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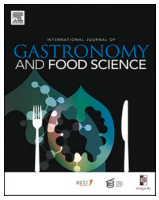

Influencing factors towards consumer acceptance of millet as a food source

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ABSTRACT

Ensuring food security and sustainability is critical to support present and future generations, while minimising negative environmental impacts. The planet provides over 250,000 edible plant species yet humans have become reliant on three main crops: wheat, maize, and rice. Underutilised crop species have the potential to alleviate the strain on the planet's resources, while providing nutritionally balanced alternative food sources. Heritage grains have been part of the human diet since the advent of agricultural practices, but many are now considered forgotten foods. Millet is a heritage grain with consumption history dating back to the Song dynasty (960-1279CE). In western society millet is an underutilised food source, yet is a reliable, sustainable, and highly nutritious crop that has the potential to alleviate food security and support healthy consumption patterns. To effectively integrate millet into current dietary behaviours greater understanding of the determinants of consumer acceptance of alternative food sources is required. This study takes a qualitative approach to assess the personal, social, cultural, economic, and psychological factors influencing British consumer decision making processes to try, utilise, and integrate millet into current dietary patterns. Consumer focus groups were conducted to identify influencing factors relating to altruistic, egoistic, habit forming, conditional and functional values. This research provides an understanding of the influencing factors associated with consumer acceptance of millet as a food source in the UK and will be of interest to practice and policy to support the development of strategies to promote sustainable food system initiatives and healthy dietary choices.

1. Introduction

Humans primarily depend on a limited number of crops for sustenance. Of the hundreds of thousands of edible species (Hummer, 2015), many are neglected, underutilised and unfamiliar (Ulian et al., 2020) particularly amongst Western consumers. There are several underutilised heritage crop species that could be incorporated into dietary behaviours towards the improvement of dietary diversity, nutritional health, food security and support of the environment(Gregory et al., 2019).

Roughly 150 plant species are cultivated extensively for food production with approximately 30 crops supplying 95% of human calorific needs (Shelef et al., 2017). There is a global reliance on three main cereal grain crops; wheat, rice and maize, which provide two-thirds of the world's food energy intake (Shiferaw et al., 2013). These grains are staple food sources in many parts of the world, due to their high yield, nutritional value, calorific density, cultural tradition, culinary versatility, and economic accessibility. Yet mainstream agricultural and food production practices are having a negative impact on the environment and often produce nutritionally inferior grains compared to alternative underutilised ones

Wheat is the most widely grown crop globally and has historically been the cornerstone of food security due its high yield, ease of processing and quality characteristics (Erenstein et al., 2022). But recent conflict between two key exporters (Ukraine and Russia) has led to increased prices and food insecurity (Lin et al., 2023). The effects of climate change have led to some uncertainty of future wheat yield (Naaz et al., 2023),with research indicating that some current wheat varieties may only be viable until 2050 (Gaydon et al., 2023). Thus, highlighting the vulnerability of global food security networks leading to an increased significance in exploring the potential of alternative crops (Shah et al., 2024).

Various nutrient rich crops can be cultivated in suboptimal environments, such as millet (Chivenge et al., 2015). Millet i s considered a climate change compliant grain (FAO, 2023), due to its adaptability, low maintenance, high tolerance of drought and extreme weather conditions

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and fast-growing nature, maturing in less than half the time of wheat (Jukanti et al., 2016). Millet can be grown on a wide variety of soils ranging from clay loams to deep sands (Chivenge et al., 2015), are easy t o cultivate and can thrive in arid and semi-arid conditions where water is a limiting factor (Zegada-Lizarazu and Iijima, 2005). In addition, millet are disease and pest resistant (FA0 2023), require few pesticides and minimal fertilisation (Hayashi et al., 2008) use 30% less water than maize and 70% less than rice (Orr et al., 2020) indicating its potential as a reliable, sustainable crop to support the growing agrarian challenges and consumption levels of populations.

1.1. Millet as a food source

Millet is the 6th largest cereal crop in terms of world agriculture production FAO, 2023). In 2024, global millet production was estimated to be around 31,763 MT, with India as the top producer, followed by Niger and China. For comparison global supply of wheat in 2024 is estimated to be 1,270,993 MT(USDA, 2024).

The United Nations named 2023 as the Year of the Millet aiming to raise awareness and direct policy attention of the nutritional and health benefits, suitability for cultivation under adverse and changing climatic conditions and the potential of new sustainable market opportunities for producers and consumers (FAO, 2023). Millet is naturally gluten free, a rich source of protein, dietary fibre, and has high nutritional value in energy, fat, vitamins (niacin, B-complex, folic-acid) and minerals (P, Ca, Zn, Fe) (Das et al., 2019) superior to wheat, maize and refined rice (Jocelyne et al., 2020) and is recognised for its health benefits (Sharma and Niranjan 2018) making it an ideal dietary addition for those on gluten restrictive diets and/or seeking healthy, nutritionally balanced dietary choices. Millet is a versatile grain that can be utilised in varied food preparations including breads, baked goods, granola, energy bars and puffed snacks. Historically millet has been made into culturally traditional dishes such as Indian 'ragi roti', African 'ugali' and Chinese millet porridge. Additionally millet can be utilised to produce fermented beverages such as beer and boza, porridge for adults and weaning infants and can be used as a direct replacement for rice, pasta, couscous or added as an alternative grain substitute in dishes such as soups, stews, paella, curries etc. But requires pre-soaking to moderate its anti-nutrient properties (Ocheme and Chinma, 2008). Currently there is much interest in product development of millet-based foods, particularly in the gluten free market (Deshpande et al., 2021).

Although a recognised food source in India, there has been a significant decline in millet consumption, which can partly be attributed to the perceived stigma of millet as a 'poor man's' or 'medicinal food' (Shah et al., 2024). Data surrounding consumption of millet is lacking globally, particularly in western cultures. Millet is successfully commercially grown in the UK and is currently primarily processed as grain cereal for bird feed and animal fodder but is not widely marketed in retail stores for human consumption. As such it is unfamiliar amongst consumers and can be considered a novel food source.

1.2. Consumer behaviour in relation to new and novel food sources

It is critical to engage with consumers to drive demand, but in order to accomplish this an understanding of the factors influencing consumers towards acceptance of millet as a food source is crucial. The foods that consumers choose to consume influences food production systems and policy decisions through consumer demand (Mozaffarian et al., 2018).

Research across disciplines has generated a wealth of conceptual and theoretical models exploring consumer behaviours in relation to food choice. These models highlight a diverse array of internal and external factors, incorporating individual, societal, and/or environmental motives and barriers which can intricately shape food choice behaviours, these can be fixed, dynamic, and/or situational in their influence on the consumer.

When assessing food choice in relation to unfamiliar and novel foods theoretical models of behaviour, such as the Health Belief Model (Rosenstock, 1974) Social Cognitive Theory Bandura, 1977) Theory of Reasoned Action (Fishbein and Ajzen, 1977) and the Theory of Planned Behaviour (Ajzen, 1985) have been extensively employed by social scientists to assess the complex influencing factors on consumers food choice. Seminal research by Lewin (1943), proposed four key categories influencing consumers food choices: taste, health, social status, and cost. This framework has been utilised as the basis for further research focusing on the cognitive, behavioural, motivational, and social influences on consumer food choice (Nestle et al., 1998). These categories are reflected in research by Köster (2009) who propose intuitive reasoning and unconscious influence such as past behaviour, habit and hedonic appreciation also play a significant role in food choice behaviour.

Modern multidisciplinary research has identified three main categories of factors influencing food choice within the fields of nutrition, psychology, social science, and marketing, each providing evidence from different perspectives, to include food related features such as sensory appeal, information and packaging; individual differences such as biological, physical and psychological factors and society related features such as culture, economic variables and policy (Chen and Antonelli, 2020) however there is no distinct model that can fully explain or predict food choice behaviours (Nestle et al., 1998).

Whilst these factors are well-established in the literature, it is important to consider additional influences when assessing the acceptance of unfamiliar and novel food sources. Modern food choices are influenced by a range of contextual, cultural, psychological and economic factors that interact with personal beliefs, environmental values and health awareness. In addition to individual level factors such as sensory appeal, food neophobia, food quality, food safety and nutritional value, other factors such as supportive food polices, food supply chain disruption, modern food environments, availability and accessibility of new foods all play a role in acceptance (Tuorila and Hartmann, 2020).

For the purpose of this research The Theory of Trying (Bagozzi and Warshaw, 1990) is adopted as the theoretical model for underpin, on the basis that the first step in understanding consumer acceptance of a new and novel food source is to focus on consumers motivations and intentions to consider integration into current dietary behaviours. Bagozzi and Warsaw's approach considers factors that influence willingness to try rather than to purchase or consume by capturing the aspects of decision-making such as curiosity, perceived risk, personal/social goals and anticipated challenges. The Theory of Trying provides a framework to understand the motives, facilitators and barriers consumers associate with acceptance and integration of a new food source, such as millet.

A conceptual model (Fig. 1) is proposed, providing a framework of the factors influencing consumers psychological processes towards the consideration of trying a new food source. This uses the Theory of Trying and extends (in darker shading) to account for altruistic, egoistic, habit forming, conditional and functional factors that reflect consumer behaviours, influences in relation to the adoption of new and novel food sources. The incorporation of these factors improves the applicability and relevance by assessing the broad influences on consumers towards trying new foods. The extension further allows for the consideration of new variables that may become important over time such as health and consumer trends, sustainability, environmental concerns and developments, policy changes/implementation and other factors that may emerge as influencing consumer behaviour.

Categorising altruistic, egoistic, habit forming and conditional and functional values helps to classify and explain the underlying motivations guiding individual actions. Altruism refers to actions motivated by the welfare of others, without direct benefit to oneself. Altruistic food choice behaviours are driven by awareness and concern for the environment, social and subjective responsibility and self-identity (Maschio et al., 2023). These actions are motivated by the intention to positively

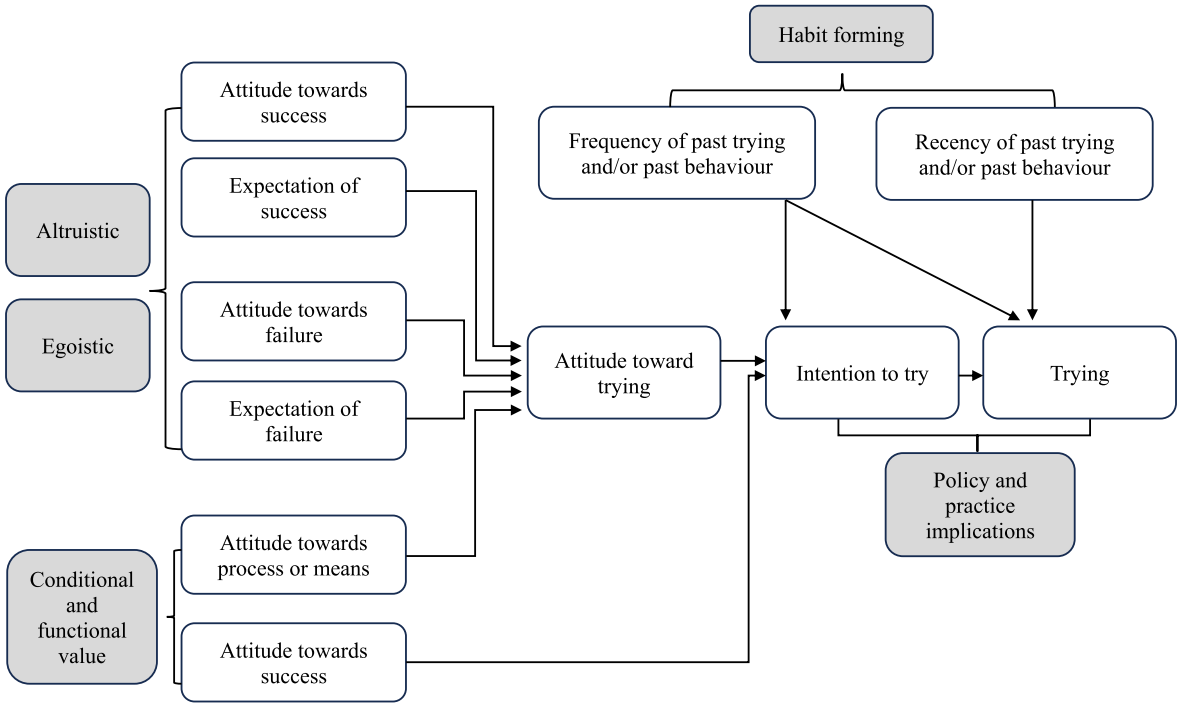

Fig. 1. Conceptual framework extending the Theory of Trying Adapted from: Bagozzi and Warshaw (1990).

contribute to society. Egoistic behaviours, by contrast, are driven by self-interest and personal benefit. Consumers engaging in egoistic behaviours prioritise their own well-being to seek personal benefits, such as health consciousness, social and subjective norm, self-identity (Birch and Memery, 2014), current lif e patterns and roles and include behaviours relating to food neophobia and sensory appeal (Kita et al., 2024).

Habit formation in food choice behaviours play a critical role in shaping long-term consumption patterns and includes factors of social and subjective norm, familiarity, life course, and familial influence Sobal and Bisogni, 2009). Understanding the influence of these factors can help explain how and why consumers develop preferences for certain foods, and the motives and barriers for incorporation of new and novel foods into current dietary patterns.

Conditional and functional factors can be useful when examining consumer behaviours in food choice. These factors include price and affordability, availability, accessibility, convenience, demographics, knowledge, and marketing influence, which are shaped by individual and societal prompts (Furst et al., 1996).

It is important to note that altruistic, egoistic behaviours with habit forming and conditional and functional factors in relation to novel food choice can co-exist and can be fluid or static in the decision-making processes towards novel food choice behaviours. For example, a consumer may have a heightened environmental concern (altruistic) and may wish to eat a diet that supports their health (egoistic), but foods to support this are not familiar (habit forming) and are not available to them in their current setting (conditional). Predicting how these factors influence consumer behaviours is critical to understanding new and novel food choices to support the development of strategies and interventions that cater to both individual needs and societal benefits (Cuevas et al., 2017).

2. Materials and methods

Inductive qualitative data collection was undertaken in the form of 3 focus group sessions, conducted on site at Bournemouth University. A total of N=16 participants were recruited via non-probability sampling initially through personal contact and then via snowball sampling. Demographics are shown in Table 1. Sampling criteria included adults aged 18 and above who reside in the locality of Dorset in United Kingdom. Participants provided a broad demographic being aged between 18 and 77 with 10 Female and 6 Male contributors. The objective was to gather insights and opinions from a diverse group of participants exploring perceptions and attitudes towards millet as a food source to provide a rich account of views grounded in the consumers own vocabulary.

A semi-structured approach was taken using a predetermined open-ended discussion guide to ensure that discussions were appropriately focused whilst retaining the flexibility to respond to unanticipated data. Preliminary scoping interviews highlighted consumers limited knowledge of millet as a food source, consequently a short factsheet to outline millet characteristics was provided part way through discussions. This allowed the facilitator to gain participants unprepared views to allow for flexibility and exploration of the topic area.

Audio recordings from the focus groups were made and subsequently transcribed verbatim. A reflexive thematic approach (Braun and Clarke, 2006) was then taken utilising NVivo 14.

Table 1
Participant demographics.

	Participant ID	Age	Gender
Group 1	1	50	F
	2	68	F
	3	74	F
	4	75	M
	5	74	F
	6	77	M
	7	25	F
	8	19	F
Group 2	9	23	M
	10	22	F
	11	45	M
	12	18	M
	13	28	F
Group 3	14	21	F
	15	28	M
	16	21	F

3. Results & discussion

Fig. 2 provides an overview of the motives, facilitators and barriers participants indicated as being important.

Participants highlighted the health benefits of millet and how this would increase their willingness to try and consider incorporation into dietary patterns;

'*Millet has all these nice middle aged women's vitamins and minerals in it [which would make me keen to try]*'' Female 50yrs

Indicating that health consciousness, described as an individual's or societal awareness of the benefits, actions, and practices of healthy behaviours (Mai and Hoffmann, 2012) is a key factor for consumers. Participants also highlighted positive marketing and social media exposure in their willingness to try millet particularly commenting that endorsement from celebrities and those of perceived high social standing would increase their acceptance of millet as a food;

'Celebrity endorsement would be a good idea' Female 50yrs

'You need a professional chef to establish its [millet] brilliance' Male 75yrs

'If the royal family were eating millet, I'd try Male 28yrs

Marketing, such as advertising, promotional campaigns and social media influence can appeal to social norms by depicting desired behaviours and lifestyles which can encourage consumers to align their actions and behaviours with perceived social expectations and can be effective in promoting sustainable lifestyles (Vemuri et al., 2024). Participants highlighted the potential marketing could have and how they would be reassured if millet were promoted by trusted sources, media outputs or recommended by friends and family;

'If you saw [millet] in the recipes of celebrity chefs' Female 50yrs

'If I saw friends and family eating [millet], I'd be more inclined to try 'Female 25yrs

As an unfamiliar food, marketing of millet will play a critical role in educating consumers of their nutritional and health benefits, environmental advantages and versatility in cooking. Effective marketing will likely have an impact on purchasing behaviour and market growth (Franco Lucas and Brunner, 2024). Participants highlighted the impact of marketing and social/subjective norms with two key statements emerging as central themes:

'If it's advertised as a human food first and animal food second, then it would become more socially acceptable' Male 23yrs

'Like a cultural shift, like how people perceive it' Female 50yrs

These results extend research by Koch et al. (2021) who found that targeted marketing and public exposure can reduce consumers uncertainty of novel foods, however introducing novel healthy foods faces challenges due to consumers innate preference for familiar foods (Tuorila and Hartmann, 2020). Without targeted marketing and social endorsement social and subjective norm could be considered a barrier towards the adoption of new and novel foods (Jahn et al., 2021).

Some participants emphasized the attributes of millet as a sustainable food source highlighting it as an option for reducing climate impacts alongside personal beliefs in social responsibility to support practices that protect global food security. Participants highlighted their interest in millet as a sustainable, healthy food choice due to several factors, including nutritional benefits, versatility in cooking and lower environmental impact than other grains;

'If I can I'll definitely go for the sustainable food, because I know it's better for me and the environment, so I like the thought of millet' Female 25yrs

Participants viewed millet as a viable component of sustainable eating due to being less resource intense than other grains to produce. This interest reflects a growing consumer demand towards foods that not only support personal health but align with environmental values (Batista et al., 2023).

Most participants had not heard of millet as a food source prior to the focus group and frequently asked questions about millet directed to the focus group facilitator. These questions were predominately centred around taste, culinary use, convenience and availability. Thus, suggesting curiosity and knowledge seeking may be strong motives towards consumers' willingness to try millet. Research suggests that curiosity plays a significant role in people's willingness to try new and novel foods and may support overcoming negative emotions and motivation towards trying the unfamiliar food (Stone et al., 2021). Knowledge seeking behaviour can motivate individuals to try new foods, this may be driven by interest in health benefits or foods that are perceived as beneficial or innovative (Verbeke, 2005). Thus, high lighting the importance of knowledge sharing, as its absence can create a significant barrier due to lack of awareness or understanding.

Participants were keen to learn how to cook with millet, but emphasized they would prefer a product that was convenient and easy to use to fit with their busy lifestyles.

'If I could pop it in the microwave' Female 21yrs

Convenience is one of the major influences on consumers food choice processes (Furst et al., 1996) and is associated with reduced time, effort and skill requirements in food-related activities which can provide insights into consumer preferences, inform food policy and support targeted marketing strategies (Bogard et al., 2024). Taste and texture were key factors for participants willingness to try millet, and they indicated a preference for millet incorporation into familiar foods such as pasta.

'I would buy it [millet]as a pasta or flour' Female 50yrs

Fig. 2. Thematic analysis of the factors influencing Millet consumption.

Familiarity has been suggested to be a factor in consumers perceptions of usage versatility, in that they may find it challenging to envisage how to incorporate unfamiliar foods into their diets (Giacalone and Jaeger, 2016). Developing consumer familiarity with new and novel foods has been shown to increase expected liking of the product leading to increased purchase intention (Legendre et al., 2019). Many part icipants had heard of millet used as bird seed;

> 'I'd heard of millet before as bird seed, but didn't know it was anything other than that' Female 25yrs

> 'The thing that springs to mind immediately is bird seed' Female 50yrs

This negative connotation and associated familiarity highlighted some participants uncertainty of millet use for human consumption leading to high levels of food neophobia, which may be moderated with repeated exposure to the unfamiliar food (Pliner et al., 1993).

Participants indicted that they had not seen millet in any mainstream or specialist food shops and that lack of availability and accessibility would be a significant barrier to them trying millet. Research has shown that increasing availability of healthier food options significantly influences food choice, although consumers often choose less healthy but widely available options (Pechey and Marteau, 2018). This scarcity affects consumers ability to access and utilise millet as a food source. The limited presence of millet in supermarkets and restaurants can deter consumers from developing familiarity and habits in relation to millet consumption. The absence of convenient millet-based food options may discourage consumers from trying millet as they are less likely to encounter it in readily accessible formats, such as prepackaged meals, snacks or familiar home/restaurant cooked dishes. This lack of exposure limits consumers familiarity and makes it challenging to incorporate it into diets without additional effort or knowledge on preparation. Limited exposure can create a barrier to adoption, as individuals may feel uncertain about how to prepare or use millet in their cooking. Without convenient options such as ready-to-eat millet-based products or popular recipes featuring millet, consumers may feel less inclined to experiment with it, ultimately affecting its adoption into mainstream diets.

Price and affordability were key factors for all participants, with many concerned that if the price was too high, this would be a significant barrier for them considering incorporating millet into current dietary patterns. Participants expressed that they would be keen to try millet if it were an affordable alternative to other grains;

> 'Main factor that could change my mind [from trying] is the pricing' Male 23yrs

With the aim of identifying key influencing factors on consumers behaviour towards trying millet, a theory driven framework is proposed to serve as a roadmap for policy and practice to facilitate the development of targeted strategies to promote millet as a food source in the UK. Raising awareness through marketing, education and knowledge sharing will reassure consumers of millet as a safe, convenient food source. Appropriate guided promotional messaging will need to be considered by all actors to highlight the health benefits and usage versatility of millet. Millet has potential to be re-purposed for human consumption globally and nationally to support growing interest in the reform of food systems and their infrastructures, build resilience in the food supply chain, improve food security, whilst consecutively reaching towards the recommended transitions to meet global nutrition and diet related non-communicable disease targets in line with the Sustainable Development Goals (UN, 2024).

4. Study limitations

The main study limitation is the small sample size that is restricted to UK consumers residing in the locality of Dorset. Notwithstanding, for the first time, this research highlights and underscores the importance of heritage grains in the consideration of food security and sustainability and provides a clear account of the motives and barriers that should inform policy and practice.

5. Conclusion

The research presented has provided an understanding of consumers food choice behaviours in relation to new and novel food sources such as millet. Factors influencing consumers' needs and preferences have been identified which may help to anticipate future trends and behaviours, support effective promotion of millet and guide product development. This study will be of interest to policymakers to guide measures such as supportive polices, investment in local agriculture and public education to influence and improve healthy, sustainable dietary choices at a population level.

It is recommended that future consumer behaviour research utilises the framework provided as a guide to assess population level influences that affect an individuals' willingness to try millet. This approach would help systematically explore various factors, such as social and subjective norms, environmental attitudes, health beliefs, accessibility, convenience and sensory qualities that may shape consumer acceptance of millet as a food source. Additionally, the framework may aid in identifying specific demographic groups more likely to adopt millet and support targeted marketing strategies to encourage broader adoption. The framework supports future research to provide insights into potential barriers such as unfamiliarity, perceived inconvenience and food neophobia and suggest targeted interventions to promote millet as a food source in the UK.

Opportunities for further work outside of consumer behaviour have been highlighted. These may include but are not limited to; sensory analysis; assessment of agricultural viability of millet in the UK; millet-product development; economic export/import potential; marketing strategies; policy in agricultural practices, public-health and healthy eating initiatives.

CRediT authorship contribution statement

Jodie Lacey: Writing – original draft. **Jeffery Bray:** Writing – review & editing. **Heather Hartwell:** Writing – review & editing.

Ethics

Full ethical approval was granted by Bournemouth University prior to data collection ID 52374.

Implication for gastronomy

Millet is a currently underutilised heritage grain that has wide potential culinary use. Culinary application is attractive given the strong nutrition profile and its naturally gluten free properties. As gluten intolerance globally is increasing, gastronomic innovation to provide inclusive, nutritionally rich and sensorially acceptable dishes is important. Further, Millet is a resilient and reliable crop that can withstand climatic variation well and, as such, is considered an attractive future addition to culinary norms.

Millet can be used as a key ingredient to cakes, breads and biscuits and has multiple further possible culinary applications. However, prior to widespread commercial application it is critical that stronger understanding of consumer preferences and acceptance of millet is gained. This is the contribution made by this paper which paves the way for further studies into specific culinary applications. Key findings related to consumer acceptance highlights a lack of knowledge of Millet as a human food source. This lack of familiarity is the current cause for some food neophobia. Notwithstanding, broad consumer interest around environmental and health concerns suggest strong potential for Millet to

be integrated into culinary practice.

Millet has recognised culinary limitations for example its lack of glutenous properties leading to poor binding characteristics. Further culinary research is recommended to enable Millet's full gastronomic potential to be realised.

Declaration of competing interest

None.

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Data availability

Data will be made available on request.

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