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WILL GREENHOUSE CONCERNS IMPACT MEAT CONSUMPTION? BEST-WORST SCALING ANALYSIS OF AUSTRALIAN CONSUMERS

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ABSTRACT

This research explores if the greenhouse emissions associated with meat production are particularly important to Australian consumers relative to a number of other factors. As well as price and quality aspects, we tested the interest in greenhouse issues relative to other credence goods relating to environmental, health and animal welfare aspects of meat production and consumption. A best-worst scaling analysis was selected over other non-market valuation approaches because of the ability to analyse relative influences of different factors on preferences. A total of 1200 participants across all states and territories in Australia were randomly drawn to participate in an online survey and, of them, 1101 completed the best-worst choice experiment. Both the counting approach and conditional logit paired model were applied to analyse the data. Based on the best-worst score, our results suggest that the factors nominated by Australian consumers as most important to them in their meat purchasing decisions are 'health' followed by 'quality and price'. Results indicate that concerns about greenhouse footprints from meat production are important but much lower relative to other factors.

KEY WORDS: meat; non-market valuation; best-worst scaling; credence factors; greenhouse

1 INTRODUCTION

There is an increasing debate about whether per capita meat consumption should reduce because of environmental concerns (Godfray et al., 2018; Poore and Nemecek, 2018; Sanchez-Sabate & Sabaté, 2019). While research has identified that price and physical attributes such as freshness, flavour, colour, packaging and fat content are important influences on meat demand (Ardeshiri & Rose, 2018; Verbeke et al., 2010;), there is growing evidence that less visible factors (termed *credence factors)* such as the provenance of production and concerns about health, animal welfare and environment are increasingly important (Henchion et al. 2014; Morales et al. 2020). The latter includes an increasing focus on lowering meat consumption to reduce Greenhouse Gas (GHG) emissions, given that livestock production generates significant levels of methane, a major GHG (Lacroix and Gifford, 2020; Tait et al., 2016). Funke et al. (2022) crystalises these arguments to outline a case for imposing consumption taxes on meat to address the externalities caused by GHG emissions and nutrient pollution.

One challenge in assessing the importance of concerns over GHG emissions in food choices is the plethora of existing and emerging credence factors relevant to meat consumption (e.g. Ali & Ali, 2020; Malek et al., 2017), which can be grouped into broad categories such as health or environmental concerns. One example of this multi-dimensionality aspect are environmental credence factors, where previous concerns have focused on potential impacts of meat production on the clearing of native vegetation to establish pasture and crops, high use of water in production systems and the generation of pollutants such as sediments and nutrients into waterways (Godfray et al., 2018; McAlpine et al., 2009; Sanchez-Sabate & Sabaté, 2019; Springman et al., 2018). This means that any assessment about how concerns about GHG emissions will impact on meat consumption needs to be cognisant of the variety of issues that consumers might consider important.

Economic techniques are widely applied to identify the importance of various factors on meat demand, in part because the analyses are grounded in consumer theory and typically describe outcomes in terms of price impacts. While the analysis of purchase data with hedonic pricing can quantify the importance of extrinsic characteristics, these struggle to deal with intrinsic factors, such as consumer reactions to credence claims. To fill this gap, stated preference techniques such as discrete choice experiments have been applied to identify how information about health and other factors influence consumer choices (Ardeshiri & Rose 2018; Malek et al. 2017; Umberger et al. 2009).

Despite the evidence that environmental factors are becoming important drivers for meat consumption in western countries (e.g. Burnier et al., 2021; Fernquist & Ekelund, 2014; Lewis et al., 2017; Umberger et al., 2009), there is currently limited research to predict the relative importance of different issues to consumers, including GHG emissions associated with meat production. In part this is because most attention has been on identifying the importance of credence factors as broad groups of influence (e.g. Malek et al., 2017, 2019; Wong et al., 2015), rather than identifying the impact of a particular factor. An important issue for the meat industry and policy makers is to identify how important consumers view the GHG footprint of meat production relative to other credence claims and extrinsic factors, and whether this will lead to substantial changes in demand.

The aim of this study is to identify the importance of GHG emissions on preferences around meat consumption relative to attention to other credence issues as well as price and taste factors. Best-worst scaling (BWS), a type of non-market valuation technique, has been selected as the methodology because it can be used to elicit preferences between a large number of different options. Its flexibility means that it can be used to analyse various influences on preferences, including emerging drivers of future consumption (Louviere et al., 2015). For this study, a BWS experiment is included in a large study of the Australian population to assess how meat consumers view a large number of different issues and factors relevant to red meat consumption. The results of the experiment are then compared to the self-reported intentions to increase, maintain or reduce meat consumption over the next five years.

The rest of the paper is organised as follows. The best-worst scaling method is described in section two, followed by experimental design and data collection in section three. Results are provided in section four, followed by a discussion of the results in section five and conclusions in section six.

2 BEST-WORST SCALING METHOD AND ECONOMETRIC ESTIMATION

The BWS method is a stated preference technique that has evolved to assess the strength of preferences about particular issues, including consumption decisions (Finn & Louviere, 1992). The technique works by presenting a small number of options (e.g. four) in each profile, where the participants then have to simply identify the most and least preferred choices. Multiple profiles are used to cover all the options, thus breaking down large sets into manageable choice tasks. The collection of two assessments for each profile (as compared to one in discrete choice analysis) and the small levels of cognitive burden involved make this an attractive non-market valuation technique for some situations (Louviere et al., 2015).

BWS has been extensively used in marketing and healthcare research because it allows many more options to be presented to participants than with discrete choice experiments (Flynn et al., 2007; Muhlbacher et al., 2016; Soekhai et al., 2021). It has also been used in environmental research (e.g. Kabaya et al., 2020; Soto et al., 2018), as well as in food quality analysis (e.g. Jaeger et al., 2008; Stanco et al., 2020) and to assess the importance of country of origin for food products (Massaglia et al., 2019; Aizaki and Sato 2020). Consumers' expectation of traceability information for meat, milk and vegetables have been explored in China (Liu et al., 2018). In relation to the meat industry, Erdem et al. (2012) used BWS to test the perceptions of farmers and consumers in the UK about responsibility for ensuring that meat cooked and eaten at home is safe to consume. Ellison et al. (2017) used BWS to assess consumers view on production aspects for beef, chicken, milk and eggs, testing the importance of seven common production claims. Merlino et al. (2018) used the BWS counting approach to analyse beef attributes and found that price was the most important attribute for consumers followed by animal welfare.

There are three types of BWS experiments, with the case 2 method employed in this research because it provides more insight than case 1 but is less complex to apply than case 3 (Aizaki & Forgaty, 2019; Flynn & Marley, 2014). The analysis of BWS data is similar to discrete choice experiments, where the results can be analysed as discrete orderings of alternatives. However, unlike in discrete choice experiments,

respondents need to select the most preferred statement/profile as well as the least preferred statement/profile in BWS. There are two main approaches for analysing BWS experimental data: the counting approach and the modelling approach (Aizaki & Forgaty, 2019; Flynn et al., 2007).

The simplest form of analysis of BWS data involves a counting approach (Merlino et al., 2018). The number of times level 'i' is selected as best (B_i) and number of times level 'i' is selected as worst (W_i) is calculated. Then the combined best and worst (BW) score for individual 'n' can be calculated as:

$$BW_{in} = B_{in} - W_{in}, \quad (1)$$

with standardised variant of:

$$std.BW_{in} = \frac{BW_{in}}{f_i}, \quad (2)$$

where f_i is the frequency of i^{th} statement

In the modelling approach, the paired model assumes that the utility for the level selected as worst (j) is negative, best (i) is positive and zero otherwise (j ≠ i). Respondents select level 'i' and 'j' from L×(K-1) possible pairs to derive the utility (Flynn et al., 2007). K is the number of attributes of L level. For choice set 'C', the paired model can be expressed as:

$$\Pr(Best = i, Worst = j) = \exp(v_i - v_j) / \sum_{p,q \in C, p \neq q} \exp(v_p - v_q), \quad (3)$$

where, v_i is the systematic component of the utility selection i, which consists of attribute variables.

3 EXPERIMENTAL DESIGN, SURVEY AND DATA COLLECTION

Experimental design in this study, the focus of interest was to identify how emerging concerns about credence factors, including GHG, were important to Australian meat consumers relative to more traditional factors such as quality and price. The survey design was based on an extensive review of the literature, as COVID-19 restrictions made it impractical to conduct focus groups. A structured approach was undertaken to initially group issues into four main attribute groups, drawing on analysis of previous literature on meat consumption preferences in Australia (e.g. Ardeshiri & Rose, 2018; Malek et al., 2017, 2019; Martin & Porter, 1985; McAlpine et al., 2009). The attribute groupings identified as most relevant were (1) health, (2) welfare and environment, (3) quality and price and (4) information and trust (Table 1). Concerns over GHG emissions were included in the second group.

Four statements were then selected to represent different issues within each of the attribute categories, generating a total of 16 statements (Table 1). Under this approach, each BWS profile consisted of four statements, one from each attribute group. The use of categories helped to ensure some balance was achieved in the profiles, with at least one statement about price or quality in each profile. As there were

four attribute groups each with four levels, 256 different profiles could be designed. An orthogonal experimental design was applied in NGENE^{TM} software (www.choice-metrics.com) to construct 24 profiles across six blocks, with participants randomly assigned to a block and completing four profiles each. In each task participants were asked to choose the most and least important statements from a given choice set (an example of best-worst choice cards is given in Fig. 1). Unlike ranking, this method has only two options to select their most and least important options (Dumbrell et al., 2016).

Table 1. Attributes and levels of BWS statements

Attribute Groups	Levels	Label	Description
Health	Health – antibiotics	Antibiotics	I have **health** concerns about meat from animals treated with **antibiotics**.
	Health – hormones	Hormones	I have **health** concerns about meat from animals treated with **growth hormones**.
	Health - general	HealthGeneral	Meat is an essential part of a healthy diet.
	Health – Fat content	Fat	**Lean meat** (low fat content) is very important to me.
Welfare and Environment	Animal welfare – general	AniGeneral	I prefer to buy meat where I know that animals have been raised and **treated humanely.**
	Environment – land & water sustainability	LandWater	I am concerned about the **environmental impact on land and water** of the meat I buy.
	Natural production	NaturalProd	I prefer to buy meat from animals raised in **natural open systems.**
	Environment – GHG emissions	GHG	I am concerned about the **carbon footprint** (CO_2 emissions) of the meat I buy.
Quality and Price	Quality (MSA[1] rating)	Quality	I always try to pick meat of the finest **quality** (Meat Standards Australia graded).
	Taste / Appearance	Taste	The best **appearance/taste** is what I am after when I buy meat.
	On special discount	Discount	I only buy meat when it is on **special discount**.
	Price	Price	**Price** is very important in my decision to buy meat.
Information and trust	Quality and freshness labelling	QualityFresh	I prefer to buy meat with **detailed labelling** about quality and freshness.
	Location and traceability	Location	**Information** that shows **where the meat was produced** and is **traceable** is important.
	Branding	Branding	I look for key brands like Angus or King Island to indicate source, quality and trustworthiness.
	Organic	Organic	**Organic certification** is very important when I buy meat.

Note: [1]MSA stands for Meat Standards Australia, and is a system to label meat quality for consumers.

Agree least	Statement	Agree most
◯	I am concerned about the **carbon footprint** (CO_2 emissions) of the meat I buy.	◯
◯	I prefer to buy meat from animals raised in **natural open** systems	◯
◯	I always try to pick meat of the finest **quality** (Meat Standards Australia graded).	◯
◯	I dislike meat coming from animals treated with **growth hormones**.	◯

Figure 1: Example of a best and worst choice exercise in the survey

3.1 Data collection

A web-based national-wide survey was conducted in Australia drawing 1200 participants randomly. Once the questionnaire was prepared, ethical approval for the study was obtained from (*details to be provided on acceptance*). The survey was executed online in May-June 2020, with an initial pre-test followed by the main collection. The questionnaire consisted of several parts, including the BWS experiment, a series of questions about consumption rates and levels of concern about health, animal welfare and the environment, and questions about socio-economic factors. From the total sample of 1200 respondents, 1101 completed the BWS exercise, as vegetarians and those who do not eat meat (e.g. respondents who only eat fish) were not asked to participate in the exercise.

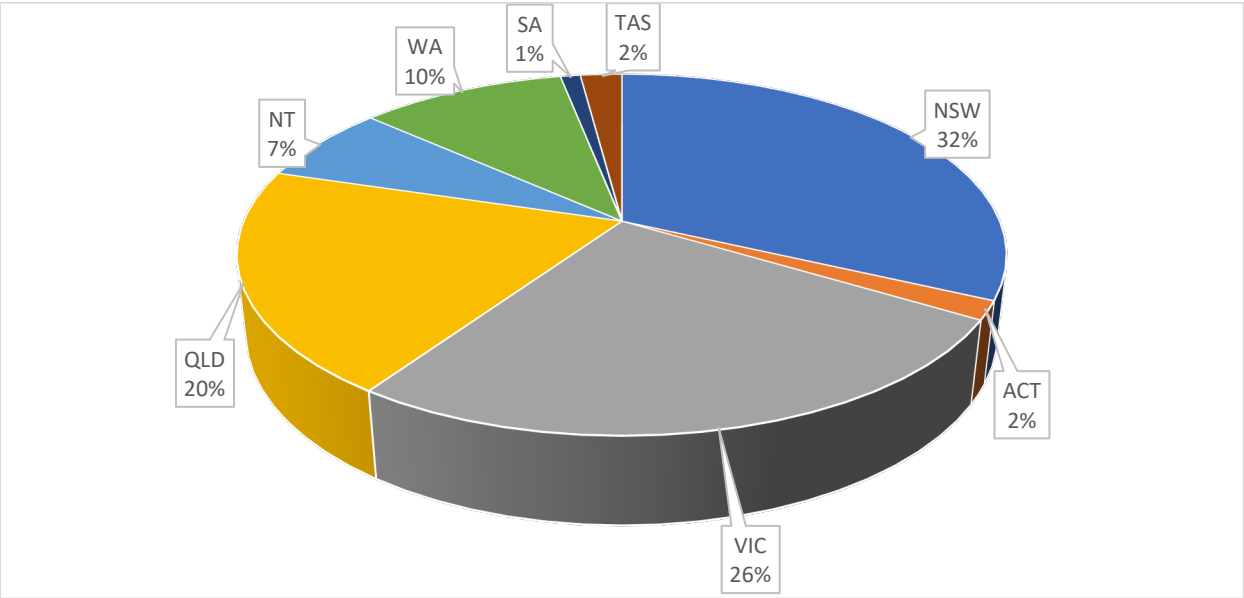

Figure 2: Survey sample distribution across Australia's states and territories. *Note: QLD = Queensland, NT = Northern territory, WA = Western Australia, SA = South Australia, TAS = Tasmania, NSW = New South Wales, ACT = Australian Capital Territory, VIC = Victoria*

3.2 Socio-economic profile of the sample

The survey participants were sampled randomly from an online panel in all states and territories of Australia at rates approximately proportional to population levels (Fig. 2). Table 2 depicts the socio-economic characteristics of participants, and compares them with Australian national statistics. While gender distribution of the sample is similar to national data from the Australian Bureau of Statistics (ABS), there are some variations for other socio-economic variables.

Table 2. Comparison of descriptive statistics of survey participants with population averages

		Survey sample	**ABS data[1]**
Gender[5]	Female	50.1	50.7
	Male	49.9	49.3
Age distribution[3,4]	18-24 years[2]	11.9***	15.7
	25-29 years	9.7**	8.7
	30-39 years	18.7*	17.2
	40-49 years	16.6	16.7
	50-59 years	15.7*	15.6
	60-69 years	13.3	13.1
	Over 70 years	14.3**	13.1
Level of education[4]	Up to year 12	27.6***	45.8
	Post school qualification	32.4**	28.7
	Tertiary education	40***	25.6
Household Status[3,5]	Single/ Separated / Divorced/ Widowed	41.1***	51.9
	Married / Partner / De facto	58.8***	48.1
Income[3,4]	Under $20,000	6.0**	4.96
	$20,000 - $39,999	16.8	17.26
	$40,000 - $59,999	16.2***	13.69
	$60,000 - $79,999	13.8***	11.37
	$80,000 - $99,999	10.8***	7.79
	$100,000 - $119,999	6.9***	11.40
	$120,000 - $139,999	4.6***	7.23
	$140,000 - $159,999	5.8***	3.16
	$160,000 - $179,999	2.8***	6.38
	Over $180,000	6.4***	16.92
	Not specified	9.9	

*Note: [1]2016 Census Data (Australian Bureau of Statistics (ABS)), [2]age category 15-24, [3] ABS Survey of Income and Housing 2017-18, [4]calculated with the normal approximation to the binomial test, [5]t-test, ***, **, * significant at 99%, 95% and 90% levels respectively.*

4 RESULTS

4.1 Counting approach

In the counting approach for analysing the BWS data, the number of times each level obtained a 'best' and 'worst' score were recorded, and the score for the difference and the standardised scores were calculated (Figure 3 and Appendix 1). The importance of attributes can be ranked according to the standardised scores for each statement (calculated as the ratio of the differences between 'best' and 'worst' scores and the number of times each statement was presented) (Figure 3). For all statements in the 'health' group, three statements in the 'quality and price' group, and two statements in 'welfare & environment' the standardised BW score was positive. These results indicate that 'health' is the most important attribute group to meat consumers, followed by 'quality and price', 'welfare and environment' and then 'information & trust' as the lowest category.

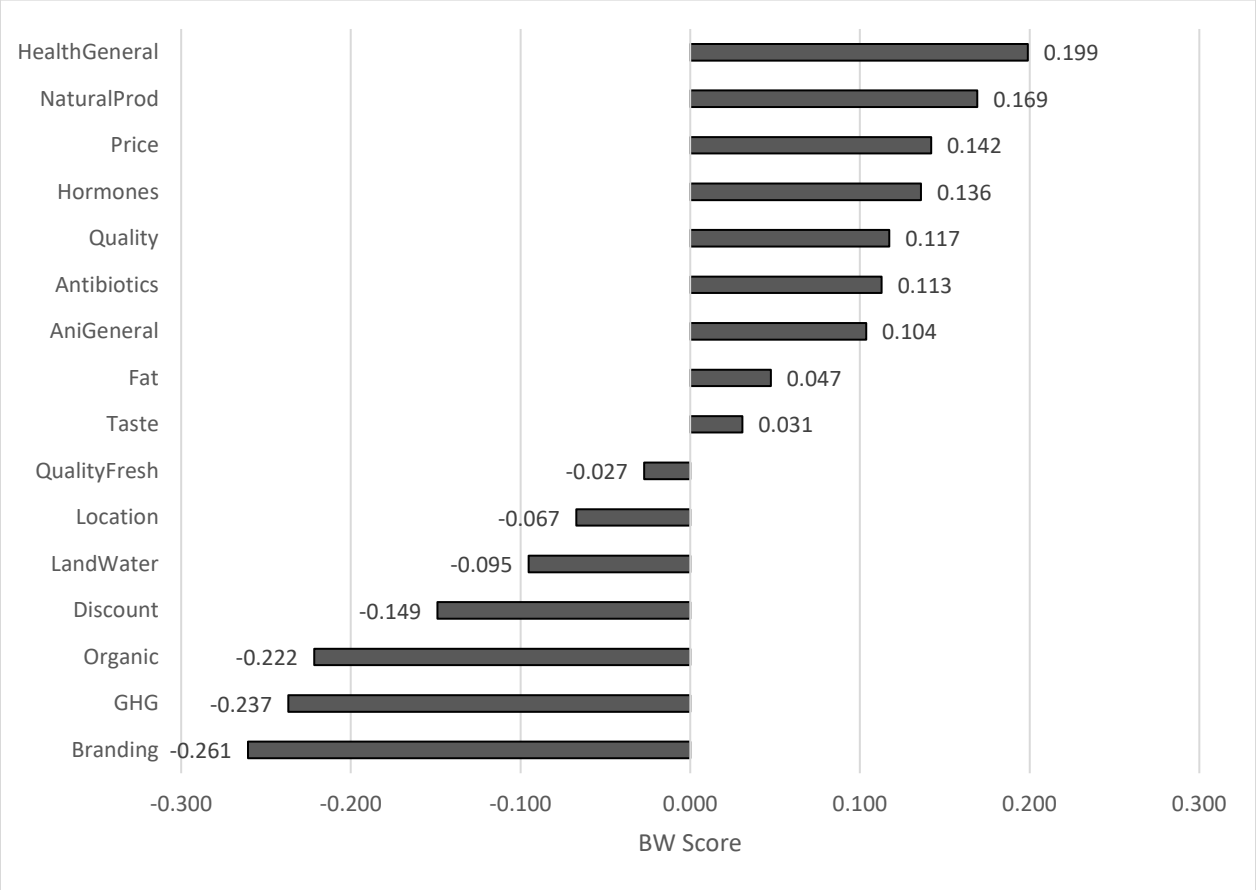

Figure 3: Standardised best worst scores for each statement in decreasing order

At the attribute levels, the most supported statements were those related to general health ('*Meat is an essential part of a healthy diet.*' (HealthGeneral)), natural production ('*I prefer to buy meat from animals raised in* ***natural open systems.'*** (NaturalProd)), growth hormones ('*I have health concerns about growth hormone use in animal production*' (Hormones)), and treated with antibiotics ('*I have health concerns*

about meat from animals treated with antibiotics.' (Antibiotics)). Price ('***Price*** *is very important in my decision to buy meat.*' (Price)) and quality ('*I always try to pick meat of the finest* ***quality*****'** (Quality)) were also identified as important factors.

The least supported statements were those relating to branding ('*I look for key brands like Angus or King Island to indicate source, quality and trustworthiness'* (Branding)), carbon footprint of meat production ('*I am concerned about the* ***carbon footprint*** *(CO_2 emissions) of the meat I buy*' (GHG)) and organic certificate (*'Organic certification is very important when I buy meat*' (Organic)). Out of 16 statements, nine statements had a positive standardised BW score values (Appendix 1). Turning to the factor of specific interest, the BW score shows that greenhouse gas emissions (GHG) are much less important to consumers than almost all other attributes.

To identify whether preferences varied across socio-demographic factors such as gender, education, age, and family status, BW score values were calculated for different demographic groups in the sample (Appendix 2). There were only slight differences in scores across the sample, suggesting a certain degree of heterogeneity in the preferences. Standardised BW scores were also calculated by current rates of beef consumption, classified into three groups of frequent, medium and less frequent consumers[1] (Appendix 3).

Another issue of interest was to identify if future meat consumption intentions are influenced by credence factors. Asked about their expected consumption changes[2] for beef in the next five years, 61% of the sample expected that their future beef consumption would not change, 7% stated it would increase and the remaining 32% stated it would decrease. Participants' BW scores for these sub-groups are reported in Appendix 4. Larger differences between groups were identified with this approach, with those planning to decrease consumption having much larger BW scores for issues, particularly in the health attribute, than those planning to increase consumption.

4.2 Paired model approach

One of the limitations of the counting approach to analyse BWS data is that the differences in BW scores between issues cannot be tested statistically (Flynn & Marley, 2014). To address this, a conditional logit model has been applied to the same data to generate additional insights. In this study, a paired model was used, as the estimations of both paired and marginal models provide similar results (Flynn et al., 2007). The model was applied so that the 16 attribute levels were compared, with 'price' omitted to act

[1] Based on the self-reported responses, respondents were categorised into three groups. The question asked in the survey "**Prior to COVID-19, but in the last 12 months, how many meals per week** (over 7 days) would you eat beef as the main component of your meal?". Three groups are: 1. Frequent meat consumers 2. Medium meat consumers and 3. Less frequent meat consumers.

[2] The groups were identified based on the self-reported answer to the survey question. The question asked in the survey *"If you think* ***forward to five years time****, how do you expect your consumption of meat will change compared to now?"*. Three categories of respondents have been identified for the responses to beef consumption: 1. No changes in future consumption, 2. Future consumption will increase and 3. Future consumption will decrease.

as a base (Table 3). The model coefficients identify that 'price', with an assumed coefficient value of zero, was preferred over almost all other attribute levels. The coefficients of the levels identify the relative importance of the different factors.

Turning to the coefficients for the individual statements, 9 out of the 15 are identified as significant influences. The order (based on the magnitude of coefficients) is more or less similar to that identified with the counting approach. The 'price' attribute is superior to all significant variables. The fat content of meat was a negative influence (-0.253), but the next most important significant variable. GHG emissions ranked as the least important factor for consumers, being highly negative and significant (-0.751, $p<0.001$).

Table 3. Results of the relative importance of different characters using modelling approach

	Model 1	
	Coefficient	SE
Antibiotics	-0.047	0.070
Hormones	-0.107	0.079
General	0.102	0.072
Fat	-0.253***	0.065
AniGeneral	-0.005	0.071
LandWater	-0.494***	0.080
NaturalProd	0.084	0.071
Quality	-0.031	0.072
Taste	-0.251**	0.078
Discount	-0.593***	0.075
QualityFresh	-0.273***	0.078
Organic	-0.746***	0.068
Location	-0.256***	0.076
Branding	-0.658***	0.067
GHG	-0.751***	0.0670
Likelihood ratio	579	
p-value	0.000	

*Note: Model 1 represents only the BWS statements, with Price omitted to act as a base. ***, ** significant at 99% and 95% respectively, 'Price' was considered as the base attribute level for the estimation. 'SE' stands for standard error of the coefficient.*

Additional models that incorporated socio-demographic and behavioural characteristics of respondents were tested to identify preference heterogeneity relating to the carbon footprint of meat production (GHG) (see Table 4). These included models to identify if support for the GHG level varied by the current rates of consumption, and those who expected to increase consumption in the next five years (7% of participants) compared to those who expected to decrease consumption in the next five years (32% of participants).

Model 2 of Table 4 reports the influence of socio-demographic variables on preferences for the GHG statement, showing that males and those with post-school education were less likely to select, whereas

younger respondents were much more likely to select the GHG statement. Model 3 of Table 4 tests the relationship between current levels of beef consumption (in terms of meals per week) and selection of the GHG statement, showing that frequent meat consumers (BeefH) are more likely to select the GHG option. Model 4 of Table 4 tests the association between importance of the GHG level and expected changes in meat (beef) consumption in the next five years, showing that respondents who expected to reduce beef consumption were more likely to select the GHG level.

Table 4. Preference heterogeneity relating to the carbon footprint (GHG emission) of meat production

	Model 2 (Socio-demographics)		*Model 3 (current meat consumption)*		*Model 4 (future meat consumption)*	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
Antibiotics	-0.048	0.070	-0.047	0.070	-0.048	0.070
Hormones	-0.108	0.079	-0.103	0.079	-0.105	0.079
General	0.104	0.072	0.103	0.072	0.102	0.072
Fat	-0.253***	0.065	-0.253***	0.065	-0.253***	0.065
AniGeneral	-0.006	0.071	-0.004	0.071	-0.005	0.071
LandWater	-0.495***	0.080	-0.493***	0.080	-0.494***	0.080
NaturalProd	0.084	0.071	0.085	0.071	0.084	0.071
Quality	-0.030	0.072	-0.031	0.072	-0.031	0.072
Taste	-0.250**	0.078	-0.245**	0.078	-0.248**	0.078
Discount	-0.594***	0.075	-0.592***	0.075	-0.593***	0.075
QualityFresh	-0.277***	0.078	-0.273***	0.078	-0.276***	0.078
Organic	-0.748***	0.068	-0.746***	0.068	-0.746***	0.068
Location	-0.256***	0.076	-0.255***	0.076	-0.260***	0.076
Branding	-0.658***	0.068	-0.659***	0.067	-0.659***	0.067
GHG	-0.689***	0.153	-0.372**	0.139	-0.880***	0.078
GHG:Dmale	-0.217**	0.100				
GHG:Status	-0.061	0.103				
GHG:DAge1	0.437***	0.130				
GHG:DAge2	0.156	0.115				
GHG:DEdu1	-0.197	0.125				
GHG:DEdu2	-0.199*	0.117				
GHG:Nonreligion	0.096	0.098				
GHG:BeefL			-0.333**	0.157		
GHG:BeefM			-0.493***	0.146		
GHG:BeefInc					0.181	0.190
GHG:BeefDecr					0.353***	0.105
Likelihood ratio	605		590		590	
p-value	0.000		0.000		0.000	

*Note: Model 2 considers how socio-economic variables influence on GHG concerns, Model 3 considers impact of the level of meat consumption on their GHG concern, Model 4 considers impact of future meat consumption intention on their GHG concerns. ***, ** and * significant at 99%, 95% and 90% respectively,*

'Price' was considered as the base attribute level for the estimation.'Coef' stands for the estimated coefficient, 'SE' stands for standard error of the coefficient. As per respondent's self-evaluation, there are three categories of future meat (beef) consumption changes; increase (BeefInc), decrease (BeefDecr) and no changes (BeefNoC – base category). BeefM, BeefH and BeefL (base) represent medium beef consumers (2 to 5 meals per week), frequent beef consumers (more than 6 meals per week) and less frequent beef consumers (one or less meas per week).

5 DISCUSSION

Given that meat is one of the main components of the diet and budget of Australian households (Sui et al., 2017), it could be expected that price and quality would be key drivers of purchasing decisions, consistent with the results of Ardeshiri and Rose (2018). The results of other studies also indicate that health concerns are major issues for consumers (Ali and Ali 2020; Malek et al., 2017). While many studies have considered different attributes of meat on consumption decisions (e.g. Ding et al., 2014; Umberger et al. 2009), the relative importance of different factors affecting meat consumption has not been a focus in previous research. This research aimed to address this gap with a BWS experiment.

According to both the calculated BW scores and logit model results, issues relating to 'health' are the most important determinant of meat purchasing decisions, followed by issues relating to 'quality and price'. The most supported statement was about meat being an essential part of a healthy diet, indicating that meat is a staple food for most households and that there are positive perceptions of meat in relation to health. Price is an important factor, but there was limited support for discounting, consistent with meat being a staple food for households.

Issues in the information and trust group received less support than the other statements, indicating that Australian consumers were not as focused on branding and labelling of meat as has been suggested in the literature (Morales et al., 2020; Umberger et al., 2009). There were low scores for organic labelling and product branding, but average scores for labelling about origin (location), quality and freshness. It appears that consumers like to know where meat has been produced and how fresh it is, but only sub-groups of consumers are actively considering branding and organic beef.

The focus of the study was to identify how Australian consumers considered the importance of GHG emissions from meat production, which could be seen as one element of environmental credence factors. The results of the logit model revealed very limited interest by consumers in GHG emissions, relative to price, which aligns with the literature (Rolfe et al., 2021). The results are consistent with similar analyses of European consumers' perception of the importance of GHG emissions from meat production (de-Magistris et al., 2017).

However it is important to note that analysis of the counting data reveals that approximately 14.6% of participants viewed GHG from meat production as an important issue (selecting it as the most important statement). In comparison, 38.1% of participants selected it as a least important statement. Analysis showed that female and younger respondents are more likely to consider GHG emission as an important

determinant of their utility. Surprisingly, the relationships between current levels of meat consumption and concerns about GHG emissions showed that more frequent consumers were more concerned (model 3 in Table 4), identifying that this appears to be an issue for consumers. A link between concerns and future intension to reduce meat consumption was identified (model 4 in Table 4), indicating that GHG concerns may underpin some decisions to reduce future consumption.

Some caveats should be noted. The survey was conducted during the Covid-19 pandemic period in which people's behaviour has been changed. Research shows people's buying and consumption patterns have significantly changed (Rolfe et al., 2021). This could be influenced by respondents' choices. We also assumed all the respondents aware of GHG emissions with beef cattle husbandry, but some respondents may not have a proper understanding.

6 CONCLUSION AND RECOMMENDATIONS

This study reports a novel approach to identifying the importance of different drivers of meat consumption in Australia by applying a best-worst scaling experiment across a random sample of 1,101 households. The application demonstrates the key advantage of the methodology in that it allows the relative importance of a large number of factors to be assessed, including credence factors that are difficult to evaluate from market data. While it does not generate value estimates in the same way that a discrete choice experiment can, it provides insights into how consumers frame a variety of different drivers of consumption that are beyond the scope of other stated preference experiments.

The BWS method was chosen because of the interest in analysing consumer perceptions around GHG emissions from meat production, and whether concerns about carbon footprints would be enough to trigger changes in consumer behaviour. Results are mixed. The analyses showed that the statement around GHG gas emissions was much less important than price. However, the count data showed that about 16% of consumers considered emission factors to be important. Consistent with the literature, these are more likely to be younger and female consumers. Importantly, there is a strong association between the 37% of consumers intending to reduce beef consumption in the next five years and the identification of meat greenhouse gas emissions as an important issue.

More broadly, while the results are largely supportive of the existing literature about drivers of meat demands, there are some additional insights generated. The first main finding is that meat continues to be a staple of Australian diets, and there appears to be broad support from Australian households to continue. While this is consistent with the analysis of Sanchez-Sabate and Sabaté (2019), it does indicate that the analysis of Malek et al. (2019) and Malek and Umberger (2021) on meat avoiders and meat reducers respectively relate to only very small groups of Australian consumers.

A second finding is that while health considerations are key drivers for Australian consumers, they are not necessarily a negative impact on consumption in the way often portrayed in the literature, where health awareness leads to lower consumption (e.g. Willett et al., 2019). While Australian consumers tend to have

negative opinions about fat levels, hormones and antibiotics in meat, meat consumption in general is viewed as a positive contribution to health, particularly if grazing occurs in natural open systems.

A third finding is that credence factors are important to consumers, but to varying degrees. Consumers prefer meat that is free of hormones and antibiotics and has been produced with high animal welfare standards. There was lower but still a baseline of support to limit environmental impacts in production on land and water assets. Importantly, there was limited support for labelling and branding options. This may indicate that consumers do not support eco-labelling and niche products as a general approach to these issues, but prefer that meat production as an industry meets baseline standards for the relevant criteria. A key challenge to the industry and policy makers is to continue improving production standards and flow of information through the supply chain to meet these consumer expectations and priorities.

Some caveats to these findings should be noted. Although we tried to sample across the national population, there are some significant differences between the characteristics of the sample and the socio economic profile of recent census statistics. Second, the selection of the 16 statements and grouping into attributes and levels was based on an extensive literature review, as Covid-19 restrictions during the design stage ruled out the use of focus groups. We recommend that future studies focus on these issues for potential improvement.

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REFERENCES

Aizaki, H., & Fogarty, J. (2019). An R package and tutorial for case 2 best–worst scaling. *Journal of Choice Modelling*, *32*, 100171.

Aizaki, H., & Sato, K. (2020). Consumer preferences for three dimensions of country of origin of a processed food product. *British Food Journal*, 122, 3361-3382.

Ali, T., & Ali, J. (2020). Factors affecting the consumers' willingness to pay for health and wellness food products. *Journal of Agriculture and Food Research*, *2*, 100076.

Ardeshiri, A., & Rose, J. M. (2018). How Australian consumers value intrinsic and extrinsic attributes of beef products. *Food Quality and Preference*, *65*, 146-163.

Burnier, P.C., Spers, E.E. & Barellos, M.D. (2021). Role of sustainability attributes and occasion matters in determining consumers' beef choice. *Food Quality and Preference*, 88, 104075.

de-Magistris, T., Gracia, A., & Barreiro-Hurle, J. (2017). Do consumers care about European food labels? An empirical evaluation using best-worst method. *British Food Journal*, 119(12), 2698-2711

Ding, M. J., Jie, F., Parton, K. A., & Matanda, M. J. (2014). Relationships between quality of information sharing and supply chain food quality in the Australian beef processing industry. *The International Journal of Logistics Management*, 25(1), 85-108

Dumbrell, N. P., Kragt, M. E., & Gibson, F. L. (2016). What carbon farming activities are farmers likely to adopt? A best–worst scaling survey. *Land Use Policy*, *54*, 29-37.

Ellison, B., Brooks, K. & Mieno, T. (2017). Which livestock production claims matter most to consumers? *Agriculture and Human Values*, 34, 819–831.

Erdem, S., Rigby, D., & Wossink, A. (2012). Using best–worst scaling to explore perceptions of relative responsibility for ensuring food safety. *Food Policy*, *37*(6), 661-670.

Fernquist, F. & Ekelund, L. (2014). Credence and the effect on consumer liking of food – A review, *Food Quality and Preference*, 32(C), 340-353. https://doi.org/10.1016/j.foodqual.2013.10.005

Finn, A., & Louviere, J. J. (1992). Determining the appropriate response to evidence of public concern: the case of food safety. *Journal of Public Policy & Marketing*, *11*(2), 12-25.

Flynn, T. N., & Marley, A. A. (2014). Chapter 8: Best-worst scaling: theory and methods. In *Handbook of Choice Modelling*. (pp. 178-201). Edward Elgar Publishing.

Flynn, T. N., Louviere, J. J., Peters, T. J., & Coast, J. (2007). Best–worst scaling: what it can do for health care research and how to do it. *Journal of Health Economics*, *26*(1), 171-189.

Funke, F., Mattauch, L., ver den Bijgaart, I., Godfray, H., Hepburn, C., Klerert, D., Springman, M. and Treich, N. (2022). Toward optimal meat pricing: Is it time to tax meat consumption? *Review of Environmental Economics and Policy*, 16(2), 219-240.

Godfray, H. C. J., Aveyard, P., Garnett, T., Hall, J. W., Key, T. J., Lorimer, J., ... & Jebb, S. A. (2018). Meat consumption, health, and the environment. *Science*, *361*(6399).

Heide, M., & Olsen, S. O. (2017). Influence of packaging attributes on consumer evaluation of fresh cod. *Food Quality and Preference*, *60*, 9-18.

Henchion, M., McCarthy, M., Reconi, V. and Troy, D. (2014). Meat consumption: Trends and quality matters. *Meat Science* 98, 561-568.

Jaeger, S. R., Jørgensen, A. S., Aaslyng, M. D., & Bredie, W. L. (2008). Best–worst scaling: An introduction and initial comparison with monadic rating for preference elicitation with food products. *Food Quality and Preference*, *19*(6), 579-588.

Kabaya, K., Hashimoto, S., & Takeuchi, K. (2020). Which cultural ecosystem services is more important? A best-worst scaling approach. *Journal of Environmental Economics and Policy*, *9*(3), 304-318.

Lacroix, K. & Giffort, R. (2020). Targeting interventions to distinct meat-eating groups reduces meat consumption. *Food Quality and Preference*, 86, 103997.

Lewis, K. E., Grebitus, C., Colson, G., & Hu, W. (2017). German and British consumer willingness to pay for beef labeled with food safety attributes. *Journal of Agricultural Economics*, *68*(2), 451-470.

Liu, C., Li, J., Steele, W., & Fang, X. (2018). A study on Chinese consumer preferences for food traceability information using best-worst scaling. *PloS one*, *13*(11), e0206793.

Louviere, J.J., Flynn, T.N. & Marley, A.A. (2015). *Best-worst scaling: Theory, methods and application*. Cambridge University Press, Cambridge UK.

Malek, L. & Umberger, W. (2021). Distinguishing meat reducers from unrestricted omnivores, vegetarians and vegans: A comprehensive comparison of Australian consumers. *Food Quality and Preference*, 88, 104081

Malek, L., Umberger, W. & Goddard, E. (2019). Is anti-consumption driving meat consumption choices in Australia? *British Food Journal*, 121(1), 123-138.

Malek, L., Umberger, W. J., & Rolfe, J. (2017). Segmentation of Australian meat consumers on the basis of attitudes regarding farm animal welfare and the environmental impact of meat production. *Animal Production Science*, *58*(3), 424-434.

Martin, W. & Porter, D. (1985). Testing for changes in the structure of the demand for meat in Australia, *Australian Journal of Agricultural Economics*, 29(1), 16-31.

Massaglia, S., Borra, D., Peano, C., Sottile, F., & Merlino, V. M. (2019). Consumer preference heterogeneity evaluation in fruit and vegetable purchasing decisions using the best–worst approach. *Foods*, *8*(7), 266.

McAlpine, C. A., Etter, A., Fearnside, P. M., Seabrook, L., & Laurance, W. F. (2009). Increasing world consumption of beef as a driver of regional and global change: A call for policy action based on evidence from Queensland (Australia), Colombia and Brazil. *Global Environmental Change*, *19*(1), 21-33.

Merlino, V. M., Borra, D., Girgenti, V., Dal Vecchio, A., & Massaglia, S. (2018). Beef meat preferences of consumers from Northwest Italy: Analysis of choice attributes. *Meat Science*, *143*, 119-128.

Milford, A. B., Le Mouël, C., Bodirsky, B. L., & Rolinski, S. (2019). Drivers of meat consumption. *Appetite*, *141*, 104313.

Morales, L.E., Griffith, G., Fleming, E., Mounter, S., Wright, V. & Umberger, W. (2020). Preferences for certified beef with animal welfare and other credence attributes in Australia. *International Journal of Food System Dynamics*, 11 (3), 202-220.

Muhlbacher, A.C., Kaczynski, A., Zweifel, P. & Johnson, F.R. (2016). Experimental measurement of preferences in health and healthcare using best-worst scaling: An overview. *Health Economics Review,* 6,1-14.

Poore, J. and Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science* 360 (6392), 987-992.

Rolfe, J., Rajapaksa, D., De Valck, J., & Star, M. (2021). Impacts of COVID-19 on patterns of meat and seafood consumption: evidence from Australia. *British Food Journal*, 124(9), 2963-2979

Sanchez-Sabate, R., & Sabaté, J. (2019). Consumer attitudes towards environmental concerns of meat consumption: A systematic review. *International Journal of Environmental Research and Public Health*, *16*(7), 1220.

Soekhai, V., Donkers, B., Levitan, B., & de Bekker-Grob, E.W. (2021). Case 2 best-worst scaling: For good or for bad but not for both. *Journal of Choice Modelling,* 41, 100325.

Soto, J. R., Escobedo, F. J., Khachatryan, H., & Adams, D. C. (2018). Consumer demand for urban forest ecosystem services and disservices: examining trade-offs using choice experiments and best-worst scaling. *Ecosystem Services*, *29*, 31-39.

Springmann, M., Clark, M., Mason-D'Croz, D., Wiebe, K., Bodirsky, B. L., Lassaletta, L., ... & Willett, W. (2018). Options for keeping the food system within environmental limits. *Nature*, *562*(7728), 519-525.

Sui, Z., Raubenheimer, D., & Rangan, A. (2017). Exploratory analysis of meal composition in Australia: meat and accompanying foods. *Public Health Nutrition*, *20*(12), 2157-2165.

Tait, P., Saunders, C., Guenther, M., & Rutherford, P. (2016). Emerging versus developed economy consumer willingness to pay for environmentally sustainable food production: a choice experiment approach comparing Indian, Chinese and United Kingdom lamb consumers. *Journal of Cleaner Production,* 124, 65-72.

Umberger, W., Boxall, P. and Lacey, R. (2009). Role of credence and health information in determining US consumers' willingness-to-pay for grass-finished beef, *Australian Journal of Agricultural and Resource Economics*, 54, 603-623. https://doi.org/10.1111/j.1467-8489.2009.00466.x

Verbeke, W., Pérez-Cueto, F. J., de Barcellos, M. D., Krystallis, A., & Grunert, K. G. (2010). European citizen and consumer attitudes and preferences regarding beef and pork. *Meat Science*, *84*(2), 284-292.

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., ... & Murray, C. J. (2019).

Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet*, 393(10170), 447-492.

Wong, L., Selvanathan, E. A., & Selvanathan, S. (2015). Modelling the meat consumption patterns in Australia. *Economic Modelling*, *49*, 1-10.

Appendix 1. Best, Worst, Best-Worst differences, Best Worst Score

Attributes	**Levels**	**B (agree most)**	**W (agree least)**	**Best-worst**	**Standardised BW score**
Health [1]	HealthGeneral	432	212	220	0.199
	Hormones	332	182	150	0.136
	Antibiotics	328	204	124	0.113
	Fat	315	263	52	0.047
Quality & Price [2]	Quality	331	202	129	0.117
	Price	403	247	156	0.142
	Taste	307	273	34	0.031
	Discount	266	430	-164	-0.149
Welfare & Environment [3]	NaturalProd	349	163	186	0.169
	AniGeneral	320	206	114	0.104
	LandWater	181	286	-105	-0.095
	GHG	161	422	-261	-0.237
Information & Trust [4]	QualityFresh	214	244	-30	-0.027
	Location	206	280	-74	-0.067
	Organic	146	390	-244	-0.222
	Branding	119	406	-287	-0.261

Note: Levels are defined in Table 1. Attribute groups are ranked in order of importance

Appendix 2: Best Worst score comparison across different socio-economic factors

		Gender		Education			Demography		Status		Age category			Religious practice	
Attributes	Levels	Male	Female	Up to year12	Post school qualification	Tertiary education	Urban	Rural	Married / Partner / De facto	Single/ Separated / Divorced / Widowed	Age 18-29	Age 30-59	Age Over 60	Non-religion	Religious
Health	Antibiotics	0.118	0.107	0.107	0.100	0.128	0.123	0.063	0.135	0.080	0.060	0.093	0.157	0.118	0.108
	Hormones	0.165	0.106	0.168	0.159	0.091	0.146	0.092	0.136	0.135	0.066	0.154	0.154	0.124	0.147
	General	0.153	0.244	0.241	0.223	0.147	0.180	0.301	0.174	0.235	0.232	0.142	0.233	0.210	0.188
	Fat	0.009	0.086	0.070	0.000	0.072	0.043	0.068	0.084	-0.002	-0.018	0.027	0.061	0.034	0.061
Welfare & Environment	AniGeneral	0.145	0.062	0.107	0.142	0.069	0.109	0.078	0.075	0.143	0.000	0.136	0.108	0.120	0.088
	LandWater	-0.064	-0.126	-0.103	-0.086	-0.097	-0.097	-0.089	-0.090	-0.102	-0.028	-0.073	-0.156	-0.117	-0.075
	NaturalProd	0.180	0.158	0.184	0.205	0.130	0.163	0.200	0.155	0.191	0.161	0.154	0.154	0.186	0.153
	GHG	-0.198	-0.279	-0.253	-0.291	-0.183	-0.232	-0.261	-0.255	-0.210	-0.106	-0.241	-0.271	-0.234	-0.240
Quality & Price	Quality	0.141	0.093	0.130	0.090	0.130	0.123	0.089	0.132	0.097	0.142	0.087	0.171	0.095	0.140
	Taste	-0.005	0.070	0.046	0.025	0.024	0.031	0.032	0.029	0.034	0.023	0.020	0.019	0.060	0.004
	Discount	-0.162	-0.137	-0.202	-0.153	-0.107	-0.144	-0.171	-0.161	-0.132	-0.194	-0.176	-0.098	-0.143	-0.154
	Price	0.135	0.149	0.145	0.132	0.148	0.141	0.149	0.139	0.146	0.083	0.123	0.175	0.147	0.136
Information & Trust	QualityFresh	-0.054	0.000	-0.046	-0.041	-0.002	-0.035	0.011	-0.031	-0.022	-0.036	-0.026	0.012	-0.007	-0.047
	Location	-0.061	-0.074	-0.065	-0.039	-0.093	-0.077	-0.021	-0.038	-0.110	-0.085	-0.071	-0.055	-0.068	-0.066
	Branding	-0.315	-0.204	-0.336	-0.213	-0.248	-0.255	-0.287	-0.228	-0.309	-0.224	-0.194	-0.328	-0.270	-0.251
	Organic	-0.195	-0.249	-0.202	-0.232	-0.227	-0.225	-0.207	-0.257	-0.170	-0.094	-0.144	-0.334	-0.265	-0.180

Of all survey participants, 50.9% do not practice any religion while the rest do

Appendix 3: Standardised Best Worst score and current level of meat (beef) consumption

Attributes	Levels	Less frequent meat consumers	Medium meat consumers	Frequent meat consumers
Health	Antibiotics	0.159	0.090	0.111
	Hormones	0.114	0.147	0.136
	HealthGeneral	0.157	0.221	0.200
	Fat	0.085	0.036	0.021
Welfare & Environment	AniGeneral	0.180	0.077	0.056
	LandWater	-0.125	-0.076	-0.115
	NaturalProd	0.125	0.196	0.153
	GHG	-0.223	-0.281	-0.066
Quality & Price	Quality	0.095	0.149	0.022
	Taste	0.061	0.008	0.062
	Discount	-0.124	-0.192	-0.020
	Price	0.140	0.163	0.051
Information & Trust	QualityFresh	-0.056	0.011	-0.133
	Location	-0.028	-0.077	-0.112
	Branding	-0.318	-0.243	-0.210
	Organic	-0.234	-0.232	-0.147

Note: 1. Less frequent meat consumers (Once week or less than) 2. Medium meat consumers (2-5 times per week) and 3. Frequent meat consumers (More than 6 meals per week)

Appendix 4: Standardised Best Worst score and participants intention about future (next five years) meat (beef) consumption

Attributes	Levels	Decrease consumption	No change	Increase consumption
Health	Antibiotics	0.150	0.090	0.145
	Hormones	0.129	0.146	0.083
	HealthGeneral	0.098	0.261	0.156
	Fat	0.061	0.025	0.184
Welfare & Environment	AniGeneral	0.070	0.123	0.096
	LandWater	-0.120	-0.087	-0.062
	NaturalProd	0.174	0.173	0.120
	GHG	-0.130	-0.287	-0.277
Quality & Price	Quality	0.119	0.127	0.026
	Taste	0.049	0.017	0.060
	Discount	-0.202	-0.131	-0.086
	Price	0.006	0.231	0.013
Information & Trust	QualityFresh	-0.029	-0.019	-0.088
	Location	-0.054	-0.073	-0.075
	Branding	-0.203	-0.304	-0.150
	Organic	-0.137	-0.277	-0.125