Distribution of stakeholder risk attitudes

The percentage distributions of the individual stakeholders in terms of general, environmental, economic, and social risks are illustrated in **Figure 5.** As can be seen, the general risk tends to be more normally distributed than the other risks. Approximately 21 percent of the sampled revealed 6,7 and 8 as their risk preferences, followed by large percentages who chosen 5 (10.5%) and 9 (8.77%). In the case of environmental risk, approximately 26 percent and 23 percent respectively preferred or ranked their risk attitudes at 5 and 6. On the other hands, approximately 25 percent of the respondents revealed 5 as their preferred risk value under the economic risk. This is followed by 15.8 percent of the respondents who choose 6 and 7, respectively as illustrated in the percentage bar chart. For social risk, the proportion of the respondents who choose 5 and 6 stood at 28.07 percent and 19.3 percent, respectively. In all, most respondents' choices are in the range of 5 and 10, attesting to their risk-loving or tend to be risk-loving attitudes. This pattern of behaviour may be a sign that risk-loving individuals are more likely to accept an innovation or change their existing practices.
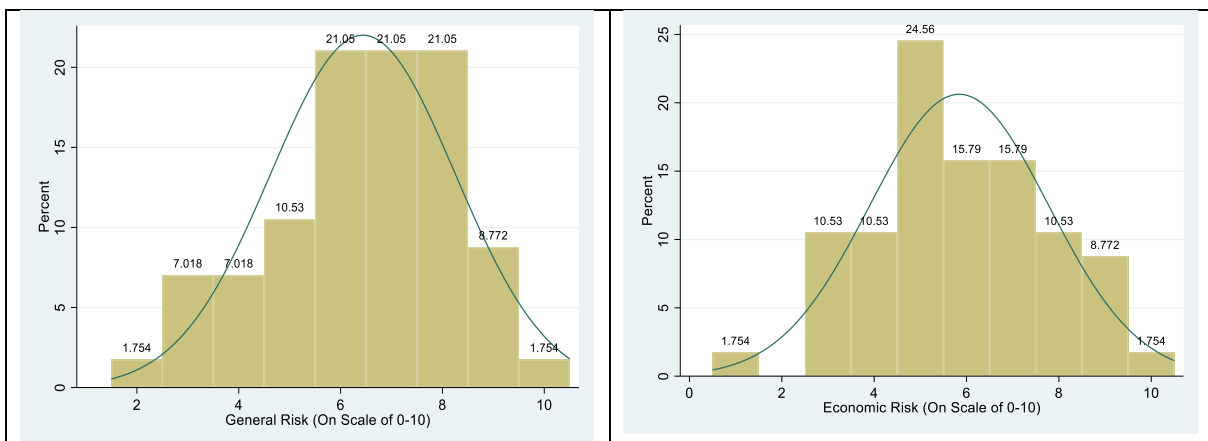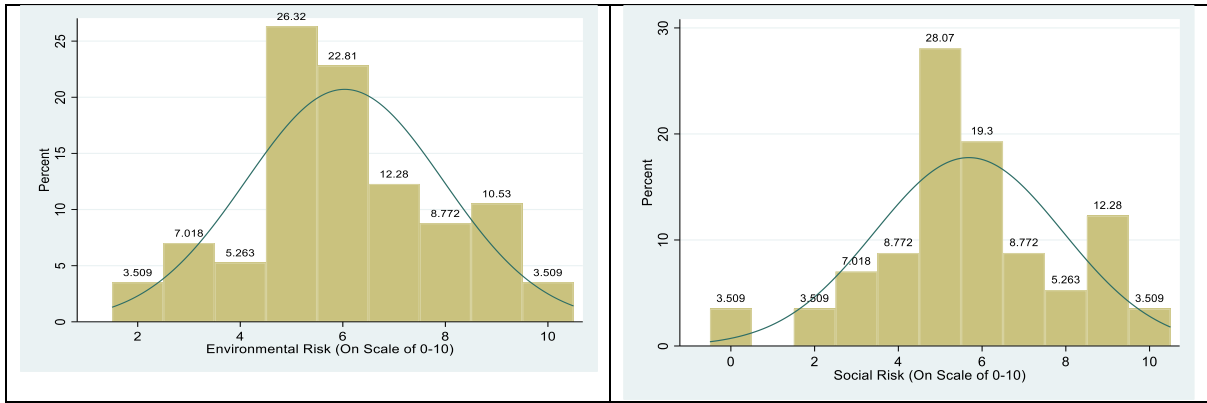
Figure 5: Individual Histogram Distributions of Risk Attitudes of Stakeholders

Risk attitudes have been identified as one of the principal factors affecting economic decisions, especially in investment and financial decisions including stocks holding (Gilad & Kliger, 2008; Dohmen *et al.*, 2011; Noussair *et al.*, 2014). It affects individual and household decision-making processes in diverse ways. For example, a risk averse person is expected to act differently from a risk-taking individual as the former may show a high degree of reluctancy when making important economic decisions whilst the latter is well and fully prepared to make decisions with a high expectation of gaining profitably from such decisions. The application of risk attitudes is also found in occupational choices and smoking decisions (Dohmen *et al.*, 2011). As a rational economic agent, individuals and households are noted for weighing the outcomes of their decisions before making them. The relationships between risk attitudes and sustainability factors as well as risk attitudes and preferences for wheat attributes are illustrated in **Table 9** and **Table 10** respectively under **Appendix 1.**

3.5   Estimates of relative willingness to pay for high fibre white wheat bread.

Results are compared across conditional logit, probit, and logit regressions. There is a slight variation in the results across modelling methods and software packages (**Table 7** and **Table 8**). The probit model appears more promising as the lead results. The result of the probit model as shown in **Table 7** indicates that lower price will increase utility/satisfaction derived from the high fibre bread. On the other hands, improvement in economic, environmental, and nutritional sustainability dimensions is associated with increased utility. In other words, the satisfaction of stakeholders is associated with reduction in price and improvement in economic, environmental and nutrition sustainability dimensions. These results align well with the *a priori* expectations and therefore considers to be robust.

The size of the coefficients of the variables as well as the odd ratios show that respondents' choices are respectively more influenced by the economic variable (GDP), followed by the nutrition variable (high fibre in bread) and least for environmental variable (environmental performance index). Decisions or preferences for access to health services have been previously reported as important economic policy by individuals who differ in waiting times, gender, and age in their preferences (Rubin *et al.*, 2006).

The estimates of WTP are calculated as the ratio of the partial derivative of the utility function with respect to the attribute of interest divided by the derivative of the utility function with respect to the price. In other words, WTP for each attribute is calculated as the ratio between

the parameter estimate of the attribute multiply by the average value of attribute and the product is divided by the price parameter. In terms of willingness to pay (WTP) for the selected sustainability attributes. Respondents are willing to pay less in the respective amount of **4p, 42p and 34p** to enjoy/for the improvement in the economic, environmental, and nutritional benefits of sustainability. The estimated average price respondents are willing to pay for the new high fibre bread is **95p**.

The results suggest that increasing the fibre content of 800g white wheat bread will not only help consumers in terms of nutrition but may also impact positively on the economy, environment, and public health. These findings align with previously expressed view that the public care about the reduction in environmental impact of human activities (Xuan & Sandorf, 2020). It also aligns well with findings that consumers are willing to pay for sustainable or environmentally eco-friendly products, e.g. toothbrushes made with bamboo versus plastic handles (Halton *et al.*, 2022). It buttresses the fact that stakeholders along the UK wheat supply chain are more likely to be satisfied with the improvements in the sustainability dimensions (economic, social, environment) that may be associated with the introduction of new high fibre white wheat. Notwithstanding, it is important to note that consumers may tend toward favouring reduction in prices to increase preferences as incentive to enjoy the associated benefits of the high fibre white wheat bread or related loaves in the UK.

Table 7: Results of Probit Regression Model

Choice Variables	Coefficients	Robust SE	Z-value	P-value	Lower CI (95%)	Higher CI (95%)	WTP	Marginal Effects
Economic	0.095	0.053	1.79	0.073	-0.008	0.199	0.04	0.034
Environment	0.014	0.004	3.84	0.000	0.007	0.021	0.42	0.005
Nutrition	0.041	0.008	5.40	0.000	0.026	0.026	0.34	0.015
Price	-2.937	0.374	-7.85	0.000	-3.671	-3.671	0.95	-1.039

Wald Chi2 (4) = 223.39, Prob > Chi2 = 0.000, Log pseudolikelihood = -1027.07, N = 1,656

Source: Data Analysis, 2023

Table 8: Results of Logistic Regression Model

Choice Variables	Coefficients (Odds Ratio)	Robust SE	Z-value	P-value	Lower CI (95%)	Higher CI (95%)	WTP	Marginal Effects
Economic	0.151 (1.163)	0.086	1.75	0.080	-0.018	0.321	0.04	0.033
Environment	0.023 (1.023)	0.006	3.87	0.000	0.011	0.035	0.42	0.005
Nutrition	0.068 (1.070)	0.013	5.38	0.000	0.043	0.093	0.35	0.015
Price	-4.831 (0.008)	0.622	-7.76	0.000	-6.050	-3.611	0.95	-1.039

Wald Chi2 (4) = 207.53, Prob > Chi2 = 0.000, Log pseudolikelihood = -1026.95, N = 1,656

Source: Data Analysis, 2023

4.0 Conclusion and Recommendations

Sustainability of the food systems is *sine qua non* to the overall economic development. Sustainable transformation of food systems requires wholistic approaches that must consider many distinct factors as well as the interconnectivity between these factors. In the wheat supply chain, the challenges vary from climate change and other production related factors such as yield to nutritional factors such as food quality as well as macro-economic issues like fluctuation in prices. Given the public concern about healthy foods and the economic importance of wheat globally, high fibre white wheat flour and bread can supply sustainable solution to health issues like type-2 diabetic and heart attack. Risk attitudes of the relevant stakeholders along the WSC may help in gaining insights into some of the behavioural issues connected with the WSC. It is also important to find attributes of high fibre wheat that will make it stand out from the crowded policy options. More importantly, preferences for sustainability dimensions should be given the desired research attention for efficient and reliable policy. In this study, we found evidence to support that the main attributes of high fibre wheat preferred by most sampled stakeholders relate to biological composition of the wheat (grain colour, taste, and protein level) while economic and public health topped the ranking for sustainability dimensions. Moreover, attitudes toward general risks as well as environmental, economic, and social risks are reportedly moderate or tend toward risk neutral. It is therefore recommended that policy makers and development partners should consider risk attitudes, high fibre wheat attributes and sustainability factors in policy formulation and implementation. Specifically, priority attention should be given to sustainability factors in food system transformation policy debates and wheat supply chain management while prioritising healthy food outcomes. Specific attention should also be given to some of the attributes of wheat including grain colour, weather resistance protein content and taste while gearing up efforts to ensure availability and affordability of high fibre white wheat bread. As consumers are willing to pay 95p or more (up to £1.31) for a loaf of 800g white wheat bread if the bread is enriched with high fibre, it is important to prioritize accessibility and affordability of the new bread product.

5.0 References

Cho, K., Falloon, P., Gornall, J., Betts, R., & Clark, R. (2012). Winter wheat yields in the UK: uncertainties in climate and management impacts. *Climate research*, *54*(1), 49-68.

Ciudad-Mulero, M., Barros, L., Fernandes, Â., CFR Ferreira, I., Callejo, M. J., Matallana-González, M. C., Fernández-Ruiz, V., Morales, P., & Carrillo, J. M. (2020). Potential health claims of durum and bread wheat flours as functional ingredients. *Nutrients*, *12*(2), 504.

Davis, K. F., Downs, S., & Gephart, J. A. (2021). Towards food supply chain resilience to environmental shocks. *Nature Food*, *2*(1), 54-65.

Deng, L., Zhang, H., Wang, C., Ma, W., Zhu, A., Zhang, F., & Jiao, X. (2021). Improving the sustainability of the wheat supply chain through multi-stakeholder engagement. *Journal of cleaner production*, *321*, 128837.

Dohmen, T., Falk, A., Huffman, D., Sunde, U., Schupp, J., & Wagner, G. G. (2011). Individual risk attitudes: Measurement, determinants, and behavioral consequences. *Journal of the european economic association*, *9*(3), 522-550.

Dossa, A. A., Gough, A., Batista, L., & Mortimer, K. (2022). Diffusion of circular economy practices in the UK wheat food supply chain. *International Journal of Logistics Research and Applications*, *25*(3), 328-347.

Gilad, D., & Kliger, D. (2008). Priming the risk attitudes of professionals in financial decision making. *Review of Finance*, *12*(3), 567-586.

Halton, C., Duane, B., Batey, A. C., Wong, J., Corley, A., Hart, F., Koh, J., & Johnston, B. (2022). How much do consumers consider sustainability when purchasing a toothbrush? A discrete choice experiment. *British Dental Journal*, *233*(4), 327-332.

Hawkesford, M. J., Araus, J. L., Park, R., Calderini, D., Miralles, D., Shen, T., Zhang, J., & Parry, M. A. (2013). Prospects of doubling global wheat yields. *Food and Energy Security*, *2*(1), 34-48.

Lombardozzi, L., & Djanibekov, N. (2021). Can self-sufficiency policy improve food security? An inter-temporal assessment of the wheat value-chain in Uzbekistan. *Eurasian Geography and Economics*, *62*(1), 1-20.

Mesterházy, Á., Oláh, J., & Popp, J. (2020). Losses in the grain supply chain: Causes and solutions. *Sustainability*, *12*(6), 2342.

Mitlin, D. (1992). Sustainable development: A guide to the literature. *Environment and urbanization*, *4*(1), 111-124.

Noussair, C. N., Trautmann, S. T., & Van de Kuilen, G. (2014). Higher order risk attitudes, demographics, and financial decisions. *Review of Economic Studies*, *81*(1), 325-355.

Pena, R. (2007). Current and future trends of wheat quality needs. Wheat Production in Stressed Environments: Proceedings of the 7th International Wheat Conference, 27 November–2 December 2005, Mar del Plata, Argentina,

Peña, R. (2002). Wheat for bread and other foods. *Bread wheat improvement and production. Food and Agriculture Organization of the United Nations. Rome*, 483-542. https://www.fao.org/3/y4011e/y4011e0w.htm

Röder, M., Thornley, P., Campbell, G., & Bows-Larkin, A. (2014). Emissions associated with meeting the future global wheat demand: A case study of UK production under climate change constraints. *Environmental Science & Policy*, *39*, 13-24.

Rubin, G., Bate, A., George, A., Shackley, P., & Hall, N. (2006). Preferences for access to the GP: a discrete choice experiment. *British Journal of General Practice*, *56*(531), 743-748.

Xuan, B. B., & Sandorf, E. D. (2020). Potential for sustainable aquaculture: insights from discrete choice experiments. *Environmental and Resource Economics*, *77*, 401-421.

Appendix 1: Relationship between Risk Attitudes and Sustainability Factors, and Risk Attitudes and Wheat Attributes

Table 9: Relationships Between Stakeholders' Risk Attitudes and Sustainability Factors

Risks:	General Risks			Environmental Risk			Economic Risk			Social Risk		
Sustainability Attributes	Chi-squared	Pearson Correlation	Spearman Correlation	Chi-squared	Pearson Correlation	Spearman Correlation	Chi-squared	Pearson Correlation	Spearman Correlation	Chi-squared	Pearson Correlation	Spearman Correlation
Social Sustainability	40.04	0.07	0.11	39.37	0.19	0.12	59.72***	0.23*	0.17	41.02	0.11	0.06
Economic	21.28	0.18	0.16	18.30	0.24*	0.24*	13.29	0.26**	0.25*	22.97	0.18	0.11

Sustainability												
Environmental Sustainability	27.73	0.26*	0.26*	52.37***	0.36***	0.26**	43.14*	0.30**	0.26**	54.83**	0.24*	0.19
Public Health Sustainability	29.80	0.33***	0.34***	38.31**	0.37***	0.34***	39.65**	0.38***	0.32**	42.98**	0.30**	0.23*

Table 10: Relationship between Risk Attitudes and High Fibre Wheat Attributes

Risks:	General Risks			Environmental Risk			Economic Risk			Social Risk		
High Fibre Wheat Attributes	Chi-squared	Pearson Correlation	Spearman Correlation	Chi-squared	Pearson Correlation	Spearman Correlation	Chi-squared	Pearson Correlation	Spearman Correlation	Chi-squared	Pearson Correlation	Spearman Correlation
Taste	65.2	-0.19	-0.15	48.54	-0.23*	-0.18	59.60	-0.26**	-0.20	62.30	-0.26*	-0.18
Demand	66.07	-0.08	-0.10	56.03	-0.05	-0.09	62.54	-0.04	-0.01	64.65	0.14	0.13
Income	71.16***	-0.12	-0.13	37.94	-0.15	-0.19	33.68	-0.10	-0.11	38.84	-0.08	-0.07
Cost/Price	84.56**	0.39***	0.43***	72.88	0.29**	0.30**	66.05	0.27*	0.27*	68.99	0.27*	0.27*
Yield/Output	48.98	0.16	0.20	62.53	0.25*	0.26**	54.00	0.26**	0.31**	60.22	0.29**	0.27**
Weather resistance	70.52	-0.18	-0.18	89.57**	-0.17	-0.16	68.87	-0.13	-0.11	95.87**	-0.24	-0.20
Grain colour	47.86	-0.16	-0.06	41.64	-0.10	-0.05	42.37	-0.09	-0.05	26.52	-0.15	-0.14
Protein level	47.45	0.01	0.01	36.50	0.01	0.02	54.11	0.01	0.03	57.05	-0.03	-0.03
Disease resistance	68.06	0.12	0.09	71.03	0.16	0.16	76.69	0.10	0.08	73.77	0.04	0.02

Appendix 2: Survey Instrument

Survey Instrument on Understanding Preferences in UK Wheat Supply Chain

Welcome and thank you for your interest in taking part in this study. This is an anonymous questionnaire (we will not collect your name) about your preferences, including 4 parts in total. This survey will last about 20 minutes and we will be asking you questions about your perceptions and preferences for high fibre wheat in the UK. Please answer these questions privately and as sincerely as possible. There is no right or wrong answer. You are free to withdraw from this survey at any time, at any stage of the process. Be assured that all the information provided will be treated with upmost confidentiality and all data collected will only be used in research.

Feel free to contact us through the email addresses below if you have questions or any concerns.
Contact E-mails: Sophie s.clot@reading.ac.uk

The questionnaire is divided into four (4) parts as detailed below:

Part 1: Your role as a consumer
This section examines your risk-taking attitudes. It should take approximately 2 minutes to complete.

Part 2: The role of price, policy, and nutrition in purchasing
This section seeks your opinion on a new high-fibre white flour currently being developed by choosing one policy among three alternative policies given the attributes relating to the economy (GDP), environment (EPI), nutrition (high-fibre) and price (price of 800g white bread). This part will take approximately 8 minutes to complete.

Part 3: Your role in the UK wheat supply chain and transformation
Part 3 include 2 subparts. Part 3A is meant to obtain your perceptions and preferences for high fibre wheat while 3B is socio-demographic variables. The estimated time for this part is 8 minutes.

Consent Statement
"By answering the interview questions/completing the questionnaire you are acknowledging that you understand the terms of participation and that you consent to these terms."

Thank you for your understanding and participation.

Part 1: Your role as a consumer

Dear Respondent,

This section assesses your willingness to taking risks. You will be asked 4 questions in total. The first question relates to your general willingness to taking risks while others relate to your willingness to taking risks with respect to environmental, economic, and social/health sustainability of high fibre white wheat bread. Please circle one number between 0 and 10.

1. How do you see yourself: **are you generally a person who is fully prepared to take risks or do you try to avoid taking risks**? Please show your willingness to taking risk between the scale of 0 and 10. Zero (0) means not at all willing to take risks while ten (10) means very willing to take risks.

_____

| 0 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

Not at all willing to take risks   Very willing to take risks.

2. How willing are you to take risks relating to **environmental sustainability of high fibre white wheat bread**? Please show your willingness between the scale of 0 and 10. Zero (0) means not at all willing to take risks while ten (10) means very willing to take risks.

_____

| 0 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

Not at all willing to take risks   Very willing to take risks.

3. How willing are you to take risks relating to **economic sustainability of high fibre white wheat bread**? Please show your willingness between the scale of 0 and 10. Zero (0) means not at all willing to take risks while ten (10) means very willing to take risks.

_____

0   2   3   4   5   6   7   8   9   10

Not at all willing to take risks   Very willing to take risks.

4. How willing are you to take risks relating to **social/health sustainability of high fibre white wheat bread**? Please show your willingness between the scale of 0 and 10. Zero (0) means not at all willing to take risks while ten (10) means very willing to take risks.

_____

0   2   3   4   5   6   7   8   9   10

Not at all willing to take risks   Very willing to take risks.

Part 2: The role of price, policy, and nutrition in purchasing

Efforts are currently underway to develop a new high fibre white bread loaf for consumption in the UK. Using **new high-fibre white flour**, which is suitable for the UK climate, our project is focused on improving dietary fibre for those who need it most, with little or no added cost. This high-fibre bread, therefore, has associated social, economic, environmental and health related benefits. However, these benefits are associated with some degrees of uncertainty. We are interested in understanding how members of the UK wheat supply chain, from breeders to supermarkets, perceive possible scenario in the UK wheat chain as well as the risks of transitioning to this new high-fibre white bread. These outcomes have been carefully reflected and captured in the design below.

Please consider the following hypothetical situation. The UK government, in agreement with an existing supermarket, is considering different policies on the white wheat bread (which constitutes over 76% of bread sales in the UK) that can improve public health (to address social, economic and environmental concerns) because of consuming more fibre through high fibre white bread. We are interested in your valuations of these policies and will now ask you to answer **the following 8 questions**. Apart from the fact that the policies differ with respect to the focus on public health, the policies also differ regarding economic issues (e.g contribution to GDP), environmental impact (via the Environmental Performance Index), nutritional benefit (higher fibre from consuming white wheat bread). The summary of the attributes and the levels of attributes are presented in **Table 1** below.

Table 1: Attributes Description and Attribute Levels

Attributes	Attributes description	Attributes Levels		
Economics (GDP)	Economic benefit, by increasing the contribution of agriculture (wheat) to GDP	High (H) (2.0%)	Medium (M)	Low (L) (0.51%)

				(1.0%)	
Environment (EPI)	Environmental impact associated with food production, in line with the environmental performance index (EPI) which reflect the health impact, climate change impacts, water resources, habitat diversity, and ecosystem vitality	High (H) (97.7)	Medium (M) (87.7)	Low (L) (77.70)
Nutrition (fibre content of bread)	Nutritional benefit of the hi-fi wheat (increased fibre contents) which will promote good health. This value stands for the average fibre content of 800g of white bread	High (H) (30g)	Medium (M) (25g)	Low (L) (19g)
Price (£)	Cost of 800g loaf of white bread	£1.00	£0.95	£0.90

Note: The EPI is an index that reflects the environmental performance of 180 countries.

1		Policy 1	Policy 2	Policy 3
	Economics (GDP)	2% (H)	0.51% (L)	1% (M)
	Environment (EPI)	77.7 (L)	87.7 (M)	97.7 (H)
	Nutrition (Fibre in Bread)	25g (M)	19g (L)	30g (H)
	Price (800g white bread)	£1.00	£0.95	£0.90
	Which would you choose?	☐	☐	☐

2		Policy 1	Policy 2	Policy 3
	Economics (GDP)	0.51% (L)	1% (M)	2% (H)
	Environment (EPI)	87.7 (M)	97.7 (H)	77.7 (L)
	Nutrition (Fibre in Bread)	25g (M)	30g (H)	19g (L)
	Price (800g white bread)	£1.00	£0.95	£0.90
	Which would you choose?	☐	☐	☐

3		Policy 1	Policy 2	Policy 3
	Economics (GDP)	0.51% (L)	2% (H)	1% (M)
	Environment (EPI)	77.7 (L)	87.7 (M)	97.7 (H)
	Nutrition (Fibre in Bread)	30g (H)	19g (L)	25g (M)
	Price (800g white bread)	£0.90	£1.00	£0.95
	Which would you choose?	☐	☐	☐

4		Policy 1	Policy 2	Policy 3
	Economics (GDP)	1% (M)	0.51% (L)	2% (H)
	Environment (EPI)	87.7 (M)	77.7 (L)	97.7 (H)
	Nutrition (Fibre in Bread)	25g (M)	30g (H)	19g (L)
	Price (800g white bread)	£0.90	£1.00	£0.95
	Which would you choose?	☐	☐	☐

Figure 1: Choice Card 1 of 2

5		Policy 1	Policy 2	Policy 3
	Economics (GDP)	2% (H)	0.51% (L)	1% (M)
	Environment (EPI)	97.7 (H)	77.7 (L)	87.7 (M)
	Nutrition (Fibre in Bread)	19g (L)	25g (M)	30g (H)
	Price (800g white bread)	£0.90	£0.95	£1.00
	Which would you choose?	☐	☐	☐

6		Policy 1	Policy 2	Policy 3
	Economics (GDP)	1% (M)	2% (H)	0.51% (L)
	Environment (EPI)	77.7 (L)	97.7 (H)	87.7 (M)
	Nutrition (Fibre in Bread)	19g (L)	30g (H)	25g (M)
	Price (800g white bread)	£0.90	£1.00	£0.95
	Which would you choose?	☐	☐	☐

7		Policy 1	Policy 2	Policy 3
	Economics (GDP)	0.51% (L)	1% (M)	2% (H)
	Environment (EPI)	97.7 (H)	77.7 (L)	87.7 (M)
	Nutrition (Fibre in Bread)	30g (H)	19g (L)	25g (M)
	Price (800g white bread)	£1.00	£0.95	£0.90
	Which would you choose?	☐	☐	☐

8		Policy 1	Policy 2	Policy 3
	Economics (GDP)	1% (M)	0.51% (L)	2% (H)
	Environment (EPI)	87.7 (M)	97.7 (H)	77.7 (L)
	Nutrition (Fibre in Bread)	19g (L)	25g (M)	30g (H)
	Price (800g white bread)	£1.00	£0.90	£0.95
	Which would you choose?	☐	☐	☐

Figure 2: Choice Card 2 of 2

Part 3: Your role in the UK wheat supply chain and transformation

Part 3 seeks to obtain your perceptions and preferences for high fibre wheat in the UK.

3A/ Please answer the following questions, as honestly as possible.

1. How much are you willing to pay for 800g high fibre white bread that will improve public health through social, economic, and environmental benefits? _____

3B/ Kindly tick the correct answer. Multiple answers allowed in some cases.

1. Which of the following categories best describe you?
   (a) Breeders-grain/seed producers (   )
   (b) Wheat farmers (   )
   (c) Wheat grain merchants including retailers/wholesalers (   )
   (d) Wheat millers (   )
   (e) Wheat bakers (   )
   (f) Grain quality compliance authority (   )
   (g) Other stakeholders group along the wheat supply chain (   ). Please specify
   _____

2. What role/responsibility do you currently have in the wheat milling industry? For example, manager/regulator/controller/technical/miller/baker/merchant/
   Please specify_____

3. Kindly rank your preferences for the following attributes on a 5-point scale of importance, where 1=not at all important and 5=extremely important.

   Please tick one choice per row.

Sustainability factors	Not at all important (1)	Slightly important (2)	Somewhat important (3)	Very important (4)	Extremely important (5)
Social					
Economics					
Environmental					
Public health					

4. What attributes/factors/reasons would make you prefer high fibre wheat to your existing wheat cultivars/grains/flour? Please rank from 1-9.

Attributes	Taste	Demand	Income	Cost	Yield	Weather resistance	Grain Colour	Protein level	Disease resistance
Rank									

5. Are you aware of any health benefits associated with high fibre wheat flour for white bread? Yes (   ), No (   )

6. If you are convinced about the potential health benefits of high fibre wheat, are you willing to change your purchasing/growing practices from your existing wheat seeds/grains/wheat flour to high fibre wheat? Yes ( ), No ( )

7. How much efforts have you made to get information about wheat cultivars/wheat grain/wheat flour/ with high fibre content? (i) No effort ( ), (ii) little effort ( ), (iii) much effort ( )

8. Overall, how do you feel about the potential impact of the availability of high fibre white wheat bread? (i) Very positive ( ), (ii) positive ( ), (iii) neutral ( ), (iv) negative ( ), (v) very negative ( )

9. There are benefits to people in Britain from consuming high fibre white wheat bread
(i) Strongly agree ( ), (ii) agree ( ), (iii) neither agree nor disagree ( ),
(iv) disagree ( ), (v) strongly disagree ( )

10. Age range: (i) less than 20 ( ), (ii) 20 – 29 ( ), (iii) 30 – 39 ( ), (iv) 40 – 49 ( ),
(v) 50 – 59 ( ), (vi) above 60 ( )

11. Your educational level: (i) Less than High School ( ), (ii) High School completed ( ), (iii) Further Education/Vocational Training ( ), (iv) University degree ( ), (v) Post-graduate degree ( ), (vi) others (specify) _____

12. What gender do you identify with? (i) Male ( ), (ii) Female ( ), (iii) Non-binary ( ),
(iv) prefer not to say ( )

13. How many years of experience do you have in this business/corporate work? _____
(i) less than or equal to 5 years ( ), (ii) 6 – 10 years ( ), (iii) 11 – 15 years ( ),
(iv) above 15 years ( )

14. How best can you describe the annual turnover of your business? (i) less than or equal to £100,000 ( ), (ii) £100,100 – £200,000 ( ), (iii) £200,100 – £300,000 ( ), (iv) £300,100 - £400,000 ( ), (v) £400,100 – 500,000 ( ), (vi) above 500,000 ( ), (vii) others (specify) _____

15. Are you a registered member of any professional association? (i) Yes ( ), (ii) No ( )

16. What are your sources of information about improved wheat and health benefits of wheat? Multiple options allowed.
(i) Radio ( ), (ii) Television ( ), (iii) Newspaper or Magazine ( ),
(iv) Professional Association/Society ( ), (v) Events like seminars/conferences/workshops ( ), (vi) others ( ) (please specify) _____