Should I really pay a premium for this? Consumer perspectives on cultured muscle, plant-based and fungal-based protein as meat alternatives

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DOI link to the version of record on the publisher's site

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23 January 2023

Should I really pay a premium for this? Consumer perspectives on cultured muscle, plant-based and fungal-based protein as meat alternatives.

David Dean[a], Meike Rombach[a], Frank Vriesekoop[b,c], Wim de Koning[a,b,c], Luis Kluwe Aguiar[b], Martin Anderson[b], Philippe Mongondry[d], Beatriz Urbano[e], Cristino Alberto Gomez Luciano[f], Bin Jiang[g], Anouk Boereboom[b], Wisnu Satyajaya[h], Puspita Yuliandari [h], Farzana Rashid[i], Imran Khan[j], and Beatriz Alvarez[k]

a. Lincoln University, Lincoln, New Zealand;
b. Harper Adams University, Newport, UK;
c. HAS University of Applied Science, Den Bosch, the Netherlands;
d. Groupe ESA, Angers, France;
e. University of Valladolid, Valladolid, Spain;
f. Specialized Institute of Higher Studies Loyola, San Cristobal, Dominican Republic; Beijing Polytechnic, Beijing, China;
g. Lampung University, Lampung, Indonesia;
h. Lahore College for Women University, Lahore, Pakistan;
i. The University of Agriculture, Peshawar, Pakistan;
j. Autonomous University of Queretaro, Queretaro, Mexico

To link to this article: https://doi.org/10.1080/08974438.2023.2169428

Abstract

Consumer willingness to accept alternative meat products has been widely explored. However, few studies have explored the key factors driving and inhibiting willingness to try, buy and pay a price premium for plant-based proteins, fungal-based proteins and cultured muscle tissue. Therefore, the present study is dedicated to this research gap and proposes a model that combines driving and inhibiting factors such as food neophobia, food technology neophobia, the environmental and specific benefits of alternative meat products as well as intrinsic attributes of meat such as taste, texture and smell. Partial least squares structural equation modelling shows that the largest drivers of consumer willingness to consume meat substitute are their perceived suitability (specific benefits) and environmental impact.

Conversely, the biggest inhibitors to consumption were the nutritional importance of meat, the importance of meat taste, texture, and smell, and food neophobia and food technology neophobia. How the drivers and inhibitors varied between plant-based, fungal-based, and cultured muscle tissue are discussed and implications for industry leaders and future research are discussed.

Keywords: Alternative meat types; Cross-cultural study; Food Neophobia; Plant-based; Mycoproteins; Cultured Meat

1. Introduction

Over the past decade meat production and consumption has been criticized in many western societies (Kumar et al., 2022; Motoki et al., 2022). Most of the criticisms have resulted from increased consumer climate consciousness, who are becoming more attentive towards the adverse effects of agricultural production (Caputo et al., 2022). Conscious consumers make informed food choices, and they are increasingly aware of the impact of their consumption and their contribution towards societal and environmental problems (Morgan et al., 2016; Langen, 2011). Livestock production and ultimately the consumption of animal-based proteins is often associated with water depletion, climate change, disruption of nutrient cycles, and adverse effects on biodiversity (Hampton et al., 2021; Michel et al., 2021; De Boer and Aiking, 2011; Phonthanukitithaworn et al., 2021).

Consequently, conscious consumers tend to avoid meat products that harm the environment, people, or animals and demand changes to how meat is produced (Lund et al., 2021). Alternative meat options such as plant-based protein consisting of soy, pea and wheat are already well established and widely available (Waniska et al., 2005; Boukid, 2021, Onwezen et al., 2021; Curtain and Grafenauer, 2019; Rondoni et al., 2021), while green biomass and pseudo-cereals are emerging sources of protein (Schweiggert-Weisz et al., 2020). The market for plant-based meats has vastly increased in the last ten years. The global market for meat substitutes was worth 6.7 billion US dollars in 2020 and it is anticipated to reach 35 billion U.S. dollars by 2027 (Statista, 2021).

Fungal-based proteins, otherwise known as mycoproteins, have good nutritional and physical-chemical properties. However, they are considered niche products in many countries (Bryant and Sanctorum, 2021; De Koning et al., 2020). Mycoprotein was commercially developed in the 1980s; derived from Fusarium Venenatum. Quorn is a branded mycoprotein product which is obtained by fermenting fungi spores along with glucose and other nutrients (Chezan et al., 2022). Until 2020, Quorn had a rather exclusive position and in many consumer markets, was the only fungal-based protein option available (Whittaker et al., 2020). However, in Sweden, Argentina and New York, businesses such as Mycorena, MyForestFoods and Eternal have developed competing products for the consumer markets with the brand Promyc, MyBacon and MycoFoods (Eternal, 2022; Mycorena, 2022a; MyFoodForest, 2022). These products either mimic the taste of meat, or are neutral in taste, so suitable for a wide variety of products such as burgers, nuggets, protein bars, and snacks (Eternal, 2022; Mycorena, 2022a; MyFoodForest, 2022). Consumers appreciate mycoprotein products for being high in fiber, low in fat, sodium, and sugar, and rich in essential amino acids, and for their meat-like texture (Derbyshire & Ayoob, 2019). In addition, compared to regular meat production, mycoprotein has a smaller water footprint and smaller carbon emissions (Ahmad et al., 2022). Cell-based meat is derived from animal muscle tissue which is cultivated in-vitro and avoids raising and slaughtering an entire animal (Post et al., 2021). Through a painless biopsy, cells are taken from an animal then further processed in a bioreactor under conditions that allow cell replication, with the ultimate aim to develop meat and fat tissue (Pakseresht et al., 2022; Tosun et al., 2021). Currently, the technology to manufacture cultured muscle tissue on a commercial scale is still in its infancy (Bekker et al., 2017, Post et al., 2021). Researchers and companies alike are searching for ways to improve existing technologies, address production and scale-up issues to make this new form of meat a cost-effective alternative to traditional animal proteins (Pakseresht et al., 2022). Baum et al. (2021) emphasize that Singapore is the only country where cultured meat is available for consumers. Singapore has seen fierce competition between startups and well-established businesses to market cultured meat and gain leadership in this segment of the meat alternative market. "Just Foods" is one of the startups that has enjoyed success with their cultured chicken nuggets available for $50 at a popular restaurant (Baum et al., 2021). California seems to be the next growth area, where Upside Foods and Blue Nalu have started producing cultured chicken, beef and fish (UpsideFoods, 2022; BlueNalu, 2022).

Various studies have explored consumer acceptance of plant-based and fungal-based proteins (Wilks and Phillipps, 2017, Weinrich et al., 2020; Zhang et al., 2020; Collier et al., 2021) as well as cultured muscle tissue (Boereboom et al., 2022; Verbeke et al., 2021; Kerslake et al., 2021; Verbeke et al., 2015a,b). Some studies have found consumer reservation towards alternative meats (Verbeke et al., 2015a,b), others indicated willingness to try (Palmieri and Forleo, 2021; De Koning et al., 2020); and some found a willingness to pay a price premium (Asioli et al., 2022; Arora et al., 2020). However, the key factors driving willingness to try, buy and pay a price premium for plant-based proteins, fungal-based proteins and cultured muscle tissue have not been widely explored, and the present study aims to fill this research gap.

There are several factors that underpin the acceptance of meat substitutes and therefore are critical to bridging the research gap and developing the proposed conceptual model. The first factor is food neophobia, an important psychological attitude that affects the consumer's consumption and acceptance of meat alternatives (Elzerman et al., 2021; Onwezen et al., 2021). Closely aligned with food neophobia is food technology neophobia (Cox and Evans, 2008; Krings et al, 2022), as consumers may not be familiar with the technology involved in the production and processing of plant and fungal based meat alternatives and cultured muscle tissue (Siegrist & Hartmann, 2020). Other more holistic factors include perceived risk to human health and adverse environmental effects, which influence perceived long-term effects and ethical reservation. These are common consumer concerns associated with these technologies and may hinder appreciation of these meat alternatives (Krings et al. 2022, Mauricio, 2022). Further factors include attributes specifically associated with meat, such as texture, smell and taste, its nutritional information, or perceptions of meat's environmental or health impacts, especially if they differ from those factors for meat alternatives (Lusk and Briggemann, 2009, Van der Weele, 2019). Thus, research shows that these factors drive consumer behavioral intention, which, in this research is willingness to try, buy and pay a price premium for plant-based proteins, fungal-based proteins and cultured muscle tissue. In the remainder of this section, each these factors are examined in detail.

2. Theory

2.1 Benefits of alternative meat products and environmental impact on food choices

Current animal husbandry systems and livestock production do not appear to be sustainable (Hwang et al., 2020) due to a range of environmental, social, and ethical problems related to traditional meat production. Alternative proteins sources such as cultured muscle tissue, plant-based and fungal-based proteins are said to decrease energy footprints, greenhouse gas emissions and water use. Cultured muscle tissue is also expected to deliver similar outcomes (Post et al., 2020; Pakseresht et al., 2022). All forms of meat alternatives also avoid factory farming, slaughter, and any other form of animal cruelty (Hwang et al., 2020). Therefore, the following hypotheses are proposed:

Hypothesis 1 (H_1). The importance placed on environmental issues when making food choices positively impacts the perceived suitability/benefits of a) plant-based protein, b) fungal-based protein and c) cultured muscle tissue.

Hypothesis 2 (H_2). The perceived suitability/benefits of alternative meat products positively impact consumers' willingness to try, buy and pay a price premium for a) plant-based protein, b) fungal-based protein and c) cultured muscle tissue.

2.2 Food neophobia

Food neophobia refers to a reluctance to eating new food items or their complete avoidance (Siegrist et al., 2013; Onwezen et al., 2021). Food neophobia can be seen as the opposite of food curiosity which refers to eaters who want to explore new and different foods, including purchasing, preparing and consuming both meat and alternatives to meat (Hwang et al., 2020). Food neophobia is regarded as an attitude building on consumer values with the intent to avoid uncertainty and risk associated with unfamiliar food (De Koning et al., 2020; Onwezen et al., 2021; Palmieri and Forleo, 2021; Gómez-Luciano et al., 2021). Previous research has shown that familiarity and the extent of consumption influences the degree of food neophobia (Hellwig et al., 2020). Consumers who had never eaten any form of alternative protein tended to have a higher degrees of food neophobia compared with consumers who had at least some experience (De Koning et al., 2020; Siegrist and Hartmann, 2020; Siegrist et al., 2013). Age, gender and cultural background have been found to be associated with food neophobia (Siegrist and Hartmann, 2020; Siegrist et al., 2013). For many consumers, plant-based protein, fungal-based protein and cultured muscle tissue, portrayed as meat alternatives, can be considered new products as those names and labels are not widely used in food retail chains (Pakseresht et al., 2022; Hwang et al., 2020). Based on this discussion of food neophobia research, the following hypothesis is proposed:

Hypothesis 3 (H_3). Food neophobia negatively impacts consumers' willingness to try, buy and pay a price premium for a) plant-based protein, b) fungal-based protein and c) cultured muscle tissue.

2.3 Food technology neophobia

The production of any form of alternative meat involves some food technology input. Since consumers are not necessarily familiar with these technologies, they may not trust them and reject these alternative meat products as means to avoid food technology (Pakseresht et al., 2022). Consumers are concerned of potential risks to their health and the health of animals and the environment, especially unforeseen long-term effects (Hwang et al., 2020). Cultured muscle tissue for those consumers can be problematic, as the production of this form of alternative meat involves the in-vitro production of animal cells in bioreactors. In-vitro production and other forms of biotechnology, even the relatively simple methods used in mycoprotein production, are often negatively regarded by consumers (Hwang et al., 2020). Plant-based protein production typically requires still lower technology processes, but consumers could be equally skeptical towards lower technology processes, if they are not familiar with them or view them as risky (Hwang et al., 2020). Since consumers commonly do not trust the technology used in the processing of alternative meat the following hypothesis is proposed:

Hypothesis 4 (H_4). Food technology neophobia negatively impacts consumers' willingness to try, buy and pay a price premium for a) plant-based protein, b) fungal-based protein and c) cultured muscle tissue.

2.4 Meat nutritional importance and health impact on food choices

A healthy diet may include meat, as it is valuable source of protein due to its amino acid composition and digestibility. In addition, meat can provide the human body with valuable nutrients, like iron, zinc, and vitamins A and B and some consumers believe that only meat offers these nutrients (Schweiggert-Weisz et al., 2020). However, while animal-based proteins have nutritional benefits, overconsumption can lead to cardiovascular disease, high cholesterol, cancer, and other illnesses (Schweiggert-Weisz et al., 2020). These potential adverse health effects have driven consumers to look for healthier options such as alternative meat products (Mathijs, 2015; Lusk and Briggemann, 2009).

Hypothesis 5 (H_5). The importance placed on the healthiness of food choices positively impacts the perceived suitability/benefits of a) plant-based protein, b) fungal-based protein and c) cultured muscle tissue.

Hypothesis 6 (H_6). The nutritional importance of meat negatively impacts the suitability/benefits of a) plant-based protein, b) fungal-based protein and c) cultured muscle tissue.

Hypothesis 7 (H_7). The nutritional importance of meat may negatively impact consumers' willingness to try, buy and pay a price premium for a) plant-based protein, b) fungal-based protein and c) cultured muscle tissue.

2.5 Meat taste, texture and smell

Intrinsic meat attributes are the product attributes inherent to meat such as freshness, tenderness, leanness, flavor/ taste, texture and smell (Bazzani et al., 2018; Slade, 2018). In particular, the latter three are essential criteria for consumers' willingness to try, accept and repeatedly purchase meat products (Wilks et al., 2021). Some alternative meat products aim to imitate the taste and texture of meat, to create as close to an identical substitute as they can in terms of intrinsic attributes. While some consumers appreciate this imitation, others perceive it unnatural and revolting (Wilks et al., 2021; Gomez-Luciano et al., 2019). An example for these kinds of imitations is a burger that is made of plant-based proteins, including beetroot and/or pea leghemoglobin, which imitate bleeding in plant-based meat analogues (Wilks et al., 2021). Thus, the following hypotheses are proposed:

Hypothesis 8 (H_8). Meat taste, texture and smell negatively impact the suitability/benefits for a) plant and b) fungal-based proteins but positively impact the perceived product benefits of c) cultured muscle tissue.

Hypothesis 9 (H_9). Meat taste, texture and smell negatively impacts consumers' willingness to try, buy and pay a price premium for a) plant-based protein, b) fungal-based protein and positively impacts their willingness to try, buy, and pay a price premium for c) cultured muscle tissue.

2.6 Conceptual model

Figure 1 is a graphical depiction of the conceptual model integrating the proposed hypotheses. The influence of environmental (H1) and healthiness (H5) consequences on food choices will positively influence the suitability of substitutes, but a high importance placed on the nutritional value of meat (H6) and intrinsic attributes of meat (H8) will negatively influence the suitability of meat substitutes. The suitability/perceived benefits of the substitutes (H2) will influence consumer willingness to try, buy, and pay a premium for them. Food neophobia (H3), food technology neophobia (H4) and the importance of meat nutrition (H7) and importance of the intrinsic attributes of meat (H9) will negatively influence consumer willingness to try, buy, and pay a premium for meat substitutes.

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3. Materials and Methods

3.1 Data collection

The data used in this research is drawn from an omnibus survey consisting of 99 questions that was administered in 12 countries. Twenty-six questions were used in the current research as they were related to plant- and fungal-based meat alternatives, and cultured muscle, plus their drivers and inhibitors. The questions not used in the current research focused on insect-based protein, food preparation and cooking habits, meat preferences, meat attitudes, and current/future meat consumption. The survey was administered as an online survey, but upon request, survey participants could complete a paper-pen version instead. The survey link was distributed via email and social media. Online and paper-pen surveys are equivalent in terms of data quality and standard instruments for data collection. The data collection occurred during 2018/2019 and resulted in a sample of 4,488 responses which consisted of 758 respondents from the United Kingdom, 649 from Pakistan, 556 from China, 521 from the USA, 491 from France, 259 from New Zealand, 230 from the Netherlands, 227 from Mexico, 212 from Brazil, 210 from Indonesia, 199 from Spain, and 176 from the Dominican Republic (Table 1).

The survey was designed and written in English and then subsequently translated in the various languages. For the English-speaking countries adjustments to grammar, spelling and dialect were made. For all other countries, the co-authors who are native speakers in their respective mother tongues and use English as their professional language translated the survey to assure translation accuracy. A centralized data collection approach assured data safety and consistency. Respectively, the data was collected at Harper Adams University (HAU) in the United Kingdom. The Human Ethics Committee at HAU approved the research design and survey instrument.

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3.2 Survey Instrument

Previous research informed the design and development of the questionnaire (De Koning et al., 2020; Pliner and Hobden, 1992; Cox and Evans, 2008; Verbeke, 2015; Roininen et al., 1999; Roberts, 1996). Table 2 presents the wording of individual items and their organisation into measurement scales.

Display: Table 2

The scales include Food Neophobia (6 items), adapted from Pliner and Hobden (1992); Food Technology Neophobia (5 items), adapted from Cox and Evans (2008), Healthiness of Food Choices (3 items), adapted from the "impact of the healthiness of food choices" scale (Verbeke, 2015); Environmental Impact of Food Choices (3 items) adapted from the "environmental impact of food choices" scales in Roberts (1996) and Verbeke (2015). The next two scales measured attitudes towards meat, including Meat Nutritional Importance (3 items), and Meat Taste, Texture, and Smell Importance (3 items) adapted from De Koning et al (2020). All the questions were presented in the form of statements to which the respondents expressed their opinion using a five-point Likert scale ranging from "strongly disagree" to "strongly agree" (Table 2).

The last scales included descriptions of cultured muscle, plant-based and fungal-based alternatives to meat proteins. Consumers were asked about their perceptions of the suitability of, or the benefits derived from, cultured muscle, plant-based and fungal-based proteins. These questions consisted of six items measuring healthiness, safety, nutrition, sustainability, taste, and affordability relative to meat protein (Table 2). Finally, a consumer behavioral intention scale was used to measure aspects such as willingness to try, willingness to buy, and willingness to pay more for cultured muscle, plant-based and fungal-based proteins. The questionnaire also collected some basic demographic characteristics of the respondents.

3.3 Analysis

The two-step PLS-SEM approach was used with the first step evaluating the measurement of the model. This step examined the scales and their items, evaluating their convergent and discriminant validity and reliability. The second step tested the model structure, assessing the significance of the hypothesized relationships between the variables, and confirming that goodness-of-fit criteria had been satisfied. Following Hair et al (2017), the two-step analysis is an appropriate methodology for measuring and examining structural models and testing coefficient paths.

3.4 Construct Validity and Reliability

Construct validity was evaluated using factor loadings and average variance extracted (AVE). As shown in Table 2, the result of convergent validity assessment indicates that all but one of the standardized loadings (Plant-based protein is cheaper) were above cut-off level of 0.5 as set by Anderson and Gerbing (1988). Table 2 also shows that the AVE of all the scales were higher than the suggested 0.5 cut-off level (Hair et al., 2017). All but three (Food Tech Neophobia, Healthiness Influence and Environmental Impact Influence) of the scales had Cronbach's Alpha values above the cut-off level of 0.7 and all the scales had composite reliability values above the suggested cut-off level of 0.7 (Sarstedt et al., 2014) indicating adequate reliability.

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The construct scales were considered to have acceptable discriminant validity, according to both the Fornell-Larker criterion and the Heterotrait-Monotrait (HTMT) ratio methods (Table 3). The Fornell-Larcker criterion is considered satisfied if the variance captured by the scale items (the diagonal) is greater than the shared variance between constructs. The HTMT ratio is considered satisfied if the HTMT correlation estimates between the scales are below the recommended threshold of 0.85 (Sarstedt et al., 2014; Hair et al., 2017).

3.5 Structural Model

Following Hair et al. (2017), the applied bootstrapping method (5,000 repetitions) allowed the assessment of the model structure including indicator weights and path coefficients. In addition, the R^2 of all constructs were estimated as a diagnostic tool to evaluate the model's explanatory power, Q^2 was used to evaluate predictive relevance and Goodness of Fit (GoF) was used to evaluate the model fit.

Table 4 depicts some results from testing the structural model indicating that the model does a good job of explaining the variance of willingness to try, buy, and pay more for all three meat substitutes. The model explains 36.7% (R^2 = 0.367) of the variance of fungal-based protein willingness, 35.9% (R^2 = 0.359) of the variance of cultured muscle tissue willingness, and 27.9% (R^2 = 0.279) of the variance of plant-base willingness. However, the model was stronger at explaining 17.5% (R^2 = 0.175) of the variance of plant-based suitability/benefits compared with the 12.8% (R^2 = 0.128) of the fungal-based protein suitability/benefits and only 3.6% ($R^2 = 0.036$) of the variance of cultured muscle tissue suitability/benefits.

Chin et al. (2008) argued that an investigator should be able to employ the magnitude of R^2 and Stone-Geisser's Q^2 value as a criterion for the predictive relevance of a model for a particular construct. The results of Q^2 calculations for all the endogenous constructs were greater than zero, indicating that they have satisfactory predictive relevance (Hair et al., 2017)

GoF was measured using the geometric mean of the communality and the average R^2 for endogenous dependent constructs. The model's GoF value of 0.382 (see Table 4) shows that the proposed model of the relationships between consumer food attitudes and their assessment of and willingness to try and purchase plant-based and insect-based proteins are large, indicating that the model has reasonable fit. Typically, GoF values are classified as small (0.02), medium (0.25) and large (0.36) (Anderson and Gerbing, 1988).

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4. Results

H1 was fully supported with significant positive relationships between environmental impact influence and the suitability/benefits of all three meat alternatives.

Consumer perceptions of the suitability and benefits of each of the meat substitutes are strong predictors of consumer willingness to try, buy, and pay a premium for them, thus fully supporting hypothesis H2. Both food neophobia and food tech neophobia had significant negative influence on willingness to consume all three meat substitutes, providing full support for hypotheses H3 and H4. Healthiness influence was hypothesized to have a positive influence on perceived suitability/benefits of the three meat substitutes, but the results were mixed. Healthiness positively influenced suitability of plant-based protein (H5a), had no influence on fungal-based protein (H5b) and a significant but negative influence on cultured muscle (H5c). H6 and H7 were fully supported as meat nutritional importance were a significant negative influence on the suitability/ benefits and willingness to consume all three meat substitutes. There was only partial support for H8, with the one significant relationship being meat taste, texture, and smell positively influencing the suitability of cultured muscle. Finally, H9 was fully supported with meat taste, texture, and smell negatively influencing willingness to consume plant-based and fungal-based meat substitutes and positively influencing willingness to consume cultured muscle.

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Finally, while the inclusion of several countries was intended to broaden the generalizabiliy of the results, and no hypotheses were devoted to cross-country differences, it was deemed important to summarize willingness to try, buy, and pay more for the meat substitutes by country. Table 6 shows that the Netherlands and Mexico samples were ranked among the most receptive to all three meat substitutes and China and Brazil were ranked among the least receptive to all three meat substitutes. With the exception of Indonesia, country samples were most receptive to plant-based proteins, followed by fungal-based, then cultured muscle. Some country samples were very consistent relative to other samples, like Brazil, which ranked 11^{th} for all three meat substitutes, and other showed dramatic change relative to other samples, with Pakistan having the largest change in rank, from lowest (12^{th}) for fungal-based protein to 4^{th} highest for cultured muscle.

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5. Discussion

The significant relationships found supporting Hypothesis (H1a/b/c) are in line with the recent body of literature, even though the impact on the environment seems to vary among the meat alternatives under investigation (Scherer et al., 2023). Plant and fungal-based meat alternatives clearly have better carbon and water footprints than traditional meat alternatives (Finnigan et al., 2017). The environmental impact for cultured meat depends on the growth medium used in the process, but theoretically is more environmentally friendly than traditionally produced meat ((Hadi & Brightwell, 2021; Mattick et al., 2015). Recent studies outline that cultured meat production is more energy intensive (Chriki & Hocquette, 2020), but this drawback is outweighed by lower carbon and water footprints, and no threat of eutrophication (Hadi & Brightwell, 2021). As consumers are increasingly aware of the links between food consumption and the environment, and the existence of and motivations for meat-reduced or meat-free diets (Kerslake et al., 2022) the support of H1a/b/c is unsurprising.

In terms of sustainability benefits, the support of hypothesis H2a/b/c confirms previous studies, like the work of Van der Veele et al. (2019) and Sogari et al (2022), who indicate that the sustainability benefits of alternative meat products, as well as their perceived cultural and culinary appropriateness are key factors in consumer acceptance. Anusha Siddiqui et al (2021) and Imm et al (2022) further outline that across several countries, marketing campaigns highlighting the sustainability benefits of these products have led to increased consumer willingness to buy. Following Dekkers et al. (2018) meat alternatives perceived as novel or new to market, such as fungal based protein and cultured meat, have been advertised as cutting-edge and sustainable, and are proving popular among consumers.

Even though the novelty of alternative meat products can be viewed as a strength, it is also a potential barrier towards willingness to try, buy and pay a price premium when considering food neophobia (Siegrist &Hartmann, 2020, Asioli et al., 2022). Food neophobia results indicate an inhibition towards the willingness to adopt all three meat substitutes as hypothesized fully supporting hypotheses H3. Similarly, the food tech neophobia score indicates an inhibition towards the willingness to adopt for all three meat substitutes, supporting H4. It is interesting to note that the food neophobia has the strongest influence on fungal-based protein and food technology neophobia has the strongest influence on cultured muscle tissue. The process to produce fungal-based proteins is very similar to beer brewing, where relatively simple sugars and other nutrients are fermented by a fungal culture (Hellweg et al., 2020).

Consumer reservations towards fungal-based protein, could be because it is based on "Fusarium venenatum", a member of mold family (Surman et al., 2015), and mold is associated with uncleanliness and neglect. However, since the production technology is technical, even though it is similar to beer brewing (Hashempour-Baltork et al., 2020), food technology neophobia is also a strong a deterrent. The findings related to mycoproteins corroborate with recent food industry challenges. New businesses like mycorena acknowledge food-neophobia and consumer fears associated with their products and devote part of their webpage detailing their production processes to counteract the issue (Mycorena, 2022b).

With respect to muscle cultured tissue, it unlikely that consumers are familiar with in-vitro culture technology which is relevant for the production of this meat alternative. Consumers may avoid or have reservations towards the food technology, especially if they view the process as unnatural or unethical (Hwang et al., 2020). For new products, consumers often have difficulty distinguishing whether their reservations are towards the food product, the technology or both (Krings et al., 2022). Food neophobia and food technology neophobia stem both from attitudes grounded in a consumer's norms and value systems. As a result, consumers are likely to be hesitant to try any form of alternative meat until the product and production technology are more established and widely available (Bäckström, 2004).

The importance of healthiness when making food choices was found to be a driver of consuming plant-based proteins, had no influence on fungal-based protein consumption, and had a negative impact on the consumption cultured muscle (supporting H5a but not H5b/c). While the results were unanticipated, perhaps they can be explained by the health-related motivations towards meat-reduced or meat-free diets. While plant-based proteins are often advertised as healthy alternative to meat (Martin et al., 2021), fungal-based and cultured muscle are often promoted for their environmental, sustainability or taste attributes (Chezan et al., 2022; Kerslake et al., 2022; Slade, 2018). Thus, when consumers make meat-reduced or meat-free food choices for health reasons, cultured muscle is not suitable as it is not meat-free, and fungal-based protein is not clearly healthier than plant-based options (Röös et al., 2022). Meat nutritional importance was found to inhibit willingness to adopt all three meat substitutes (supporting H_6) and meat nutritional importance negatively influenced the perceived suitability/benefits of all three meat substitutes (supporting H_7). These findings confirm the recent body of literature presenting product related and external barriers to the adaption of meat alternatives (Antoniak et al., 2022; Onwezen et al., 2021). The importance of meat taste, texture, and smell inhibited willingness to adopt plant-based and fungal-based proteins (Table 5), but positively influenced willingness to adopt cultured muscle tissue (supporting H_8). However, while the importance of meat taste, texture, and smell enhanced the perceived suitability/ benefits of cultured muscle, it inhibited the perceived suitability/benefits of fungal-based protein (Table 5) and had no significant influence on the suitability/benefits of plant-based protein (supporting $H_{9b,9c}$

but not H_{9a}). The importance of meat taste, texture, smell and the nutritional importance of meat are consistent with the findings of Schouteten et al. (2016) and Mishyna et al. (2020).

5.1 Managerial Implications

These findings are of relevance to food retail and producers of alternative meat products, in particular fungal-based protein as a niche product and cultured muscle tissue as an emerging product. Familarizing consumers with these products and making production processes transparent and understandable will be crucial to wider acceptance. It is well known that food neophobia and food technology neophobia can be overcome through trustworthy food system actors. Food retailers and regulators are called to assess, assure and communicate the safety of their products and the technology employed to produce alternatives to meat. Addressing benefits and value systems of different consumer groups will be essential to this endeavour. Targeting consumers with specific lifestyles, like vegetarian or vegan diets, is likely to be succesful as these groups tend to be more familiar and open to alternative meat products, and these products are already in line with their values and ideals.

5.2 Suggestions for future research

Future research could build on the work of Lusk and Briggemann (2009), who explored food values for meat products building on human values and using a best-worst approach. The research could also be extended through the exploration of the specific nature of cultured muscle tissue. In addition, cross-country comparisons of plant-based protein, insect-based protein and fungal-based protein following Verbeke (2015) would be of interest. The inclusion of consumer profiles and food values for Middle Eastern and

African countries would also be an extension to the recent body of literature. Given the increased number of global inhabitants in the Middle Eastern & African Metropoles, demand for alternative meat products can be expected.

Lastly, the role of religion and emotion related to alternative meat consumption need to be explored as these factors are mentioned in the existing body of literature as influentual factors, but not yet explored in-depth. Other than sensitivity and digust in the context of food neophobia and food neophobia technology, the role of emotion remains widely unexplored (Onwezen et al., 2022), even though emotions are closely associated with eating and the sensory experience of food.

5.3 Limitations

The sampling approach and the findings of the present study deserve critical appraisal, as survey participants were recruited via social media and email. However, the comparative nature of the study in terms of meat alternatives adds value to the recent body of literature. A purposive sample is of non-probablistic character, which needs to be acknowledged in terms of generalizability of the results. Budget constraints required following a purposive sampling approach via social media. Recruitment was seen as an advantage, as social media platforms allow researchers to access their personal contacts who are members of interest groups that connect other users throughout the internet. Such groups commonly share interests, attitudes, and, in the case of this study's context, consumption habits. A multi-referral sampling approach can mitigate the risk of obtaining one-dimensional information from survey participants.

The voices of elderly consumers are under-represented in the present study, as the sample of is relatively young, but it is in line with the age groups that are likely to consume meat alternatives as outlined in the recent body of literature. Recruitment through opt-panel providers in the future would allow for representative sampling.

6. Conclusion

The present study focuses on key factors driving consumers willingness to try, buy and pay a price premium for plant-based protein, fungal-based protein and cultured muscle tissue as meat alternatives. The study highlighted food neophopia and food technology neophia as inhibiting factors to trying, buying and paying a price premium for the different types of alternative meats. Envornmental and health benefits as well as the perceived impact on sustainability of alternative meats were important drivers that positively impacted consumers willingness to try buy and pay.

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Funding

No specific funding has been attributed to the project

Conflicts of Interest

The authors declare no conflict of interest in the context of this publication. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript or in the decision to publish the results.

Informed Consent

All participants gave their informed consent for inclusion before they participated in the study

Data availability: The corresponding author will make the data available upon request.

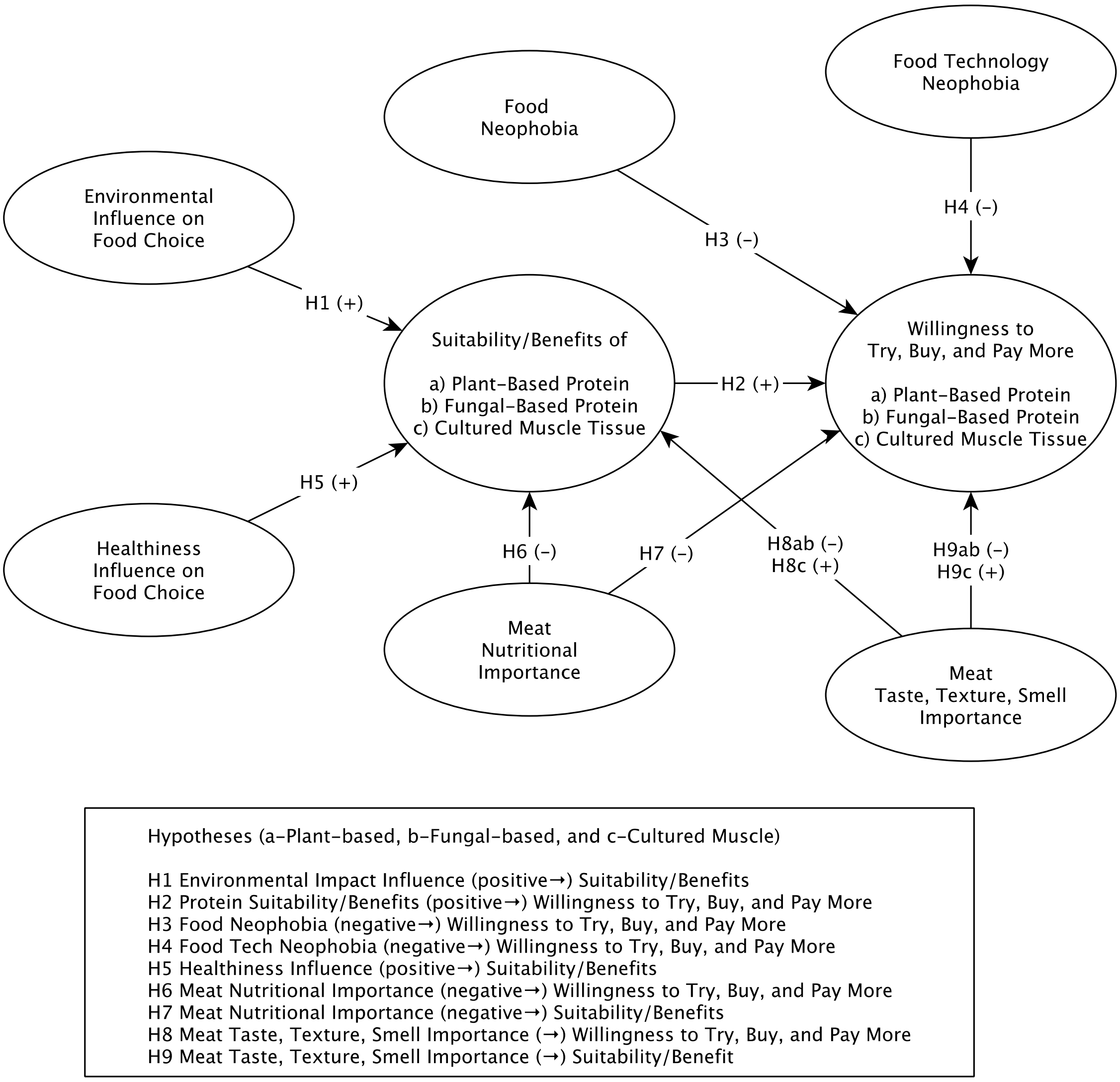

Figure 1. Conceptual framework

Table 1. Sample Size, Gender, and age by Country

	Demographics			
Country	**n**	**Male %**	**Female %**	**Age (Mean)**
UK	758	71.1%	28.6%	31.1
Pakistan	649	65.6%	34.1%	23.6
China	556	37.9%	60.8%	31.2
USA	521	75.6%	24.0%	44.0
France	491	81.7%	18.1%	29.0
New Zealand	259	54.1%	44.8%	38.6
Netherlands	230	62.6%	37.4%	29.4
Mexico	227	65.6%	33.9%	39.4
Brazil	212	57.5%	42.5%	42.7
Indonesia	210	55.2%	43.3%	35.6
Spain	199	49.2%	48.7%	35.1
Dominican Republic	176	65.3%	33.5%	26.2
Total (percentage)		63.6%	35.8%	
Total (count/average)	4488	2855	1606	33.2

Table 2. Scale Loadings, Reliabilities, and Convergent Validity

Scales and Items	Factor Loadings	Cronbach's Alpha	Composite Reliability	Average Variance Extracted
Food Neophobia		0.770	0.845	0.521
I am constantly sampling new and different foods (reverse)	0.676			
I do not trust new foods	0.698			
I like foods from different countries (reverse)	0.704			
At dinner parties I will try a new food	0.599			
I am afraid to eat things I have never had before	0.651			
I like to try new foods from all over the world (reverse)	0.770			
Food Tech Neophobia		0.693	0.813	0.521
The benefits of new food technologies are often grossly overstated	0.596			
There are plenty of tasty foods around so that we do not need to use new food technologies	0.714			
New food technologies decrease the natural quality of foods	0.720			
New products using new food technologies can help people have a balanced diet (reverse)	0.741			
Innovations in food technology can help us produce foods in a sustainable manner (reverse)	0.748			
Healthiness Influence		0.668	0.81	0.591
The healthiness of food has little impact on my food choices (reverse)	0.723			
I am very particular about the healthiness of the food I eat	0.839			
I eat what I like and I do not worry much about the healthiness of food (reverse)	0.822			
Environmental Impact Influence		0.631	0.803	0.577
When I buy foods I try to consider how my use of them will affect the environment	0.717			
I am worried about our ability to provide the nutritional needs for all people living on earth now	0.811			
Something drastic has to change in order to feed all the people on earth by 2050	0.767			
Meat Nutritional Importance		0.741	0.855	0.666
Eating meat is necessary for obtaining beneficial nutrients	0.876			
The nutritional benefits of meat can easily be matched by alternative protein sources	0.722			
Meat is an important part of a healthy and balanced diet	0.897			
Meat Taste, Texture, Smell Importance		0.935	0.959	0.885
The taste of meat is important to me	0.952			
The texture of meat is important to me	0.955			
The smell of meat is important to me	0.931			

(reverse)=score was reverse coded

Table 2. Scale Loadings, Reliabilities, and Convergent Validity (con't)

Scales and Items	Factor Loadings	Cronbach's Alpha	Composite Reliability	Average Variance Extracted
Plant-Based Protein Suitability/Benefits		0.782	0.85	0.538
Plant-based protein is healthy	0.842			
Plant-based protein is safe to eat	0.713			
Plant-based protein is nutritious	0.846			
Plant-based protein is more sustainable	0.753			
Plant-based protein is cheaper	0.490			
Plant-Based Protein Willingness to Try, Buy, and Pay More		0.712	0.839	0.637
Willing to try plant-based protein	0.762			
Willing to purchase plant-based protein	0.896			
Willing to pay more for plant-based protein	0.748			
Fungal-Based Protein Suitability/Benefits		0.851	0.896	0.639
Fungal-based protein is healthy	0.886			
Fungal-based protein is safe to eat	0.866			
Fungal-based protein is nutritious	0.879			
Fungal-based protein is more sustainable	0.770			
Fungal-based protein is cheaper	0.515			
Fungal-Based Protein Willingness to Try, Buy, and Pay More		0.777	0.872	0.697
Willing to try fungal-based protein	0.844			
Willing to purchase fungal-based protein	0.922			
Willing to pay more for fungal-based protein	0.725			
Cultured Muscle Tissue Suitability/Benefits		0.862	0.901	0.652
Cultured muscie tissue is healthy	0.899			
Cultured muscle tissue is safe to eat	0.897			
Cultured muscle tissue is nutritious	0.861			
Cultured muscle tissue is more sustainable	0.737			
Cultured muscle tissue is cheaper	0.508			
Cultured Muscle Willingness to Try, Buy, and Pay More		0.821	0.894	0.739
Willing to try cultured muscle tissue	0.877			
Willing to purchase cultured muscle tissue	0.936			
Willing to pay more for cultured muscle tissue	0.750			

(reverse)=score was reverse coded

Table 3. Scale Discriminant Validity

Fornell-Larcker Criterion	A	B	C	D	E	F	G	H	I	J	K	L
A Cultured Muscle Suitability/Benefits	0.808											
B Cultured Muscle Willing to Try, Buy, and Pay More	0.576	0.860										
C Environmental Impact Influence	0.132	0.107	0.760									
D Food Neophobia	0.055	0.142	0.107	0.722								
E Food Tech Neophobia	0.290	0.286	0.093	0.206	0.722							
F Fungal-Based Protein Willing to Try, Buy, and Pay More	0.157	0.303	0.238	0.263	0.188	0.835						
G Fungal-Based Protein Suitability/Benefits	0.344	0.161	0.260	0.196	0.222	0.544	0.799					
H Healthiness Influence	-0.090	-0.069	0.203	0.066	-0.035	0.154	0.109	0.769				
I Meat Nutritional Importance	-0.011	-0.016	-0.253	-0.193	-0.014	-0.367	-0.301	-0.174	0.816			
J Meat Taste, Texture, Smell Importance	0.047	0.073	-0.173	-0.082	0.013	-0.283	-0.204	-0.131	0.605	0.941		
K Plant-Based Protein Suitability/Benefits	0.242	0.103	0.292	0.101	0.089	0.304	0.517	0.152	-0.358	-0.212	0.733	
L Plant-Based Protein Willing to Try, Buy, and Pay More	0.108	0.241	0.265	0.204	0.142	0.596	0.296	0.198	-0.431	-0.331	0.388	0.798
Heterotrait-Monotrait Ratio												
A Cultured Muscle Suitability/Benefits												
B Cultured Muscle Willing to Try, Buy, and Pay More	0.663											
C Environmental Impact Influence	0.183	0.165										
D Food Neophobia	0.103	0.171	0.169									
E Food Tech Neophobia	0.368	0.371	0.215	0.280								
F Fungal-Based Protein Willing to Try, Buy, and Pay More	0.196	0.381	0.341	0.330	0.253							
G Fungal-Based Protein Suitability/Benefits	0.415	0.192	0.356	0.247	0.286	0.655						
H Healthiness Influence	0.163	0.111	0.277	0.207	0.168	0.238	0.147					
I Meat Nutritional Importance	0.135	0.061	0.371	0.251	0.086	0.485	0.374	0.272				
J Meat Taste, Texture, Smell Importance	0.085	0.094	0.223	0.095	0.040	0.337	0.229	0.183	0.717			
K Plant-Based Protein Suitability/Benefits	0.310	0.139	0.406	0.157	0.149	0.375	0.632	0.187	0.437	0.225		
L Plant-Based Protein Willing to Try, Buy, and Pay More	0.147	0.320	0.384	0.283	0.211	0.801	0.366	0.312	0.585	0.397	0.485	

Table 4. Model Goodness of Fit (GoF) Index.

Scale	Average Variance Extracted	Explained Variance (R^2)	Predictive Relevance (Q^2)
Cultured Muscle Suitability/Benefits_	0.652	0.036	0.034
Cultured Muscle Willing to Try, Buy, and Pay More	0.739	0.359	0.087
Fungal-Based Protein Suitability/Benefits	0.639	0.128	0.125
Fungal-Based Protein Willing to Try, Buy, and Pay More	0.697	0.367	0.206
Plant-Based Protein Suitability/Benefits	0.538	0.175	0.173
Plant-Based Protein Willing to Try, Buy, and Pay More	0.637	0.279	0.235
Average Score	0.650	0.224	0.143
AVE * R^2		0.146	
GoF = $\sqrt{(AVE * R^2)}$		0.382	

Table 5. Path Cofficients

Hypothesised Path Relationship	Coefficient	t-Statistic	P Value
H1a: Environmental Impact Influence→Plant-Based Protein Suitability/Benefits	0.178	9.667	0.000
H1b: Environmental Impact Influence→Fungal-Based Protein Suitability/Benefits	0.165	8.417	0.000
H1c: Environmental Impact Influence→Cultured Muscle Suitability/Benefits	0.114	5.346	0.000
H2a: Plant-Based Protein Suitability/Benefits→Plant-Based Protein Willing to Try, Buy, and Pay More	0.261	14.298	0.000
H2b: Fungal-Based Protein Suitability/Benefits→Fungal-Based Protein Willing to Try, Buy, and Pay More	0.432	26.165	0.000
H2c: Cultured Muscle Suitability/Benefits→Cultured Muscle Willing to Try, Buy, and Pay More	0.528	41.226	0.000
H3a: Food Neophobia→Plant-Based Protein Willing to Try, Buy, and Pay More	-0.091	5.377	0.000
H3b: Food Neophobia→Fungal-Based Protein Willing to Try, Buy, and Pay More	-0.127	8.220	0.000
H3c: Food Neophobia→Cultured Muscle Willing to Try, Buy, and Pay More	-0.076	5.047	0.000
H4a: Food Tech Neophobia→Plant-Based Protein Willing to Try, Buy, and Pay More	-0.061	3.916	0.000
H4b: Food Tech Neophobia→Fungal-Based Protein Willing to Try, Buy, and Pay More	-0.044	3.000	0.003
H4c: Food Tech Neophobia→Cultured Muscle Willing to Try, Buy, and Pay More	-0.108	7.198	0.000
H5a: Healthiness Influence→Plant-Based Protein Suitability/Benefits	0.060	3.481	0.001
H5b: Healthiness Influence→Fungal-Based Protein Suitability/Benefits	0.022	1.246	0.213
H5c: Healthiness Influence→Cultured Muscle Suitability/Benefits	-0.098	5.159	0.000
H6a: Meat Nutritional Importance→Plant-Based Protein Suitability/Benefits	-0.379	16.564	0.000
H6b: Meat Nutritional Importance→Fungal-Based Protein Suitability/Benefits	-0.253	10.448	0.000
H6c: Meat Nutritional Importance→Cultured Muscle Suitability/Benefits	-0.075	3.028	0.002
H7a: Meat Nutritional Importance→Plant-Based Protein Willing to Try, Buy, and Pay More	-0.278	13.131	0.000
H7b: Meat Nutritional Importance→Fungal-Based Protein Willing to Try, Buy, and Pay More	-0.179	9.290	0.000
H7c: Meat Nutritional Importance→Cultured Muscle Willing to Try, Buy, and Pay More	-0.052	2.665	0.008
H8a: Meat Taste, Texture, Smell Importance→Plant-Based Protein Suitability/Benefits	-0.005	0.255	0.798
H8b: Meat Taste, Texture, Smell Importance→Fungal-Based Protein Suitability/Benefits	-0.067	2.975	0.003
H8c: Meat Taste, Texture, Smell Importance→Cultured Muscle Suitability/Benefits	0.094	3.889	0.000
H9a: Meat Taste, Texture, Smell Importance→Plant-Based Protein Willing to Try, Buy, and Pay More	-0.129	6.563	0.000
H9b: Meat Taste, Texture, Smell Importance→Fungal-Based Protein Willing to Try, Buy, and Pay More	-0.097	5.428	0.000
H9c: Meat Taste, Texture, Smell Importance→Cultured Muscle Willing to Try, Buy, and Pay More	0.097	4.881	0.000

Table 6. Willingness to try, buy, and pay more for meat substitutes (ranked) by Country

Plant-Based			Fungal-based			Cultured muscle		
Country	**Mean**	**StDev**	**Country**	**Mean**	**StDev**	**Country**	**Mean**	**StDev**
Netherlands	2.47	0.49	Indonesia	2.39	0.47	Netherlands	2.12	0.68
Mexico	2.30	0.45	Mexico	2.24	0.46	Mexico	2.01	0.56
USA	2.29	0.55	Netherlands	2.21	0.62	Indonesia	1.86	0.57
Indonesia	2.29	0.43	Spain	2.18	0.50	Pakistan	1.84	0.64
UK	2.27	0.56	UK	2.15	0.65	Dominican Republic	1.84	0.59
Spain	2.27	0.45	USA	2.09	0.63	New Zealand	1.79	0.63
France	2.24	0.48	France	2.04	0.57	UK	1.77	0.65
Dominican Republic	2.22	0.48	New Zealand	2.02	0.58	Spain	1.73	0.52
New Zealand	2.21	0.53	Dominican Republic	2.00	0.58	USA	1.68	0.63
Pakistan	2.20	0.54	China	1.99	0.56	China	1.65	0.58
Brazil	2.20	0.54	Brazil	1.99	0.61	Brazil	1.63	0.58
China	2.10	0.54	Pakistan	1.87	0.60	France	1.55	0.56
Total	2.24	0.52	Total	2.07	0.60	Total	1.76	0.63

StDev=Standard Deviation