Agribusiness & Economics Research Unit
LINCOLN UNIVERSITY

Consumer willingness to pay for environmental attributes – results from AERU research

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Research to improve decisions and outcomes in business, resource and environmental issues.

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Summary Questions

1. A best assessment of average premium for environmental attributes

The results show a wide variation in wilingness to pay for attributes depending upon context, market and products (and also market segment). The average premium for environmental attributes from the AERU studies range from relatively low levels especially in the US and the UK around 5 per cent through to much higher percentages for developing countries such as India and China at 16 to 47 per cent. However, it must be stressed that the AERU research does not just include environmental condition but separates out attributes that are associated with this which also capture more specific environmental attributes.

A relevant study here is the meta-analysis of 94 studies of choice experiments which found the following:-

> ' for a one unit change of livestock product associated with credence attributes, the WTP a price premium is predicted to range from 20% (for 'Traceability') to 36% (for 'Organic'). The red meat model shows us the predicted values of WTP a price premium for red meat products with credence attributes, and the predicted values are relatively lower than those in the whole sample model. The highest predicted WTP (31%) is associated with organic red meat products, while the lowest value (18%) is associated with 'Traceability'. When looking at the dairy model, 'Food safety' was predicted to produce the highest WTP a price premium for dairy products (39%), whereas the lowest WTP (18%) relates to 'Environment-friendly'. Considering the differences between the predicted values of the three models, results from the subsample models may provide more representative WTP estimates compared to the whole sample model. 'Yang, W. and Renwick, A. (2019).[1]

Based on this and our research a premium of around 20 per cent could be thought to be reasonable.

2. A brief comment on premiums for water quality attributes along with any available figures on the quantum of this

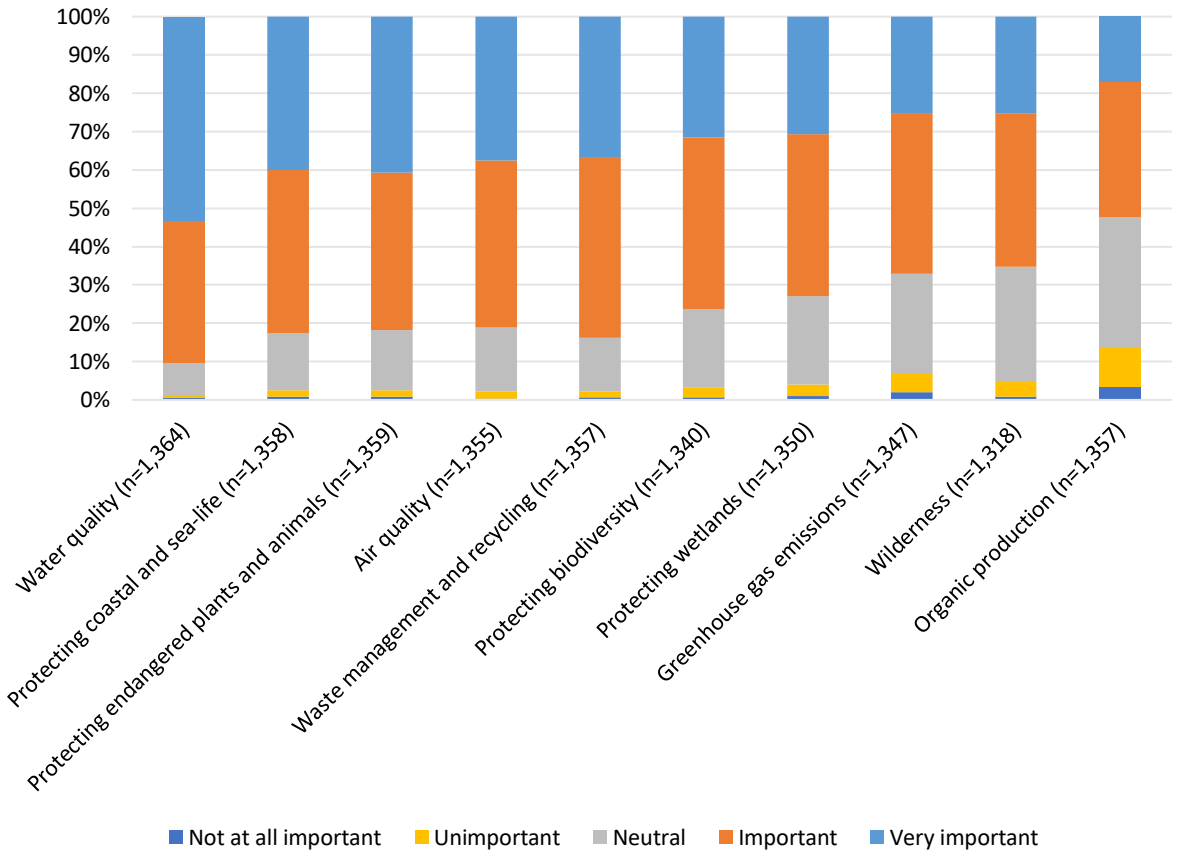
As stated above, the results show a wide variation in willingness to pay for attributes depending upon context, market and products. In the case of water, the AERU has included this specifically in a few studies in a number of ways. Improvements in water efficiency were shown to have a positive willingness to pay of around 10 per cent. Regarding water pollution, the willingness to pay was greatest in India at around 20 per cent followed by China at 16 per cent for dairy whereas the wiliness to pay in the UK was relatively low at around 5 per cent. In the case of wine, water management was seen as important in California with respondents stating they would pay 18 per cent more, and in Shanghai for kiwifruit 45 per cent more.

[1] Yang, W. and Renwick, A. (2019) Consumer Willingness to Pay Price Premiums for Credence Attributes of Livestock Products – A Meta-Analysis, Journal of Agricultural Economics Vol 70 (3).

3. A brief description of what customers by market (including by country and commodity) mean by environmental attributes and the importance they place on these attributes.

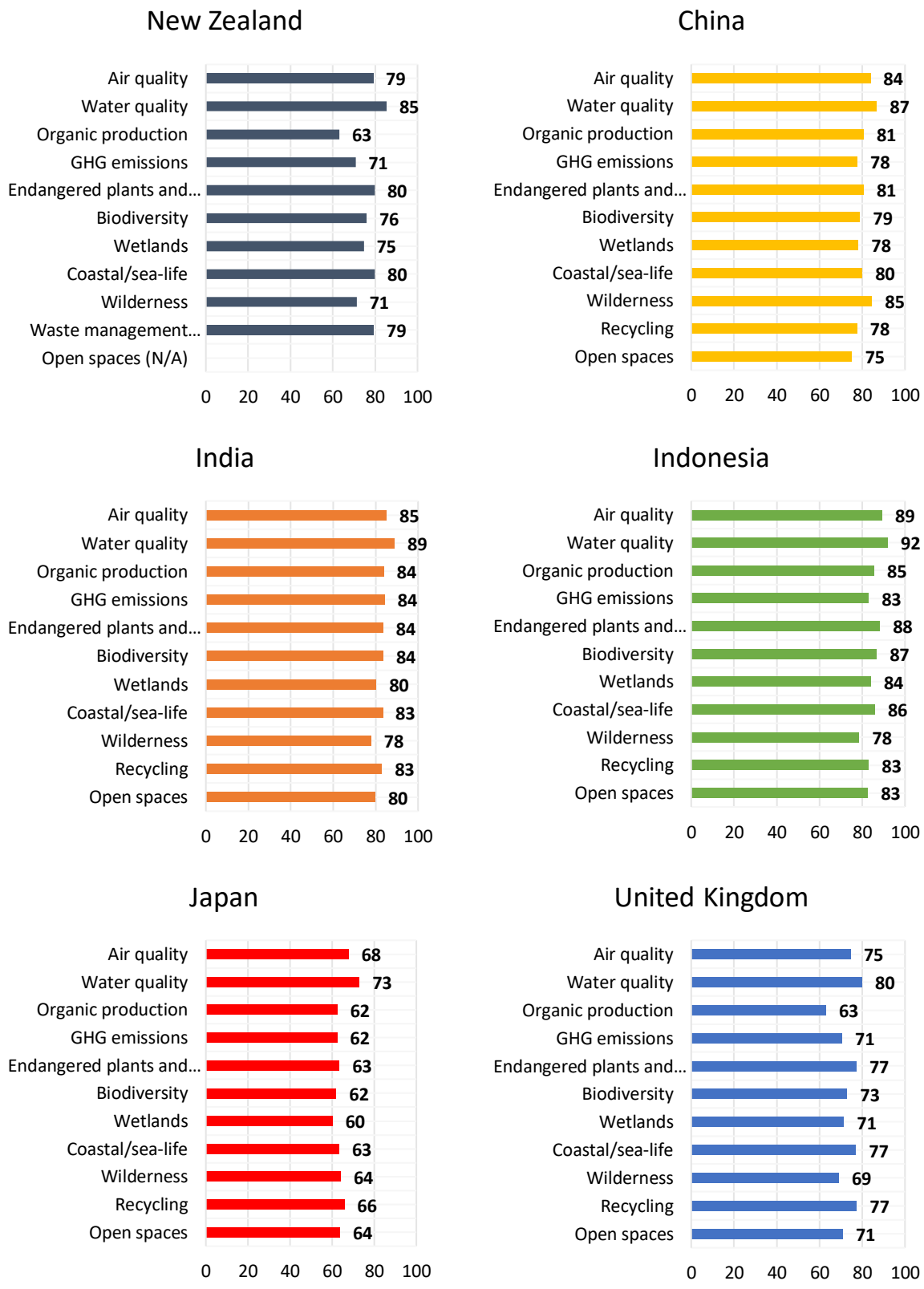
The AERU in its surveys has asked participants which factors they regard as important when considering environmental condition in food and beverage production and supply. In particular, this is shown in the results from the Maximising Export Returns surveys. The results, as shown in the figure below, indicate that while most attributes were similar in terms of their overall rating of importance, over half of the participants (53 per cent) considered water quality as *very important*. This was closely followed by the protection of coastal and sea-life and endangered species, air quality and waste management and recycling, all with similarly high ratings. Furthermore, the protection of wetlands and biodiversity were considered to be of similar importance. While a large proportion of respondents also considered greenhouse gas (GHG) emissions, wilderness and organic production to be either *important* or *very important* (between 65 per cent and 67 per cent), the amount of *neutral* or *unimportant* were also relatively high. Finally, whilst organic production was considered to be *important* by many respondents, based on these results it was the lowest ranked attribute in relation to environmental condition.

Figure: Importance of factors in relation to environmental condition in food and beverage production and supply



New Zealand results were similar to all other countries in that *water quality* was indicated to be the most important factor of environmental condition. As shown in the series of figures below, participants from developing countries rated all factors of environmental condition higher than their developed country counterparts, with New Zealand responses most closely resembling those of the UK. In all countries water quality was the most important.

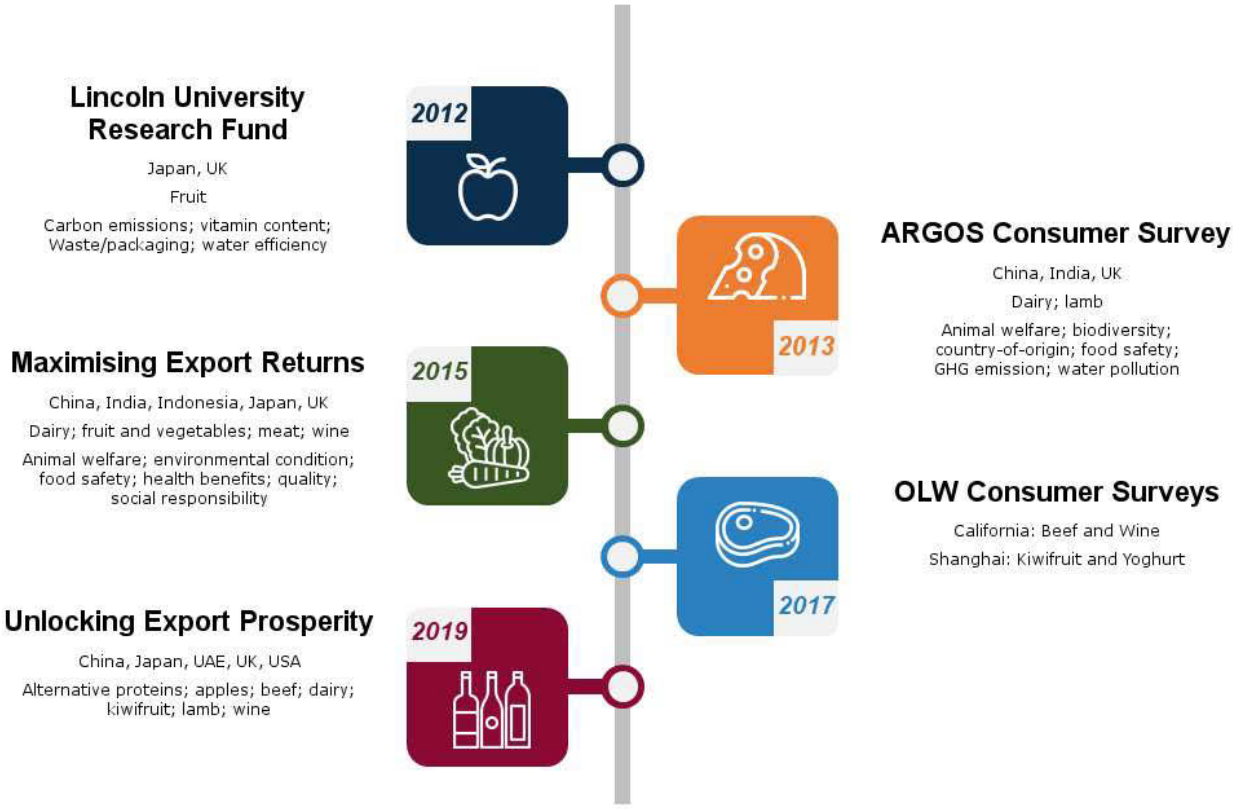
Figure: Importance of factors in relation to environmental condition in food and beverage production and supply – international comparison



Source: Guenther et al. 2015

Introduction

This is a brief report summarising the research undertaken at the AERU on the willingness-to-pay (WTP) for attributes of food by consumers for different products and in different markets. The research here covers the period from 2012 to 2019 and the key timelines and studies are illustrated in the figure below.



Consumer preference research in the AERU is predominantly focused on estimating preferences for credence attributes. Examples of credence attributes include those relating to food safety, animal welfare, environmental outcomes, country-of-origin, functional (or healthy) foods and the use of organic production methods. As distinct from search attributes such as appearance or weight, and experience attributes such as taste or texture, credence attributes are not directly verifiable by the consumer either before or after purchase. Where available, consumers rely on labelling or certification schemes to signal the presence of credence attributes. Estimating preferences for credence attributes is empirically difficult due to the lack of labelling of attributes of interest, such as environmental outcomes associated with New Zealand agri-food exports. Even when labels are present (such as pasture-raised or grass-fed), the market price data typically confounds these attributes, therefore negating the ability to use this data to identify the role of individual attributes in consumer preferences. In response to this, the AERU has developed expertise in applying the economic valuation method of Choice Experiments (CE).

Choice experiments have been extensively used to value international consumer preferences for food product credence attributes. As opposed to revealed preference methods such as using direct or indirect market prices, this survey-based approach facilitates valuation of attributes that may not be directly observable in markets. Consumers are therefore unable to express their willingness-to-pay (WTP) for

these attributes in a way that generates observable market data that could reveal preferences. The ability of this method to identify which individual attributes are more important in consumer choices, and to estimate marginal WTP for these attributes, has seen this approach to valuation become increasingly favoured by researchers. The method involves simulating the context in which consumers would normally make choices among a set of competing food alternatives. This is achieved by designing an experiment in which attributes are systematically and independently varied to produce multiple-choice scenarios. Consumers are then asked to indicate their preferred food alternative in each scenario, with the observed levels of attributes in the chosen and non-chosen alternatives modelled in a probabilistic econometric framework. The interested reader can find more detail on the Choice Experiment approach to valuation in the Appendix of this report.

Lincoln University Research Fund (LURF)

United Kingdom and Japanese fruit consumers

- Tait PR, Saunders C, Guenther M. **2015**. Valuing preferences for environmental sustainability in fruit production by United Kingdom and Japanese consumers. Journal of Food Research, 4(3) http://dx.doi.org/10.5539.
- Samples of 300 people from each country collected in 2012 who purchase fruit at least monthly.
- Fruit consumer willingness to pay estimated as a percentage increase in product price.

WTP for fruit production officially certified for:	**United Kingdom**	**Japan**
10% reduction in **Carbon emissions**	22% (17, 26)	23% (18, 26)
20% increase in **water efficiency**	10% (8, 12)	11% (8, 12)
33% increase in **vitamin content**	11% (7, 15)	5% (4, 6)
20% reduction in **waste and packaging**	2% (-1, 3)	4% (3, 5)

Median WTP reported (lower quartile, upper quartile)

Agricultural Research Group on Sustainability (ARGOS)

Chinese, Indian and United Kingdom lamb consumers

- Tait PR, 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. http://dx.doi.org/10.1016/j.jclepro.2016.02.088.
- Samples of 700 people collected in 2013 from each country who purchase lamb at least monthly.
- Lamb consumer willingness to pay estimated as a percentage increase in product price.

WTP for lamb production officially certified:	**China**	**India**	**UK**
as **safe to eat**	34% (24,42)	49% (3,121)	15% (4,37)
to meet at least **minimum animal welfare standards**	9% (7,10)	29% (14,53)	18% (3,46)
to **minimise water pollution**	7% (6,9)	21% (17,28)	6% (5,8)
to **minimise greenhouse gas emissions**	8% (6,10)	28% (22,38)	6% (1,13)
to **protect biodiversity**	5% (2,8)	26% (0,63)	4% (-3,17)

Median WTP reported (lower quartile, upper quartile)

Chinese, Indian and United Kingdom dairy consumers

- Saunders, C., Guenther, M., Tait, P. and Saunders, J. (2013). Consumer attitudes and willingness to pay for attributes of food, in particular from New Zealand. Contributed paper prepared for presentation at the 57th AARES Annual Conference, Sydney, New South Wales, 5th-8th 2013. https://bit.ly/2Sgem1A

- Samples of 700 people collected in 2013 from each country who purchase dairy products at least monthly.

- Dairy consumer willingness to pay estimated as a percentage increase in product price.

WTP for dairy production officially certified:	**China**	**India**	**UK**
as **safe to eat**	74% (67,79)	73% (64,81)	16% (15,18)
to meet at least **minimum animal welfare standards**	26% (23,28)	42% (37,47)	17% (16,18)
to **minimise water pollution**	16% (14,19)	19% (16,23)	3% (2,4)
to **minimise green-house-gas emissions**	25% (23,28)	38% (33,42)	7% (6,8)
to **protect biodiversity**	22% (19,24)	27% (23,31)	6% (5,7)

Median WTP reported (lower quartile, upper quartile)

Maximising Export Returns

Indian, Indonesian, Japanese and United Kingdom fruit & vegetable, dairy, and meat consumers

- Miller S, Tait P, Saunders C, Dalziel P, Rutherford P. Abell W. 2017. Estimation of consumer willingness-to-pay for social responsibility in fruit and vegetable products: A cross-country comparison using a choice experiment. Journal of Consumer Behaviour 1-13. http://dx.doi.org/10.1002/cb.1650.

- Samples of 1,000 people from each country collected in 2015 who purchase relevant products at least monthly.

- Consumer willingness to pay estimated as a percentage increase in product price.

WTP for certified improvement in production standards above minimum standard for:	**India**	**Indonesia**	**Japan**	**UK**
Fruit and Vegetables				
Biodiversity	44%	22%	22%	18%
Environmental condition	25%	11%	5%	4%
Food safety	27%	23%	4%	5%
Health benefits	-	-	-	16%
Product quality	22%	18%	-	22%
Social responsibility	41%	23%	14%	13%
Dairy products				
Animal welfare	40%	29%	39%	21%
Environmental condition	18%	27%	7%	14%
Food safety	40%	27%	8%	6%
Health benefits	-	19%	-	-
Product quality	44%	31%	17%	14%
Social responsibility	52%	27%	-	6%
Meat products				
Animal welfare	36%	27%	24%	12%
Environmental condition	-	16%	9%	9%
Food safety	41%	25%	-	4%
Health benefits	19%	25%	-	6%
Product quality	33%	17%	13%	11%
Social responsibility	38%	18%	7%	9%

Median WTP reported. Blank cells where no WTP estimate provided indicate insignificant parameter in relevant model.

Our Land and Water (OLW) Consumer Surveys

California: Beef

- Tait, P.R., Rutherford, P., Driver, T., Li, X., Saunders, C.M., Dalziel, P. and Guenther, M. (2018b). Consumer insights and willingness to pay for attributes: New Zealand beef products in California, USA. AERU Research Report No. 348, June 2018. Agribusiness and Economics Research Unit, Lincoln University: Lincoln, New Zealand. https://hdl.handle.net/10182/10037.
- Sample of 1,000 people from California, USA, collected in 2017 who purchase ground beef, sirloin, and ribeye products at least monthly.
- Consumer willingness to pay estimated in USD/lb for each product category and expressed as a percentage of product price.

Californian consumer willingness-to-pay (WTP) for selected attributes of *ground beef* products

Attribute	Median WTP (USD/lb)	Lower and Upper Quartiles	WTP as % of average price*
100% grass-fed	$2.46	(1.12, 4.17)	35%
Grain-fed	$-0.51	(-0.57, -0.42)	-7%
No added antibiotics	$0.71	(-0.24, 1.82)	9%
No added hormones	$1.13	(0.99, 1.25)	16%
Traceability	$0.45	(0.40, 0.51)	6%
Social responsibility	$1.00	(0.66, 1.43)	14%
GMO-free	$1.01	(0.91, 1.15)	14%
Feed-lot raised	$-1.13	(-1.79, -0.27)	-16%
100% pasture-raised	$2.00	(1.33, 2.87)	29%
Organic	$1.72	(0.64, 2.81)	23%
Enhanced animal welfare	$1.04	(0.93, 1.18)	15%
Environmentally sustainable	$0.52	(0.46, 0.59)	7%
US raised and processed	$1.52	(0.97, 2.23)	22%
NZ raised, US processed	$1.38	(0.01, 3.12)	20%
NZ raised and processed	$1.54	(0.46, 2.92)	22%
Australian raised, US processed	$-1.80	(-2.16, -1.34)	-26%

*Average price as used in the Choice Experiment.

Californian consumer willingness-to-pay (WTP) for selected attributes of *top sirloin steak* products

Attribute	Median WTP (USD/lb)	Lower and Upper Quartiles	WTP as % of average price*
100% grass-fed	$2.72	(1.31, 4.35)	15%
Grain-fed	$-0.55	(-0.65, -0.44)	-3%
No added antibiotics	$0.88	(-0.28, 1.86)	4%
No added hormones	$1.20	(1.12, 1.29)	7%
Traceability	$0.49	(0.46, 0.53)	3%
Social responsibility	$1.09	(0.75, 1.48)	6%
GMO-free	$1.11	(1.04, 1.19)	6%
Feed-lot raised	$-1.22	(-2.05, -0.32)	-7%
100% pasture-raised	$2.18	(1.51, 2.96)	12%
Organic	$1.82	(0.72, 2.96)	10%
Enhanced animal welfare	$1.13	(1.06, 1.22)	6%
Environmentally sustainable	$0.57	(0.53, 0.61)	3%
US raised and processed	$1.68	(1.12, 2.32)	9%
NZ raised, US processed	$1.54	(0.04, 3.26)	9%
NZ raised and processed	$1.71	(0.55, 3.05)	10%
Australian raised, US processed	$-1.96	(-2.46, -1.40)	-11%

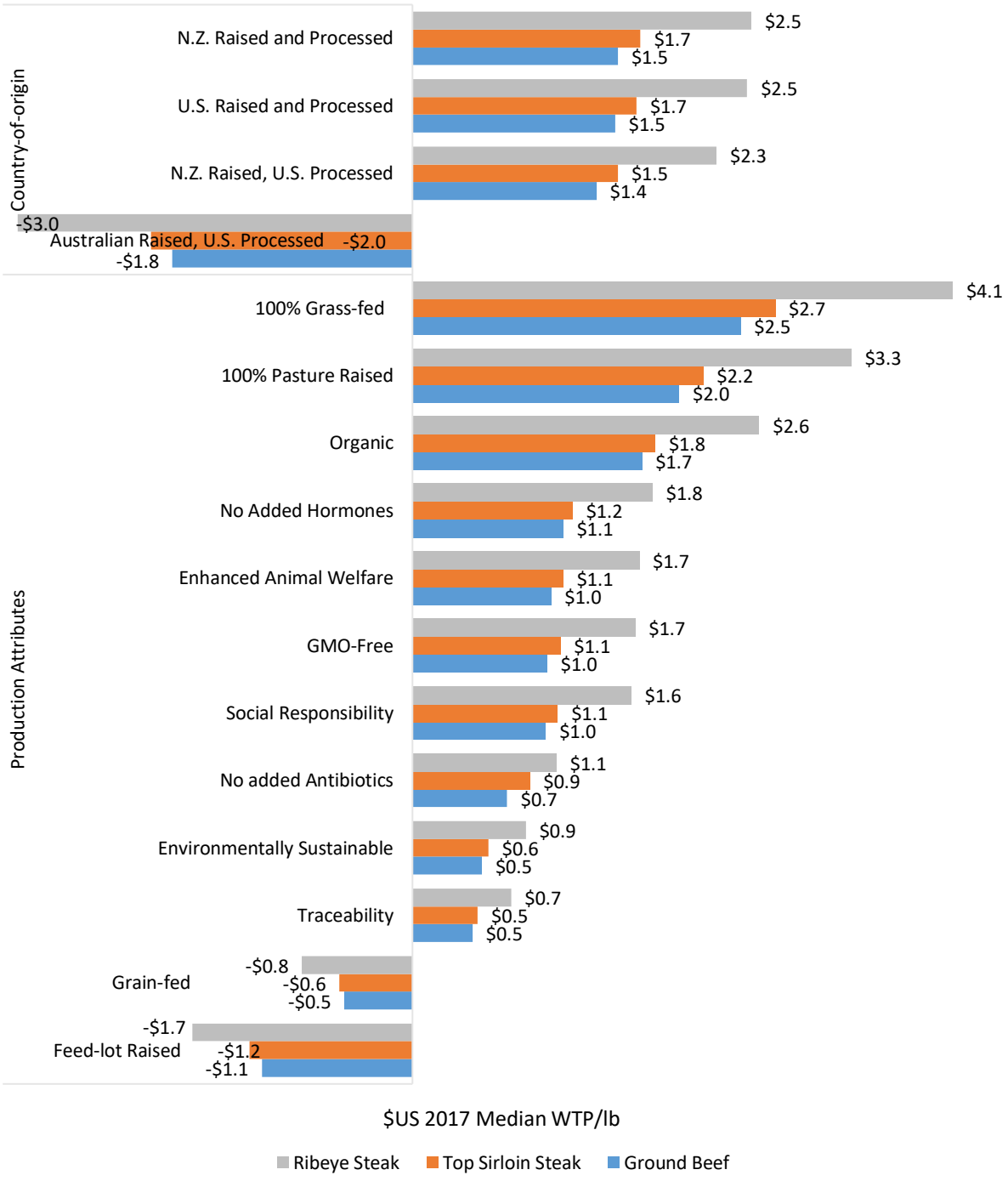
*Average price as used in Choice Experiment.

Californian consumer willingness-to-pay (WTP) for selected attributes of *ribeye steak* products

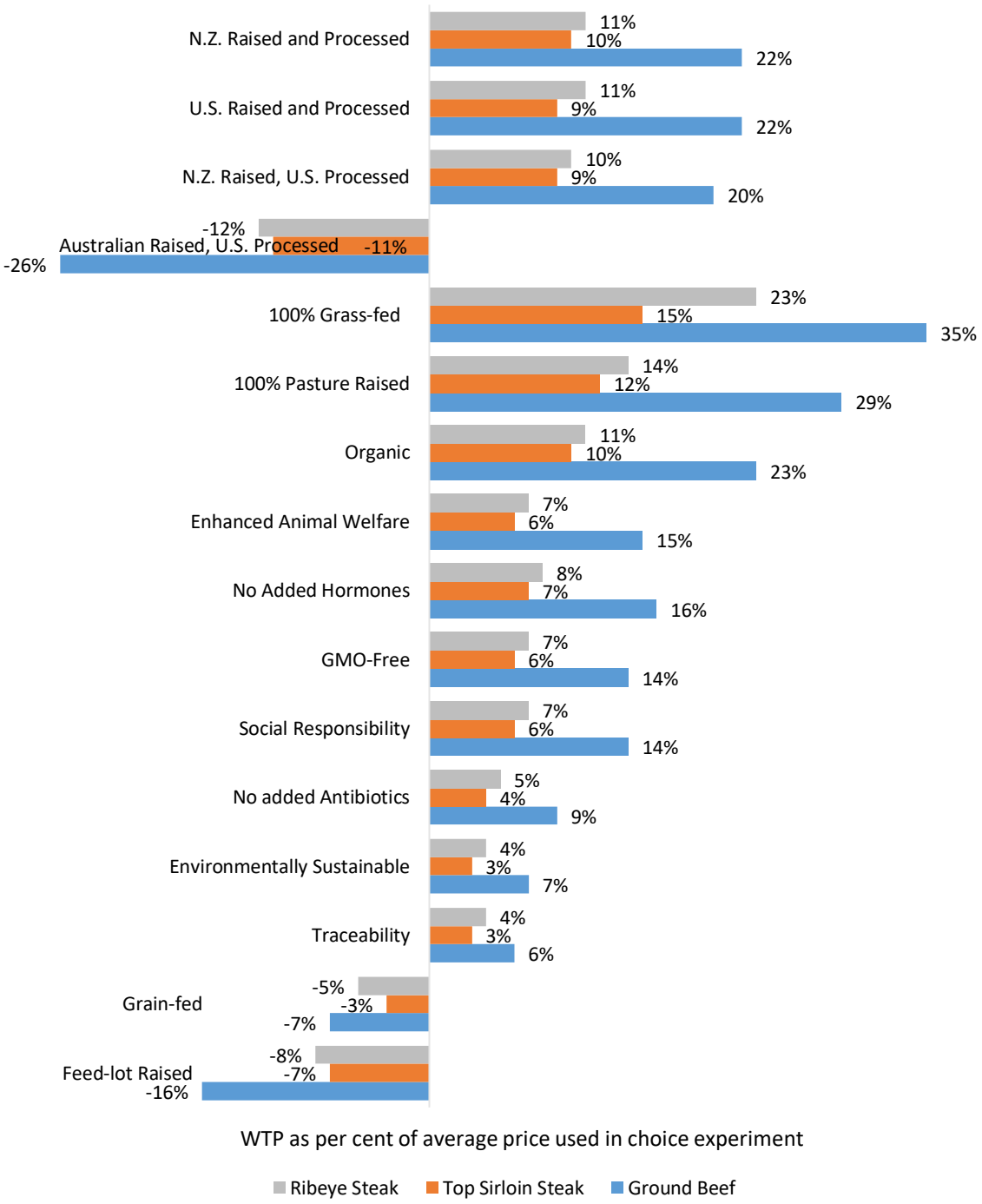
Attribute	Median WTP (USD/lb)	Lower and Upper Quartiles	WTP as % of average price*
100% grass-fed	$4.05	(1.90, 6.67)	23%
Grain-fed	$-0.83	(-0.96, -0.67)	-5%
No added antibiotics	$1.08	(-0.42, 2.87)	5%
No added hormones	$1.80	(1.66, 1.98)	8%
Traceability	$0.74	(0.68, 0.81)	4%
Social responsibility	$1.64	(1.11, 2.27)	7%
GMO-free	$1.67	(1.53, 1.83)	7%
Feed-lot raised	$-1.65	(-3.02, -0.47)	-8%
100% pasture-raised	$3.29	(2.23, 4.55)	14%
Organic	$2.60	(1.04, 4.44)	11%
Enhanced animal welfare	$1.70	(1.56, 1.87)	7%
Environmentally sustainable	$0.85	(0.78, 0.93)	4%
US raised and processed	$2.51	(1.64, 3.56)	11%
NZ raised, US processed	$2.28	(0.04, 5.00)	10%
NZ raised and processed	$2.54	(0.79, 4.68)	11%
Australian raised, US processed	$-2.96	(-3.63, -2.13)	-12%

*Average price as used in Choice Experiment.

Californian consumer median willingness-to-pay for selected attributes of beef products (ground beef, top sirloin steak, ribeye steak) (WTP in US$/lb)



Californian consumer median willingness-to-pay for selected attributes of beef products (ground beef, top sirloin steak, ribeye steak) (WTP in percentage of average product price*)



*Average price as used in Choice Experiment.

California: Wine (Sauvignon Blanc)

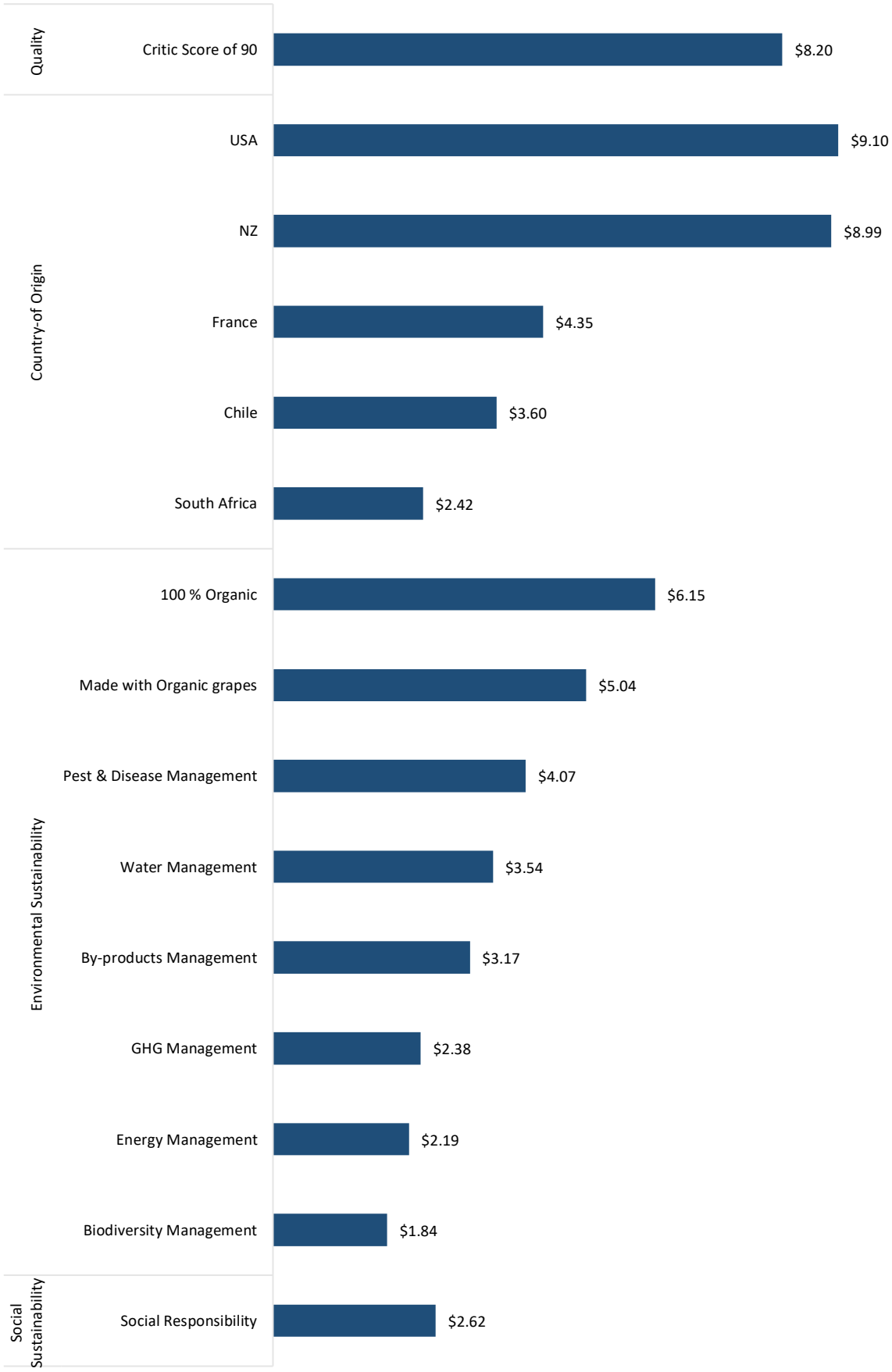
- Tait, P.R., Rutherford, P., Driver, T., Li, X., Saunders, C.M., Dalziel, P. and Guenther, M. (2018c). Consumer insights and willingness to pay for attributes: New Zealand wine in California, USA. AERU Research Report No. 349, June 2018. Agribusiness and Economics Research Unit, Lincoln University: Lincoln, New Zealand. https://hdl.handle.net/10182/10038.
- Sample of 1,000 people from California, USA, collected in 2017 who purchase Sauvignon Blanc at least monthly.
- Consumer willingness to pay estimated in USD/750mL and expressed as a percentage of product price.

Californian consumer willingness-to-pay (WTP) for selected attributes of Sauvignon Blanc

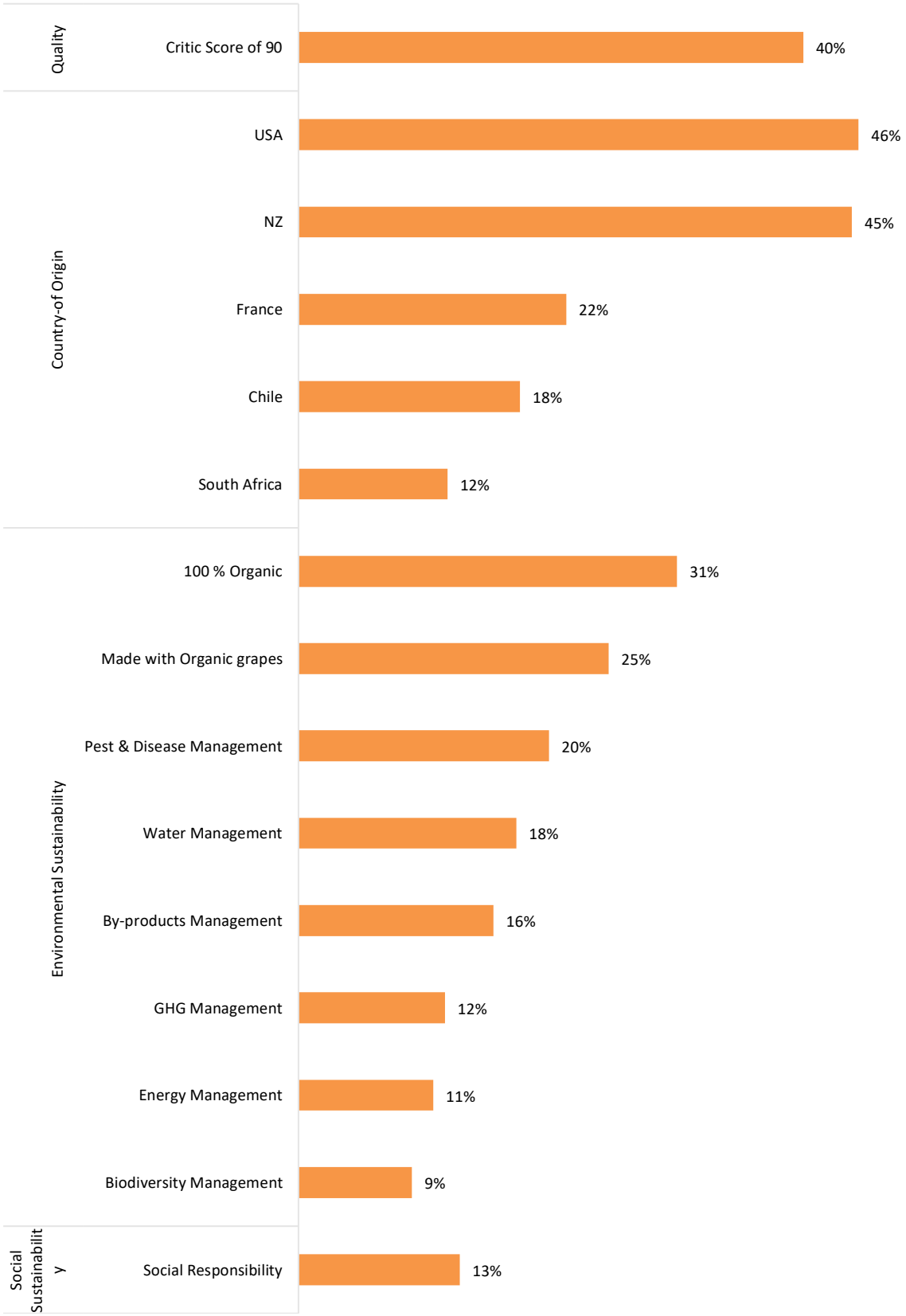
Attribute	Median WTP (USD/750mL)	Lower and Upper Quartiles	WTP as % of average price*
Biodiversity management	$1.84	(1.53, 2.14)	9%
Water management	$3.54	(3.19, 3.87)	18%
By-products management	$3.17	(2.88, 3.46)	16%
Energy management	$2.19	(1.89, 2.49)	11%
Pest and disease management	$4.07	(3.76, 4.39)	20%
GHG management	$2.38	(2.08, 2.67)	12%
Social responsibility	$2.62	(2.28, 2.96)	13%
Made with organic grapes	$5.04	(4.66, 5.41)	25%
100% organic	$6.15	(5.82, 6.48)	31%
Critic score ($ per 1 point above 80)	$0.82	(0.78, 0.85)	4%
Origin: Chile	$3.60	(3.28, 4.01)	18%
Origin: South Africa	$2.42	(1.92, 2.93)	12%
Origin: France	$4.35	(3.49, 5.18)	22%
Origin: USA	$9.10	(8.70, 9.54)	46%
Origin: New Zealand	$8.99	(8.05, 9.93)	45%

*Average price as used in Choice Experiment.

Californian consumer median willingness-to-pay (WTP) for selected attributes of Sauvignon Blanc (WTP in US$/750mL bottle of wine)



Californian consumer median willingness-to-pay (WTP) for selected attributes of Sauvignon Blanc (WTP as percentage of average product price*)



*Average price as used in the Choice Experiment.

Shanghai: Kiwifruit

- Tait, P.R., Rutherford, P., Driver, T., Li, X., Saunders, C.M., Dalziel, P. and Guenther, M. (2018a). Consumer insights and willingness to pay for attributes: Kiwifruit in Shanghai, China. AERU Research Report No. 346, June 2018. Agribusiness and Economics Research Unit, Lincoln University: Lincoln, New Zealand. https://hdl.handle.net/10182/10039

- Sample of 1,000 people from Shanghai, China, collected in 2017 who purchase kiwifruit at least monthly.

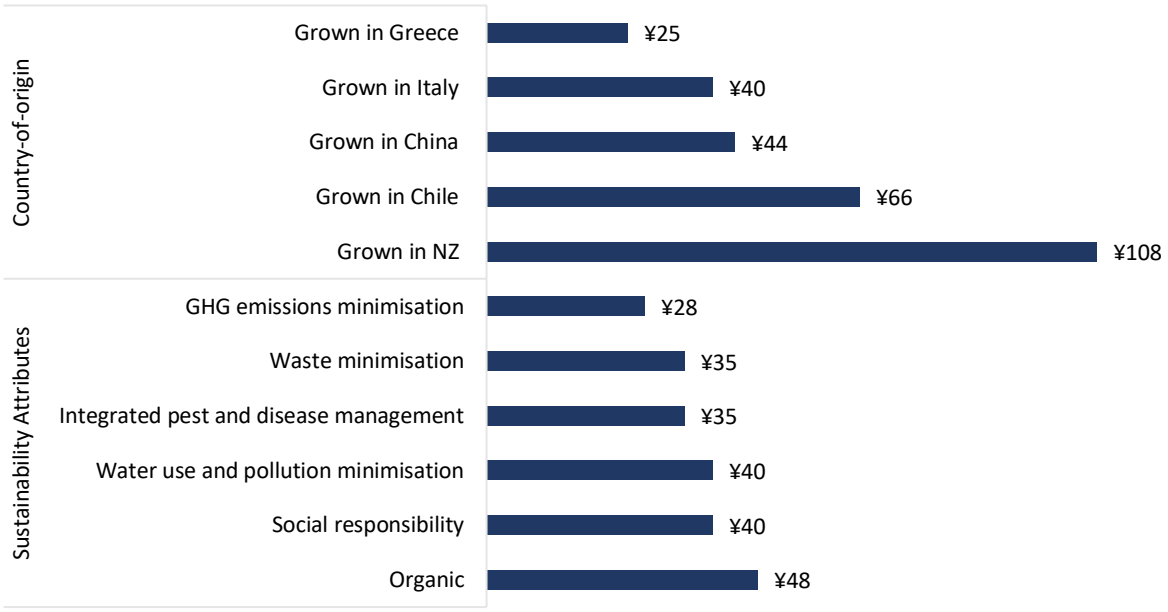
- Consumer willingness to pay estimated in Yuan/kg and expressed as a percentage of product price.

Shanghai consumer willingness-to-pay (WTP) for selected attributes of kiwifruit

Attribute	Median WTP (¥/kg)	Lower and Upper Quartiles	WTP as % of average price*
Water use and pollution minimisation	¥40	(35,44)	45%
Integrated pest and disease management	¥35	(29,41)	40%
Organic	¥49	(41,55)	55%
Waste minimisation	¥35	(32,37)	40%
GHG emissions minimisation	¥28	(20,35)	32%
Social responsibility	¥40	(33,47)	46%
Grown in China	¥44	(33,54)	50%
Grown in New Zealand	¥108	(93,124)	123%
Grown in Italy	¥40	(28,52)	46%
Grown in Greece	¥25	(17,33)	29%
Grown in Chile	¥65	(54,77)	75%

*Average price as used in Choice Experiment.

Shanghai consumer median willingness-to-pay (WTP) for selected attributes of kiwifruit (WTP in ¥/kg)



Shanghai consumer median willingness-to-pay (WTP) for selected attributes of kiwifruit (WTP as percentage of average product price*)

4303	0
4303	0
4303	0
4303	0
4303	0
4303	0
4303	0
4303	0
4303	0
4303	0
4303	0
Account	0

*Average price as used in Choice Experiment.

Shanghai: Yogurt

- Tait, P.R., Rutherford, P., Driver, T., Li, X., Saunders, C.M., Dalziel, P. and Guenther, M. (2018d). Consumer insights and willingness to pay for attributes: New Zealand yogurt in Shanghai, China. AERU Research Report No. 347, June 2018. Agribusiness and Economics Research Unit, Lincoln University: Lincoln, New Zealand. https://hdl.handle.net/10182/10036

- Sample of 1,000 people from Shanghai, China, collected in 2017 who purchase yogurt at least monthly.

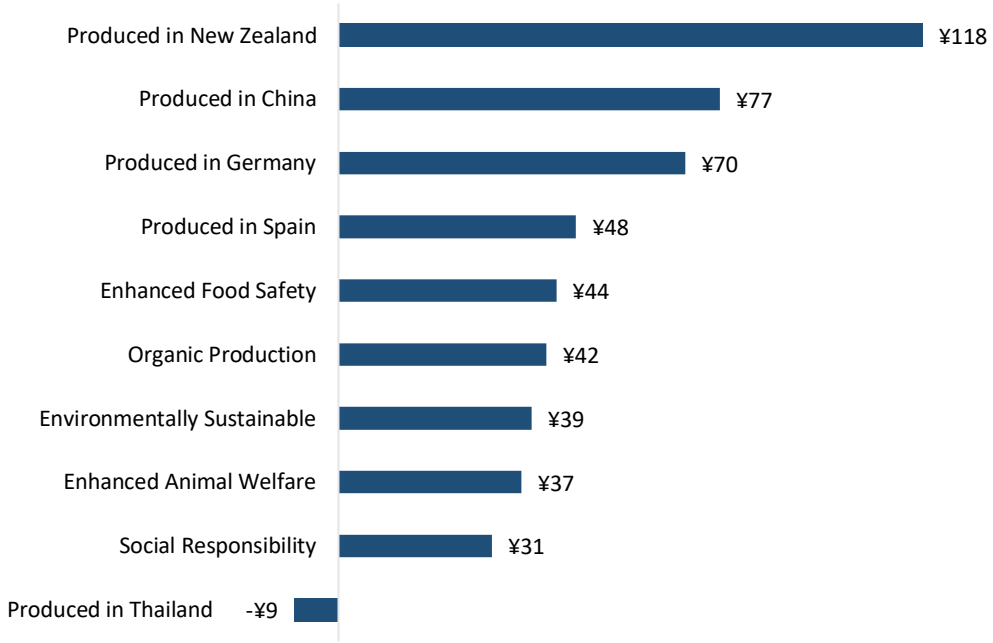
- Consumer willingness to pay estimated in Yuan/kg and expressed as a percentage of product price.

Shanghai consumer willingness-to-pay (WTP) for selected attributes of yoghurt products

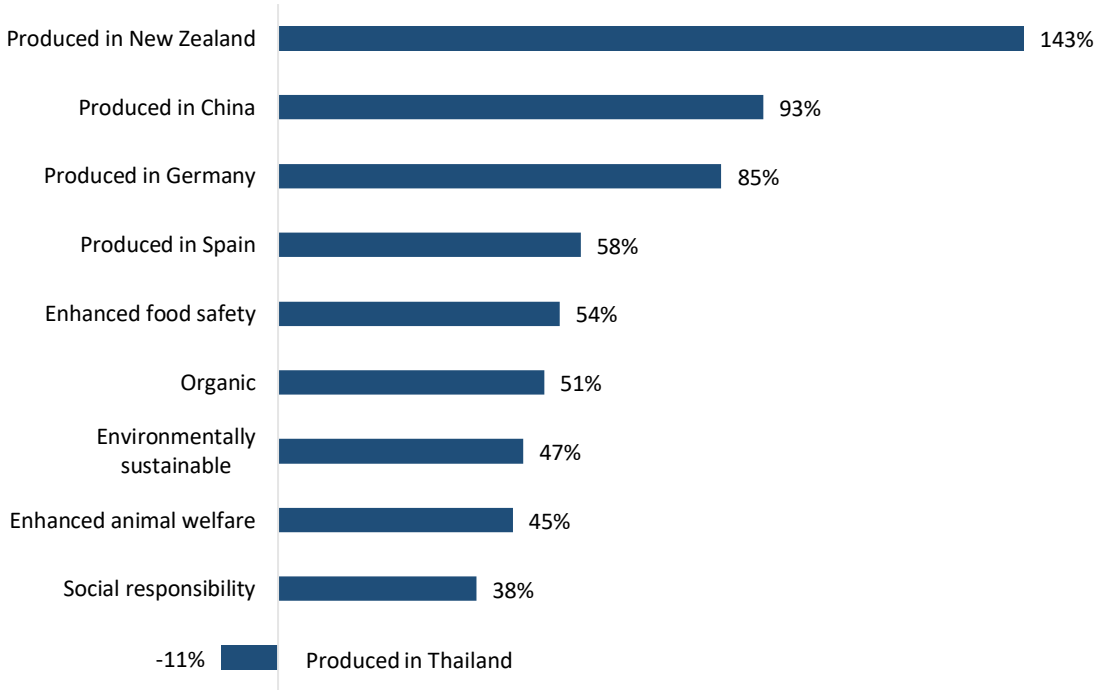
Attribute	Median WTP (¥/kg)	Lower and Upper Quartiles	WTP as % of average price*
Enhanced food safety	¥44	(38,50)	54%
Enhanced animal welfare	¥37	(32,44)	45%
Environmentally sustainable	¥39	(34,46)	47%
Social responsibility	¥31	(26,38)	38%
Organic	¥42	(37,49)	51%
Origin: China	¥77	(57,85)	93%
Origin: Germany	¥70	(62,81)	85%
Origin: Spain	¥48	(38,59)	58%
Origin: Thailand	¥-9	(-17,-2)	-11%
Origin: New Zealand	¥118	(104,140)	143%

*Average price, as used in Choice Experiment.

Shanghai consumer median willingness-to-pay (WTP) for selected attributes of yoghurt products (WTP in ¥/kg)



Shanghai consumer median willingness-to-pay (WTP) for selected attributes of yoghurt products (WTP as percentage of average product price/kg*)



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Unlocking Export Prosperity

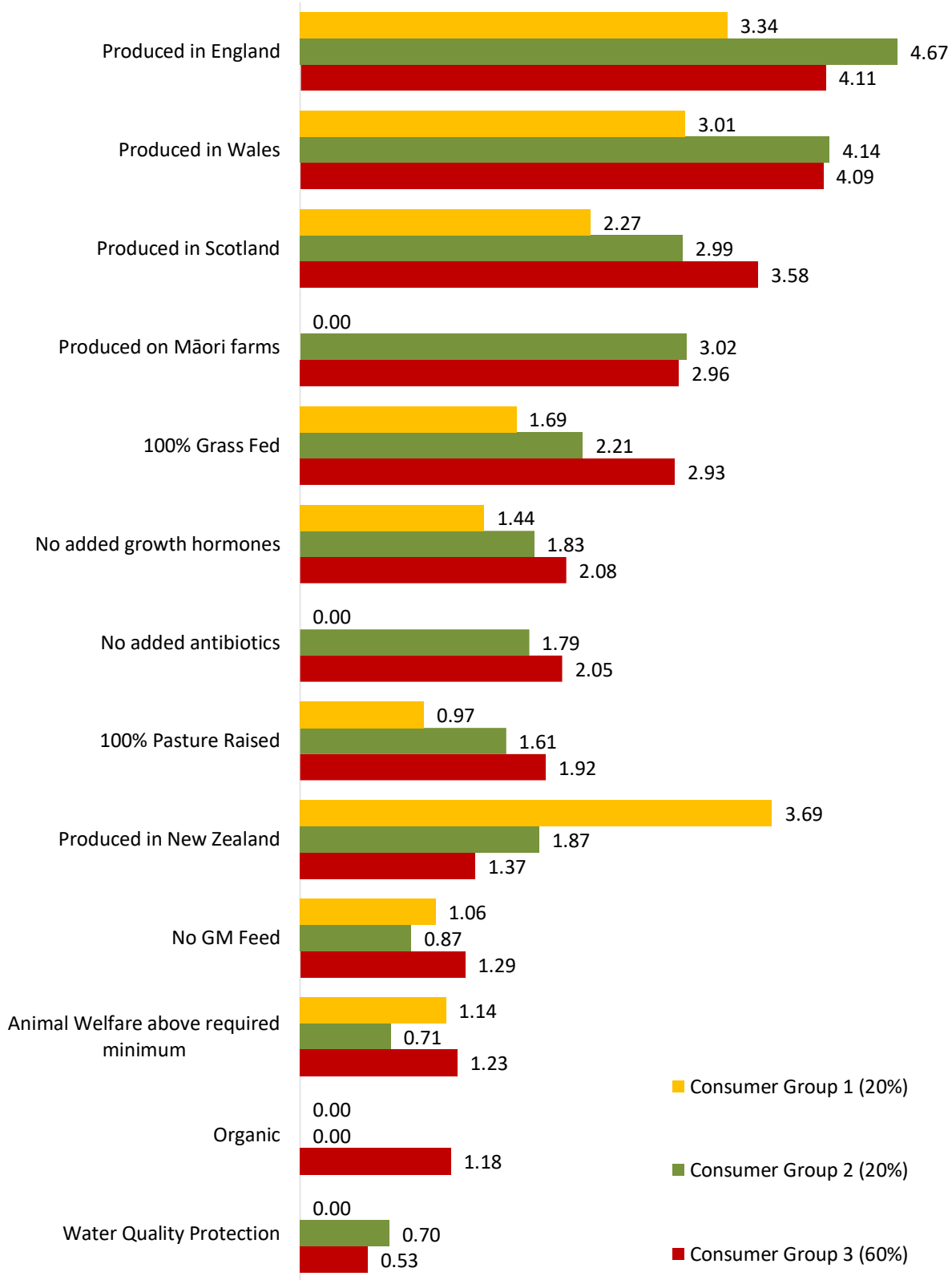
- Sample of 1,000 people from United Kingdom collected in 2019 who purchase lamb leg at least monthly.
- Consumer willingness to pay estimated in £/kg and expressed as a percentage of product price.
- These WTP values are estimated for each of three groups of consumers who are found to have different preferences for the lamb attributes presented.

UK consumer willingness-to-pay (WTP) for selected attributes of lamb products

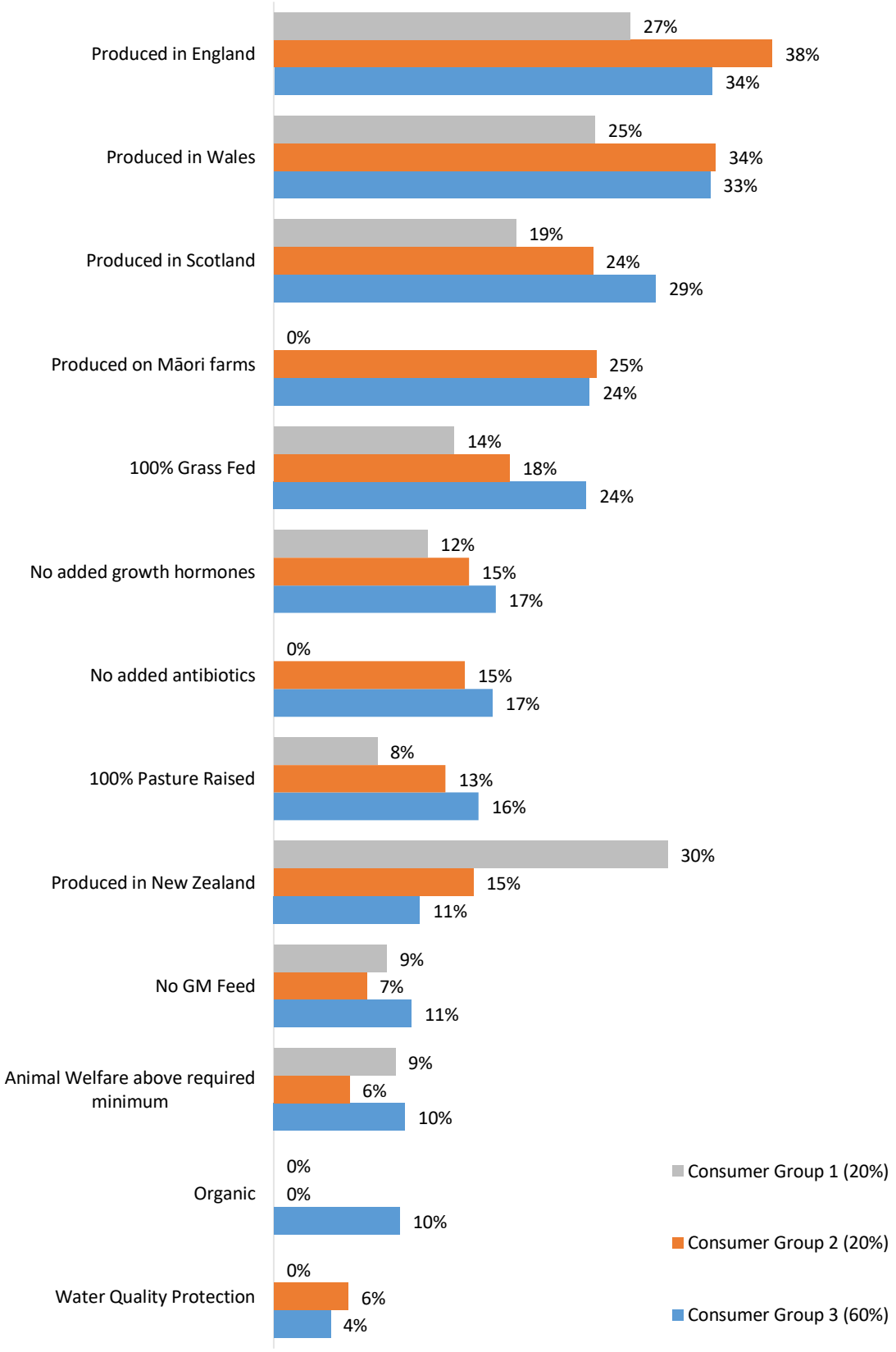
Attributes	Consumer Group 3 (60%)	Consumer Group 2 (20%)	Consumer Group 1 (20%)
Water Quality Protection	0.53 (-0.1,1.07)	0.7 (-0.11,1.55)	-
Organic	1.18 (0.32,2.03)	-	-
Animal Welfare above required minimum	1.23 (0.71,1.73)	0.71 (0.11,1.32)	1.14 (0.42,1.86)
No GM Feed	1.29 (0.63,1.93)	0.87 (-0.01,1.75)	1.06 (0.22,1.89)
Produced in New Zealand	1.37 (-0.12,2.87)	1.87 (0.27,3.46)	3.69 (1.65,5.75)
100% Pasture Raised	1.92 (1.21,2.61)	1.61 (0.94,2.27)	0.97 (0.29,1.65)
No added antibiotics	2.05 (1.25,2.85)	1.79 (0.96,2.63)	-
No added growth hormones	2.08 (0.96,3.18)	1.83 (0.75,2.91)	1.44 (0.14,2.75)
100% Grass Fed	2.93 (1.51,4.35)	2.21 (1.17,3.24)	1.69 (0.16,3.23)
Produced on Māori farms	2.96 (1.36,4.55)	3.02 (1.47,4.57)	-
Produced in Scotland	3.58 (2.36,4.78)	2.99 (1.85,4.14)	2.27 (0.98,3.57)
Produced in Wales	4.09 (2.31,5.85)	4.14 (2.71,5.57)	3.01 (0.91,3.57)
Produced in England	4.11 (2.24,5.99)	4.67 (3.03,6.31)	3.34 (1.02,5.66)

Average WTP reported (95% Confidence Interval). Blank cell indicates insignificant model parameter.

UK consumer median willingness-to-pay (WTP) for selected attributes of lamb products (lamb leg) (WTP as £/kg)



UK consumer median willingness-to-pay (WTP) for selected attributes of lamb products (WTP as percentage of average product price*)



*Average price, as used in Choice Experiment.

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Appendix A: Estimation of WTP Statistical Method

This appendix provides technical details of statistical analysis of choice data. The appendix includes a brief description of the theoretical foundations of choice analysis followed by statistical probability estimation approaches, focusing on contemporary models applied in this report. Lastly, the method used in generating monetary estimates is described.

A.1 Conceptual Framework

In Choice Experiments (CEs), researchers are interested of what influences, on average, the survey respondents' decisions to choose one alternative over others. These influences are driven by people's preferences towards the attributes but also the individual circumstances such as their demographics or perceptions of the choice task (e.g., the level of difficulty or understanding) (Hensher et al. 2015).

Each alternative in a choice set is described by attributes that differ in their levels, both across the alternatives and across the choice sets. The levels can be measured either qualitatively (e.g., poor and good) or quantitatively (e.g., kilometres). This concept is based on the characteristics theory of value (Lancaster 1966) stating that these attributes, when combined, provide people a level of utility[2] *U* hence providing a starting point for measuring preferences in CE (Hanley et al. 2013; Hensher et al. 2015). The alternative chosen, by assumption, is the one that maximises people's utility[3] providing the behavioural rule underlying choice analysis:

$$U_j > U_i \tag{0.1}$$

where the individual *n* chooses the alternative *j* if this provides higher utility than alternative *i*. A cornerstone of this framework is Random Utility Theory, dated back to early research on choice making (e.g., Thurstone 1927) and related probability estimation. This theory postulates that utility can be decomposed into systematic (explainable or observed) utility *V* and a stochastic (unobserved) utility ε (Hensher et al. 2015; Lancsar and Savage 2004).

$$U_{nj} = V_{nj} + \varepsilon_{nj} \tag{0.2}$$

where *j* belongs to a set of J alternatives. The importance of this decomposition is the concept of utility only partly being observable to the researcher, and remaining unobserved sources of utility can be treated as random (Hensher et al. 2015). The observed component includes information of the attributes as a linear function of them and their preference weights (coefficient estimates).

[2]Related terminology used in psychology discipline is *the level of satisfaction* (Hensher et al. 2015).
[3]In choice analysis, utility is considered as *ordinal utility* where the relative values of utility are measured (Hensher et al. 2015).

$$V_{nsj} = \sum_{k=1}^{K} \beta_k x_{nsjk} \quad (0.3)$$

with *k* attributes in vector x for a choice set s. Essentially, the estimated parameter β shows "the effect on utility of a change in the level of each attribute" (Hanley et al. 2013, p. 65). This change can be specified as linear across the attribute levels, or as non-linear using either dummy coding or effect coding approaches. The latter coding approach has a benefit of not confounding with an alternative specific constant (ASC) when included in the model (Hensher et al. 2015).

A.2 Statistical Modelling of Choice Probabilities

The statistical analysis aims to explain as much as possible of the observed utility using the data obtained from the CE and other relevant survey data. In order to do so, the behavioural rule (eq. 1.1) and the utility function (eq. 1.2) are combined (Hensher et al. 2015; Lancsar and Savage 2004) to estimate the probability of selecting an alternative *j*:

$$\Pr_{nsj} = \Pr\left(U_{nsj} > U_{nsi}\right) = \Pr\left(V_{nsj} + \varepsilon_{nsj} > V_{nsi} + \varepsilon_{nsi}\right) = \Pr\left(\varepsilon_{nsi} - \varepsilon_{nsj} < V_{nsj} - V_{nsi}\right) \forall j \neq i \quad (0.4)$$

where the probability of selecting alternative *j* states that differences in the random part of utility are smaller than differences in the observed part. A standard approach to estimate this probability is a conditional logit, or multinomial logit (MNL) model (McFadden 1974). This model can be derived from the above equations (1.2 and 1.3) by assuming that the unobserved component is independently and identically distributed (IID) following the Extreme Value type 1 distribution (see e.g. Hensher et al. 2015; Train, 2003). Although the MNL model provides a "workhorse" approach in CE, it includes a range of major limitations (see e.g. Fiebig et al. 2010; Greene and Hensher 2007; Hensher et al. 2015):

- Restrictive assumption of the IID error components
- Systematic, or homogenous, preferences allowing no heterogeneity across the sample
- Restrictive substitution patterns, namely the existence of independence of irrelevant alternatives property where introduction (or reduction) of a new alternative would not impact on the relativity of the other alternatives
- The fixed scale parameter obscures potential source of variation

Some or all of these assumptions are often not realised in collected data. These restrictive limitations can be relaxed in contemporary choice models. In particular, the random parameter logit (RPL) model (aka, the mixed logit model) has emerged in empirical application allowing preference estimates to vary across respondents (Fiebig, et al. 2010; Hensher et al. 2015; Revelt and Train, 1998). This is done by specifying a known distribution of variation to be parameter means. The RPL model probability of choosing alternative *j* can be written as:

$$\Pr_{nsj} = \frac{\exp(\beta_n' x_{nsj})}{\sum_J \exp(\beta_n' x_{nsj})} \quad (0.5)$$

where, in the basic specification, $\beta_n = \beta + \eta_n$ with η being a specific variation around the mean for k attributes in vector x (Fiebig, et al. 2010; Hensher et al. 2015). Typical distributional assumptions for the random parameters include normal, triangular and lognormal distributions, amongst others. The normal distribution captures both positive and negative preferences (i.e., *utility* and *disutility*) (Revelt and Train, 1998). The lognormal function can be used in cases where the researcher wants to ensure the parameter has a certain sign (positive or negative), a disadvantage is the resultant long tail of estimate distributions (Hensher et al. 2015). The triangular distribution provides an alternative functional form, where the spread can be constrained (i.e., the mean parameter is free whereas spread is fixed equal to mean) to ensure behaviourally plausible signs in estimation (Hensher et al. 2015). Further specifications used in modelling include parameters associated with individual specific characteristics (e.g, income) that can influence the heterogeneity around the mean, or allowing correlation across the random parameters. The heterogeneity in mean, for example, captures whether individual specific characteristics influence the location of an observation on the random distribution (Hensher et al. 2015). In this study, the frequency of visits to rivers, streams and lakes was used to explain such variance.

Another way to write this probability function (in eq. 1.4) (Hensher et al. 2015) involves an integral of the estimated likelihood over the population:

$$L_{njs} = \int_{\beta} \Pr_{nsj}(\beta) f(\beta|\theta) d\beta \qquad (0.6)$$

In this specification, the parameter θ is now the probability density function conditional to the distributional assumption of β. As this integral has no closed form solution, the approximation of the probabilities requires a simulation process (Hensher et al. 2015; Train, 2003). In this process for data *X*, *R* number of draws are taken from the random distributions (i.e. the assumption made by the researcher) followed by averaging probabilities from these draws; furthermore these simulated draws are used to compute the expected likelihood functions:

$$L_{nsj} = E(\Pr_{nsj}) \approx \frac{1}{R} \sum_{R} f(\beta^{(r)}|X) \qquad (0.7)$$

where the $E(\Pr_{nsj})$ is maximised through Maximum Likelihood Estimation. This specification (in eq. 1.6) can be found in Hensher et al. (2015). In practice, a popular simulation method is the Halton sequence which is considered a systematic method to draw parameters from distributions compared to for example, pseudo-random type approaches (Hensher et al. 2015).

A.3 Econometric Extensions

Common variations of the RPL model include specification of an additional error component (EC) in the unobserved part of the model. This EC extension captures the unobserved variance that is alternative-specific (Greene and Hensher 2007) hence relating to substitution patterns between the alternatives (Hensher et al. 2015). Empirically, one way to explain significant EC in a model is SQ-bias depicted in the stochastic part of utility if the EC is defined to capture correlation between the non-SQ alternatives (Scarpa et al., 2005).

Another extension which has gained increasing attention in recent CE literature, is the Generalized Mixed Logit (GMXL) model (Czajkowski et al. 2014; Hensher et al. 2015; Juutinen et al. 2012; Kragt 2013; Phillips 2014). This model aims to capture remaining unobserved components in utility as a source of choice variability by allowing estimation of the scale heterogeneity alongside the preference heterogeneity (Fiebig et al. 2010; Hensher et al. 2015). This scale parameter is (inversely) related to the error variance, and in convenient applications such as MNL or RPL, this is normalised to one to allow identification (Fiebig et al. 2010; Louviere and Eagle 2006). However, it is possible that the level of error variance differs between or within individuals, due to reasons such as behavioural outcomes, individual characteristics or contextual factors (Louviere and Eagle 2006).

Recent GMXL application builds on model specifications presented in Fiebig et al. (2010), stating that β_n (in eq. 1.4) becomes:

$$\beta_n = \sigma_n \beta + \gamma \eta_n + (1-\gamma)\sigma_n \eta_n \tag{0.8}$$

where σ is the scale factor (typically = 1) and $\gamma \in \{0,1\}$ is a weighting parameter indicating variance in the residual component. In the case the scale factor equals 1, this reduces to the RPL model. The importance of the weighting parameter is the impact on the scaling effect on the overall utility function (population means) versus the individual preference weights (individual means): when *γ* parameter approaches zero the scale heterogeneity affects both means, whereas when this approaches one the scale heterogeneity affects only the population means (Hensher et al. 2015; Juutinen et al. 2015). Interpretation of these parameters includes

- If *γ* is close to zero, and statistically significant, this supports the model specification with the variance of residual taste heterogeneity increases with scale (Juutinen et al. 2012); and
- If *γ* is not statistically significant from one, this suggests that the unobserved residual taste heterogeneity is independent of the scale effect, that is the individual-level parameter estimates differ in means but not variances around the mean (Kragt, 2013)

The scale factor specification (eq. 1.7) can also be extended to respondent specific characteristics associated with the unobserved scale heterogeneity (Hensher et al. 2015; Juutinen et al. 2015):

$$\sigma_n = \exp\{\overline{\sigma} + \tau \omega_n\} \tag{0.9}$$

where $\overline{\sigma}$ *is* the mean parameter in the error variance; and ω is unobserved scale heterogeneity (normally distributed) captured with coefficient *τ* (Hensher et al. 2015; Juutinen et al. 2015; Kragt, 2013). Juutinen et al. (2012), for example, in context of natural park management found that respondents' education level and the time spent in the park explained the scale heterogeneity ($\tau > 0$, p-value < 0.01). In this study, the respondents indicated levels of choice task understanding and difficulty were used to explain scale heterogeneity.

A.4 Estimation of Monetary Values

Typically the final step of interest in the CE application is the estimation of monetary values of respondent preferences for the attributes considered in utility functions. These are commonly referred to as marginal willingness-to-pay (WTP). WTP estimation is based on the marginal rate of substitution expressed in dollar terms providing a trade-off between some attribute k and the cost involved (Hensher et al. 2015) and is calculated using the ratio of an attribute parameter and the cost parameter. WTP can take into account interaction effects, if statistically significant, such as with the respondent demographics. WTP of attribute *j* by respondent *i* is calculated as the ratio of the estimated model parameters accommodating the influence of the random component (Cicia et al. 2013) as:

$$WTP_i^j = -\left(\frac{\beta_j + \varepsilon_{ij}}{\beta_{price} + \varepsilon_{ip}} \right) \tag{0.10}$$

The estimated mode parameters can also be used to estimate compensating surplus (CS) as a result of policy or quality change in a combination of attributes, using (Hanemann, 1984):

$$\mathbf{CS} = \frac{-1}{\beta cost} \left[\ln \sum_{j=1}^{J} \exp\left\{V_j^0\right\} - \ln \sum_{j=1}^{J} \exp\left\{V_j^1\right\} \right] \tag{0.11}$$

which calculates the difference in utilities before the policy or quality change (V_0) and after the policy or quality change (V_1) (Hanley et al. 2013; Lancsar and Savage 2004). Similar to WTP, the monetary estimation of this change is possible by using the estimate for the monetary attribute $\beta_{cost.}$. Lastly, there are some challenges associated with the empirical estimation of the WTP in the RPL based models. One approach is to use a fixed cost, which simplifies the WTP estimation (Daly et al. 2012) but which may not be as behaviourally a plausible consideration as allowing heterogeneous preferences towards the cost attribute (Bliemer and Rose, 2013; Daziano and Achtnicht, 2014). Conceptually, the estimated cost parameter is a proxy for the marginal utility of income for respondents and economic theory suggests individuals will respondent differently to varying income levels. The use of a random cost parameter however, presents complications in deriving population distribution moments from the ratio of two random parameters.