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Consumer co-creation of hybrid meat products: A cross-country European survey

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ABSTRACT

Hybrid meat products are blends of meat and plant-based ingredients that could bridge the gap for consumers who want to reduce their meat intake, without sacrificing the taste, convenience and familiarity of traditional processed meat products. However, little is known about consumers' preferred formulations, willingness to try (WTT), willingness to buy (WTB), and how they are perceived compared to meat products and plant-based meat-free alternatives. Therefore, this study aimed to: 1) identify hybrid recipes with the most potential for acceptance using a co-creation approach; 2) understand WTT and WTB for hybrid products and 3) compare hybrid meat products vs meat products and plant-based meat-free alternatives on several attributes (healthy, ethical, environmentally friendly, convenient, affordable, tasty, enjoyable, acceptable, aspirational, nutritious, simple, safe). The online survey with a total of 2,405 consumers in Denmark, Spain and the UK, revealed that across countries consumers prefer a hypothetical beef burger made with 25% or 50% plant-based ingredients (onions, herbs, spices, garlic and mushrooms) and with a nutritional claim on protein or fat. At least 57% of consumers were willing to try and at least 46% were willing to buy hybrid meat products. Across countries and for most attributes, hybrid meat products scored similarly to plant-based meat-free alternatives and differently from meat products. Hybrid meat products and plant-based meat-free alternatives were considered as healthy, ethical and environmentally friendly, while meat products were considered affordable, tasty, enjoyable and simple. These findings provide insights and practical suggestions for companies manufacturing innovative solutions for meat products and policy makers aiming to promote more varied diets.

1. Introduction

Consumer food selections are known to have a significant impact on the environment (Siegrist & Hartmann, 2019), as such feeding the world in a sustainable way has been deemed one of the futures most pressing challenges (Ritchie & Roser, 2017). In particular, animal protein consumption has a major environmental impact (Shukla et al., 2019) and its reduction is an essential compromise of an environmentally sustainable diet (Siegrist & Hartmann, 2019). In high proportions, meat consumption is associated with many negative health outcomes, such as cancer, diabetes and cardiovascular disease (Yip, Lam, & Fielding, 2018). Yet, many consumers are highly attached to meat (Graça, Calheiros, & Oliveira, 2015) and are not motivated to cut it completely from their diet (Lentz, Connelly, Mirosa, & Jowett, 2018).

Research suggests that rather than eliminate it, consumers are more likely to reduce their meat consumption. Thus, a diet which is mostly plant-based and includes a modest amount of meat should be encouraged (Corrin & Papadopoulos, 2017). Kim et al. (2020) reported that in the majority of countries investigated, diets that included animal products for only one meal per day were less greenhouse gas (GHG)-intensive than lacto-ovo vegetarian diets (with no terrestrial and aquatic meats) in part due to the GHG-intensity of dairy foods. Such unrestricted, meat-reducing diet, known as 'flexitarianism', is also likely to support weight loss and promote metabolic health benefits including reduced diabetes risk and blood pressure (Derbyshire, 2017). Flexitarian eaters employ strategies that include both spreading meat consumption throughout the week and occasionally eating entirely plant-based meat-free meals, and also reducing meat portion sizes whilst increasing consumption of plant-based proteins and other vegetables (Kemper & White, 2021).

Meat consumption behaviours are driven by numerous factors that influence choice and attitudes, including social norms and concerns

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about the environment (Cheah, Sadat Shimul, Liang, & Phau, 2020). Key egoistic factors for purchase choice in meat-reducers also include price, health, nutrition and taste (Malek & Umberger, 2021). Health is a particularly strong driver of consumption (Kemper & White, 2021) and perceived benefits of meat reduction include weight control, decreased saturated fat and prevention of diseases (Cheah et al., 2020). Interestingly, whilst those adhering to a flexitarian diet are accepting of milk substitutes, they have indicated that they would personally avoid meat substitutes over health concerns because the products are seen as over-processed (Kemper & White, 2021).

Hybrid meat products combine a blend of meat and plant-based ingredients in a convenient ready-to-cook form, such as sausages, burgers and mince (Grasso & Jaworska, 2020). There are no set ratios of meat to plant based ingredients nor specific limitations to the plant-based component of the hybrid meat product, which can include legumes, fruit and vegetables as a blend or single ingredient. It has been suggested that one possible pathway to make substitution of meat more compatible with convenience culture is by introducing unfamiliar foods into the existing foods that convenience orientated consumers like (Schösler, Boer, & Boersema, 2012). Thus, hybrid meats aim to reformulate these familiar products and deliver in taste and convenience without dramatically altering consumer's diets (Grasso & Jaworska, 2020).

As future resilience of the meat industry will require responding to food expenditure patterns and trends of meat consumption (James, Lomax, Birkin, & Collins, 2021), these hybrid products support value growth by providing an opportunity to build a strategy around the growing flexitarian demographic (Hicks, Knowles, & Farouk, 2018).

There is currently enough scientific knowledge available to manufacture healthier meat products incorporating plant-based ingredients (Grasso, Brunton, Lyng, Lalor, & Monahan, 2014) and meat products with claims such as "one of your five a day" and "source of fibre" have been launched in the market (Grasso & Jaworska, 2020; Waitrose, 2018), however it is not well known which reformulations would be most accepted by consumers. Soliciting consumer insights early in the new food development process is critical for achieving consumer acceptability (Filieri, 2013; Olsen, 2015). In particular, flavour has been highlighted as a key area for influencing perception of hybrid products (Shan et al., 2017), and so it is essential to capture consumers' preferred flavours to give manufacturers confidence that they are delivering on what consumers desire (Dijksterhuis, 2016). Whilst previous research has found consumers are accepting of a hybrid burger blended with mushrooms (Lang, 2020), more research is needed to explore a broader range of meat and plant-based ingredients that could be used based on individual preferences. Co-creation is defined as a process of collective creativity (Sanders & Stappers, 2008). It involves consumers from the early stages of new product development and leads to products with higher chance of success in the market (Filieri, 2013). Barone et al. (2021) recently co-created new meat solutions with European consumers using focus groups (n = 48) which highlighted consumers' values and showed potential for implementation on a larger scale. Therefore in this study we aimed to: 1) investigate the preferred hybrid meat product formulations using a novel co-creation approach with a large sample of European consumers, 2) explore consumers' willingness to try (WTT) and willingness to buy (WTB), 3) compare hybrid meat products vs meat products and plant-based meat-free alternatives on several attributes. Participants were recruited from three countries in Europe (UK, Spain and Denmark) with particularly high meat consumption rates (≈80 kg per person/year in UK and Denmark and >100 kg per person/year in Spain) (Ritchie & Roser, 2017). This paper will describe the methodological approach, the results, and the findings which provide valuable insights for both manufacturers and policy makers.

2. Material and methods

2.1. Participants and survey structure

During September 2020, a survey was distributed via the online survey tool and market research company Qualtrics to a total of 2,405 participants (Denmark n = 802, Spain n = 801, UK n = 802). The survey was written in English, translated into Spanish and Danish and then back-translated to ensure it was comprehensible in the participants' native language. Participants were screened on the basis of age, gender, being partly or primarily responsible for food purchases, as well as on the basis of their frequency of meat purchase and consumption. Only participants who consumed meat products were eligible to take part in the survey. Quotas were implemented to ensure participants in each country were equally distributed in terms of age and gender. The study was granted ethical approval by the School's Ethics committee (Ethical Clearance Application Reference Number 1327D).

The questionnaire recorded several factors to understand consumer eating behaviours. A summary of the survey questions is reported in Table 1.

The first part included screening questions and questions on purchasing and consumption habits. Consumers were then asked about their intended consumption for fresh meat (defined as "fresh meat has not undergone any preserving process other than chilling or freezing, including meat that is vacuum-wrapped or wrapped in a controlled atmosphere"), meat products (defined as "the result from the processing of meat, so that the cut surface shows no characteristics of fresh meat, e.g., burgers, sausages, meatballs") and plant-based meat-free substitutes (defined as "products that mimic the taste, texture, and appearance of animal-based products"), using the question "In the next 3–6 months, what is your intended consumption for the below products? Thank you for being honest!" (Bryant, 2019). Consumers were asked two closed questions (if they had ever purchased meat products where a part of the meat has been replaced with plant-based ingredients and if they had heard of meat products with plant-based ingredients before taking the survey) and how willing would they be to try and buy hybrid meat products (on 7-point scales, from 1 = Definitely would not to 7 = Definitely would). Next, consumers were given a series of attributes and were asked to rate fresh meat, hybrid meat products and plant-based meat-free alternatives using the attributes on a scale from 1 (Not at all) to 7 (Extremely). Attributes included: healthy, ethical, environmentally friendly, convenient, affordable, tasty, enjoyable, acceptable, aspirational, nutritious, simple (with few ingredients), safe. The first ten attributes were taken from Bryant (2019) and the last two were added by the researchers as they were considered relevant to this study.

The questionnaire then presented consumers with a novel co-creation task to elicit their preferences for hybrid meat. Participants were asked five hypothetical questions (on the preferred type of meat

Table 1
Summary of survey questions.

1) Introduction to the study and consent to participate.
2) Preliminary questions: screener (cheap talk, age, gender, food purchase responsibility, purchase and consumption of fresh meat and meat products), purchase and consumption of plant-based meat-free substitutes.
3) Intended future consumption of fresh meat, meat products and plant-based meat substitutes.
4) Definition of meat product with plant-based ingredients.
5) Closed questions: 1) have you ever purchased meat products where a part of the meat has been replaced with plant-based ingredients 2) had you heard of meat products with plant-based ingredients before taking the survey.
6) Willingness to try and willingness to buy scales from 1 (Definitely would not) to 7 (Definitely would).
7) Rating meat products, hybrid meat products and plant-based meat-free alternatives using the attributes on a scale of 1 (Not at all) to 7 (Extremely).
8) Hybrid meat product co-creation: selection of meat product, type of meat, ratio of meat to plant-based ingredients, nutritional claims, plant-based ingredients.
9) Socio-demographic questions.

product, base meat, ratio of meat to plant-based ingredients, nutritional claims and plant-based ingredients) to ascertain the hybrid meat combination that would be most preferable to them. In the first four questions, consumers were asked to rank the options given from most preferred to least preferred (1 = most preferred), while for the last question a check-all-that-apply (CATA) list was used. A summary of the five co-creation questions is shown below:

Q1: Which of the below meat products would you prefer to be made with plant-based ingredients? Rank from the most preferred (1) to the least preferred (5). Options given: sausages, burgers, meatballs, chicken nuggets, minced meats.

Q2: So (answer carried over from Q1) are your preferred meat product to be made with plant-based ingredients. Now rank the below types of meats from the most preferred (1) to the least preferred (4) to be used with your chosen meat product with plant-based ingredients. Options given: pork, beef, chicken, lamb.

Q3: So (answer carried over from Q1) made from (answer carried over from Q2) are your preferred meat product to be made with plant-based ingredients. Now rank the below ratios of meat to plant-based ingredients from the most preferred (1) to the least preferred (3) to be used on your chosen meat product with plant-based ingredient. Options given: 75% meat:25% plant-based, 50% meat:50% plant-based, 25% meat:75% plant-based. The options 100% meat and 100% plant-based were not provided to keep the focus on the co-creation of hybrid options only.

Q4: So (answer carried over from Q1) made from (answer carried over from Q2) with meat to plant-based ratio (answer carried over from Q3) are your preferred meat product to be made with plant-based ingredients. Below you can find a list of nutritional claims that could be made on your chosen meat products with plant-based ingredients, please rank them from the most preferred (1) to the least preferred (8). Options given: fibre (source of or high in), fat (reduced or low in), salt (reduced or low in), protein (source of or high in), omega-3 fatty acids (source of or high in), minerals such as calcium or iron (source of or high in), vitamins such as vitamin C or B12 (source of or high in), no claim.

Q5: So (answer carried over from Q1) made from (answer carried over from Q2) with meat to plant-based ratio (answer carried over from Q3) with nutritional claim (answer carried over from Q4) are your preferred meat product to be made with plant-based ingredients. When thinking about the plant-based portion of your chosen meat product, which ingredients would you prefer to have in it? Check all that apply. Options given: garlic, onion, herbs (parsley, thyme, coriander, etc), spices (chili, black pepper, paprika, etc), pulses (lentils, chickpeas, beans, peas, etc), grains (wheat, barley, rice, oats, etc), mushroom, soy sauce, tomato, pepper, spinach, beetroot, cauliflower, soya, carrot, nuts, seeds, sweetcorn, other (please specify).

At the end of the co-creation task, participants were presented with a summary of their responses and the final hybrid meat product created. They were asked to confirm if they were happy with their choices or not. Those who were happy with their choices proceeded to the next question and those who were not had the option to go back and edit their answers. The choices given were "go back" or "next". Due to the novel nature of this task, it was possible that some consumers had no prior experience of creating a product via a questionnaire, so it was important to provide participants with the opportunity to validate their answers.

The questionnaire ended with socio-demographic questions (education, marital status, children, employment, income).

2.2. Statistical analysis

Friedman tests with pairwise comparisons were conducted to assess the ranking data for preferred meat product, base meat, ratio of meat to plant-based ingredients and the most appealing nutritional claims. For the attribute ratings, a Kruskal-Wallis H test with multiple pairwise comparison was used. Contingency tables were generated for the CATA data by counting the frequency of the plant-based ingredients for each country. For WTT and WTB, answers to "would", "probably would" and "definitely would" were added together and computed as percentages of the total sample. Statistical analyses were performed using SPSS (version 26) statistical software (IBM Inc. Chicago, IL, USA) and graphs were created using Excel 2016 (Microsoft Co.).

3. Results

3.1. Sample characteristics

The socio-demographic characteristics of the sample are presented in Table 2. The recruitment quotas were effective at achieving an equal split across gender in all countries. Similarly, the proportions of age groups across countries were well matched. Overall, 25.63% were 18–32 years old, 24.74% were 33–46 years old, 31.68% were 47–61 years old and 17.95% were 62–75 years old. Over 60% had no children in their household. Over 50% of the sample had an annual income before tax less than £39,000 (equivalent to ≈US$53,000), while almost 60% of the respondents were public or private sector employees. In terms of education, over 80% of the consumers had an undergraduate university degree. Over 60% of participants were primarily responsible for food shopping. In the UK and Spain the majority of the sample purchased fresh meat once a week (51.6% in the UK and 47.7% in Spain), while in Denmark a third selected the option "once a week" (33.2%) and a third "2–3 times a week" (34.3%). In terms of fresh meat consumption, across countries at least 33% reported consuming fresh meat 2–3 times a week. The purchase of meat products was once a week for 29–51% of the sample and less than once a week for 28–51%. For the UK sample, the most selected options for frequency of meat product consumption were "once a week" (29.7%) and "2–3 times a week" (31.3%). In Spain the most selected options for meat product consumption were "less than once a week" (39.8%), "once a week" (30.3%) and "2–3 times a week" (24.1%). In Denmark more than a third of participants (33.2%) reported consuming meat products 2–3 times a week. Across countries, the majority of the sample (at least 59%) never purchased or consumed plant-based meat-free substitutes.

3.2. Intended consumption of fresh meat, meat products and plant-based meat-free substitutes

Table 3 shows European consumers intended future consumption of fresh meat, meat products and plant-based meat-free substitutes. It suggests that the majority of consumers (75–80%) intended to maintain their current eating frequency of fresh meat at the same level and 14–20% were looking to decrease consumption. For meat products, 55% in Spain intended to maintain the same level of consumption, while this percentage was 66% for the UK and 74% for Denmark. In Spain, almost 40% of consumers intended to decrease their meat product consumption, while this figure was lower in the other two countries (29% in the UK and 22% in Denmark). As for plant-based meat-free substitutes, consumers were more spread out across the categories, with 40–60% of consumers intending to keep the consumption the same, 14–40% intending to eliminate them and 16–25% intending to increase their consumption. Interestingly, in the three countries there were more people intending to eliminate plant-based meat-free substitutes from their diets than eliminate meat products or fresh meat.

3.3. Awareness and consumption of hybrid meat

The concept of hybrid meat was introduced to consumers as "meat products where part of the meat had been replaced with plant-based ingredients". When consumers were asked if they had heard of these before, the majority said yes (UK = 71.4%; Spain = 84.3%, Denmark = 92.4%). They were also asked if they had previously purchased this type of product before and fewer people said yes (UK = 35.2%, Spain = 45.5%, Denmark = 39.9%). The most popular hybrid meat products that

Table 2
Socio-demographic characteristics of the consumers in UK, Spain and Denmark (total N = 2,405).

Socio demographics: number (%)	UK (N = 802)	Spain (N = 801)	Denmark (N = 802)
Gender			
Male	393 (49.0%)	402 (50.2%)	401 (50%)
Female	409 (51.0%)	399 (49.8%)	401 (50%)
Age			
18–32	180 (22.4%)	205 (25.6%)	225 (28.1%)
33–46	220 (27.4%)	196 (24.5%)	179 (22.3%)
47–61	251 (31.3%)	269 (33.6%)	242 (30.2%)
62–75	150 (18.7%)	131 (16.4%)	155 (19.3%)
Children			
Yes	526 (65.5%)	512 (63.9%)	588 (73.3%)
No	276 (34.5%)	289 (36.1%)	214 (26.7%)
Annual household income before taxes*			
Less than £10,000	59 (7.4%)	37 (4.6%)	36 (4.5%)
£10,000 to £19,999	144 (18.0%)	155 (19.4%)	61 (7.6%)
£20,000 to £29,999	133 (16.6%)	177 (22.1%)	103 (12.8%)
£30,000 to £39,999	128 (16.0%)	128 (16.0%)	81 (10.1%)
£40,000 to £49,999	102 (12.7%)	101 (12.6%)	90 (11.2%)
£50,000 to £59,999	71 (8.9%)	54 (6.7%)	59 (7.4%)
£60,000 to £69,999	32 (4.0%)	35 (4.4%)	53 (6.6%)
£70,000 to £79,999	26 (3.2%)	23 (2.9%)	55 (6.9%)
£80,000 to £89,999	15 (1.9%)	11 (1.4%)	49 (6.1%)
£90,000 to £99,999	21 (2.6%)	7 (0.9%)	45 (5.6%)
£100,000 to £149,999	20 (2.5%)	10 (1.2%)	60 (7.5%)
£150,000 or more	9 (1.1%)	5 (0.6%)	12 (1.5%)
I do not want to declare	31 (3.9%)	40 (5.0%)	75 (9.4%)
I do not know	11 (1.4%)	18 (2.2%)	23 (2.9%)
Employment			
Student	23 (2.9%)	64 (8.0%)	94 (11.7%)
Independent worker (e.g. consultant)	32 (4.0%)	117 (14.6%)	25 (3.1%)
Private-sector worker	297 (37.0%)	244 (30.5%)	240 (29.9%)
Public-sector worker	149 (18.6%)	106 (13.2%)	140 (17.5%)
Retired	120 (15.0%)	113 (14.1%)	162 (20.2%)
Unemployed (seeking work)	60 (7.5%)	95 (11.9%)	66 (8.2%)
Not in paid employment (not seeking work)	87 (10.8%)	18 (2.2%)	19 (2.4%)
Other	34 (4.2%)	44 (5.5%)	56 (7%)
Education			
Primary school	6 (0.7%)	6 (0.7%)	60 (7.5%)
High school	217 (27.1%)	109 (13.6%)	124 (15.5%)
Higher education (not university)	266 (33.2%)	218 (27.2%)	236 (29.4%)
Bachelor's Degree	221 (27.6%)	333 (41.6%)	240 (29.9%)
Master's Degree	65 (8.1%)	110 (13.7%)	132 (16.5%)
Postgraduate University Degree (PhD)	27 (3.4%)	25 (3.1%)	10 (1.2%)
Responsibility for food shopping			
Partly	239 (29.8%)	296 (37.0%)	317 (39.5%)
Primarily	563 (70.2%)	505 (63.0%)	485 (60.5%)
Frequency of fresh meat purchase/consumption			
Never	0	0	0
Less than once a week	160 (20.2%)/ 116 (14.5%)	144 (18.0%)/ 147 (18.4%)	159 (19.8%)/ 129 (16.1%)
Once a week	414 (51.6%)/ 200 (24.9%)	382 (47.7%)/ 231 (28.8%)	266 (33.2%)/ 175 (21.8%)
2–3 times a week	175 (21.8%)/ 278 (34.7%)	218 (27.2%)/ 309 (38.6%)	275 (34.3%)/ 266 (33.2%)
More than 3 times a week	42 (5.2 %)/158 (19.7%)	43 (5.4%)/90 (11.2%)	71 (8.9%)/172 (21.4%)
Daily	11 (1.4%)/50 (6.2%)	14 (1.7%)/24 (3.0%)	31 (3.9%)/60 (7.5%)
Frequency of meat products purchase/consumption			
Never	0	0	0
Less than once a week	226 (28.2%)/ 174 (21.7%)	344 (42.9%)/ 319 (39.8%)	413 (51.5%)/ 321 (40.0%)
Once a week	412 (51.4%)/ 238 (29.7%)	321 (40.1%)/ 243 (30.3%)	234 (29.2%)/ 212 (26.4%)
2–3 times a week	126 (15.7%)/ 251 (31.3%)	101 (12.6%)/ 193 (24.1%)	124 (15.5%)/ 171 (21.3%)
More than 3 times a week	30 (3.7%)/99 (12.3%)	27 (3.4%)/38 (4.7%)	26 (3.2%)/65 (8.1%)
Daily	8 (1.0%)/40 (5.0%)	8 (1.0%)/8 (1.0%)	5 (0.6%)/33 (4.1%)
Frequency of plant-based meat-free substitutes purchase/consumption			
Never	478 (59.6%)/ 473 (59.0%)	544 (67.9%)/ 551 (68.8%)	587 (73.2%)/ 597 (74.4%)
Less than once a week	194 (24.2%)/ 179 (22.3%)	170 (21.2%)/ 154 (19.2%)	152 (19.0%)/ 139 (17.3%)
Once a week	89 (11.1%)/84 (10.5%)	52 (6.5%)/63 (7.9%)	52 (6.5%)/47 (5.9%)
2–3 times a week	27 (3.4%)/44 (5.5%)	27 (3.4%)/21 (2.6%)	8 (1.0%)/16 (2.0%)
More than 3 times a week	7 (0.9%)/18 (2.2%)	4 (0.5%)/7 (0.9%)	3 (0.4%)/3 (0.4%)
Daily	7 (0.9%)/4 (0.5%)	4 (0.5%)/5 (0.6%)	0/0

* Euros and Danish Kroner were converted into Great British Pound equivalents.

consumers had purchased were sausages and burgers in the UK (sausages=21.3% and burgers=20%) burgers in Spain (41.4%) and minced meat in Denmark (26.4%). Fig. 1 indicates that at least 50% of consumers were willing to try hybrid meats (they selected "would", "probably would" or "definitely would" try), but they were less willing to buy them. Spanish consumers seemed to be the most favourable, with 71% willing to try and 63% willing to buy.

3.4. Preferred type of meat product

The rankings of the preferred meat product for hybrid meat are listed in Table 4. Overall, burgers were universally ranked the most favourably and chicken nuggets were ranked the least favourably. In all countries there was a significant difference in the preferred meat product ($p < 0.0001$ in all countries). In the UK the most preferred product was burgers, followed by sausages and with no significant difference between the two. In Spain burgers were also ranked as the most preferred product, followed by meatballs (significantly lower). Danish consumers also ranked burgers as the preferred meat product, followed by mincemeat and with no significant difference between the two.

3.5. Preferred base meat

The rankings of the preferred base meat are listed in Table 5. Overall, beef was universally ranked the most favourably and lamb was ranked the least favourably. In the three countries there was a significant difference in preferred base meat ($p < 0.0001$ in all countries). In all countries, beef was ranked as the most preferred base meat for a hybrid meat product, followed by chicken, then pork and finally lamb. However in Spain there was no significant difference between beef and chicken, while for UK and Denmark this difference was significant.

3.6. Preferred ratio of meat to plant-based ingredients

The rankings of the preferred ratio of meat to plant-based ingredients are listed in Table 6. Overall, the ratios with at least 50% meat were preferred. The least preferred ratio was 25:75 in all countries. There was a significant difference in preferred meat to plant-based ingredients ratio in all countries ($p < 0.0001$ in all countries). In the UK and Denmark there was no significant difference between the ratios 75:25 and 50:50, indicating that both ratios were deemed equally preferable. Spanish consumers ranked the 50:50 ratio as the most preferable, followed by 75:25 (significantly lower).

3.7. Preferred nutritional claims

The rankings of the preferred nutritional claims are listed in Table 7.

Table 3
Intended consumption of fresh meat, meat products and plant-based meat-free substitutes in UK, Spain and Denmark (percentages shown).

	Fresh meat			Meat products			Plant-based meat-free substitutes		
	UK	Spain	Denmark	UK	Spain	Denmark	UK	Spain	Denmark
Eliminate	0.7%	1.0%	1.1%	1.5%	3.0%	1.7%	14.5%	28.2%	40.0%
Greatly decrease	3.2%	6.2%	1.9%	7.4%	17.1%	4.7%	1.9%	2.9%	1.0%
Slightly decrease	15.3%	14.0%	11.8%	21.2%	22.7%	17.2%	3.6%	4.2%	1.2%
Maintain the same	75.1%	75.7%	80.3%	66.2%	55.1%	74.2%	59.6%	40.1%	41.9%
Slightly increase	4.5%	2.7%	4.2%	3.2%	2.0%	1.9%	17.3%	22.6%	14.3%
Greatly increase	1.1%	0.4%	0.6%	0.5%	0.1%	0.2%	3.1%	2.0%	1.5%

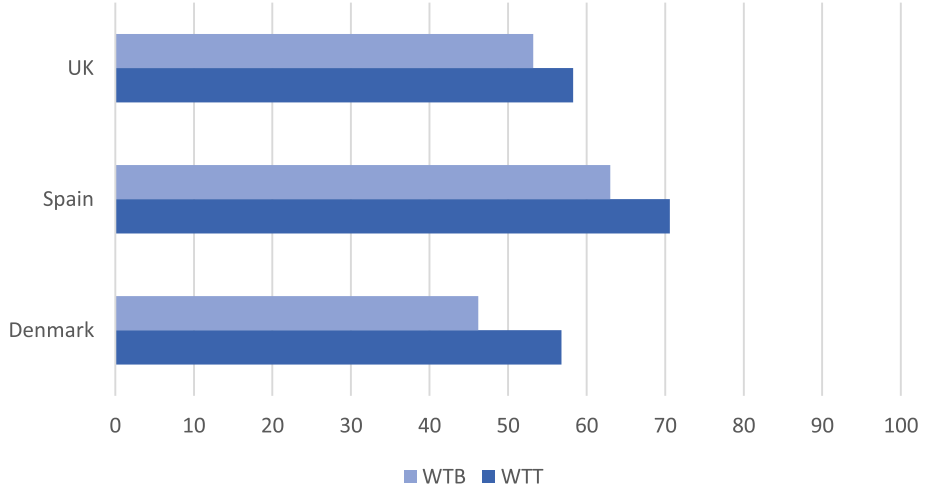

Fig. 1. Consumer willingness to try and buy hybrid meat products in UK, Spain and Denmark.

Table 4
Preferred meat product in UK, Spain and Denmark (means and standard deviations).

UK		Spain		Denmark	
Meat product	Mean ± SD	Meat product	Mean ± SD	Meat product	Mean ± SD
1st Burgers	$2.53 \pm 0.1.31^{a}$	1st Burgers	$2.04 \pm 0.1.27^{a}$	1st Burgers	2.79 ± 1.28^{a}
2nd Sausages	2.65 ± 1.33^{ab}	2nd Meatballs	2.87 ± 1.24^{b}	2nd Mincemeat	2.81 ± 1.59^{ab}
3rd Meatballs	3.09 ± 1.29^{c}	3rd Mincemeat	3.17 ± 1.38^{c}	3rd Sausages	3.04 ± 1.33^{c}
4th Mincemeat	3.26 ± 1.41^{cd}	4th Sausages	3.25 ± 1.27^{cd}	4th Meatballs	3.07 ± 1.30^{cd}
5th Nuggets	3.46 ± 1.50^{de}	5th Nuggets	3.67 ± 1.38^{e}	5th Nuggets	3.29 ± 1.49^{e}

Values with the same letter in the same column are not significantly different at $P < 0.05$. Options given: burger, sausages, meatballs, mincemeat and nuggets.

Table 5
Preferred base meat in UK, Spain and Denmark (means and standard deviations).

UK Base meat	Mean ± SD	Spain Base meat	Mean ± SD	Denmark Base meat	Mean ± SD
Beef	2.03 ± 0.99^{a}	Beef	1.95 ± 0.98^{a}	Beef	1.98 ± 1.0^{a}
Chicken	2.30 ± 1.15^{b}	Chicken	2.09 ± 1.0^{ab}	Chicken	2.27 ± 1.0^{b}
Pork	2.60 ± 1.05^{c}	Pork	2.50 ± 0.93^{c}	Pork	2.46 ± 0.96^{c}
Lamb	3.07 ± 0.99^{d}	Lamb	3.45 ± 0.84^{d}	Lamb	3.29 ± 0.99^{d}

Values with the same letter in the same column are not significantly different at $P < 0.05$.

Table 6
Preferred ratio of meat to plant-based ingredients in UK, Spain and Denmark (means and standard deviations).

Meat: Plant Ratio	UK Mean ± SD	Meat: Plant Ratio	Spain Mean ± SD	Meat: Plant Ratio	Denmark Mean ± SD
75:25	1.73 ± 0.86^{a}	50:50	1.76 ± 0.52^{a}	75:25	1.77 ± 0.89^{a}
50:50	1.78 ± 0.52^{ab}	75:25	1.92 ± 0.91^{b}	50:50	1.77 ± 0.50^{ab}
25:75	2.49 ± 0.79^{c}	25:75	2.32 ± 0.86^{c}	25:75	2.46 ± 0.80^{c}

Values with the same letter in the same column are not significantly different at $P < 0.05$.

Overall, claims which stated the hybrid product was 'high in or a source of protein' or 'reduced or low in fat' were the most preferred. There was a significant difference in the preferred claims across all countries ($p < 0.0001$). In the UK consumers ranked 'high in or a source of protein' as their most preferred nutritional claim, followed by 'reduced or low in fat', with no significant difference between the two. In Denmark the most preferred nutritional claim was 'high in or a source of protein', followed by the 'reduced or low in fat' an 'high in or a source of fibre' claims (significantly less preferred). In Spain the most preferred claims were those on fat and protein, with no significant difference between the two.

Table 7
Preferred nutritional claims in UK, Spain and Denmark (means and standard deviations).

UK		Spain		Denmark	
Claim	Mean ± SD	Claim	Mean ± SD	Claim	Mean ± SD
Protein	3.35 ± 2.17^{a}	Fat	3.18 ± 2.18^{a}	Protein	3.16 ± 2.05^{a}
Fat	3.56 ± 2.23^{ab}	Protein	3.53 ± 2.16^{ab}	Fat	3.62 ± 2.25^{b}
Fibre	4.09 ± 1.97^{c}	Fibre	4.32±0.1.96^{c}	Fibre	3.91 ± 1.93 ^{bc}
Salt	4.28 ± 2.15^{cd}	Salt	4.35 ± 2.11^{cd}	Omega	4.51 ± 1.97^{d}
Vitamins	4.48 ± 2.01^{de}	Vitamins	4.44 ± 1.95^{cde}	Minerals	4.60 ± 1.90 ^{de}
Minerals	4.68 ± 1.87^{ef}	Omega	4.52 ± 1.94^{cdef}	Vitamins	4.75 ± 1.94 ^{def}
Omega	4.89 ± 1.92^{fg}	Minerals	4.53 ± 1.89^{cdefg}	Salt	4.87 ± 2.08 ^{defg}
No claim	6.64 ± 2.35^{h}	No claim	7.14 ± 1.89 ^{h}	No claim	6.58 ± 2.45^{h}

Values with the same letter in the same column are not significantly different at $P < 0.05$.

3.8. Preferred plant-based ingredients

The contingency table (Table 8) summarises the frequency of use for each CATA ingredient by consumers. The five most frequently selected plant-based ingredients in UK and Spain were onion, herbs, spices, garlic and mushrooms, while in Denmark they were onion, spices, herbs, garlic and pulses.

3.9. Attitudes towards meat products, hybrid meat products and plant-based meat-free substitutes

Consumer attitudes towards meat products, hybrid meat products and plant-based meat-free substitutes are shown in Table 9.

In the UK, hybrid meat products scored similarly to plant-based meat-free substitutes for all attributes. Hybrid and plant-based meat-free substitutes scored higher than meat products for healthy, ethical, environmentally friendly and aspirational. Meat products scored higher than hybrid and plant-based meat-free substitutes for convenient, affordable, tasty, enjoyable, acceptable and simple. There were no significant differences among the three products for the attributes nutritious and safe.

In Spain, there was no significant difference among the three product categories for the attribute acceptable. Hybrid meat products scored similarly to plant-based meat-free substitutes for all attributes. Hybrid and plant-based meat-free alternatives scored higher than meat products for the attributes healthy, ethical, environmentally friendly, convenient and safe, while meat products scored higher for affordable, tasty, enjoyable, aspirational and simple.

In Denmark, there was no significant difference among the three product categories for the attributes acceptable and safe. Hybrid meat products scored similarly to plant-based meat-free substitutes for all attributes. Hybrid and plant-based meat-free alternatives scored higher than meat products for the attributes healthy, ethical, environmentally friendly and nutritious. Meat products scored higher than the other two categories for convenient, affordable, tasty, enjoyable, aspirational and simple.

Table 8
Most to least selected CATA ingredients in the UK, Spain and Denmark.

UK		Spain		Denmark	
Onion	552	Onion	530	Onion	544
Herbs	503	Herbs	498	Spices	530
Spices	468	Garlic	430	Herbs	475
Garlic	466	Spices	416	Garlic	472
Mushroom	450	Mushroom	399	Pulses	396
Pepper	399	Tomato	395	Carrot	395
Pulses	330	Carrot	388	Mushroom	377
Tomato	327	Pulses	376	Spinach	327
Carrot	281	Pepper	331	Pepper	282
Grains	260	Spinach	310	Cauliflower	273
Spinach	249	Nuts	272	Tomato	270
Sweetcorn	216	Seeds	270	Nuts	244
Soy sauce	172	Grains	250	Grains	231
Cauliflower	159	Soya	202	Sweetcorn	204
Nuts	157	Soy sauce	165	Beetroot	191
Soya	148	Sweetcorn	120	Seeds	164
Beetroot	145	Cauliflower	93	Soya	146
Seeds	142	Beetroot	90	Soy sauce	107
Other	8	Other	19	Other	32

4. Discussion & conclusions

This is the first study to co-create hybrid meat products with consumers from the UK, Spain and Denmark. The preferred hybrid meat product formulations using a novel co-creation approach were investigated in each country, consumers' WTT and WTB for hybrid meat products were explored, and several attributes were used to compare hybrid meat products, meat products and plant-based meat-free alternatives.

The co-creation task showed that although some differences were found cross country, some overarching similarities also apply. Results in fact indicated that future hybrid meat product development should focus on a beef burger type product with added whole foods such as onions, mushrooms, pulses and natural flavourings like herbs, spices, and garlic. These findings agree with a co-creation study using online focus groups, indicating hybrid meat products as the most promising in terms of healthier meat product formulations (Barone et al., 2021). Consumers were also keen on seeing on-pack nutritional claims on hybrid meat products, especially those on protein (source of or high in) and fat (reduced or low in). Therefore, new hybrid meat products should be suitably formulated to be able to carry such nutrition claims and the use of these claims should be encouraged on-pack to communicate the health benefits to consumers. Research has shown that it is possible to manufacture hybrid meat products with such nutritional characteristics (Baune et al., 2021; Grasso, Pintado, Pérez-Jiménez, Ruiz-Capillas, & Herrero, 2020; Pérez-Montes, Rangel-Vargas, Lorenzo, Romero, & Santos, 2021) and several meat products with nutrition claims are available in the market (Danish Crown, 2019; Waitrose, 2018).

Another interesting finding is that the majority of consumers had heard of the concept of hybrid meat products and were willing to try such products. This familiarity could be beneficial in the adoption of hybrid meat products in the diet and a transition to a more plant-based diet, as it has been reported that consumers tend to refuse or avoid unfamiliar food products (Tuorila & Hartmann, 2020). However it is important to note that this study did not compare WTT of hybrid vs other plant-based foods or meat products, therefore it is unknown if hybrids would be more easily adopted compared to plant-based foods for example.

Looking at the result from the attribute-scoring task, we found some differences across countries, but overall hybrid meat products were seen as more similar to plant-based meat-free alternatives than to meat products. Hybrid meat products and plant-based meat-free alternatives were considered as healthy, ethical and environmentally friendly, while meat products were considered affordable, tasty, enjoyable and simple. This is an interesting finding because even though hybrid products possess both meat and plant-based ingredients, consumers in the three countries perceived them as closer to the plant-based category. A recent study reported that plant-based attitudes positively affected participants' attitude towards hybrid products both in Denmark and the UK (Banovic, Barone, Asioli, & Grasso, 2022). The authors concluded that even though regularly eating meat, in these countries participants open

Table 9
Rating of attributes across the three countries for meat products, hybrid meat products and plant-based meat-free alternatives using a scale of 1 (Not at all) to 7 (Extremely).

	UK			Spain			Denmark		
	Meat products	Hybrid	Plant-based	Meat products	Hybrid	Plant-based	Meat products	Hybrid	Plant-based
Healthy	4.09 ± 1.69^{b}	4.90 ± 1.50^{a}	4.89 ± 1.55^{a}	3.61 ± 1.81^{b}	4.59 ± 1.71^{a}	4.38 ± 1.79^{a}	3.45 ± 1.63^{b}	4.55 ± 1.53^{a}	4.45 ± 1.57^{a}
Ethical	3.86 ± 1.69^{b}	4.76 ± 1.59^{a}	4.92 ± 1.60^{a}	3.45 ± 1.75^{b}	4.27 ± 1.76^{a}	4.19 ± 1.81^{a}	3.45 ± 1.60^{b}	4.44 ± 1.72^{a}	4.40 ± 1.76^{a}
Env. friendly	3.72 ± 1.73^{b}	4.84 ± 1.59^{a}	4.94 ± 1.58^{a}	3.40 ± 1.83^{b}	4.41 ± 1.76^{a}	4.41 ± 1.79^{a}	3.20 ± 1.73^{b}	4.68 ± 1.60^{a}	4.65 ± 1.66^{a}
Convenient	5.27 ± 1.38^{a}	4.39 ± 1.58^{b}	4.46 ± 1.55^{b}	3.69 ± 1.72^{b}	4.21 ± 1.73^{a}	4.04 ± 1.83^{a}	4.59 ± 1.54^{a}	3.77 ± 1.56^{b}	3.74 ± 1.61^{b}
Affordable	4.80 ± 1.49^{a}	3.57 ± 1.61^{b}	3.64 ± 1.62^{b}	4.10 ± 1.55^{a}	3.11 ± 1.56^{b}	3.03 ± 1.55^{b}	4.37 ± 1.43^{a}	3.22 ± 1.37^{b}	3.21 ± 1.39^{b}
Tasty	5.25 ± 1.56^{a}	3.76 ± 1.80^{b}	3.67 ± 1.87^{b}	4.52 ± 1.66^{a}	3.60 ± 1.76^{b}	3.49 ± 1.77^{b}	4.36 ± 1.66^{a}	3.35 ± 1.70^{b}	3.23 ± 1.74^{b}
Enjoyable	5.21 ± 1.56^{a}	3.70 ± 1.81^{b}	3.63 ± 1.86^{b}	4.20 ± 1.57^{a}	3.70 ± 1.70^{b}	3.59 ± 1.69^{b}	4.16 ± 1.66^{a}	3.30 ± 1.68^{b}	3.17 ± 1.73^{b}
Acceptable	4.82 ± 1.48^{a}	4.53 ± 1.67^{b}	4.54 ± 1.73^{b}	4.07 ± 1.53^{ns}	4.01 ± 1.64^{ns}	3.87 ± 1.69^{ns}	4.14 ± 1.52^{ns}	4.18 ± 1.74^{ns}	4.04 ± 1.73^{ns}
Aspirational	3.50 ± 1.72^{b}	3.91 ± 1.84^{a}	3.94 ± 1.86^{a}	3.96 ± 1.62^{a}	3.65 ± 1.66^{b}	3.54 ± 1.67^{b}	3.77 ± 1.58^{a}	3.34 ± 1.62^{b}	3.36 ± 1.71^{b}
Nutritious	4.55 ± 1.54^{ns}	4.56 ± 1.61^{ns}	4.57 ± 1.67^{ns}	4.06 ± 1.65^{b}	4.29 ± 1.63^{a}	4.16 ± 1.74^{ab}	3.89 ± 1.61^{b}	4.30 ± 1.53^{a}	4.17 ± 1.57^{a}
Simple	4.80 ± 1.51^{a}	4.08 ± 1.61^{b}	4.18 ± 1.59^{b}	3.68 ± 1.60^{a}	3.36 ± 1.62^{b}	3.40 ± 1.68^{b}	3.99 ± 1.60^{a}	3.42 ± 1.51^{b}	3.47 ± 1.52^{b}
Safe	4.75 ± 1.45^{ns}	4.79 ± 1.48^{ns}	4.85 ± 1.50^{ns}	3.86 ± 1.59^{b}	4.33 ± 1.61^{a}	4.17 ± 1.69^{a}	3.96 ± 1.50^{ns}	4.01 ± 1.54^{ns}	3.98 ± 1.58^{ns}

Within each country, values with the same letter in the same row are not significantly different at $P < 0.05$. Means and standard deviations are reported.

towards a plant-based diet still consider hybrid products as acceptable. Our findings are also consistent with those of another study on vegetarian and vegan diets (Bryant, 2019). Indeed, this study reported that UK consumers consider a plant-based diet to be healthy, ethical, and environmentally friendly, but less affordable, enjoyable, tasty and simple.

As for the motivations to consume hybrid meat products, two consumer studies reported that hybrid meat products would be chosen for health reason rather than for environmental or animal welfare concerns (Lang, 2020; Profeta et al., 2021), while another consumer study reported that both health consciousness and environmental self-identity would facilitate consumers' purchase intention towards hybrid products (Banovic et al., 2022).

It is well known that consumers are not willing to compromise taste for health (Verbeke, 2006). It is therefore of paramount importance that future hybrid meat products are formulated to deliver first of all in taste. Some promising results on the sensory acceptability of hybrid meat products vs plant-based meat-free alternatives and meat products have been reported (Grasso, Rondoni, Bari, Smith, & Mansilla, 2021; Neville, Tarrega, Hewson, & Foster, 2017). For example Grasso et al. (2021) in a blind consumer test with commercial samples reported that hybrid burgers scored significantly higher in overall acceptability than both beef and plant-based meat-free burgers. The authors concluded that "hybrid meat products could represent an effective way for consumers to lower their meat consumption without compromising too much on the sensory quality and could represent a transition product to a more plant-based diet". Neville et al. (2017) compared the sensory acceptability of hybrid, meat and meat-free products with consumers. They found no significant difference between hybrid and meat products, while meat-free products were less accepted.

A limitation of this study lies in the creative nature of this task, which allowed consumers to design hypothetical hybrid meat products that could potentially not work in real life. The addition of the plant-based ingredients in a meat product would in fact lead to changes in taste, flavour, texture and functionality. For example the creation of a burger with 50% onion might not be feasible from a food manufacturing point of view. These results should be taken as a first creative effort, with initial ideas to develop further, rather than as definitive recipes.

Future research avenues are suggested. First, choice experiments should be conducted to elicit consumer willingness to pay using commercially available hybrid meat products in real market settings and in conjunction with consumer sensory analysis to be able to better capture consumer valuations towards these new products. Further, experiments should be conducted to test if providing information messages with specific goals (e.g., taste, health, and environment) may further allow to identify persuasive paths for adoption of hybrid products. Moreover, the replication of this study in other countries, especially non-European, would be useful to deepen the understanding of consumers' attitudes towards hybrid products.

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CRediT authorship contribution statement

Simona Grasso: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Daniele Asioli:** Conceptualization, Writing – original draft. **Rachel Smith:** Conceptualization, Data curation, Formal analysis, Writing – original draft.

Declaration of Competing Interest

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

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