

The carbon footprint of high-protein foods

Perceptions and impact of consumer-facing information in the UK



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Authors

M.C. Alamar^{a*}, A. Psichas^{b*}, M. Spence^{c*} and S. Willcock^{d,e,f*}

a Plant Science Laboratory, Cranfield Soil and Agrifood Institute, School of Water, Energy and Environment, Cranfield University, Cranfield, MK43 0AL

b Metabolic Research Laboratories and MRC Metabolic Diseases Unit, Wellcome Trust-MRC Institute of Metabolic Science, Addenbrooke's Hospital, University of Cambridge, Cambridge CB2 0QQ

c Institute for Global Food Security, School of Biological Sciences, Queen's University Belfast, Belfast, BT9 5AG

d Centre for Biological Sciences, University of Southampton, Southampton, SO17 1BJ

e Scotland's Rural College, Edinburgh, EH9 3FH

f School of Environment, Natural Resources and Geography, Bangor University, Bangor, LL57 2UW

* Authors contributed equally to this work.

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Executive summary

The aim of this study was to explore how UK stakeholders and consumers perceive consumer-facing information that shows the carbon footprint embodied in high-protein food products. The study consisted of nine semi-structured interviews with participants from four stakeholder groups (supermarket chains, government agencies, certification bodies and consumer groups) and an online survey of 406 consumers.

Interviews with stakeholders revealed several key findings:

- Over-prioritisation of carbon footprints detracts from, and may conflict with, other important issues (e.g. biodiversity, animal welfare).
- Carbon footprint information could be displayed on the front of product packaging, though there is much competition over space.
- Stakeholders are sceptical:
 - o Carbon analysis is technically challenging, onerous and costly. A standardised methodology able to differentiate emissions at a field or farm level would be required.
 - o Despite food and agriculture accounting for 30% of global greenhouse gas emissions, stakeholders doubt the impact that changing consumer behaviour can have on greenhouse gas emissions, and believe that other industries should be primarily targeted.
 - o Displaying carbon footprint information could have a negative impact on British and Irish beef production.
 - o Public engagement outside of the retail environment is a necessary pre-requisite for carbon labelling to be successful.

The survey indicates that provision of carbon footprint information could meaningfully reduce beef and poultry consumption, with concomitant increases in consumption of pulses and meat alternatives. This indicated shift in consumer behaviour (from foods with a high carbon footprint to those associated with lower emissions) could potentially result in an emissions reduction of ~0.73 kgCO₂e per person per month. Consumers desire the information to be displayed on the product packaging, and show a high preference for the use of simplified, more relatable metrics, such as car miles and traffic lights.



Background

Impact of livestock on greenhouse gases and climate change

Climate change is one of the most important global policy issues for the 21st century (Godfray *et al.*, 2010). Given that changing food consumption patterns has the potential to impact greenhouse gas (GHG) emissions, there is considerable interest in exploring how consumers can be ‘nudged’ towards making more sustainable food choices.

After decades of negotiations, governments across the world have acknowledged the risks associated with global temperature increases in excess of 2°C. Governments have pledged to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, as part of the Paris Agreement, adopted by consensus at the 21st Conference of Parties of the United Nations Framework Convention on Climate Change (UNFCCC, 2015). Furthermore, countries aim to reach “global peaking of greenhouse gas emissions as soon as possible” (UNFCCC, 2015). However, projections based on current emission scenarios anticipate a global warming of between 4 and 6°C by 2100 (Sherwood *et al.*, 2014).

Our dietary choices affect GHG emissions. The agri-food sector is responsible for 30% of total GHG emissions making it a major driver of climate change (Audsley *et al.*, 2009; Aston *et al.*, 2012). Despite this, food, especially in the context of consumption, is rarely discussed within global climate change accords. Within the agri-food sector, livestock-based products contribute more to GHG emissions than any other food group (ca. 50% of agri-food GHG, ca. 15% of total GHG; Weidema *et al.*, 2008; Defra, 2013, Bailey *et al.*, 2014). Furthermore, within this food group, the impact of red meat from ruminants (e.g. beef and lamb) on GHG production is far greater than that of meat from monogastric animals (e.g. pork and chicken; see Sutton and Dibb (2013) for further details). Therefore, this report has focussed on high-protein foods, where the current high associated emissions may indicate a great potential for GHG reductions. There are several other potential methods to reduce GHG emissions associated with the agri-food sector (e.g. reducing overall consumption or reductions in waste), but these are beyond the scope of this report.

Consumer awareness and understanding of carbon footprints and labelling

Whilst the carbon footprints of a wide range of food products have already been measured and reported by the scientific community (Virtanen *et al.*, 2011), there appears to be a lack of consumer awareness regarding the environmental impact of daily/habitual food choices. An Ipsos MORI multi-country survey commissioned by Chatham House and Glasgow University Media Group revealed a very low awareness of the impact of livestock production on climate change (Bailey *et al.*,

2014). Furthermore, Hartikainen *et al.* (2014) found that there was a considerable misunderstanding in Finnish consumers’ perception of ‘product carbon footprints’ where only a small proportion of the respondents linked GHG emissions to either the product (7%) or climate change (5%). Raising public awareness of the link between food choices and climate change is an important pre-requisite to enabling voluntary dietary changes. However, despite the enormous potential for emissions reductions offered by a shift in consumer behaviour towards more sustainable food choices, research into how best to communicate the environmental impact of food to consumers is relatively limited. However, whilst raising awareness is important, it is unlikely to change dietary habits when tackled as an isolated approach. Hence, research is needed into how best to raise awareness of the GHG emissions associated with food, but also into what other policies may be required to best achieve behavioural change.

One approach to raising awareness of the carbon footprints of foodstuffs is via carbon labelling. Several studies have assessed the use of sustainability labels and/or carbon labelling on food product packaging. A survey of UK supermarket shoppers suggested a strong demand for carbon labels on products; 72% of shoppers were in favour of including GHG emission information on products (Gadema and Oglethorpe, 2011). However, in accordance with a lack of understanding regarding the concept of carbon footprints *per se*, it was clear that an even higher percentage of respondents (89%) found carbon labelling confusing and difficult to interpret. Furthermore, reporting on the public perceptions of carbon labelling of groceries, Upham *et al.* (2011) also revealed differences between awareness and understanding of labels; thus, even though consumers had heard about carbon labelling they failed to define its “precise meaning”. More recently, in a study carried out in six European countries, Grunert *et al.* (2014) concluded that sustainability labels (within which carbon footprint was included) did not play a major role in consumers’ purchasing behaviour. This highlights that information alone may not be sufficient to cause behaviour change and that information provision should be complemented with other approaches.

Carbon labelling is still in its infancy; there are currently no regulations governing its use. Over the last decade, a number of carbon labelling initiatives have been carried out in the UK; from corporates working with the Carbon Trust (e.g. PepsiCo for Walkers Crips) to retailers (e.g. Tesco), including wider ‘industry’ approaches (e.g. from beverage industry; Upham and Bleda, 2009). In 2008, Tesco launched a pilot project for carbon-labelling 30 representative own-brand products; their expectation was to include the label on both the pack and shelf-edge. That same year, the UK’s largest water producer (Highland Spring Ltd.) launched a pilot scheme exploring carbon labelling. However, these pilot studies have never been

successfully translated into carbon labelling on a commercial/ industrial scale. For example, Tesco's initiative, although 'praised' by the media, was unsuccessful mainly due to high costs, a lack of 'uptake' by other retailers and the issue of poor consumer understanding of carbon footprint metrics (i.e. an emission of 800 g CO₂ means little to most people).

Shifting consumer behaviour towards more sustainable food choices

Raising awareness of the carbon footprint and impact of foods on climate change alone will not necessarily lead to behaviour change. One of the main challenges of attempting to change consumers' behaviour from less sustainable to more sustainable foods is that consumers may not perceive a tangible or immediate benefit to themselves (e.g. price, taste, quality; Creese and Marks, 2009). One approach would therefore be to emphasise co-benefits, which directly affect consumers, such as financial incentives or health benefits (Bailey *et al.* 2014). Despite being more expensive, this has been a successful strategy for organic versus conventional food products which are perceived as a 'healthier/sustainable' option (Röös and Tjärnemo, 2011). An alternative approach could be to make consumers aware that the environmental cost of meat consumption may ultimately be reflected in the price of food (e.g. in the form of a 'shadow carbon tax'). A 'shadow carbon tax' provides an indication of how much a product would cost if a GHG emissions related taxation scheme were in operation without changing the actual cost of the product. A shadow carbon tax could be used as a tool to raise awareness and fuel public dialogue, and potentially shift food consumption towards more sustainable practices. Public campaigns with messages similar to "less but better" may also play a key role when moving towards a lower protein based diet. De Boer *et al.* (2014) concluded that strategies supporting consumption of smaller meat portions, better quality meat or even reducing the frequency of meat intake (e.g. 'meat-free Monday'), could have particular strengths depending on consumer preferences. The authors suggested that, to make a real dietary change all of the studied approaches would need to be considered together and within the whole diverse range of customers and their dietary choices.

Given recent international developments, investigation into the emission reductions associated with carbon-labelled products is timely. However, factors such as price, taste, health and food safety, as well as availability and habits, still govern food purchasing (Röös and Tjärnemo, 2011; Bailey *et al.*, 2014; Government Office for Science, 2015). For this reason, research effort is needed to better understand how consumers' 'intended behaviour' could eventually be translated into an 'actual behaviour' shift towards more sustainable eating habits.

Here, we aim to explore how UK stakeholders and consumers perceive consume-facing information that shows the carbon footprint embodied in high-protein food products. We evaluate the impact of carbon footprint information and different metrics, as well as methods of raising awareness, on consumers' intention to buy high-protein foodstuffs, and interview different stakeholders in order to identify the barriers to implementation of these methods.



Materials and Methods

The study adopted a mixed research design, drawing on interview and survey methodologies to collect qualitative and quantitative data. Interviews were conducted with a number of key stakeholders in the food sector to obtain in-depth information on the perceptions of public and private bodies towards carbon labelling and other emission reduction methods. The results of these interviews were used to frame the survey, which was conducted online to obtain as large a sample as possible. The survey collected information from consumers as to their preferences, within the limits of feasibility defined by the stakeholders interviewed. The study was approved by the Ethics Committee at the University of Southampton.

Semi-structured interviews with stakeholders

Sample

Key stakeholders (predominantly employees of supermarket chains but also government agencies, certification bodies and consumer groups) were identified and invited via email to take part in a semi-structured interview. Every effort was made to recruit participants, who were involved in, or responsible for, one or more of the following areas: sustainable and ethical sourcing; compliance; corporate affairs; food packaging; and scientific/policy advice. This method of sampling allowed the selection of specific participants to provide rich, detailed information on the topic of interest (Patton, 2005) and yielded a total of nine participants who gave oral informed consent to be interviewed. The majority of participants were employed in a sustainability role (n=5) and represented four large supermarket chains (n=5).

Questioning structure

Based upon a review of previous literature, we developed an interview topic guide (Table 1). Questions were pre-tested for clarity, comprehension, reliability and timing with an individual with a food policy/industry background and refined prior to implementation. The three main topic areas were designed to elicit participants' perceptions towards consumer-facing carbon information in general and specifically in relation to meat, and, to explore the practicalities of bringing carbon into food purchasing decisions. The display of this information at point of purchase (vs. the product label) was proposed as an alternative method to raise consumer awareness of the carbon footprint of food.

Data collection

Interviews were conducted in-person (n=3), via phone (n=5) or video conferencing (n=1), between 6th June and 27th July 2016, by one of the four authors. Although the interviewer varied, differences in interview technique were minimised by following the topic guide (Table 1). Interviewees were given assurances (e.g. that there were 'no right or wrong answers', their anonymity would be kept intact and they could opt out at any point) before the interviewer proceeded to ask a series

of guided open-ended questions (Table 1) whilst taking non-verbatim notes on the responses. The interview concluded with a final question ('how do you see consumer-facing carbon information evolving?') when all topics had been covered and no new information emerged. The interviews lasted between 30 and 75 minutes; a proportion of which (n=5) were audio-recorded; recording was only possible when the interviewees' gave their explicit permission.

Data analysis

After the interview, non-verbatim notes were typed up from both the hand-written notes and audio-recordings. These notes were then coded thematically (Braun & Clarke, 2006). The interview notes were coded by the person who conducted the interview and subsequently checked by all authors for coding consistency to maximise validity and reliability. Finally, codes were grouped into categories before discussing their interpretation of the data. Within each category, the data were interpreted, focussing on themes of general consensus. By reporting on areas of general agreement, we hope to assist decision-making as policies supported by the majority of key stakeholders are much more likely to gain traction within the agri-food sector.

Online consumer survey

Sample

Participants were invited to take part via a web link received in an email or posted on a social media site (e.g. via personal Twitter or Facebook accounts). Altogether, >1,000 people clicked on the link, 464 started the questionnaire and 406 completed it. All participants were invited to take part in the survey after being informed of its purpose (... "to explore personal views on the purchase and consumption high-protein foods..., which may help researchers, decide how best to help consumers make healthy, sustainable and informed food choices") and why sustainable food choices are important (... "as the global population increases, this puts pressure on valuable resources, including food and water. In turn, food production, along with other aspects of modern living such as driving, results in greenhouse gas emissions that cause climate change. So, to ensure that there is enough food for future generations, it is important to consider the sustainability of the diets we eat as well as whether or not the overall diet is healthy"). Participants ticked (checked) an online box to indicate that they consented to take part in the survey. Table 2 describes the characteristics of the participants who completed the survey. The diversity of our study sample was low; >60% of participants were female, >60% were aged 20-39 years, >80% were white, and >60% were educated to postgraduate level. Hence, results from this study should only be used indicatively, and extrapolated with appropriate caution.

Questioning structure

Based upon a review of previous literature, a questionnaire was devised which was comprised of 41 multiple-choice questions (piloted with three independent professionals for appropriate vocabulary and technical functioning; e.g. question order, response categories, and timing). First, the participants answered questions on their current food habits by indicating how often they typically consume 8 high-protein foods (beef, eggs, lamb, pork, poultry, pulses, Quorn and tofu) and how importantly they viewed different purchase attributes, such as price, taste and carbon footprint, when purchasing these foods. They then rated on a scale of 1 to 5 (1 being 'not at all aware' and 5 being 'extremely aware'), how aware they were about the carbon footprint of these high-protein foods before proceeding to rank them in order of their carbon footprint. Participants were then presented with a table (Table 3) alongside the following introduction "this table shows the carbon footprint associated with 1 kg of each food (arranged from highest to lowest). It includes all the emissions produced on the farm, in the factory, on the road, and in the shop. It also shows how many miles you need to drive to produce that many greenhouse gases. For example, you need to drive 99 miles to produce the same emissions as eating 1 kg of beef". Given this information, subsequent questions enquired about anticipated future consumption of these high-protein foods, and, their preference for how this information might be presented. Specifically, on a scale of 1 ('very low preference') to 5 ('very high preference') participants rated their preference for the five metrics in Table 4 and where/how they should be displayed: on the shelf, on the packet, by QR code, with an 'arrange by' function online, and at point-of-purchase (check-out screen/receipt). Finally, participants were asked to rate the likelihood of four approaches influencing their purchasing behaviour of high-protein foods. The four approaches were: carbon footprint information, minor financial incentives (e.g. loyalty card points or discount vouchers), a 'shadow carbon tax' (i.e. displaying the price of the product if a carbon tax was in force), and positive advertising campaigns (such as 'meat-free Mondays'). An open question was used to capture any comments at the end of the survey.

Data collection and analysis

Survey responses were collected over a 4-week period, from 22nd August until 19th September 2016, using an online survey designed using the isurvey software program (<https://www.isurvey.soton.ac.uk/>). Data analysis was performed using R software using the following assumptions:

1. For ranges (i.e. 5-6 times a week), the midpoint was used.
2. If consumed less than once a month, then 0.5 per month was used.
3. A month was assumed to have 30 days.
4. "I don't know" was assumed to be never.
5. One portion is equal to 110g; this standard portion size was used for meat, fish, poultry, legumes, beans and meat alternatives (FSA, 2005).
6. Mean kg CO₂e data were obtained from Nijdam *et al.* (2012) and are displayed in Table 3.



Results and Discussion

Semi-structured interviews with stakeholders

In general, stakeholders felt that any additional product information given to consumers would be a positive development, as it would help consumers to make more informed food choices. However, stakeholders felt that climate change and carbon footprints are a low priority for the majority of consumers. Furthermore, stakeholders were of the general opinion that any effort and resource expended on the carbon labelling of meat (and high protein alternatives) in the retail environment would currently be misdirected, given that there is “still ongoing debate/scientific discussion on this topic” with key concerns (outlined below) that need to be addressed.

1. Methodological challenges of calculating carbon footprints: product GHG emission data are misleading/inaccurate

On the whole, stakeholders were in agreement that current methods used to measure the carbon footprints of food products are not “fit-for-purpose”. They lack the sensitivity to accurately quantify the climate change impacts between and within high-protein food groups at the required level (e.g. farm or field level, so individual farmers could ‘compete’ to produce the lowest emissions and supermarkets could actively source produce from low emission farmers). Indeed, stakeholders felt that not only was there no international consensus on the single best method for calculating carbon footprints, but there was also “so much guesswork in the calculation” that it just became “an average of an average” which failed to appropriately take into account differences in production efficiency between species and systems. In line with this, certain stakeholders raised the issue of a lack of trust in product GHG emission data and one stressed that there would need to be “100% agreement [on the methodology] before any information goes onto products” and that this was critical regarding consumer trust both in them and in labels in general.

During the interviews, stakeholders listed many factors that, in their view, could affect the climate change impact of a product; these included growing practices (e.g. organic versus conventional), seasonality, the locality of the product to individual stores, and storage. They recognised that all these factors made it very difficult to calculate the climate change impact of a meat product, especially if one considers that a primary meat product may be periodically sourced from different farms and regions. Stakeholders queried how carbon labelling could ever be achieved for a more complicated composite meat product considering the issues involved with primary products.

A number of stakeholders also mentioned the onerous and

costly nature of the required data collection and calculation of the carbon footprints of products, as well as the cost associated with the certification process. Ultimately, “the benefits of calculating carbon footprints would need to outweigh the disadvantages and, currently, this is not the case”.

Stakeholders also felt that there should be a “clear case that changing meat consumption would produce positive impacts upon climate change” before any effort and resource was expended on carbon labelling. Some stakeholders felt that carbon impacts should be targeted earlier in the supply chain, and questioned whether “polluting industries” should be targeted in the first instance.

2. Over-prioritisation of a single environmental issue not only detracts from but also conflicts with other important issues that also require urgent attention (e.g. biodiversity, water, rural livelihoods)

Even though stakeholders felt that climate change was an important environmental concern, they highlighted that focusing solely on carbon emissions in relation to meat was “a bit out-dated and perhaps narrow in focus in terms of environmental impact”. Whilst one stakeholder highlighted that the European Commission is currently piloting a product environmental footprint, which covers 15 environmental impacts (European Commission, 2016), it was felt that industry and government were united in their view that the key issues are carbon, water and biodiversity. Thus, we should be asking ourselves “how do we convey water, carbon and biodiversity [information] to the consumer?” Akin to traffic light labelling, one stakeholder stated: “we never wanted a single traffic light because we recognised that people all have different interests... we wanted a certain level of breakdown”. Stakeholders acknowledged that considering multiple food impacts could result in clear conflicts of interest; not only between carbon footprints and other environmental issues, but also between, for example, carbon and animal welfare; i.e. chickens raised intensively indoors may have a lower carbon emission than those that are free-range or organic.

As agriculture makes a major contribution to the UK economy, stakeholders also voiced that they would be concerned about the potential impact of carbon communication strategies on British/Irish beef suppliers (including farmers and processors) and on the sustainability of the UK and Irish beef production. UK agriculture was viewed as an industry which already faced budget cuts and “further pressure would be an unfair additional burden”.



Understanding the impact on this 'key industry' was considered to be an important barrier.

Overall, it was felt that a holistic view of the 'social cost' of products was critical.

3. Communication design issues associated with raising awareness of GHG emissions in the retail setting

Stakeholders were unanimous in emphasising that the metric used to communicate carbon footprint information should be "simple, understandable and relatable", whilst not imposing a significant cognitive burden on the consumer. Current back-of-pack labels, which attempt to convey carbon footprints (such as grams of CO₂ and/or tracked reductions over time), were viewed as "meaningless" and unhelpful for product comparisons from a consumer perspective.

A number of stakeholders raised the issue of confusion surrounding existing product labels and symbols, e.g. organic vs. fairtrade, best before and use-by dates, traffic light labelling and serving size information. They felt that carbon footprinting is a "very complicated message to get across".

Stakeholders called for one consistent front-of-pack carbon label, which facilitated comparisons between food products (perhaps incorporating a traffic light system for easy interpretations, as previously reported by Sacks *et al.* (2009)) and placed the product's climate change impact in a context which consumers could relate to (e.g. light bulb hours, car miles). Stakeholders cautioned that this label should complement nutritional information and should perhaps be integrated with other key environmental and social concerns.

Given that individual high-protein products differ so widely in their carbon footprint, it was felt that carbon footprints should be displayed on-pack or online (when purchase decisions are being made), as opposed to at the point-of-purchase i.e. at check-outs or on till receipts. Stakeholders felt that whilst attempting to communicate carbon emission information at this point in grocery shopping would be technologically feasible, it would further slowdown the speed of a sale; something which would be very unpopular with both the consumer and retailer. One stakeholder stated: "We already ask the consumer if they have filled up with fuel/do they want bags and a receipt/have they got a loyalty card/and tell them to have a nice day? It's like also asking...would you now like to leave your shopping behind because of the carbon footprint?"

However, the already limited space for additional labels on packets was also a concern.

4. Carbon labelling is "not a silver bullet" which can change meat consumption, other interventions outside of the retail environment are required first and may be a more effective use of resources

The actual challenge of articulating carbon emissions of foodstuff (e.g. "the public do not want this information ... it is confusing") can be used as an argument against the implementation of consumer-facing carbon footprinting by different actors (e.g. companies' marketing teams). However, one of the interviewees stated that "a significant minority care...these customers do want to know and they have the right to this information". Even if a low percentage of consumers positively respond to carbon labelling, "these people can then act as champions and slowly alter the behaviour of society".

In line with this, stakeholders accepted that there was a small percentage of consumers (i.e. "the worried well-off") who "very much cared" about the climate change impacts associated with the food they eat. However, the majority of stakeholders felt that the rush to achieve carbon labelling was premature ("just not where consumers were at") and that other interventions outside of the retail environment were required first. Indeed, one stakeholder recalled that whilst retailers had been working on ways to reduce food waste for years, they observed that the issue had only just gained consumer interest and consideration as a result of nation-wide media campaigns. Certain stakeholders suggested that people are likely to be more receptive to celebrity chef endorsements, social media and TV programmes/campaigns than in-store information. Consumers would "need to be engaged on a rational as well as emotional level". Consequently, the majority of stakeholders felt that any effort to communicate the carbon footprint of foods to the consumer in the retail setting should be preceded by attempts, not only to raise awareness about how consumption of high-protein foods may impact upon climate change, but to foremost change our culture around eating meat as "people have an emotional attachment with meat". It was also emphasised that, for any action to be successful it had to be "led jointly" by retailers and government agencies and that "all food providers need to go on the same journey together, the whole industry should be on the same page".

Taxing red meat to reduce climate change impacts was considered a very controversial issue and was generally viewed negatively by stakeholders. Despite acknowledging

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that it may initially change meat consumption, this effect was assumed to be one that would be “short-lived”; with consumers ultimately accepting the tax and reverting back to their usual purchasing patterns. One stakeholder commented that this was indeed the case with a non-food item: “single-use plastic carrier bag usage [within their shop] is creeping back up because people have accepted the charge”.

Stakeholders felt that any negative messages should be avoided; a stakeholder suggested that people tend to dissociate from them, and that consumers should instead be positively nudged towards consuming high-protein foods with a lower carbon impact. This includes adopting a range of change strategies to help meet health and sustainability goals such as in-store promotions and reformulation. For example, framing plant-based dinners not only around environment benefits but also health and weight-loss benefits which are of personal relevance to the consumer, or around how these meals are not only delicious but have the potential to save the consumer money. “Rather than carbon-labelling, we would go down the route of saying “here is a healthy meal solution and it happens to be based on lentils”. This is on-trend, not negative like carbon labelling, and something that consumers are demanding more of due to the health concerns associated with red meat consumption”.

Online consumer survey

Awareness of the carbon footprint associated with high-protein foods

As part of the online survey, participants were asked to rate “on a scale of 1 to 5 (1 being ‘not at all aware’ and 5 being ‘extremely aware’) how aware they are of the carbon footprint of high-protein foods”. The mean score in response to this question was 2.8 (95% CI [1.3, 4.4]), suggesting that on average, people feel moderately aware of the carbon footprint of high-protein foods. To assess this, they were then asked to “rank the high-protein foods in order of their carbon footprint from 1 to 8, where 1 has the lowest carbon footprint and 8 has the largest carbon footprint”. Overall, the consumers who participated in this study had a good understanding of which high-protein foods have the lowest carbon footprints. A Spearman’s rank correlation was conducted to assess the association between the actual rankings and those provided by the respondents, which was statistically significant (p -value = 0.001). Furthermore, overall, the respondents correctly identified that beef and lamb have high carbon footprints. This may reflect the high level of education attained by the majority of our sample group, which is not representative of the general population (Table 2). However, many respondents mistakenly

believed that the carbon footprint associated with pork is higher than that associated with lamb. Notably, there was also a group that showed very poor awareness of the carbon footprint of high-protein foods. Approximately 20% of survey respondents indicated that they were not at all aware of the carbon footprint of foods and ca. 7% incorrectly ranked beef as having the lowest carbon footprint.

Factors influencing the purchasing of high-protein foods

Participants were asked to rate “on a scale of 1 (not at all important) to 5 (extremely important) what factors they considered when purchasing high-protein foods”. They identified taste (mean score of 4.3), quality (4.3) and health (4.0) as the most important factors influencing their decision-making when purchasing high-protein food products. These factors were closely followed by considerations regarding animal welfare (3.8) and price (3.7). The carbon footprint was deemed to be of average importance (3.0). However, overall, out of 10 options, the carbon footprint was ranked 8th and only ‘branding’ (2.3) and ‘religious restrictions’ (1.3) were considered less important by our sample group.

These results are consistent with those of previous UK consumer studies such as Gadema and Oglethorpe (2011), who found that ‘quality/taste’ and ‘nutrition’ were the attributes with the highest importance, followed by price. In further accordance with our results, ‘carbon’ and ‘attractive branding’ were also found to be of low importance (Gadema and Oglethorpe, 2011).

Survey: Carbon footprint awareness

- **Taste, quality and health** are the most important factors for consumers, followed by animal welfare and price.
- The carbon footprint is of average importance and is a **low priority**.
- On average, respondents felt they were **moderately aware** of the carbon footprints of food.
- Overall, consumers showed a **good understanding** of which high-protein foods have the lowest and highest carbon footprints.
- A minority showed **poor awareness**. Approximately 20% of respondents indicated that they were not at all aware of the carbon footprint of foods and 7% incorrectly ranked beef as having the lowest carbon footprint.



Consumption of high-protein foods prior to, and following, carbon footprint information

The respondents were invited to indicate “how often they typically consume each of the following high-protein foods”: beef, eggs, lamb, pork, poultry (including chicken and turkey), pulses (including peas, beans and lentils), Quorn, and tofu. Pulses, eggs and poultry were identified by the online survey as the most frequently consumed high-protein foods (mean portions per person per month of 10.1 [95% confidence interval (CI): 2.4, 17.9], 9.0 [1.7, 16.4], and 8.3 [1.1, 15.4], respectively) (Table 5). Lamb, tofu and Quorn, on the other hand, were rarely consumed by the sample group (<2 portions per person per month). This is supported by data published by both Sutton and Dibb (2013) and Defra (2013), which showed that ‘at home’ poultry consumption was the highest (190 grams per person per week) followed by beef and veal, pork, and lamb and mutton (112, 56 and 37 grams per person per week, respectively). It is possible that participants underestimated their consumption of high protein foods as the combined mean number of portions per person per month consumed was only 38. However, it is difficult to speculate, as information on other sources of dietary protein (such as fish and seafood) was not collected.

The participants were later shown the carbon footprint (GHG emissions [kgCO₂e]) of each high-protein food along with the equivalent car mile information (Table 3), and were asked how often they thought they would typically consume these high-protein foods having been made aware of this information. The effect of this information was a likely reduction in the consumption of beef and poultry and a likely increase in the consumption of meat alternatives (Figure 1). Indicated beef and poultry consumption were reduced by 0.6 (95% CI: -2.6, 1.4) and 1.0 (-3.7, 1.7) portions per person per month respectively,

reflecting a percentage change of -17.0% and -12.3%. Indicated lamb consumption, on the other hand, remained unchanged but its initial reported consumption was very low (Table 5). Indicated consumption of meat alternatives increased following the provision of GHG information, with pulses, tofu and Quorn increasing by 2.6 (95% CI: 8.8, -3.7), 1.2 (6.4, -4.1) and 0.9 (4.7, -3.0) portions per person per month (means) respectively, reflecting percentage changes of +25.5%, +96.8% and +45.5%.

Assuming portion sizes of 110g (FSA, 2005), we calculated the GHG emissions associated with the reported consumer habits before and after exposure to GHG information. The overall change in indicated consumption of high-protein foods in response to GHG information corresponded to a mean reduction in GHG emissions of 0.73 kgCO₂e per person per month (95% CI: -8.9, 6.2). However, it is not possible to directly link these indicated shifts in consumption habits with realised behaviour change and further studies would be needed.

Red meat contains high levels of protein and is an important source of micronutrients including iron (free and haem), zinc and B vitamins. The magnitude of the suggested reduction in meat consumption at a population level is unlikely to have any negative impacts on public nutrition. “Mean protein intakes are well above the Reference Nutrient Intakes (RNIs) in all age/sex groups” according to recent NDNS data (NDNS, 2014), noting potential limitations around under- and over-reporting. Furthermore, the mean plasma ferritin concentration (an indicator of iron store levels) and B vitamin levels for each age/sex group were found to be “above the lower limit of the normal range for that group” (NDNS, 2014). Nevertheless, there may be ‘at risk’ groups within the general population for whom a reduction in meat intake may not be advisable.

Results and discussion

On the other hand, the processing and cooking of meat can result in the formation of known or suspected carcinogenic chemicals (Bouvard *et al.*, 2015). In a meta-analysis of colorectal cancer cohort studies, levels of red and processed meat consumption were found to positively correlate with increased risk of cancer (“statistically significant dose-response relationship, with a 17% increased risk [95% CI: 1.05-1.31] per 100g per day of red meat and an 18% increase [95% CI: 1.10-1.28] per 50g per day processed meat”; IARC, 2016 and Bouvard *et al.*, 2015). Therefore, it is conceivable that the theoretical reduction in consumption of red meat, and assumed reduction of processed meat, may even translate into a public health benefit.

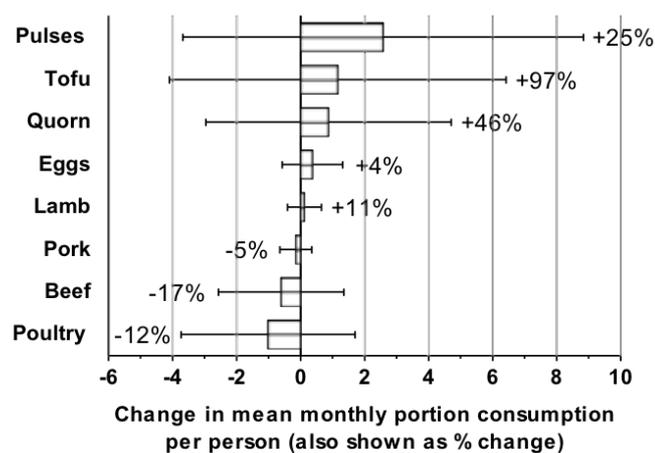


Figure 1. Change in likely consumption of high-protein food products following carbon footprint (GHG emission) information. The change is depicted as the calculated change in mean portions per person per month (\pm 95 % confidence intervals) and as a percentage (%) change in mean portions per person per month (n=406).

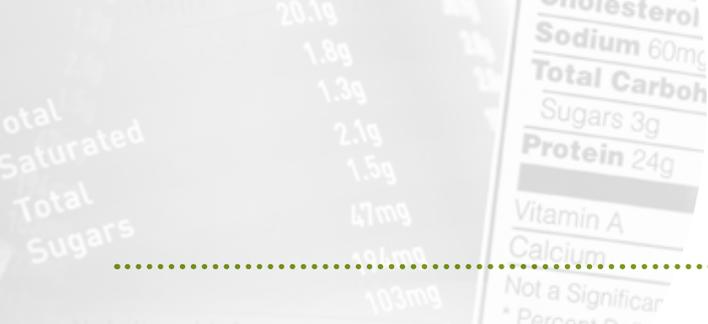
Survey: Impact of carbon footprint information

- Eggs, poultry and pulses are most frequently eaten, followed by pork and beef.
- Lamb, tofu and Quorn are rarely consumed.
- Given GHG information, **beef and poultry consumption drops considerably**. Lamb consumption remains unchanged.
- **Consumption of pulses and meat alternatives increases**.
- The indicated consumer behaviour results in a **reduction in emissions of 0.73kgCO₂e** per person per month.

Carbon footprint and high-protein foods: How do we display information to the consumer?

Participants were presented with five different metrics (carbon footprint data [kgCO₂e], car miles, lightbulb hours, product comparisons, traffic light system; Table 4) and were asked to “on a scale of 1 (very low preference) to 5 (very high preference) please indicate [their] preference for each metric”. A simplified version of Table 4 can be found below. The two metrics favoured with high preference were car miles (mean of 3.4) and the traffic light system (3.7).

Metric	Example image
Carbon footprint	
Car miles	
Lightbulb hours	
Product comparison	
Traffic light system	



Respondents were presented with five different methods of displaying carbon footprint information ('arrange by' option online, at 'point-of-purchase' e.g. on self-checkout screen, on the packet, on the shelf, by QR code). They were then asked to "on a scale of 1 (low preference) to 5 (high preference) please indicate [their] preference for each display method". The consumers sampled demonstrated a very high preference for information to be displayed on the product packet (mean of 4.5), followed by a high preference for information to be displayed on the shelf. Therefore, these results suggest that consumers want immediate and easy access to the information, rather than with a lag, e.g. at 'point-of-purchase' or with QR codes.

Carbon footprint and high-protein foods: How do we influence consumer behaviour?

Participants were presented with four approaches to influencing purchasing behaviour (advertising positive change/campaigns, information on the packet, minor financial incentives [e.g. loyalty card points] and a 'shadow' carbon tax). They were then asked "on a scale of 1 (very low likelihood) to 5 (very high likelihood) [to] please indicate the likelihood that each mechanism would impact [their] decision-making when purchasing high-protein food stuffs". As was found for 'how to display carbon footprint information', consumers surveyed showed a high preference for carbon footprint information to be displayed on the packet (mean of 3.9). This echoes the findings of a previous UK consumer survey, which found that 72% of respondents expressed preference for carbon labels on food items (Gadema and Oglethorpe, 2011). Nevertheless, a medium-to-high preference was indicated for all other approaches: campaigns (3.6), minor financial incentives (3.6) and a 'shadow' carbon tax (2.9), suggesting that a combination of multiple methods may provide the most impact.

In open-ended questions (answered by 61 out of 406 participants), several participants suggested that a combination of metrics would be preferable, especially the combination of carbon footprint data and a traffic light system. Representative comments include "If the carbon footprint logo could state the carbon footprint of the product and [be given a] colour using the traffic light system, this would help me make a better choice" and "A combination of metric and colour on packaging could be good - similar to the nutritional labelling on the front of many products".

Comments such as "a labelling system reinforced by an advertising campaign would be the best way to help make better carbon footprint choices" support the finding that information combined with other drivers of change is desirable, and may be the avenue to maximising impact. Several respondents also felt that "pop culture is more likely to influence people's dietary choices, especially in their

Survey: Carbon display and influencing consumer behaviour

Metrics and display

- Consumers demonstrate a **very high preference for information to be displayed on the packet**, followed by on the shelf.
- **Car miles** and the **traffic light system** were the most popular metrics.

Impact of mechanisms on purchasing behaviour

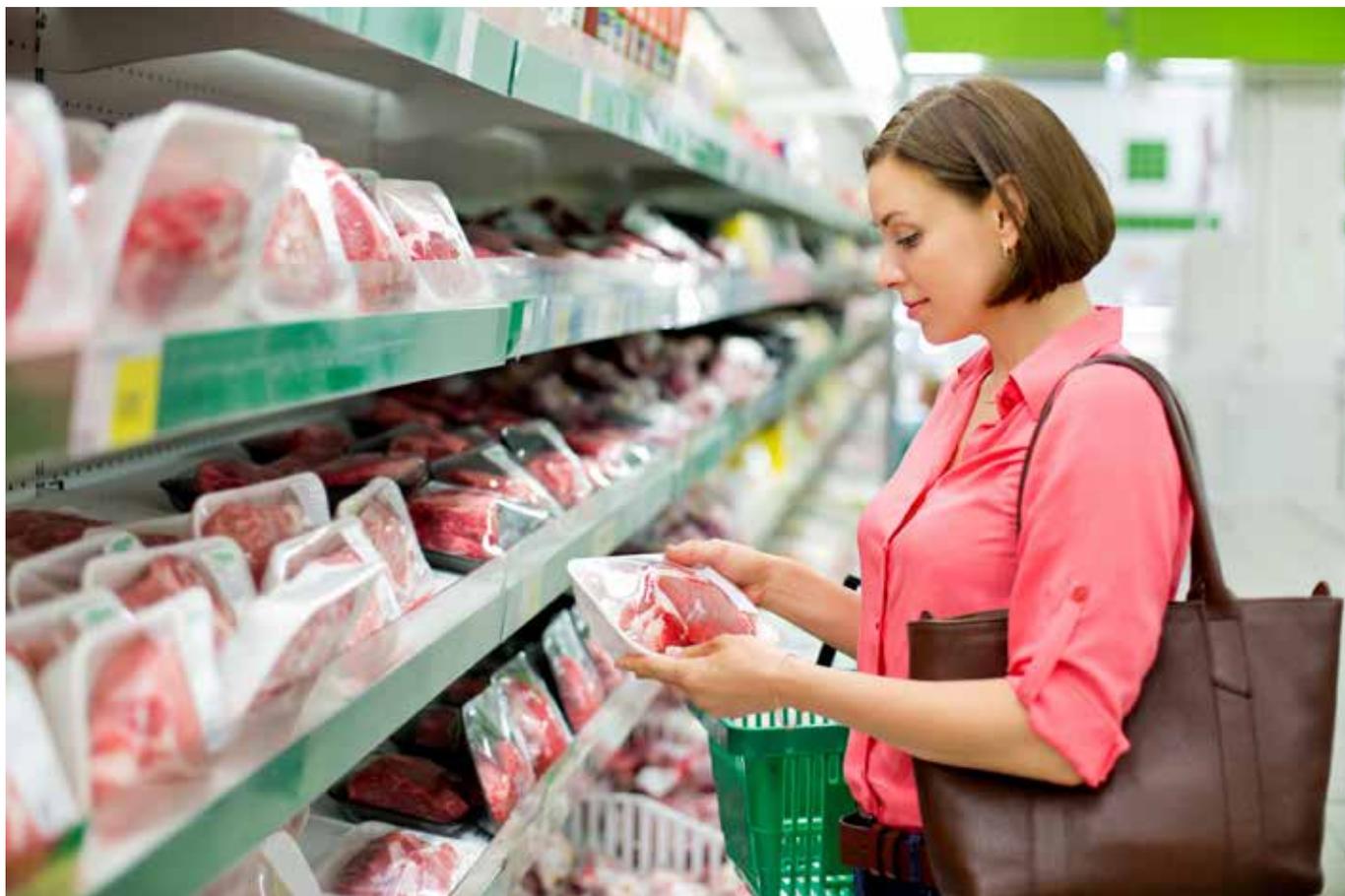
- Consumers show a strong preference for product **carbon footprint information**.
- All other options including campaigns advertising positive change, minor financial rewards, and a shadow carbon tax were of medium to high preference, therefore, **a combination of all may be the most effective approach**.

formative years" and that "TV ads [and] internet ads" would be influential. This was also in agreement with what several interviewees stated: "celebrities... have a lot of say with lay people and politicians" and "people might be more receptive to social media campaigns, ... advertising, informative TV programmes (BBC) and school campaigns...".

The 'shadow carbon tax' was the least preferred option. A couple of participants felt that it may be confusing to consumers and as a result, may even have the opposite effect, e.g. a "shadow carbon tax will make people who don't really understand what it is think that they are getting a bargain!".

The power of price as a driver of purchasing behaviour was also emphasised: "unless people can be persuaded to internalise and feel strongly about environmental issues, price and convenience will always win over logos and labels". Finally, consumers indicated that the product label should include information on a product's overall environmental impact, including water and biodiversity, and that we "should not collapse environmental impact into [carbon dioxide] CO₂", reflecting one of the views highlighted by the stakeholder interviews.

Conclusion



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Semi-structured interviews with stakeholders from supermarket chains, government agencies, certification bodies and consumer groups have highlighted willingness within the retail sector to reduce GHG emissions amid scepticism regarding the calculation and display of product carbon footprint information. An online survey of 406 consumers suggested a strong desire from consumers for this information to be displayed on product packets and using relatable metrics such as car miles or the traffic light system. Our results suggest that displaying product GHG emission information would likely shift consumer purchasing intentions towards lower-emission foodstuffs, resulting in an emissions reduction of 0.73 kgCO₂e per person per month. However, further research is required to ensure GHG information is nuanced enough to differentiate between similar products (e.g. the same product from different suppliers), and that the information is accompanied with other environmental metrics (e.g. biodiversity, water), enabling consumers to make more informed decisions.

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Tables

Table 1. Interview questions posed to stakeholders who were involved in one or more of the following areas: sustainable and ethical sourcing; compliance; communication; corporate affairs; food packaging; nutrition and scientific/policy advice.

Question category	Questions
1. Stakeholder attitudes towards consumer-facing carbon footprinting of food products	<p>Q1: What do you think of product carbon footprinting in general?</p> <p>Q2: Do you think certain food products should be given priority in terms of being assigned a carbon footprint?</p> <p>Q3: Research shows that human consumption of meat and dairy products is a major driver of climate change, and, shifting the global demand for meat and dairy produce is central to limit the rise in global temperatures to two degrees Celsius. With this in mind, do you think that the carbon footprints of meat and dairy should be presented to the consumer to inform purchasing decisions?</p> <p>Q4: In your opinion, what is the best way of increasing consumer' awareness of the carbon footprint of meat and dairy products?</p> <p>Q5: Do you think consumers are interested in product carbon footprinting? (and climate change?)</p> <p>Q6: In relation to meat and dairy products, do you think consumers would change their purchasing behaviour if exposed to consumer-facing carbon information?</p> <p>Q7: Do you think consumers would respond to GHG emission information better in Tons CO₂, in car miles, in potential warming contribution, a traffic light system etc.?</p> <p>Q8: In your opinion, what is the best way of changing consumer purchasing of meat and dairy in order to reduce GHG emissions?</p>
2. Practicalities of bringing carbon into food purchasing decisions	<p>Q9: Has [INSERT INTERVIEWEE SUPERMARKET CHAIN OR USE RETAILERS IN GENERAL] ever attempted to calculate the carbon footprint of food products? Or display this to the consumer?</p> <p>Q10: What are the potential barriers to introducing consumer-facing carbon footprinting of meat and dairy?</p> <p>Q11: If these barriers to implementation could be overcome, would you/retailers be willing to introduce consumer-facing carbon footprinting?</p>
3. Display of carbon footprints at check-outs and/or on till receipts	<p>Q12: Do you think this is technologically feasible? (Would this type of system (or aspects of it) work for you?)</p> <p>Q13: What are the potential barriers to implementation?</p> <p>Q14: If these barriers to implementation could be overcome, would you/retailers be willing to introduce consumer-facing carbon footprinting?</p> <p>Q15: Can you think of any ways in which the retailer could potentially support this scheme, once it was implemented?</p> <p>Q16: What would retailers gain from implementing such a scheme</p> <p>Q17: Would this system be more desirable than carbon labelling individual meat and dairy products?</p> <p>Q18: How do you think consumers would respond to this new method of information exchange?</p>

Table 2. Characteristics of the sample who completed the survey (n=406).

Demographic specifications		Sample α (%)
Gender	Female	61.4
	Male	36.4
	Prefer not to say	2.2
Age	18-29	0.2
	20-29	35.5
	30-39	28.6
	40-49	14.2
	50-59	13.9
	60+	5.9
	Prefer not to say	1.7
Ethnicity	White	
	English/Welsh/Scottish/Northern Irish/British	55.4
	Irish	5.9
	Any other White background	24.6
	Mixed / Multiple ethnic groups	
	White and Black African	0.2
	White and Asian	1.7
	Any other Mixed/Multiple ethnic background	2.0
	Asian / Asian British	
	Indian	1.5
	Pakistani	0.2
	Bangladeshi	0.2
	Chinese	1.0
	Any other Asian background	1.5
	Black / African / Caribbean / Black British	
African	1.0	
Other ethnic group		
Any other ethnic group please describe	1.7	
Do not state	3.0	
Highest education level	Primary school	0
	Secondary school (to age 15-18)	1.7
	Professional training	4.6
	University undergraduate/ nursing qualification	22.4
	University postgraduate	68.3
	Prefer not to say	2.9

Tables

Table 3. The carbon footprint associated with 1 kg of each food). It includes all the emissions produced on the farm, in the factory, on the road, and in the shop.

Product	Carbon footprint (kg CO ₂ e)	Car miles
Lamb	48	149
Beef	32	99
Pork	6	18
Poultry (inc. chicken and turkey)	3	11
Eggs	3	11
Tofu	3	11
Quorn	3	11
Pulses (inc. beans and lentils)	1	4

Table 4. Survey participants were asked to state their preference for the following metrics of conveying the carbon footprint.

Metric	Description	Example image
Carbon footprint	The equivalent CO ₂ emissions emitted per 100g of product over its entire the life cycle	
Car miles	The number of miles that would have to be driven in a car to result in the same equivalent CO ₂ emissions per 100g of product	
Lightbulb hours	The number of hours that a lightbulb would have to left on to result in the same equivalent CO ₂ emissions per 100g of product	
Product comparison	How the equivalent CO ₂ emissions of the product compares to similar products	
Traffic light system	A colour-based classification identifying the product as having high, medium or low equivalent CO ₂ emissions.	

Tables

Table 5. Frequency of self-reported typical consumption of high-protein food products prior to carbon footprint information.

Consumption frequency	Beef	Lamb	Pork	Poultry	Eggs	Tofu	Quorn	Pulses
Every day	2	1	2	7	21	1	1	18
5-6 times a week	2	1	8	37	26	0	8	56
2-4 times a week	60	3	41	174	178	19	32	171
Once a week	116	31	81	93	112	29	30	121
1-3 times a month	119	97	122	46	84	52	43	57
Less than once a month	64	172	85	27	21	110	90	21
Never	100	148	117	78	20	243	242	19
I don't know	1	2	2	1	1	9	16	1
Mean portions per person per month	3.5	1.1	3.1	8.3	9.0	1.2	1.9	10.1

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