



Agribusiness and Economics Research Unit

A Lincoln University Research Centre.
New Zealand's specialist land-based university.

Estimating Bread Consumers' Willingness-to-pay for New Zealand Grown Grain as a Flour Ingredient

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April 2022



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Key Points

- The Agribusiness and Economics Research Unit at Lincoln University and the Foundation for Arable Research, has estimated willingness-to-pay values for selected attributes of bread by New Zealand consumers, with a focus on identifying preferences for New Zealand grown grain as a source of flour ingredient.
- This report presents results from a repeat of the same survey conducted in 2019. The descriptions of survey design and method are duplicated here so that the current report may function independent of the 2019 application. The results section details the new results, and a comparison of the two surveys is presented in Section 4 Comparison to 2019 survey.
- There are no observable market prices available that reveal what NZ residents are willing-to-pay for New Zealand grown grain as a source of flour ingredient. A non-market valuation methodology, choice experiments, was therefore used. This involved an online survey of New Zealand residents in February 2022 using a research panel.
- The survey process achieved 941 responses with good representation of key population demographics.
- Results indicate that many New Zealanders have significant positive preferences for New Zealand grown grain as a source of flour ingredient in bread loaves.
- We identify three groupings of bread loaf consumers and the probability that a randomly selected bread loaf purchaser belongs to that grouping.
- Group One is the largest with a membership probability of 54%. The average member of this group is willing-to-pay \$0.56 more for a bread loaf that is made with New Zealand origin flour over one that is not. These members are also interested in Organic production, environmental management claims and Added Health Claims.
- Group Three, with a 35% membership probability, has members on average willing-to-pay \$0.55 more for a bread loaf that is made with New Zealand origin flour over one that is not. They are also willing-to-pay for NZ Biodiversity Enhancement (\$0.39) and Added Health Claims (\$0.28).
- Group Two is the smallest of the three with a membership probability of 11%. The average member of this group is willing-to-pay \$0.14 more for a bread loaf that is made with New Zealand origin flour over one that is not.
- **Compared to the 2019 survey:** Consumer preferences for NZ origin flour have strengthened. With a significant increase in the number of respondents who indicate a positive willingness-to-pay for this bread attribute. And a moderate increase in the overall amount they are willing-to-pay.
- Preferences for NZ Organically produced flour is now significant compared to 2019 where they were not.
- Preferences for NZ Carbon neutral produced flour have fallen slightly but remain consistent with 2019.
- Preferences for NZ biodiversity enhancing produced flour remain consistent with 2019.
- Preferences for NZ water quality protection produced flour is now significant compared to 2019 where they were not.
- Preferences for flour with added health claims has expanded with a significant increase in the number of respondents with positive willingness-to-pay.
- Prices usually paid have increased and are significant for some bread types.

1 Introduction

This report details the development and application of a Choice Experiment survey used to identify and measure New Zealand residents' preferences for New Zealand grown grain as a source of flour ingredient in bread loaves. The concept of country-of-origin and its effect on consumer product evaluations and purchase choices has been extensively researched and been found to be an important consideration in food products as it can serve as a proxy for other attributes such as food safety or quality, and hence influence consumer preferences and purchase choices¹. Identifying and measuring country of origin preferences for ingredients in bread loaves sold in New Zealand using market data is currently precluded by the general absence of country-of-origin labelling. The lack of market transaction data makes valuing these attributes in economic terms much more difficult. The Choice Experiment method has previously been applied internationally and domestically within the food and beverage preference arena to estimate consumer values of product attributes². We used a Choice Experiment approach involving an online survey of the general public. This report provides willingness-to-pay estimates for selected attributes that could be included within a consideration of bread market strategies. The project involved collaboration between the Agribusiness and Economics Research Unit (AERU) at Lincoln University and the Foundation for Arable Research (FAR)³.

The project in 2019 comprised seven main phases:

1. Identification of selected bread attributes of interest
2. Literature review identifying approaches to Choice Experiment design relevant to the objectives
3. Development of the Choice Experiment questionnaire, combining literature review findings with client discussion, and results of cognitive interviews with the general public.
4. Administration of the resultant Choice Experiment survey to a representative sample of New Zealand residents using an online mode.
5. Analysing data employing appropriate econometric models.
6. Estimation of monetary values that residents have for selected bread attributes.
7. Reporting.

This project is applying the method and survey developed in 2019 and a comparison is made.

¹ Miller et al. 2016. High Value Nutrition: Country of Origin Literature Review. AERU Client Report, prepared for the High Value Nutrition National Science Challenge. Lincoln University: Agribusiness and Economics Research Unit.

² Tait et al. 2019. Estimating wine consumer preferences for sustainability attributes: A discrete choice experiment of Californian Sauvignon Blanc purchasers. *Journal of Cleaner Production*, 233:412-420. <https://doi.org/10.1016/j.jclepro.2019.06.076>

³ www.far.org.nz

1.1 Research Questions

The focus of this study is provided by the following key research questions:

- Where does the New Zealand consumer buy their bread from?
- How much do they pay for a loaf of bread?
- Do they understand the health benefits of eating wholegrain bread?
- Does the New Zealand consumer know where the grain in the bread that they buy comes from?
- Do they care where it comes from?
- Would consumers pay a premium for the New Zealand grown flour in the bread that they buy?
- Would consumers pay a premium for other bread attributes: a health attribute, organic production, environmental sustainability?

2 Method

2.1 Choice Experiment Method

The selection of economic measurement tools to value consumer preferences is driven primarily by the availability of appropriate data that can describe the product attributes to individuals. There is a dearth of observable market prices available that reveal what New Zealand residents are willing-to-pay for flour made from New Zealand grown grain. Therefore, a non-market valuation methodology is required of which Choice Experiments is appropriate. The Choice Experiment method simulates market observations by creating a hypothetical market scenario within a survey that enables people to indicate their preferences for changes in bread loaf attributes and the associated costs to them. In this way, a Choice Experiment produces information on quantities and prices similar to what is found in observed markets which can then be analysed to measure the influence of changes in bread loaf attributes on consumer's bread loaf choices. The method is grounded in the same Welfare Economics framework that facilitates the use of observed market prices to measure changes in the value of benefits and costs.

Originating in marketing research to test the influence of new product attributes on consumer choices, Choice Experiments have, for over four decades, also been more widely applied in economics to value a variety of goods and services such as transport, cultural heritage, environmental quality and health care. This approach has been previously applied in other countries to value bread product attributes where no market

data is available⁴ and has an established New Zealand literature across diverse applications⁵.

Choice Experiments are a survey-based method in which respondents are presented with a series of choice tasks. For each choice task, respondents choose between at least two broad options. In this study, the options represent alternative bread loafs with each described by several selected attributes. In each choice task, the combinations of attributes are systematically varied to denote different bread options. Respondents are asked to choose the option with the combination of attributes that they prefer. We assume that the options chosen by respondents are what they think are best for them.

Statistical information derived from these choice tasks is econometrically modelled to quantify the relative importance of each bread loaf attribute. By including one key monetary attribute in choice tasks, the monetary value of other non-monetary attributes can be calculated. Economists express this as willingness-to-pay, e.g. how much I am willing-to-pay to have a New Zealand grown flour ingredient.

2.2 Choice Experiment Survey Design

The survey design process was initiated with a meeting of the research team of the AERU and FAR to identify the central purpose of the research design, establish a set of research questions to be addressed, and to inform development of a draft survey. Comments from the research team on the initial draft were subsequently incorporated into a version for use in cognitive interviews with members of the general public that were used at this phase to explore consumer behaviours. Then followed an iterative approach to incrementally adapt the survey instrument in response to interview findings that culminated in a pre-test version circulated to the research team. That version was subsequently piloted on 100 respondents of the general public using an online mode. In this way, cognitive interviews were used to develop an understanding of bread purchase behaviour that informed the survey design, as well as to pre-test the finalised survey instrument.

⁴ Balcombe et al. 2014. Using Attribute Importance Rankings within Discrete Choice Experiments: An Application to Valuing Bread Attributes. *Journal of Agricultural Economics*, 0(2):446–462. Doi: 10.1111/1477-9552.12051.

Edenbrandt et al. 2017. Consumers' Preferences for Bread: Transgenic, Cisgenic, Organic or Pesticide-free? *Journal of Agricultural Economics*, 69(1):121–141, doi: 10.1111/1477-9552.12225.

Fiore et al. 2017. Predicting consumer healthy choices regarding type 1 wheat flour. *British Food Journal*, 119(11):2388-2405, doi 10.1108/BFJ-04-2017-0200.

Meyerding et al. 2018. Consumer Preferences for Superfood Ingredients—the Case of Bread in Germany. *Sustainability*, 10:4667, doi: 10.3390/su10124667.

Wongprawmas et al. 2016 Willingness-to-Pay for Multiple Units of Eco-Friendly Wheat-Derived Products: Results from Open-Ended Choice Experiments, *Journal of Food Products Marketing*, 22(6):658-682, doi: 10.1080/10454446.2015.1121438.

Zysk et al. 2019. Role of Front-of-Package Gluten-Free Product Labeling in a Pair-Matched Study in Women with and without Celiac Disease on a Gluten-Free Diet. *Nutrients*, 11:398, doi: 10.3390/nu11020398.

⁵Tait et al. 2017. Valuing conservation benefits of disease control in wildlife: A choice experiment approach to bovine tuberculosis management in New Zealand's native forests. *J. Environ. Manage.* 189:142-149, doi.org/10.1016/j.jenvman.2016.12.045.

2.2.1 Attributes and Levels

The following set of selected attributes to be included in the Choice Experiment design were:

- Country of origin for grain as flour ingredient
- Environmental sustainability
- Enhanced health claim
- Organic production
- Price per loaf

The levels for each bread attribute used in the Choice Experiment are presented in Table 1.

Table 1. Attribute descriptions and levels for choice tasks

Bread Loaf attributes	Description	Attribute levels				
Country of origin for grain as flour ingredient	The bread may be labelled with the country where the grain used to make the flour in the bread was grown .	No Label	Australia	New Zealand		
Environmental Sustainability	The bread may be labelled showing if it has been made using a management system that is either Carbon Neutral, Enhances Biodiversity, or Protects Waterways .	No Label	No Label	Carbon Neutral	Biodiversity Enhancement	Water Protection
Enhanced Health Claim	The bread may be labelled with a claim of additional health benefits compared to standard bread. For example, low GI, added fibre and vitamins, or reduced fat, sugar, salt and carbohydrates.	No Label	No Label	Certified		
Organic Production	The bread may be labelled showing if both growing and processing are organic without GMOs or synthetic fertilisers or agrichemicals.	No Label	No Label	Certified		
Price per loaf	Dietary Requirements (GF/DF/Vegan)	\$6.50, \$7.00, \$7.50, \$8.50, \$9.00, \$9.50, \$10.00, \$10.50				
	All Other bread types	\$1.50, \$2.00, \$2.50, \$3.00, \$3.50, \$4.00, \$4.50, \$5.50				

2.2.2 Experimental Design

It is not possible to present respondents with all possible combinations of attribute levels (Table 1). Instead, Experimental Design methodology is used to create combinations of attribute levels, which represent a subset of the total combinations possible, and maximise the amount of statistical information available. These combinations are formed into choice sets. Figure 1 presents an example of a choice set shown to respondents. Each choice set comprises three options representing alternative bread loaves described

by varying combinations of the attribute levels presented in Table 1. An opt-out option is also included “I would buy a different bread loaf.”

The study employs NGene⁶ software to apply a D-efficient fractional factorial design approach⁷. Providing information on the likely values of model coefficient estimates improves this process. For the initial experimental design, we looked at similar studies for design parameters, then updated these with coefficient estimates from a model fitted to pilot survey data (n=100). The resulting updated experimental design is applied to the remaining number of respondents with each respondent answering seven choice sets.

Set 1 of 7 In this question, imagine you are **buying a loaf of bread** from your usual retailer for personal consumption. **Which of the following bread loaves do you prefer?**

	Loaf A	Loaf B	Loaf C	
Organic Production				
Enhanced Health Claim	Certified		Certified	
Environmental Sustainability	Biodiversity Enhancement		Biodiversity Enhancement	
Country where the grain to make flour was grown		Australia	NZ	
Price/loaf	\$2.00	\$2.00	\$5.50	
Selection:	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/> I would choose a different loaf

Figure 1. Example choice set presented to respondents

2.2.3 Cognitive Interviews

Cognitive Interviews are a leading methodology for testing questionnaires during design and implementation phases. The central aim is an assessment of whether respondents comprehend questions as intended by the researcher and whether questions can be answered accurately⁸. The method involves respondents being prompted individually to respond to a questionnaire by an interviewer who asks them to think aloud as they go through the survey and tell the interviewer what is being thought about the questions and how answers are being formed. The interviewer probes in order to explore issues including interpretation of questions.

Cognitive interviews were employed in 2019 to obtain feedback on draft questionnaires from a number of people in order to identify wording, question order, visual design, and navigation problems. Six interviews were conducted across a mix of gender, age, and occupation, each with duration of 1 to 1.5 hours.

⁶ ChoiceMetrics. 2014. Ngene 1.1.2 User Manual & Reference Guide, Australia.

⁷ Cook RD, Nachtsheim CJ. 1980. A comparison of algorithms for constructing exact D-optimal designs. *Techometrics* 22:315-324.

⁸ Dillman DA, et al. 2009. *Internet, Mail, and Mixed-Mode Surveys: The Tailored Design Method*. -3rd ed. John Wiley & Sons Inc., Hoboken, New Jersey.

2.2.4 Survey Administration

The sample of New Zealand resident respondents was obtained from Dynata™ (dynata.com), a research consultancy that provides analytical services and maintains one of the largest global databases of survey respondents. Their panel of members is paid for completed surveys. This sampling method allowed for the pre-stratification of the sample by age, gender, income, and regional location. That would not be possible if drawing a sample from the commonly used Electoral Roll which does not include most of these variables. This sampling method was also chosen based on the research timeframe that precluded the use of a mail-and-return mode.

Prior to full launch of the survey instrument, we conducted a pilot study with a subsample of the population (n=100) in order to evaluate interconnections among questions, the questionnaire, and the implementation procedure. This confirmed that the survey instrument was functioning appropriately.

An Internet-based survey of a sample of New Zealand residents from an online panel was conducted 17-28 February using contact details obtained from a database maintained by Dynata™. The final sample consisted of 941 usable responses from throughout New Zealand.

The survey was administered using an online survey mode employing Qualtrics™ online survey software, and proprietary software for implementing Choice Experiment surveys maintained by AERU. The process consisted of contact through an email invitation to New Zealand residents that contained a link to the online survey.

3 Results

3.1 Sample Characteristics

A total of 941 useable responses were collected from New Zealand residents.

Table 2 describes the composition of the sample by various demographic variables, including location. To determine whether the sample is representative of the general New Zealand population, we statistically tested that the distribution of the observed sample demographics was consistent with that of the general population, as provided by Statistics New Zealand data. The sample composition overall is a good representation of the New Zealand population, however there is overrepresentation of tertiary education, and of higher income brackets.

Table 2. Sample characteristics

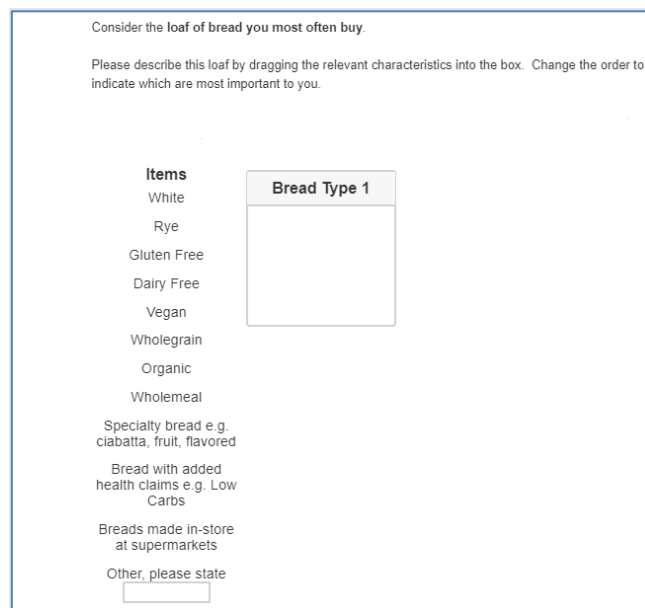
Demographic Variable		Sample Distribution (%)	NZ Population Distribution (%) ¹
Age [p = 0.93] ²	18 - 24 years old	9	12
	25 - 34 years old	17	18
	35 - 44 years old	19	16
	45 - 54 years old	18	18
	55 - 64 years old	17	16
	65 years old or more	20	20
Gender [p = 0.70]	Female	53	51
Education [p < 0.00]	None	5	21
	High school	25	50
	Trade/technical qualification or similar	31	9
	Undergraduate diploma/certificate/degree	26	14
	Postgraduate degree	12	6
Ethnicity [p = 0.18]	New Zealand European / European	77	67
	Māori	9	13
	Pacific Islander	3	6
	Asian	11	14
Occupation ³ [p = 0.22]	Unemployed	8	4
	Retired	18	14
	Unpaid voluntary work	1	1
	Student	3	6
	Paid employment	61	65
	Home duties	7	8
Personal Income [p = < 0.00]	Loss	1	1
	\$0 - \$20,000	6	16
	\$20,001 - \$40,000	21	24
	\$40,001 - \$70,000	25	34
	\$70,001 - \$100,000	19	14
	\$100,001 - \$150,000	17	7
Household Size [p = 0.49]	\$150,001 or more	11	4
	One	16	22
	Two	37	34
	Three	20	17
	Four or more	27	27
Region [p = 0.99]	Auckland	32	33
	Bay of Plenty	5	7
	Canterbury	13	13
	Gisborne	1	1
	Hawke's Bay	4	4
	Manawatu-Wanganui	6	5
	Marlborough	1	1
	Nelson	1	1
	Northland	3	4
	Otago	5	5
	Southland	2	2
	Taranaki	3	2
	Tasman	1	1
	Waikato	10	10
Wellington	12	11	
West Coast	1	1	

¹ Distributions from Statistics NZ Census 2018. ² Values in brackets are p-values for Pearson's Chi-squared test of the null hypothesis that the frequency distribution of the observed sample demographic variable is consistent with the population distribution provided by Statistics NZ Census 2013 data. A p-value less than 0.1 indicates a statistically significant difference between the distributions; p-values greater than 0.1 indicate that the demographic distribution is not statistically different to the population and therefore are representative of the general population. ³ Population distributions from 2013 Household Labour Force Survey.

3.2 Consumption and Purchase Behaviour

The survey began by asking respondents to describe the types of loaves they usually buy, how many of these types of loaves they usually buy in a fortnight and how much they usually pay per loaf. To elicit this information a question format was designed that allowed consumers to combine the bread loaf characteristics that they used to describe the main types of bread loaves that they buy. Respondents ranked items to indicate the main characteristic of the bread loaf (Figure 2).

- Respondents were able to construct up to three bread loaf formulations, with all respondents completing the bread loaf they most often buy, 49% of respondents constructed two loaves, and 26% provided three. In total 1,745 loaves were detailed.
- The number of items used to describe each loaf changed over the number of loaves described. Half of the main (first) loaves were described using two or more items, and a quarter used at least three items. While the majority of subsequent loaves were described using a single item.



Consider the loaf of bread you most often buy.

Please describe this loaf by dragging the relevant characteristics into the box. Change the order to indicate which are most important to you.

Items

- White
- Rye
- Gluten Free
- Dairy Free
- Vegan
- Wholegrain
- Organic
- Wholemeal
- Specialty bread e.g. ciabatta, fruit, flavored
- Bread with added health claims e.g. Low Carbs
- Breads made in-store at supermarkets
- Other, please state

Bread Type 1

[Empty box for drag-and-drop items]

Figure 2. Drag-and-drop bread loaf description exercise

- Of the total number of bread loaves described (1,745), wholegrain was the item used most often (42%) (Figure 3)

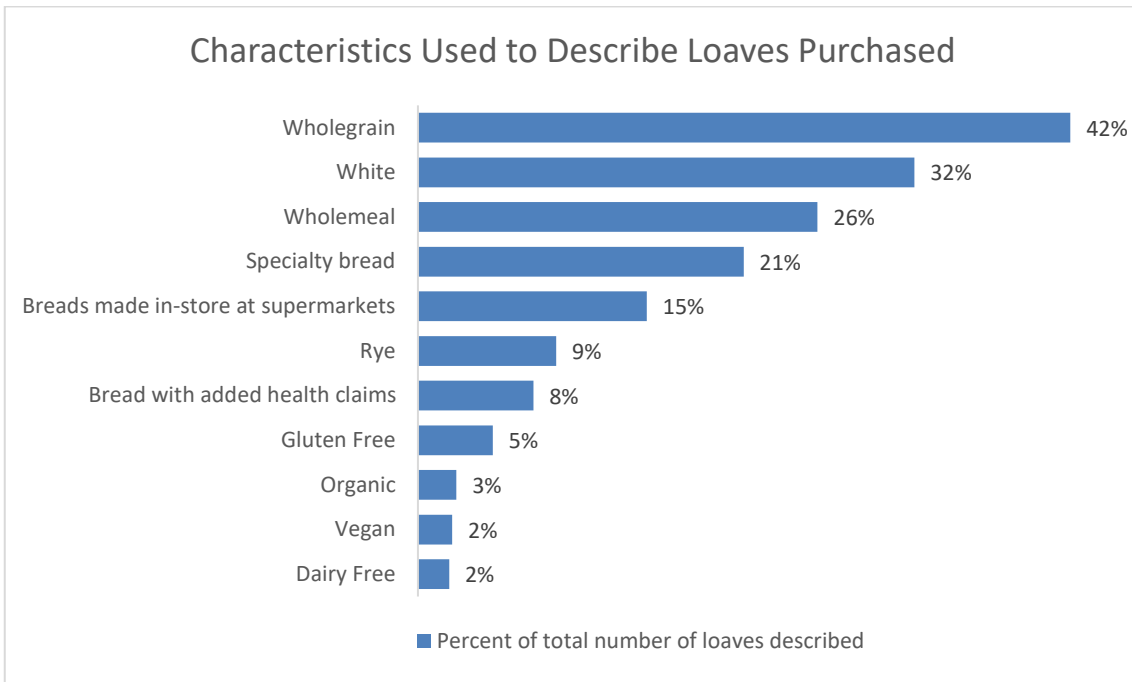


Figure 3. Characteristics used to describe loaves purchased

- Over all loaves, wholegrain was ranked as the most important characteristic most often (30%) (Figure 4).

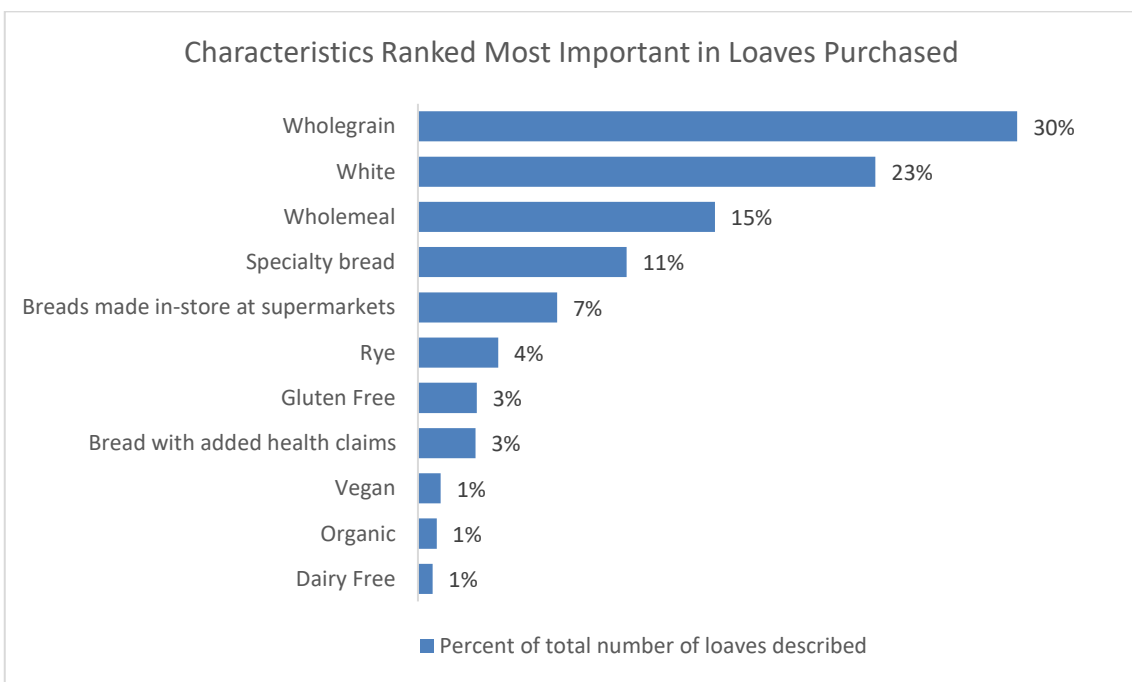


Figure 4. Characteristics ranked first

- The average number of loaves purchased in a fortnight reported by respondents was 4.7 loaves (Figure 5).

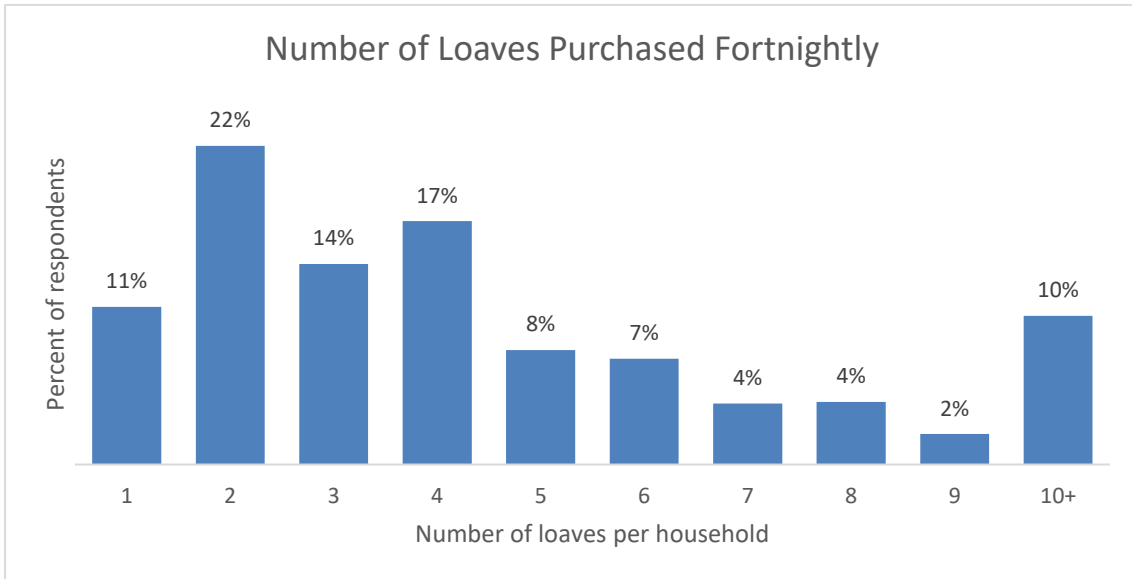


Figure 5. Number of loaves purchased fortnightly per household

- When we account for the number of people in each household, the total number of loaves purchased in a fortnight ranged from 1 to 15, with an average of 2.0 loaves per person per fortnight (Figure 6).

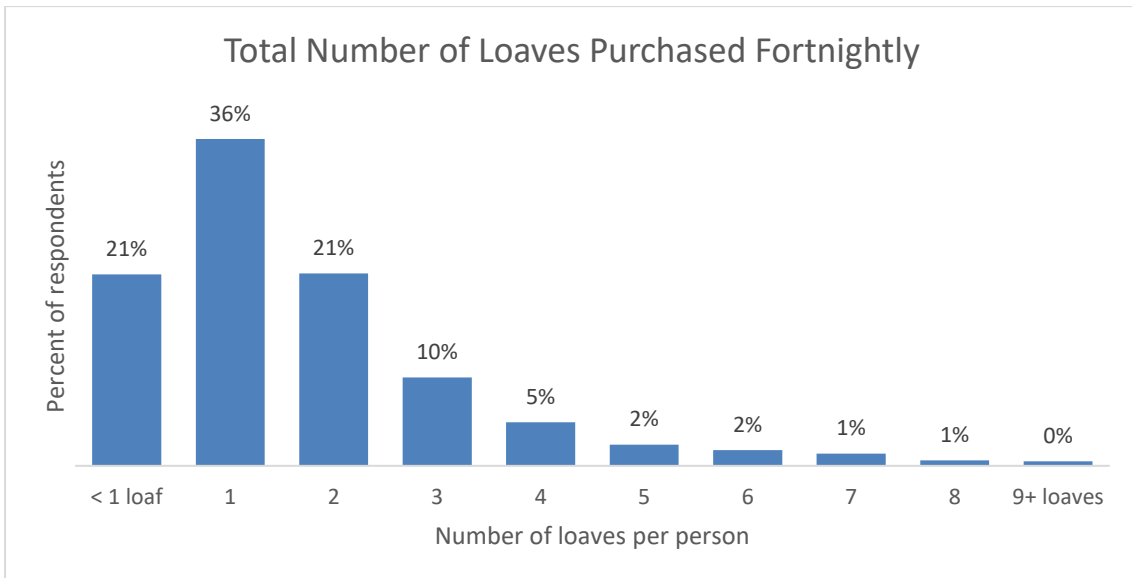


Figure 6. Number of loaves purchased fortnightly per person

- When we break down the purchase frequency by the main bread characteristic selected, we can see that purchase frequency is highest for those consumers who have dietary requirements, with an average of 1.3 loaves per person per fortnight for vegan and dairy-free bread loaves (Figure 7).

- Whereas those consumers who prefer 'specialty' breads purchase the least number with an average of 0.5 loaves per person per fortnight.

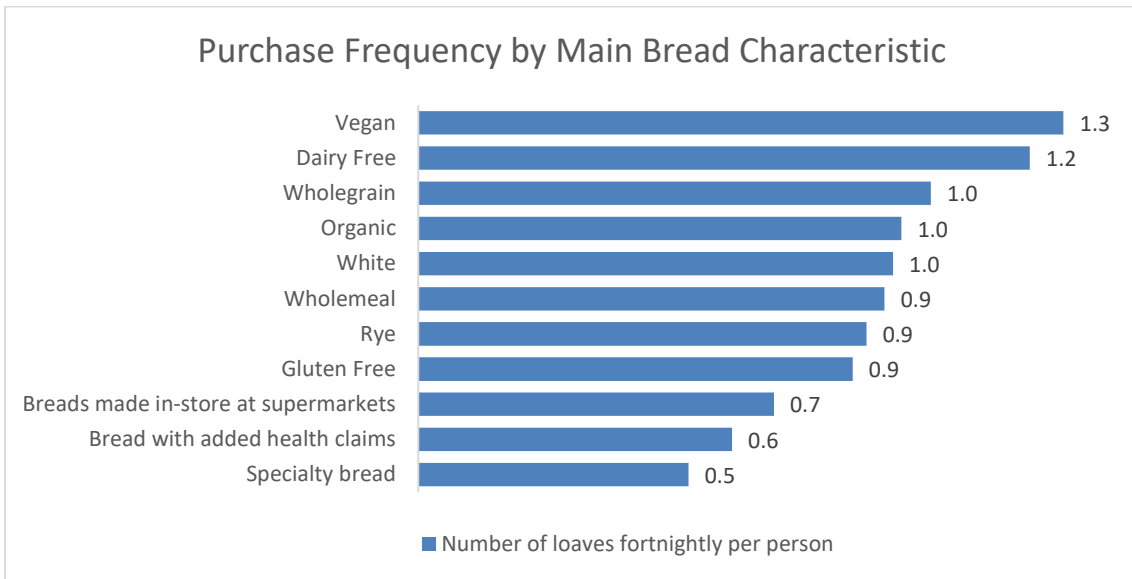


Figure 7. Purchase frequency by breads main characteristic

- Respondents paid on average \$3.75/loaf. At either end of the price range, one small group paid \$1-\$1.99/loaf (13%) and another over \$10/loaf (2%) (Figure 8).

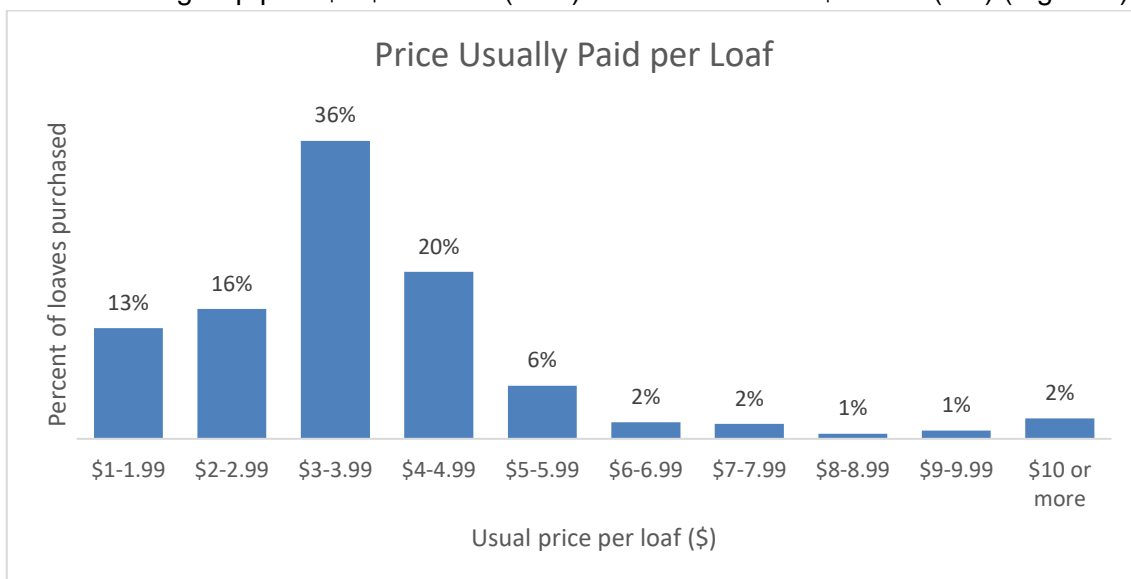


Figure 8. Price usually paid per loaf

- Breaking down price per loaf by the main bread characteristic shows that those consumers who prefer 'white' bread pay the least on average at \$2.99/loaf (Figure 9), while those with dietary requirements pay some of the highest prices.

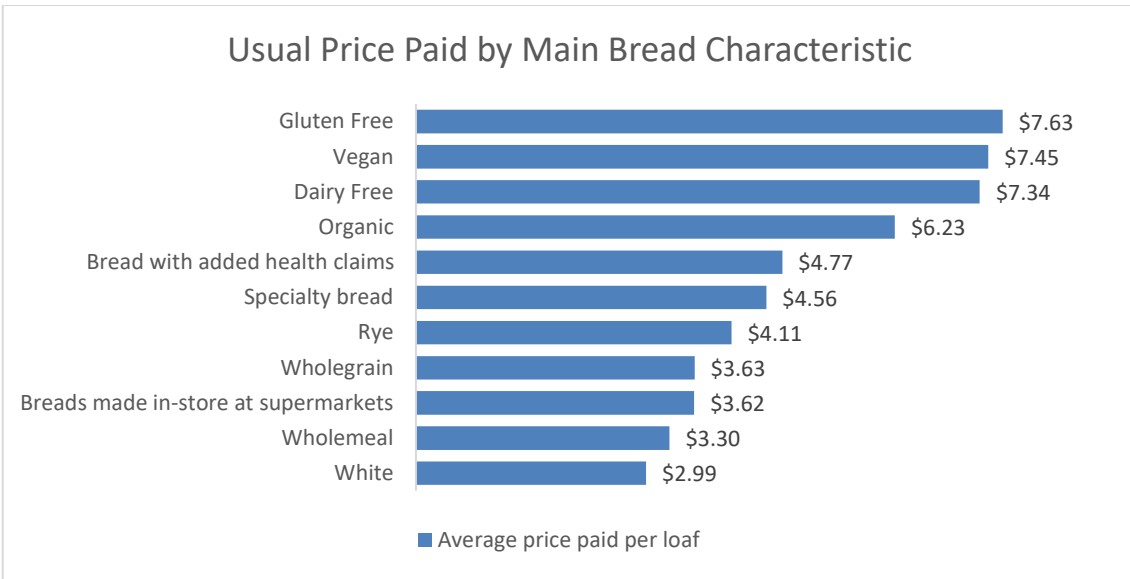


Figure 9. Usual price paid by main bread characteristic

- Those respondents who purchased breads with a 'wholegrain' characteristic were asked to indicate what if any health benefits that they consider 'wholegrain' bread to provide (Figure 10).
- The most common health benefit associated with wholegrain bread was higher fibre content (22%) and this is consistent with the next most described benefit being gut health and digestive benefits (18%).
- 12% thought there were benefits but were not able to describe them.

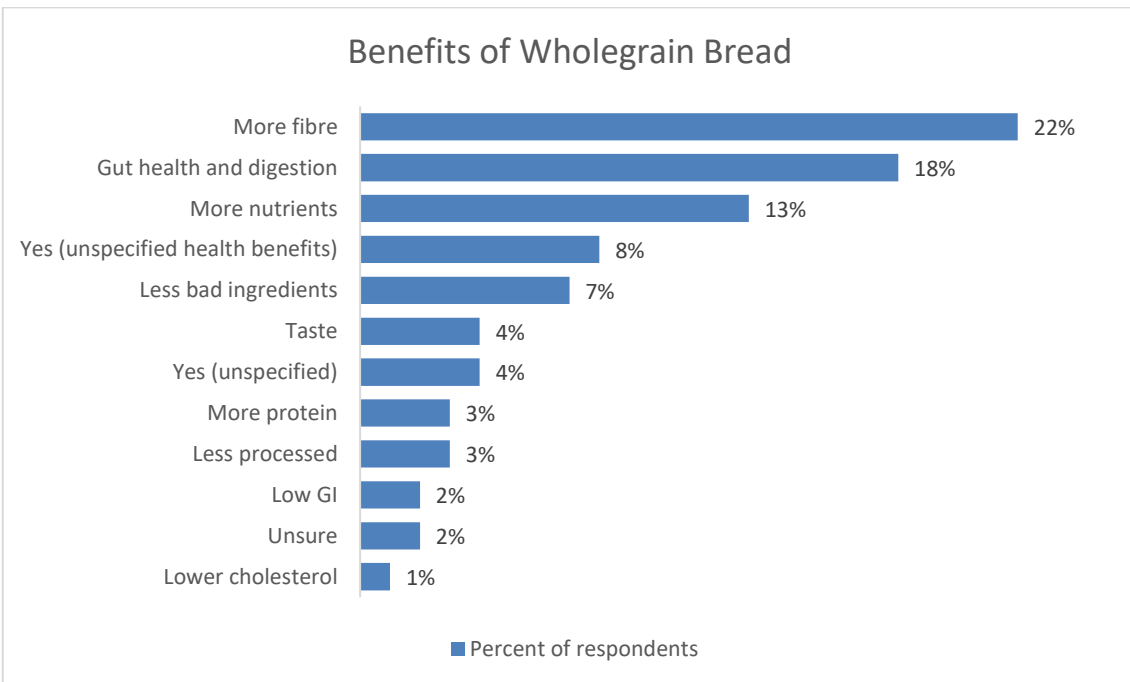


Figure 10. Benefits of Wholegrain Bread

- The vast majority of consumers prefer to purchase their bread from supermarkets with 52% of consumers only using this retailer (Figure 11).

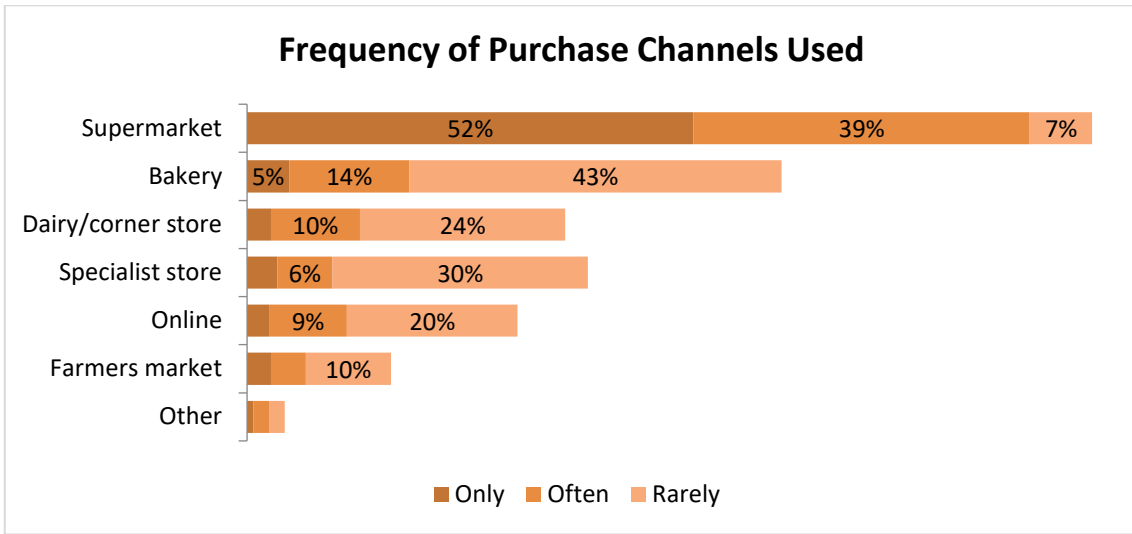


Figure 11. Frequency of purchase channels used

- While some respondents reported buying only one bread brand regularly there was also considerable interest across a number of brands (Figure 12).

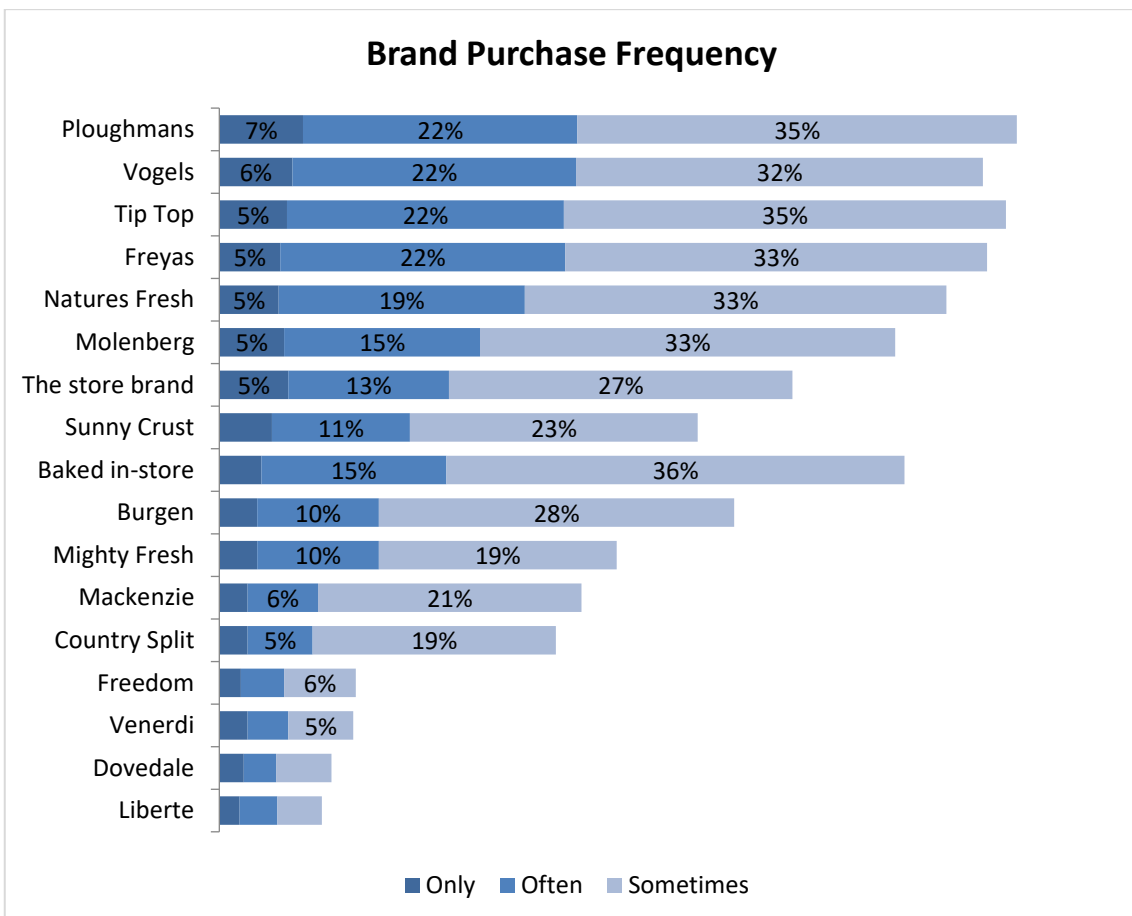


Figure 12. Brand purchase frequency

- Respondents were asked to consider whether their expenditure on bread loaves has changed since the same time last year.
- Most respondents had not changed their overall expenditure, while 30% had increased their expenditure and 6% had decreased expenditure, meaning that overall expenditure has increased (Figure 13).

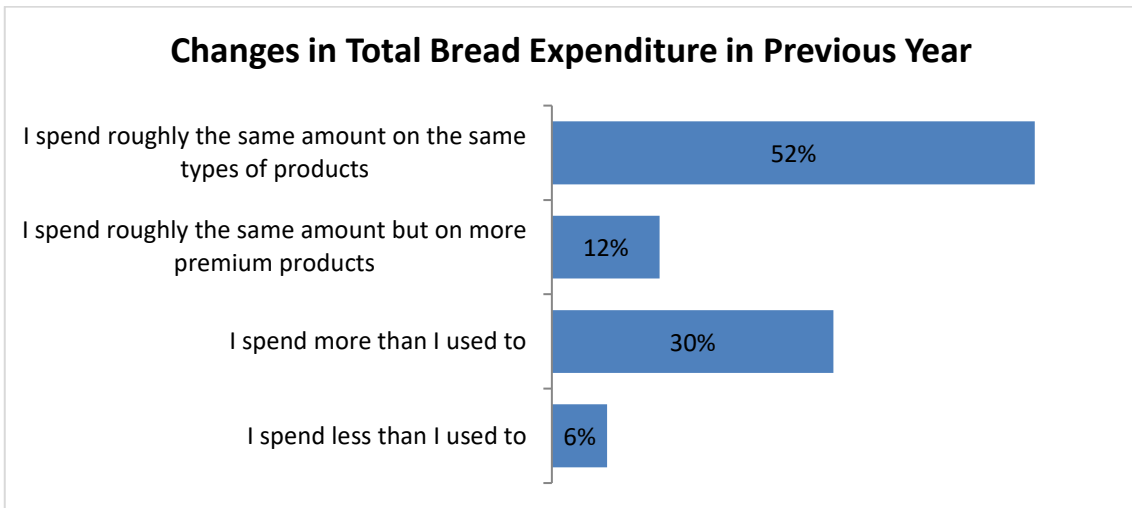


Figure 13. Changes in total bread loaf expenditure in previous year

- The main reason for increases in bread expenditure was price increases (Figure 14).
- Changes in income and number of family members was associated with both expenditure increases and decreases.

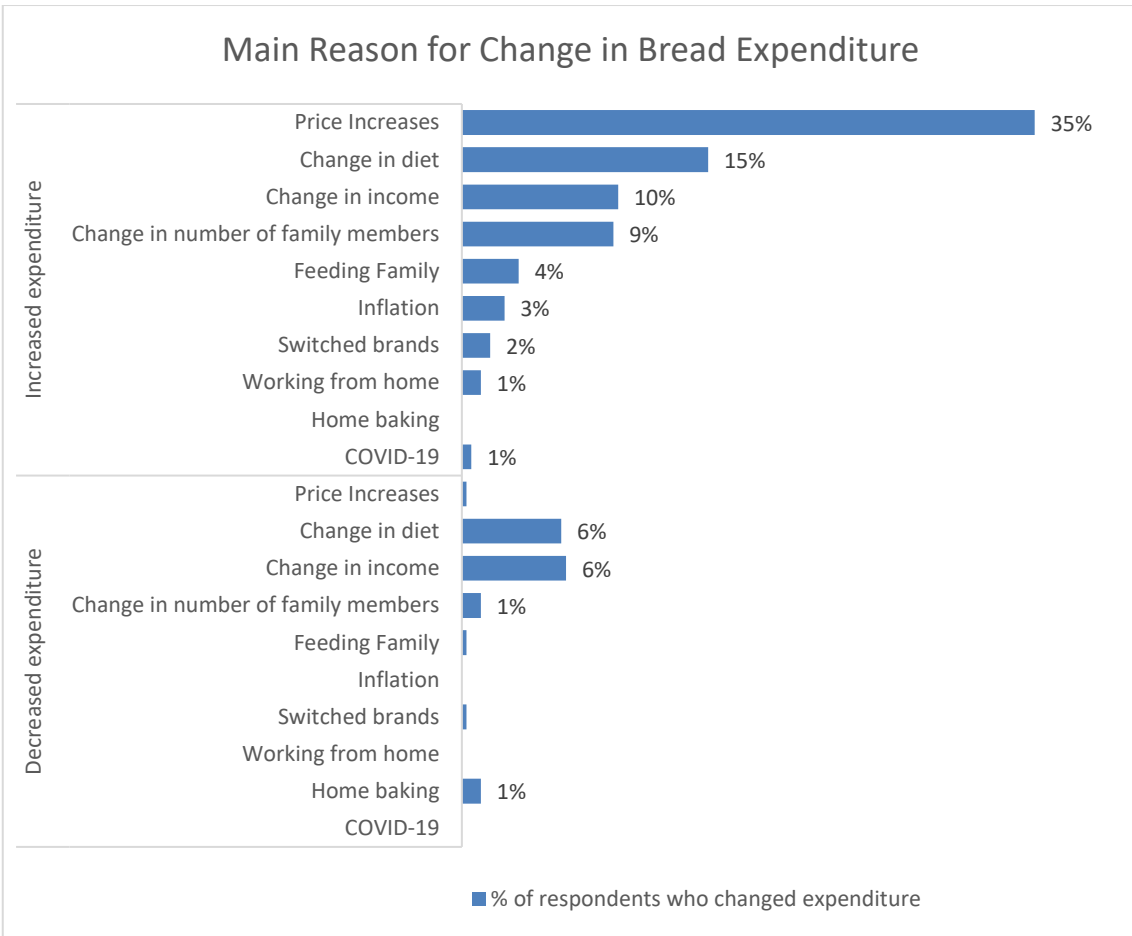


Figure 14. Main reason for change in bread expenditure

- Respondents were asked how important it is to them where the grain used to make flour in the bread they buy is grown (Figure 15). A third of respondents thought that it was moderately or very important to them.

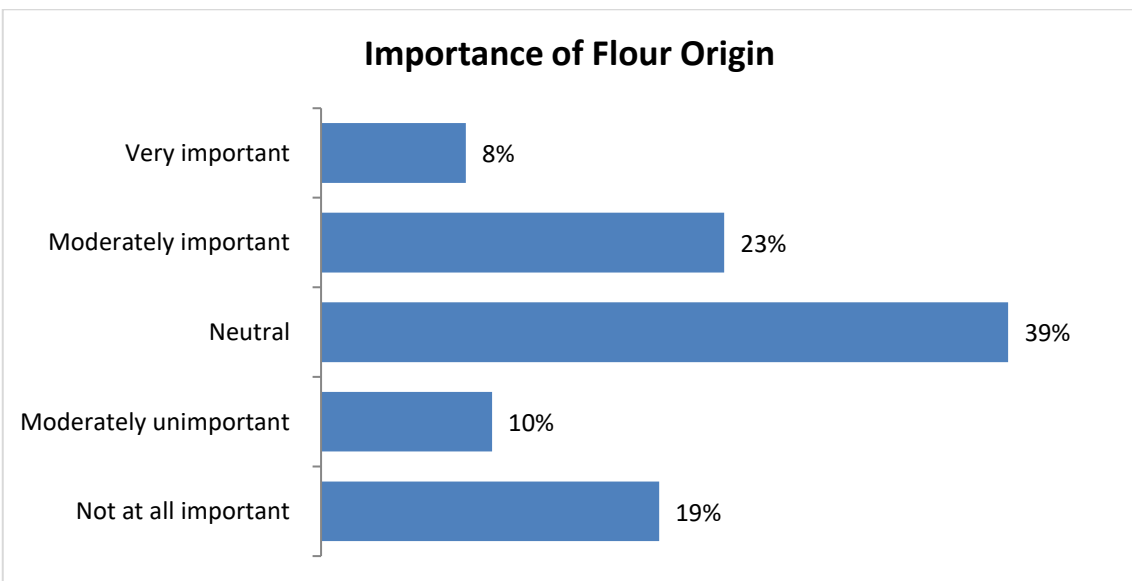


Figure 15. Importance of flour origin

- Those respondents who indicated that it was important were asked to describe, in a text response, *where* they thought the grain used to make flour in their bread purchases comes from, and *why* it matters to them (Figure 16).
- Of the 295 respondents who had previously indicated that it was important, 260 provided an answer (88%).
- From those respondents, indications of origin were typically given with a degree of uncertainty, with qualifiers including ‘probably’ and ‘maybe’ used in most cases.
- A majority thought that New Zealand or Australia was the origin (53%), while the remaining did not know or could not provide an answer.

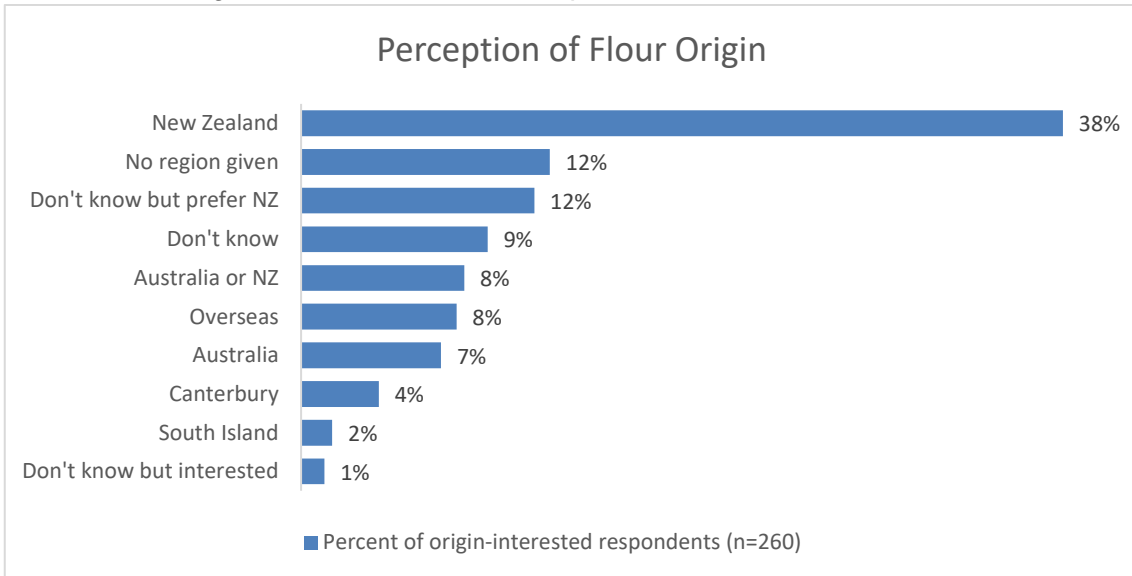


Figure 16. Perception of flour origin

- These respondents considered origin important mainly to support local New Zealand enterprises and growers and for high quality product (Figure 17).
- The relevance of environmental impacts also comes through as a significant reason for local origin being important with lower ‘Food Miles’ the most frequent environmental benefit of local production stated.

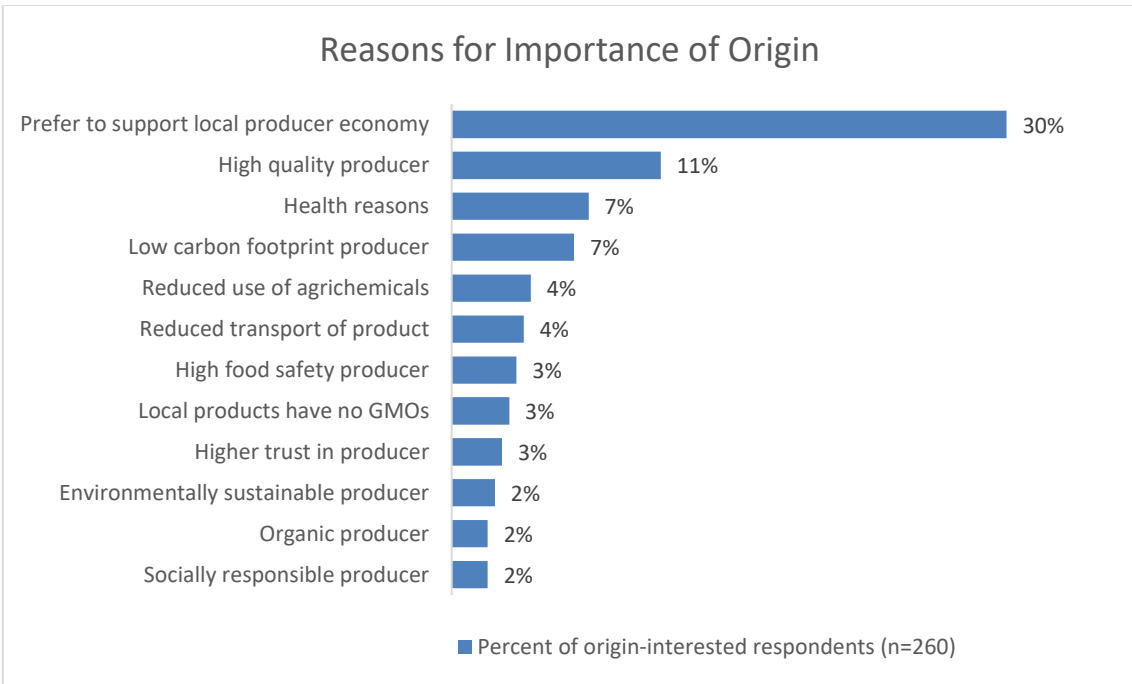


Figure 17. Reasons for importance of origin

- All respondents were then asked to indicate how much of the grain used to make flour ingredients in the bread they buy comes from various countries (Figure 18). Although India, China and the USA do not currently provide flour ingredient into New Zealand, they are included in the question design to avoid leading the respondent's selection.
- Over two thirds of respondents thought that at least *some* flour came from New Zealand and half thought some came from Australia. However, many respondents suggested countries that currently do not supply New Zealand. The wide-ranging responses suggest that there is a relatively mixed level of awareness within a considerable proportion of consumers.

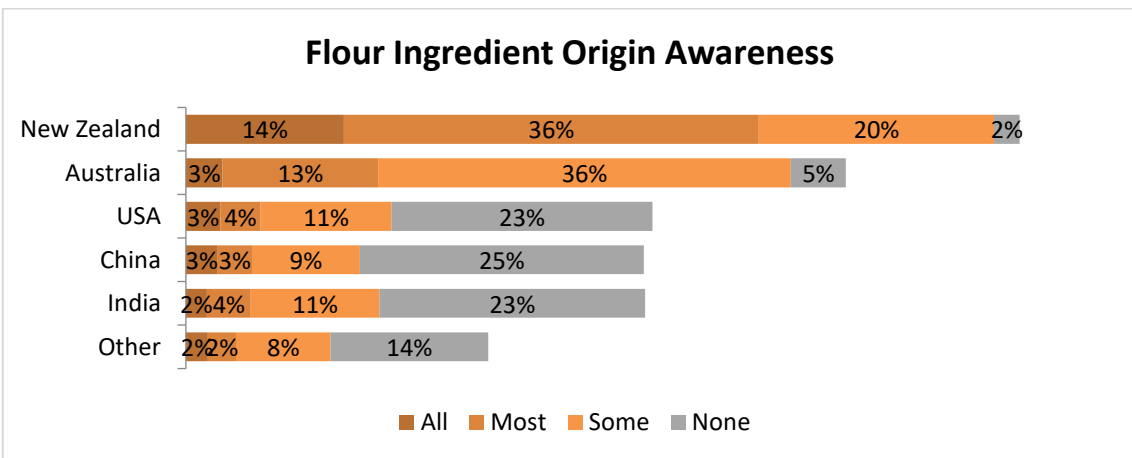


Figure 18. Flour ingredient origin awareness

- When considering which bread loaf to buy, sensory attributes such as freshness and texture rank highest in importance to consumers (Figure 19).
- Familiarity and past experience are also important to consumers.
- Local production is important to over half of respondents and 46% of consumers consider New Zealand grown grain flour ingredient as important.

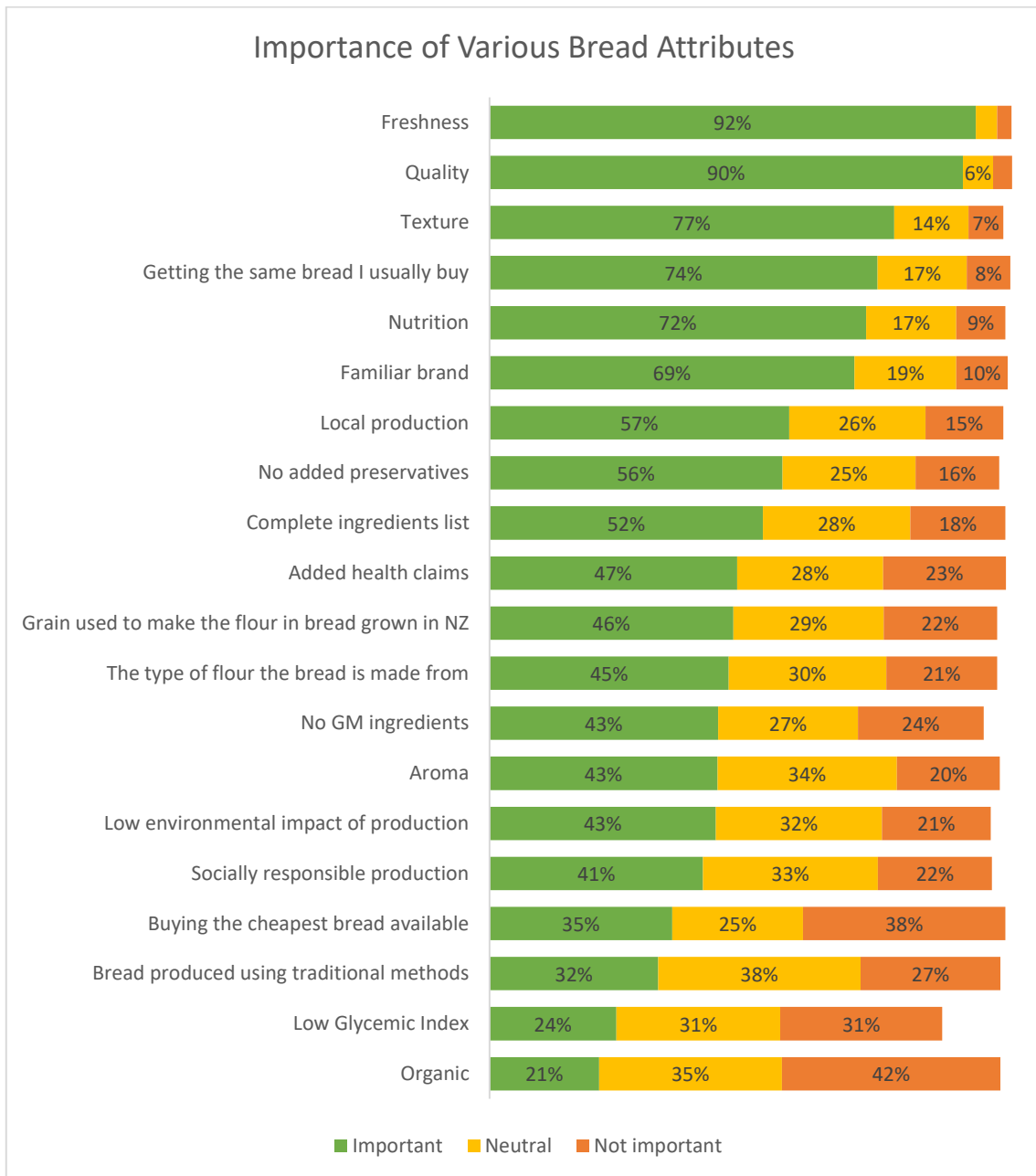


Figure 19. Importance of various bread attributes

- Respondents were asked to indicate their level of agreement with a series of statements describing the use of labels on bread loaves (Figure 20).
- Only about a third of respondents indicated that they pay attention to labels while a similar sized group indicated that they would be interested in more detailed labelling.

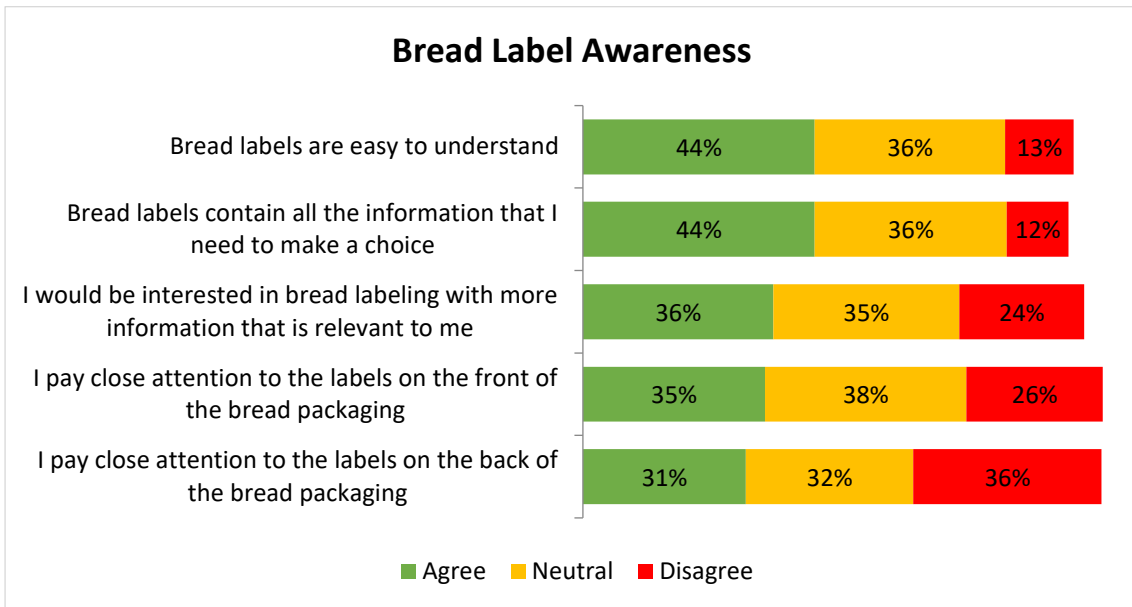


Figure 20. Bread label awareness

3.3 Choice Experiment Results

The outcomes associated with respondents chosen bread loaf option, and those from the other options that they did not select, are analysed using a Latent Class model (see Appendix A for technical details). This model segments individuals into a number of classes across which preferences vary discretely and provides an estimate of the proportional size of each class. We apply this model to test for the influence on bread choices of the attributes in the choice sets.

When making choices, respondents may select the “I would buy a different loaf of bread” option in a choice task rather than select one with an associated cost (see Figure 1). This is usually a truthful indication of their *unwillingness to pay* for the bread options presented in the choice tasks. This option was chosen 1,012 times in total (15% of all 6,587 choices across the sample). Respondents who chose this option more than four times (n=23) were asked a follow up question to ascertain their main reason (Figure 20).

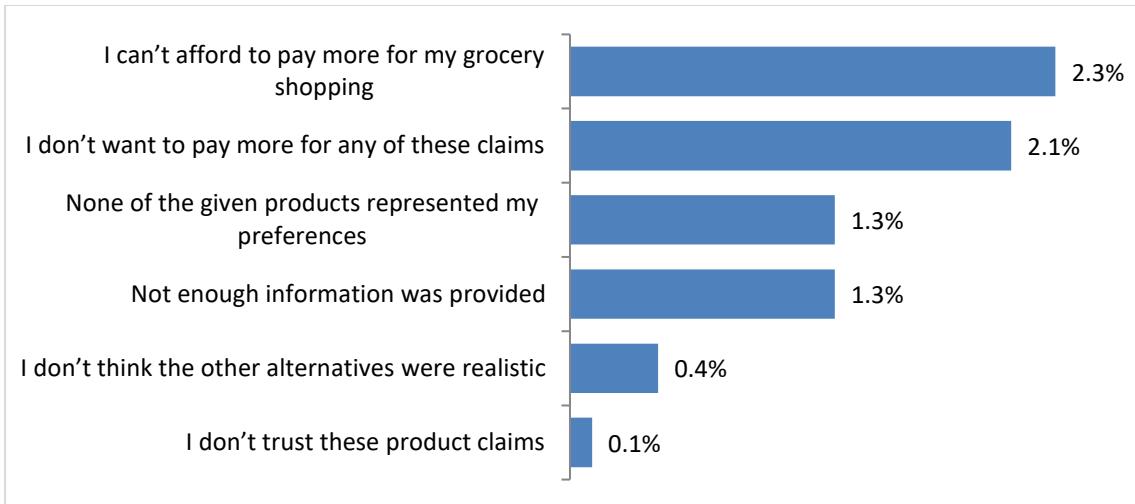


Figure 21. Main reason for “I would buy a different bread loaf” option choices

An underpinning statistical assumption is that all the information that a respondent sees in a choice set has a role to play in determining their choice of bread loaf option. If respondents ignore some of the attributes when they select their preferred option, this assumption is weakened and requires further examination. Following the choice experiment task, respondents were asked to indicate to what degree they paid attention to each attribute (Figure 22). We can see that each attribute is ignored to some degree, and most attended was Price. To determine whether incorporating this information improves statistical modelling we fit a stated attribute non-attendance model but find no improvement on the results presented in Table 3.

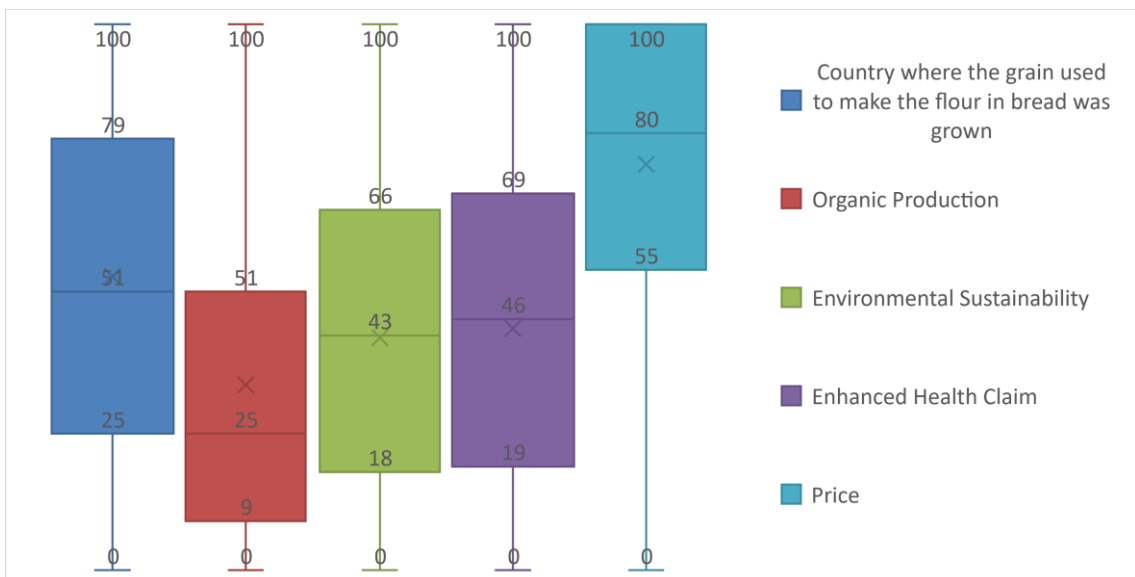


Figure 22. Box and whisker graph of reported attendance to bread loaf attributes in choice tasks (0% = No attendance, 100%= Full Attendance)

Following the choice tasks, respondents are asked a series of debriefing questions to ascertain their ability to reliably complete the choice experiment exercise (Figure 23). While overall understanding and ability to complete are relatively high, about 8% of respondents had some difficulty in understating the choice experiment process and in interpreting the meaning of attributes. Respondents who find choices difficult to make or do not understand the choice task process may have higher variability in the way they make choices compared to respondents' who do not, and these effects can influence the reliability of modelling results. We test for the inclusion of this information in modelling using a Generalised Mixed Logit model specified using a respondents' indication of choice task difficulty and understanding, but find no improvement on the results presented in Table 3. To ameliorate hypothetical bias, respondents' choice data are weighted by their indication of how certain they are that their choices reflect real-world decisions, with the effect of weighting down uncertain respondents, and subsequently lowering average willingness-to-pay.

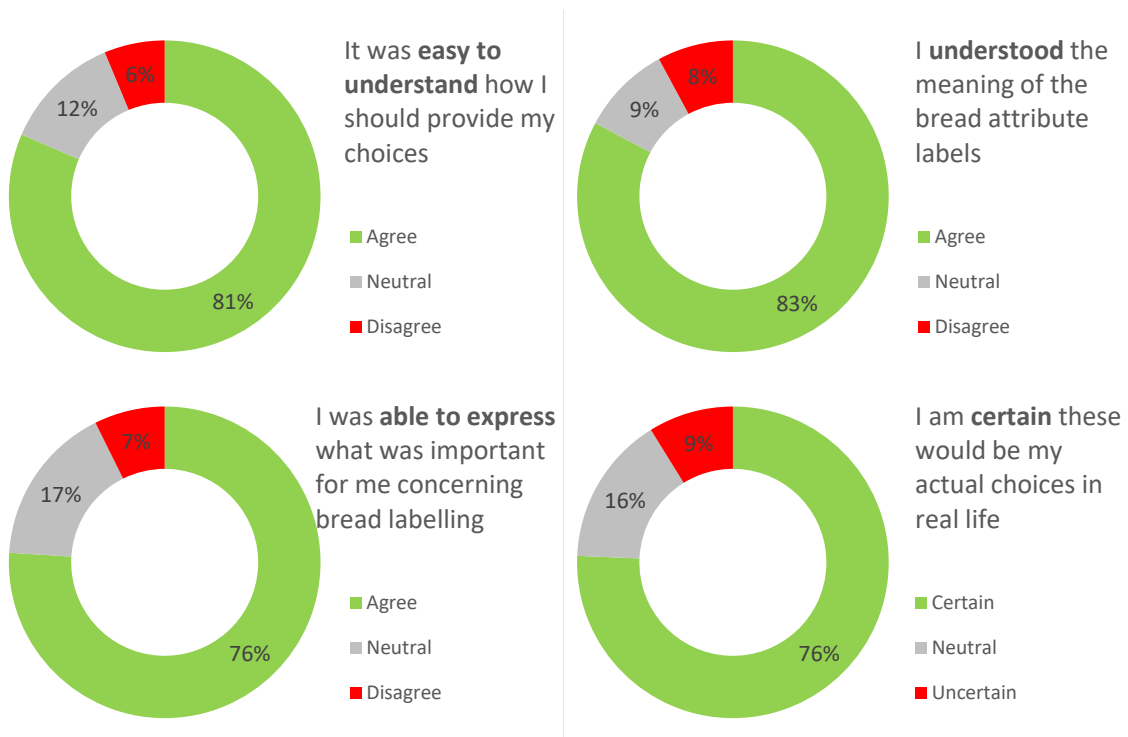


Figure 23. Choice task debriefing questions: task understanding, ability to express preferences, attribute understanding, certainty of choices made

The choice experiment data allows us to estimate parameters that represent consumers' marginal utilities for different product attributes, while the ratio of any two coefficients represents the marginal rate of substitution of one attribute over the other-how a consumer trades off each against another. Willingness-to-pay estimates are formed when we calculate the trade-off between an attributes estimated coefficient and the price per loaf coefficient.

The comparative advantage of the Latent Class model is that it facilitates the identification of market segments (i.e., different groups of consumers with similar underlying preference) via covariates in the class membership function. Each probability reported refers to the probability that a randomly selected bread loaf purchaser belongs to that class. The estimated thetas, when statistically significant, indicate whether the class

membership variable is positively or negatively correlated with membership in that class, compared to membership in class three. We tried multiple combinations of potential class membership variables and ultimately selected a combination of variables that improved model fit.

By conventional econometric standards, the model reported in Table 3 performs well in representing respondent choices given the attributes presented to them. Consistent with economic demand theory, the coefficient on price is negative and significant meaning that consumers prefer bread loaves that cost less. The coefficient on the 'opt-out' option is negative and significant indicating that, overall, respondents prefer to select from the bread loaf options presented than to opt-out. The model does show a statistically significant negative effect for Australian origin for the majority of respondents that indicates that most consumers would prefer not to have this source if given a New Zealand alternative.

Table 3. Latent Class bread choice model

Utility parameters	Class 1	Class 2	Class 3
New Zealand Origin	1.43***(0.07)	0.73***(0.22)	0.71***(0.10)
Australian Origin	0.23** (0.09)	- 0.72***(0.30)	- 1.99***(0.24)
Organic Production	- 0.91***(0.13)	- 1.11***(0.46)	- 2.90***(0.24)
Organic*NZ	0.81** (0.34)	1.44 (1.52)	0.25 (2.58)
Carbon Neutral	- 1.03***(0.09)	- 0.87***(0.33)	- 1.25***(0.34)
Carbon Neutral*NZ	1.39* (0.11)	1.00 (1.10)	0.41 (0.44)
Biodiversity Enhancement	- 1.23***(0.09)	- 1.71***(0.37)	- 4.37* (2.48)
Biodiversity Enhancement*NZ	1.06***(0.11)	0.17 (0.47)	4.98***(2.48)
Water Quality Protection	- 0.42***(0.08)	- 2.23 (1.92)	- 0.21* (0.11)
Water Quality Protection*NZ	0.86***(0.12)	1.02 (0.93)	0.01 (0.16)
Added Health Claim	0.51***(0.05)	- 0.50***(0.20)	0.36***(0.07)
Price per loaf	- 2.53***(0.31)	- 5.17***(0.68)	- 1.30***(0.42)
Opt-out option	0.14 (0.28)	- 0.11 (0.11)	- 0.34***(0.04)
Average class probability	0.54	0.11	0.35
Model Fit Statistics			
Log Likelihood function	- 7,299		
Log Likelihood chi ² stat (47 d.f.)	3,663***		
McFadden Pseudo R ²	0.21		
Number of observations	6,587		
Number of respondents	941		

***, **, * denote statistical significance at the 1%, 5% and 10% levels respectively for the null hypothesis that a parameter estimate is not significantly different from zero.

Standard errors in brackets.

¹ Parameter mean estimates indicates the estimated average value in the model, for each different parameter

Profiles for each of the three classes are presented in Table 4.

Table 4. Profiles of consumers from each Latent Class

	Class 1	Class 2	Class 3
Class size proportion	54%	11%	35%
Age (average age bracket)	35-44	55-64	45-54
Income (average income bracket)	\$70k-\$100k	\$40k-\$70k	\$40k-\$70k
Proportion of females	52%	61%	52%
Proportion with University Degree or higher	47%	22%	33%
Proportion in paid employment	70%	46%	54%
Number of loaves usually bought fortnightly	5.6	5.0	4.7
Number of loaves usually bought fortnightly per person	2.0	1.9	1.8
Average price per loaf usually paid	\$5.34	\$3.22	\$3.35
Average fortnightly expenditure on bread per person	\$10.90	\$6.30	\$5.90
Use non-supermarket supply channel	36%	32%	34%
Average number of adult household members	2.2	2.2	2.1
Average number of children household members	0.6	0.4	0.6
Proportion with dietary requirements (GF/DF/Vegan)	13%	20%	7%
Low GI is important	29%	14%	21%
Low environmental impact of production is important	47%	33%	40%
Buying their usual bread is important	70%	84%	77%
Organic production is important	25%	17%	16%
The grain used to make the flour in bread is grown in NZ is important	46%	40%	48%

3.4 Consumer willingness-to-pay estimates for Bread Attributes

Applying model estimates (Table 3) and equation 1.10 (Appendix A4) generates estimates of respondents' willingness-to-pay for the bread attributes modelled. Willingness-to-pay is an estimate of how much money a respondent would be willing to give up for a change in the relevant bread attribute. Table 5 presents respondent willingness-to-pay for each of the statistically significant and positive attributes, across each of the three classes.

- Estimates show that the highest marginal willingness-to-pay for New Zealand origin flour is by members of class one, which is the largest class size at 54% of consumers. This result suggests that the average consumer in this class would be willing-to-pay \$0.56 more for a loaf that contained New Zealand origin flour over one that does not. This value should be considered within the context of the range provided by the Confidence Interval reported. The 95% Confidence Intervals reflect the uncertainty inherent in modelling sample data to draw inference on the wider population of bread loaf consumers. The true average value lies between this range, and so for class one could be as low as \$0.41 or as high as \$0.72. Class two members also have a positive and significant willingness-to-pay for New Zealand origin flour ingredient, although to a much lesser extent, at an average of \$0.14 per loaf and a Confidence Interval of \$0.06 to \$0.22. Class three, which accounts for 35% of consumers, has a similar

average willingness-to-pay to Class one at \$0.55, but importantly the Confidence Interval around this estimate is significantly wider than for Class one consumers. This indicates a much greater degree of preference diversity within this group of consumers relative to Class one consumers.

- Class one consumers are the only consumers to be willing-to-pay for Organic production with an average of \$0.32/loaf. However, the Confidence Interval can be considered as very wide with the true value ranging from \$0.03 to \$0.61/loaf.
- Respondents are only willing-to-pay for environmental outcomes if they are associated with New Zealand origin flour ingredient, they are not willing-to-pay for environmental outcomes if flour origin is not New Zealand. Class one is willing-to-pay on average \$0.41 per loaf for bread produced using Carbon Neutral production over one that is not, and \$0.16 per loaf for production method with water quality protection outcomes Likewise, \$0.48 per loaf for production method with Biodiversity Enhancement outcomes. However, caution is advised in the reliability of this average estimate as the Confidence Interval spans a sizable portion of negative value (-\$0.36 to \$0.62). This indicates that, although the average is positive, there are many consumers in this group who would not be prepared to pay for this outcome. Class three stands out as the consumers who have the strongest preferences for added health claims, with the average consumer in this class willing-to-pay \$0.28 per loaf for this attribute.

Table 5. Willingness-to-pay estimates for bread attributes

	Class 1	Class 2	Class 3
New Zealand Origin	\$0.56*** (\$0.41, \$0.72)	\$0.14*** (\$0.06, \$0.22)	\$0.55*** (\$0.23, \$0.87)
NZ Organic	\$0.32** (\$0.03, \$0.61)		
NZ Carbon Neutral	\$0.41*** (\$0.31, \$0.50)		
NZ Biodiversity Enhancement	\$0.48*** (-\$0.36, \$0.62)		\$0.39*** (-\$0.06, \$0.81)
NZ Water Quality Protection	\$0.16*** (\$0.08, \$0.24)		
Added Health Claim	\$0.21*** (\$0.13, \$0.27)		\$0.28*** (\$0.11, \$0.44)

Average marginal willingness-to-pay **per loaf** in NZ dollars in 2019 year.

Lower and Upper bounds of the 95% Confidence Interval in brackets.

***, **, * denote statistical significance at the 1%, 5% and 10% levels indicating that a willingness-to-pay estimate is significantly different from zero.

4 Comparison to 2019 survey

In August of 2019, the Agribusiness and Economics Research Unit (AERU) was previously commissioned by Foundation for Arable Research (FAR) to provide insights to New Zealand consumer preferences and willingness-to-pay (WTP) for bread products using New Zealand grown grain as a source of flour ingredient. Two reports were prepared (Tait et al., 2019a; 2019b). This allows the current survey to be compared with a prior baseline conducted prior to the impacts of the COVID-19 pandemic on New Zealand consumer behaviour.

- Both surveys were administered using an identical internet-based sampling process.
- Looking at the demographic variables we can see that both samples are remarkably similar. While there is a moderate level of difference in the mix of tertiary qualifications, and urban vs. suburban locations between surveys (Table 6).

Table 6. Sample Characteristics (2019 cf. 2022)

Category	Characteristic	2019		2022	
		<i>n</i>	%	<i>n</i>	%
Age [<i>p</i> = 0.99]	18-24 years	92	9	86	9
	25-34 years	164	17	162	17
	35-44 years	186	19	176	19
	45-54 years	195	20	173	18
	55-64 years	157	16	156	17
	65 years or more	186	19	188	20
Region [<i>p</i> = 0.99]	Auckland	327	33	297	32
	Bay of Plenty	62	6	49	5
	Canterbury	130	13	126	13
	Gisborne	3	0	11	1
	Hawke's Bay	36	4	33	4
	Manawatu-Wanganui	51	5	53	6
	Marlborough	10	1	12	1
	Nelson	13	1	13	1
	Northland	37	4	25	3
	Otago	47	5	50	5
	Southland	20	2	20	2
	Taranaki	25	3	25	3
	Tasman	7	1	13	1
	Waikato	98	10	93	10
	Wellington	107	11	111	12
West Coast	7	1	10	1	
Gender [<i>p</i> = 0.55]	Male	492	50	436	46
	Female	488	50	501	53
	Diverse	0	0	4	0
Annual Household Income [<i>p</i> = 0.94]	Loss	4	0	10	1
	\$0 to \$20,000	85	9	59	6
	\$20,001 to \$40,000	211	22	197	21
	\$40,001 to \$70,000	237	24	232	25
	\$70,001 to \$100,000	174	18	175	19
	\$100,001 to \$150,000	169	17	161	17
\$150,001 or more	100	10	107	11	
Ethnicity [<i>p</i> = 0.90]	NZ European/Pākehā	777	79	722	77
	Māori	66	7	88	9
	Pacific Islander	19	2	27	3
	Asian	98	10	103	11
Type of Area [<i>p</i> = 0.02]	Other ethnicity	88	9	79	8
	Urban	400	41	276	29
	Suburban	440	45	542	58
	Rural	131	13	117	12

Category	Characteristic	2019		2022	
		n	%	n	%
Education [p = 0.04]	Up to High School	19	2	41	4
	High School	252	26	234	25
	Tertiary qualification other than Degree	183	19	295	31
	University Degree	383	39	249	26
	Post-graduate Degree	139	14	116	12
	Other			6	1
Employment [p = 0.87]	Full-time paid employment	416	42	427	45
	Part-time paid employment	145	15	145	15
	Unpaid voluntary work	10	1	9	1
	Home duties	82	8	68	7
	Retired	178	18	173	18
	Student	56	6	30	3
	Unemployed	75	8	72	8
	None of the above	17	2	15	2

Values in brackets are p-values for Pearson's Chi-squared test of the null hypothesis that the frequency distributions of the two samples are consistent with each other. A p-value less than 0.1 indicates a statistically significant difference between the distributions; p-values greater than 0.1 indicate that the samples are not statistically different.

- The distributions of bread loaf descriptors are essentially identical between surveys (Figure 24).

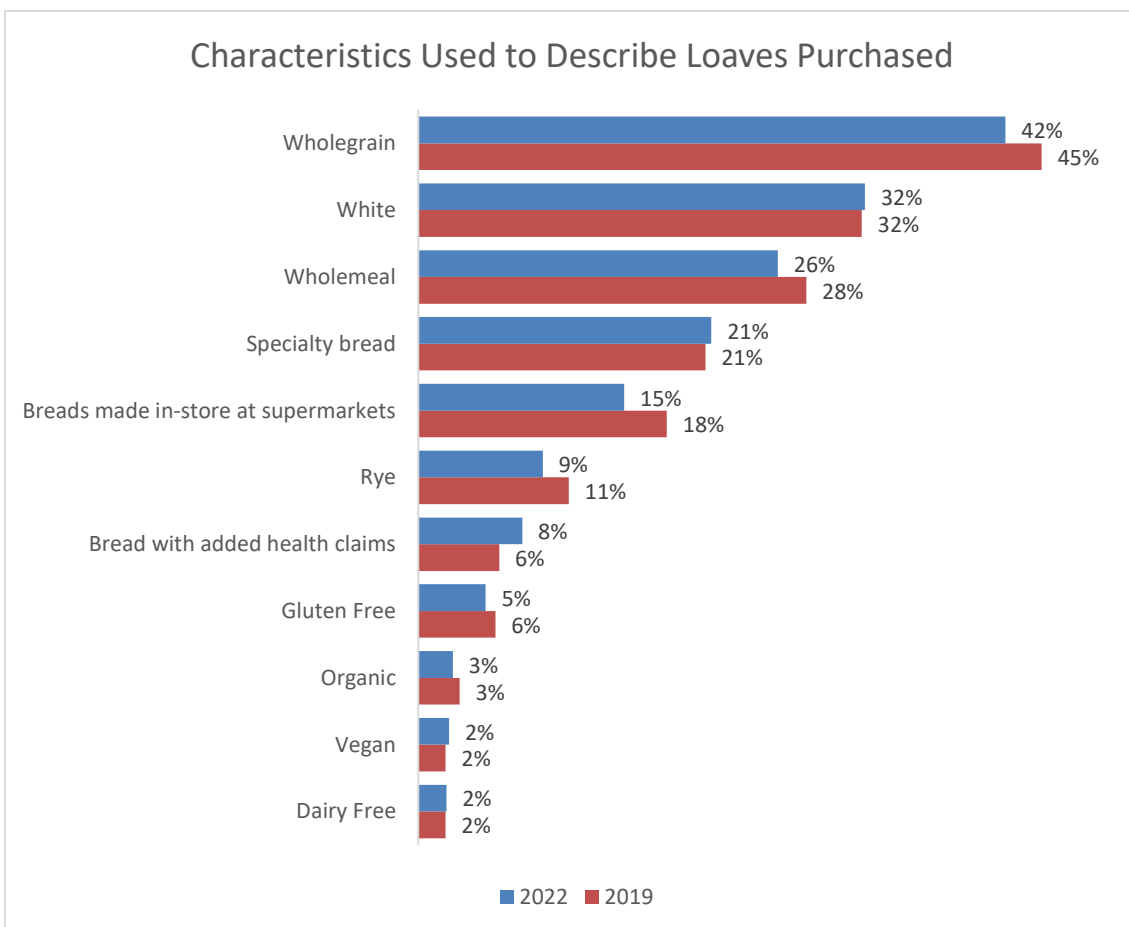


Figure 24. Characteristics used to describe loaves purchased (2022 cf. 2019)

- Respondents ranking of their most important bread descriptor has not changed between surveys (Figure 25).

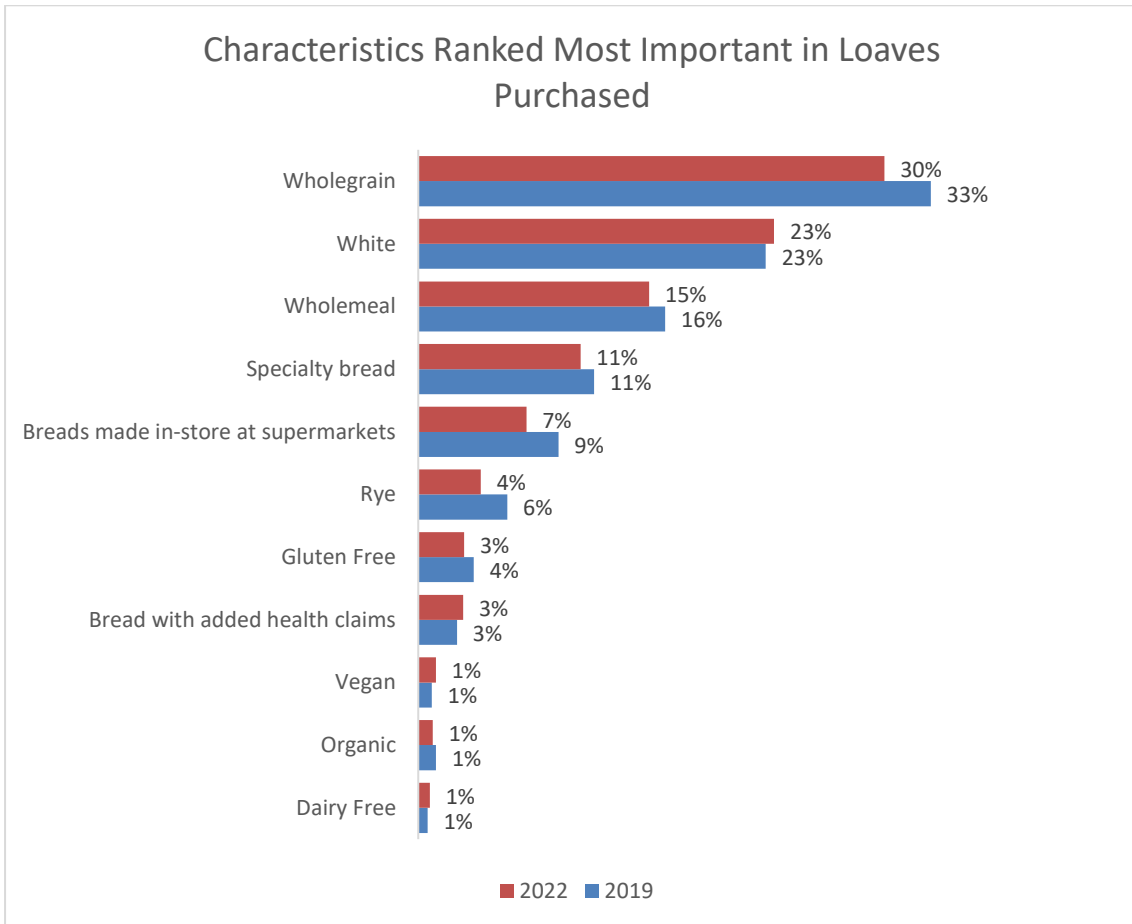


Figure 25. Characteristics ranked most important in loaves purchased (2022 cf. 2019)

- The distribution of number of loaves purchased has remained consistent between surveys, both in terms of loaves per household (Figure 26) and loaves per person (Figure 27). The average number of loaves per person in the respondents household remained the same, at 2.0 loaves per person.

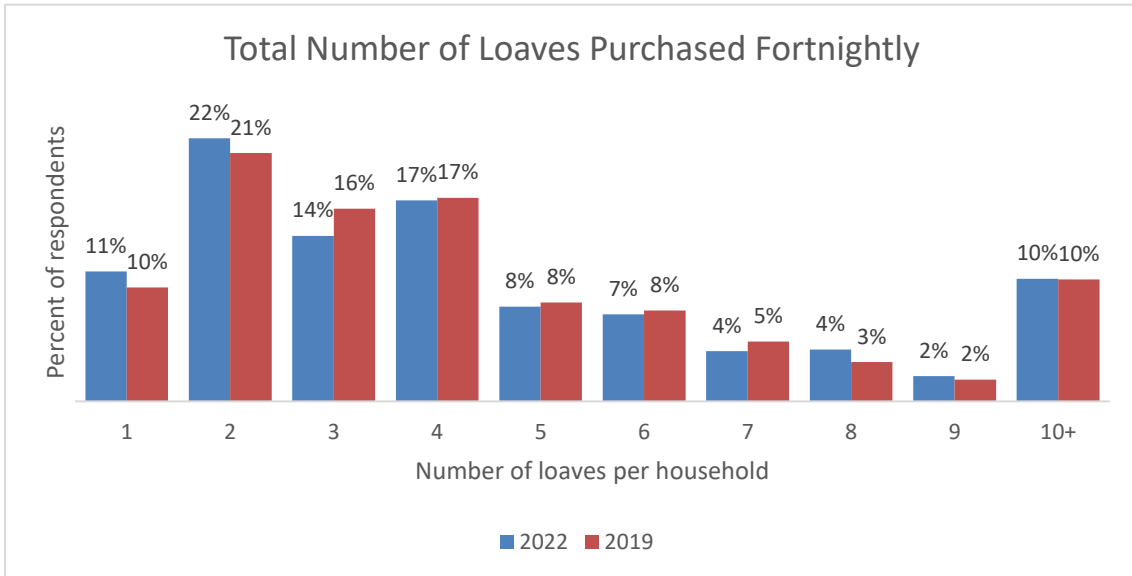


Figure 26. Total number of loaves purchased fortnightly per household (2022 cf. 2019)

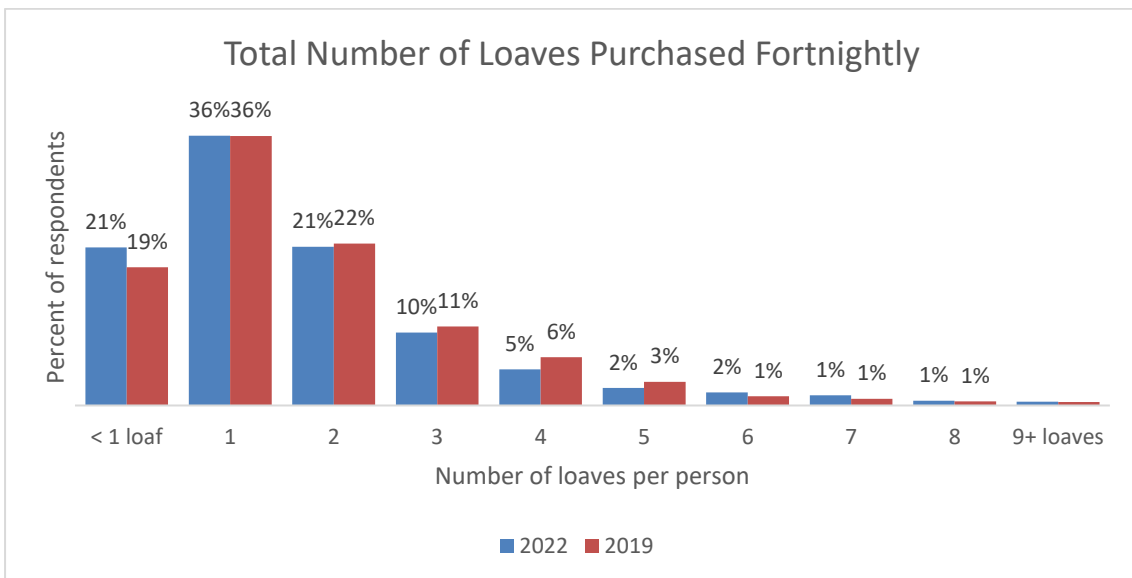


Figure 27. Total number of loaves purchased fortnightly per person (2022 cf. 2019)

- While the number of ‘standard’ bread types remained consistent across 2019 and 2022 (Figure 28), the number of ‘specialty’ type loaves purchased by those respondents vegan and dairy free has increased. However, the overall proportion of these loaf types remains low.

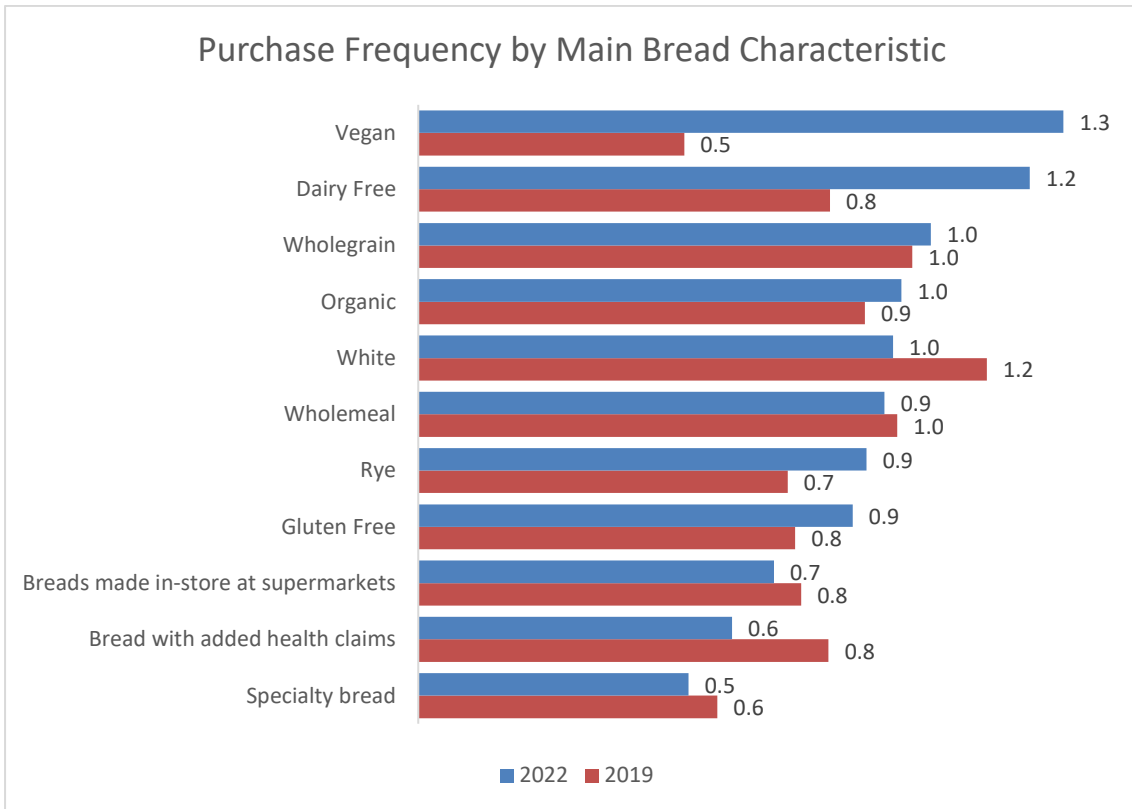


Figure 28. Loaf purchase frequency by main bread characteristic, fortnightly loaves per person (2022 cf. 2019)

- The distribution of average price paid by a respondent shows that the proportion of lower prices has reduced while the portion of higher prices has increased, particularly in the \$4.00 to \$4.99 bracket where we see an almost doubling of loaves at this price point (Figure 29).

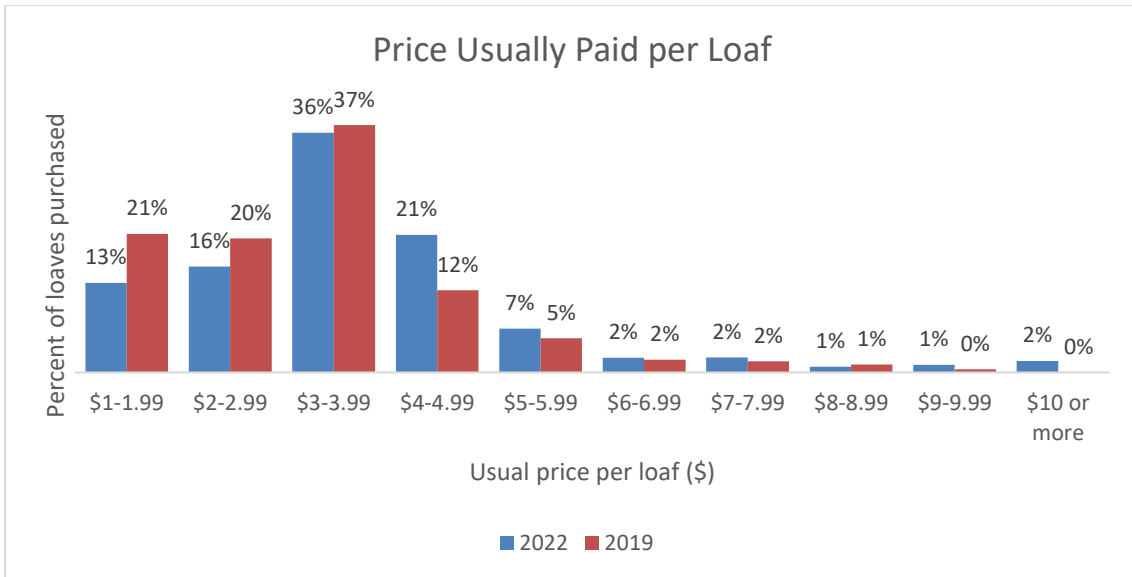


Figure 29. Price usually paid per loaf (\$) (2022 cf. 2019)

- When split into the different loaf types, usual prices paid have increased the most for some of the lower volume bread types including dairy free (87%) and vegan (69%) (Figure 30). While significant increases are also found for high volume types such as white (27%) and wholemeal (30%).

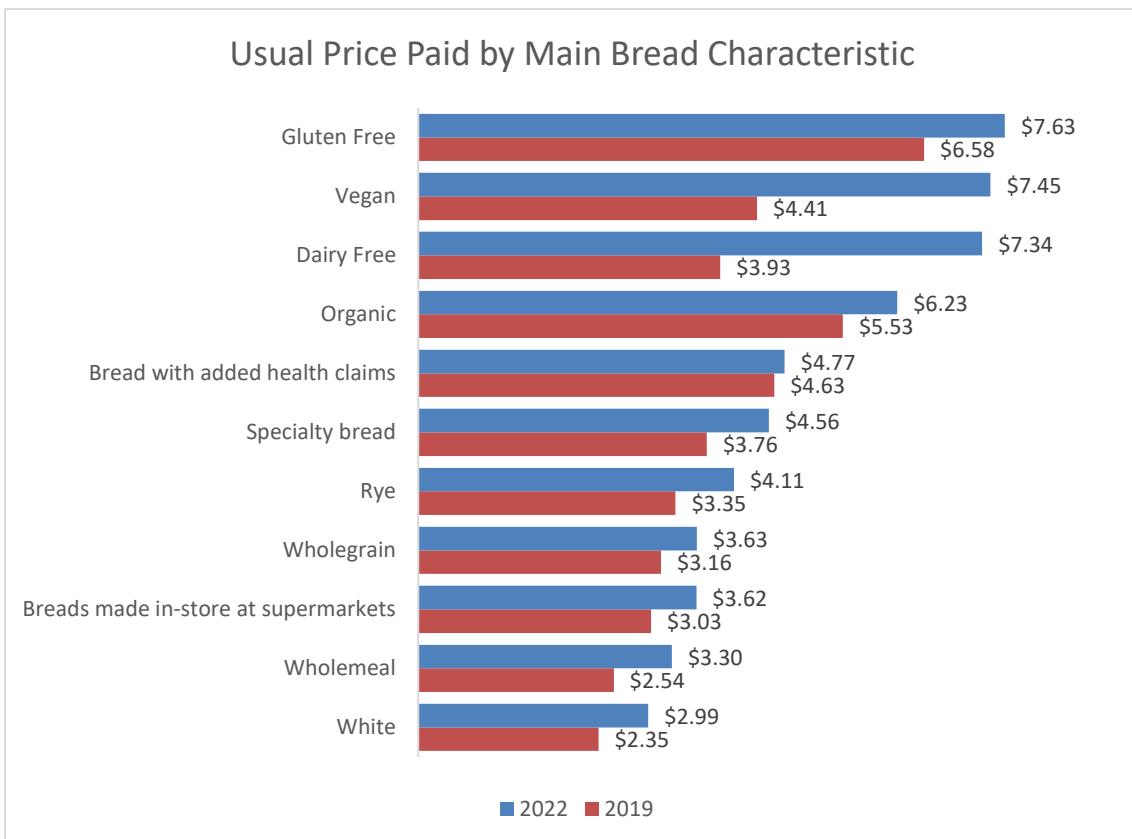


Figure 30. Usual price paid by main bread characteristic (2022 cf. 2019)

- There is little change in the awareness of the benefits of wholegrain bread since 2019 (Figure 31).

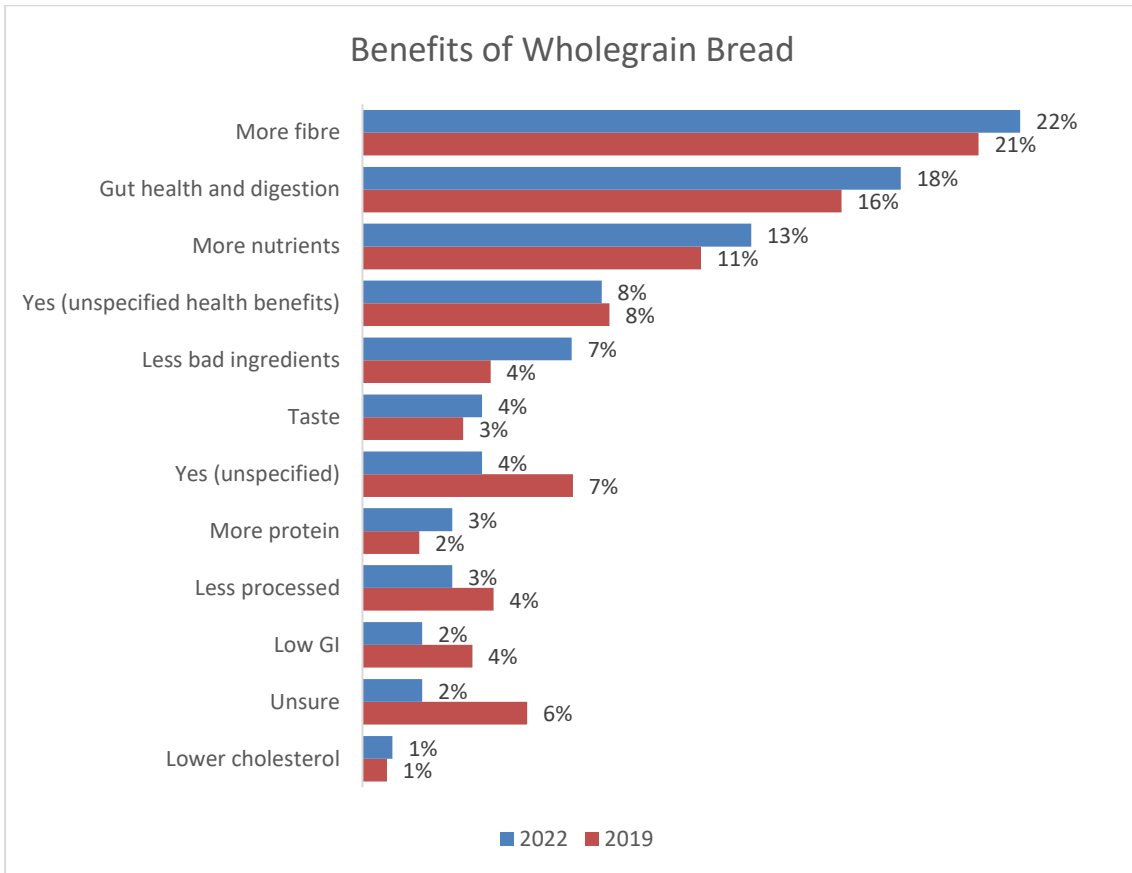


Figure 31. Benefits of wholegrain bread (2022 cf. 2019)

- Supermarkets remain the most used purchase channel by a considerable margin over the next most used, bakeries, which also remains consistent with 2019 findings (Figure 32).
- There are significant increases in the use of farmers markets, corner store/dairy, and online purchasing.

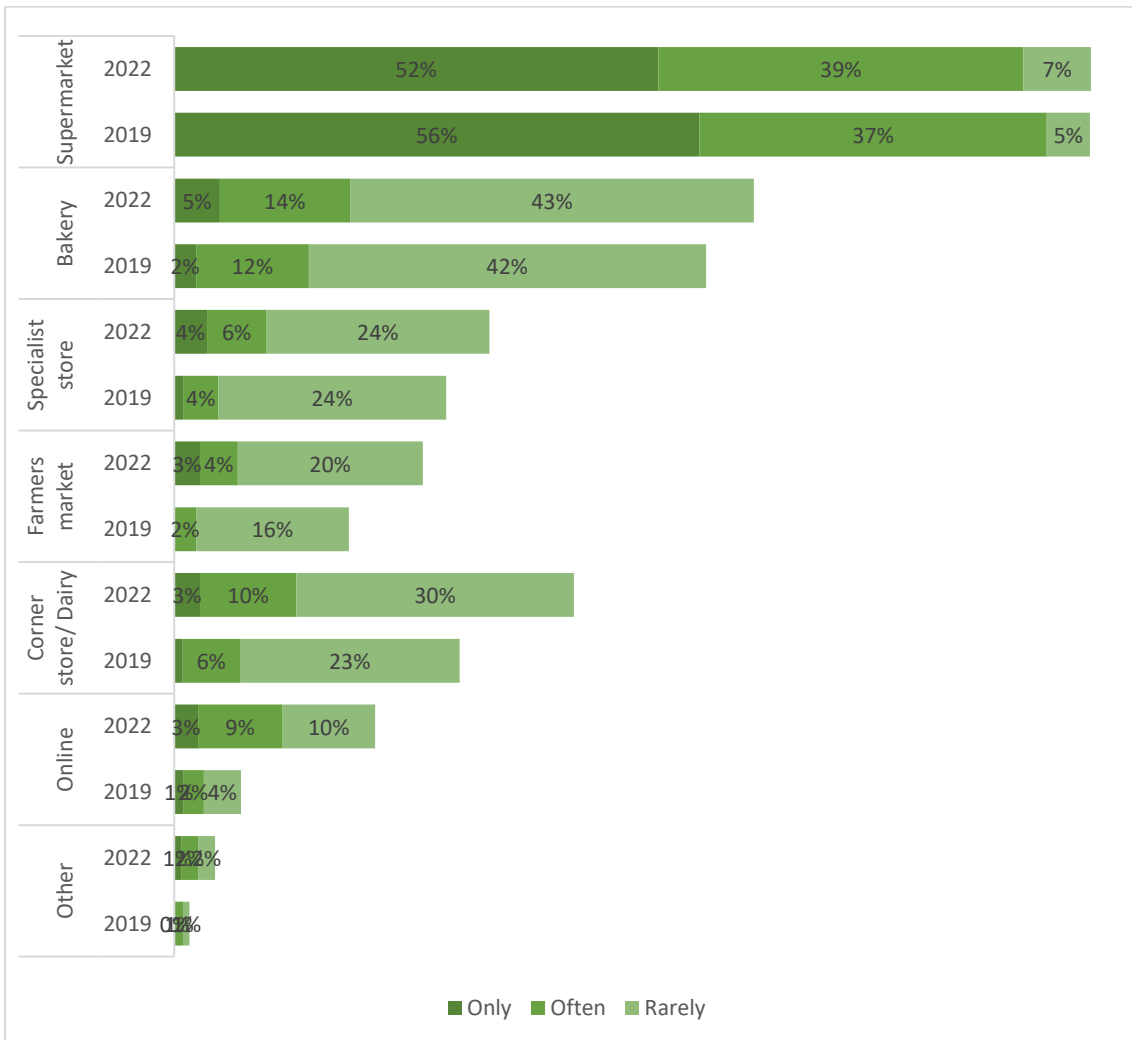


Figure 32. Frequency of purchase channels used (2022 cf. 2019)

- The proportion of respondents indicating strong preferences towards individual brands (purchase 'only') show moderate increase and in some brands and is overall consistent across surveys (Figure 33). However, respondents in 2022 show broader willingness to purchase a range of brands compared to 2019.
- Behaviour towards 'store brands' and 'baked in store' has remained unchanged.

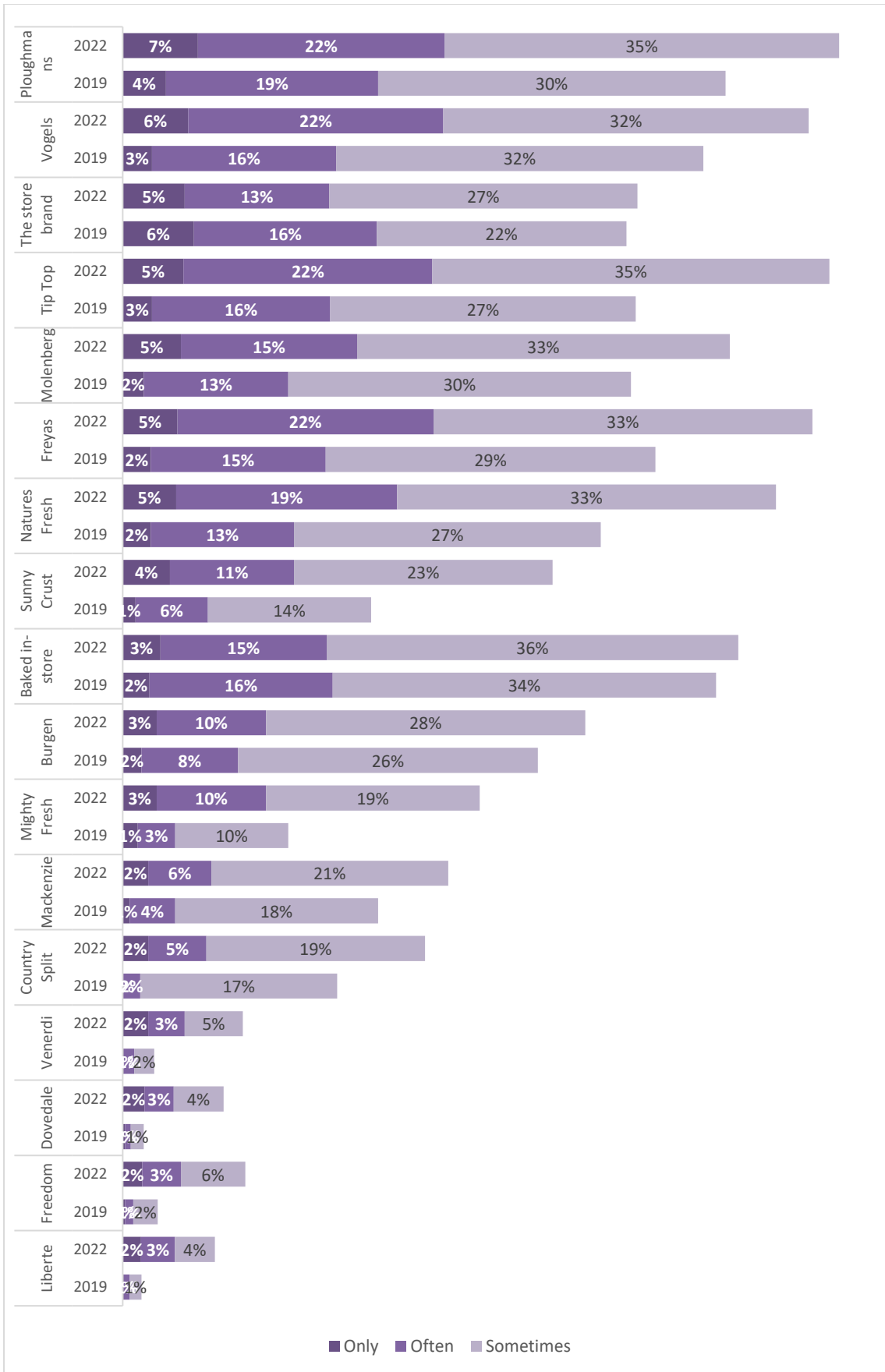


Figure 33. Brand purchase frequency (2022 cf. 2019)

- There has been an increase in the number of consumers spending more, and in those substituting towards higher quality products (Figure 34).

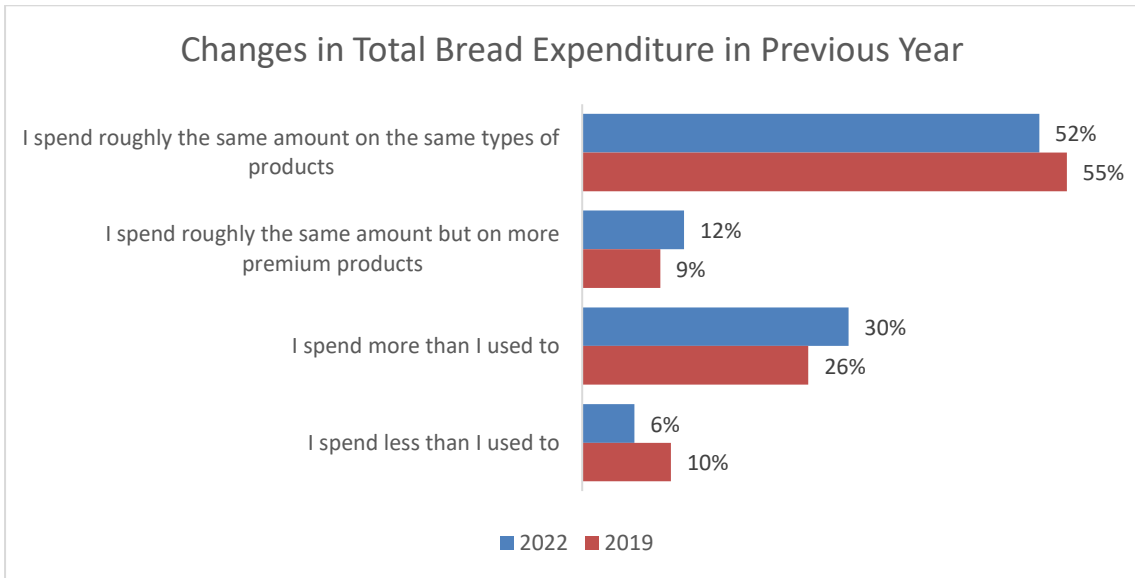


Figure 34. Changes in total bread expenditure in previous year (2022 cf. 2019)

- The main reason for change in bread expenditure in 2022 was given as increase in loaf price, while change in diet was previously the main reason for change (Figure 35).

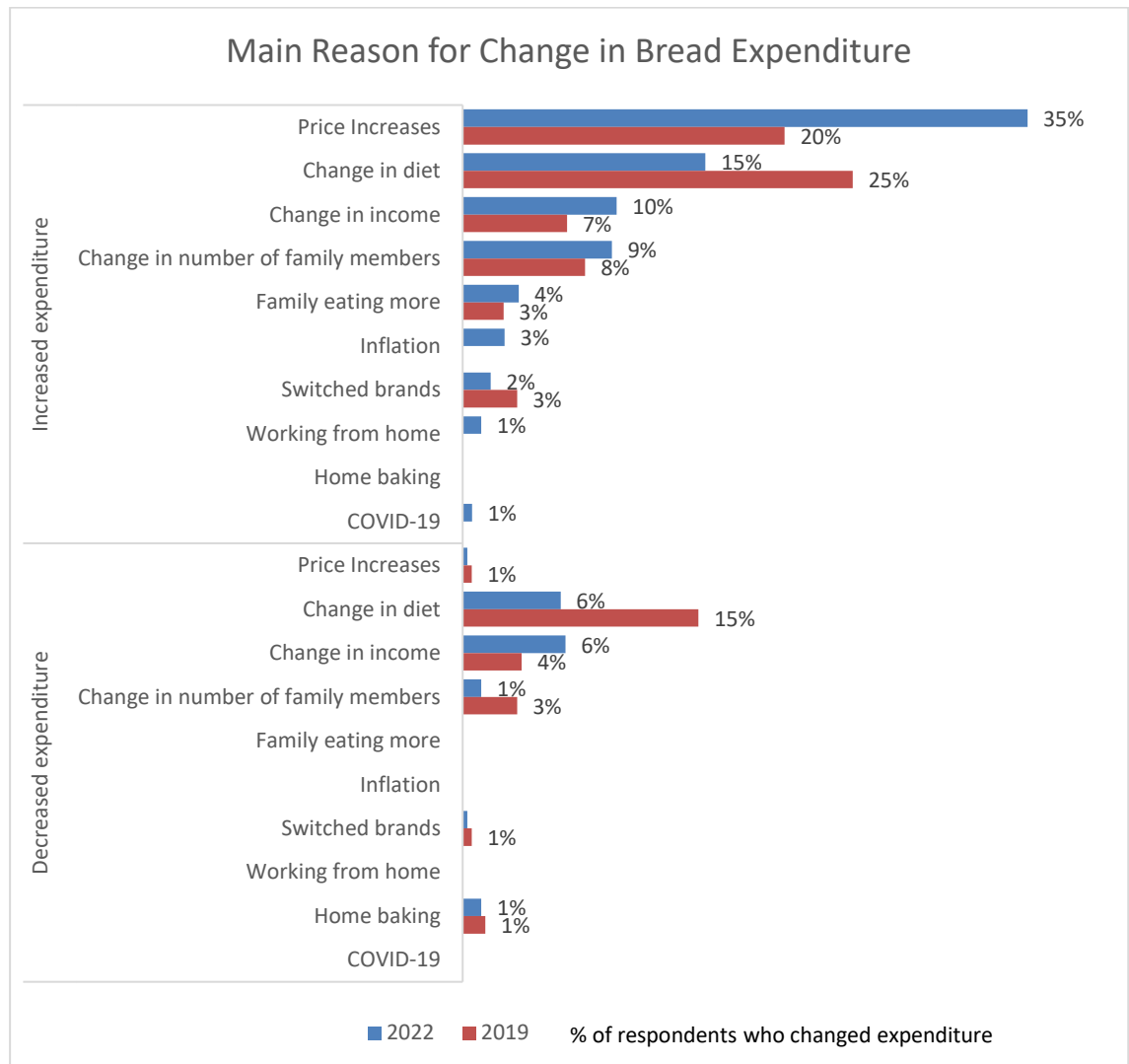


Figure 35. Main reason for change in bread expenditure (2022 cf. 2019)

- The importance of flour origin to respondents has remained relatively unchanged over 2019 to 2022 (Figure 36).

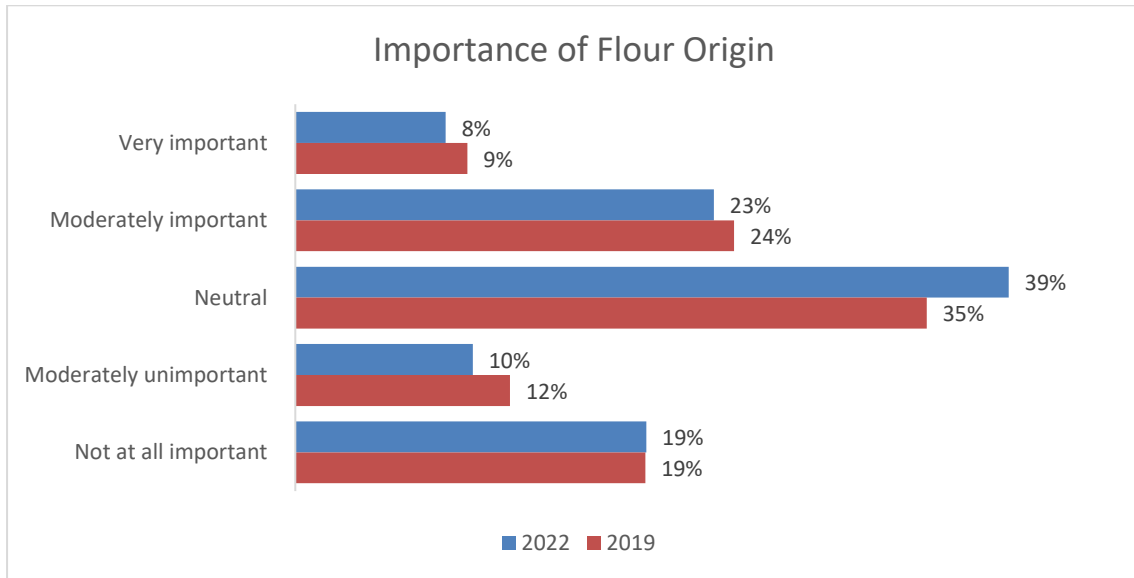


Figure 36. Importance of flour origin (2022 cf. 2019)

- Respondents' perception of where flour comes from is similar between surveys, with a slight increase in New Zealand and Australian origin awareness (Figure 37). However there has also been an increase in the perception of flour coming from China and India.

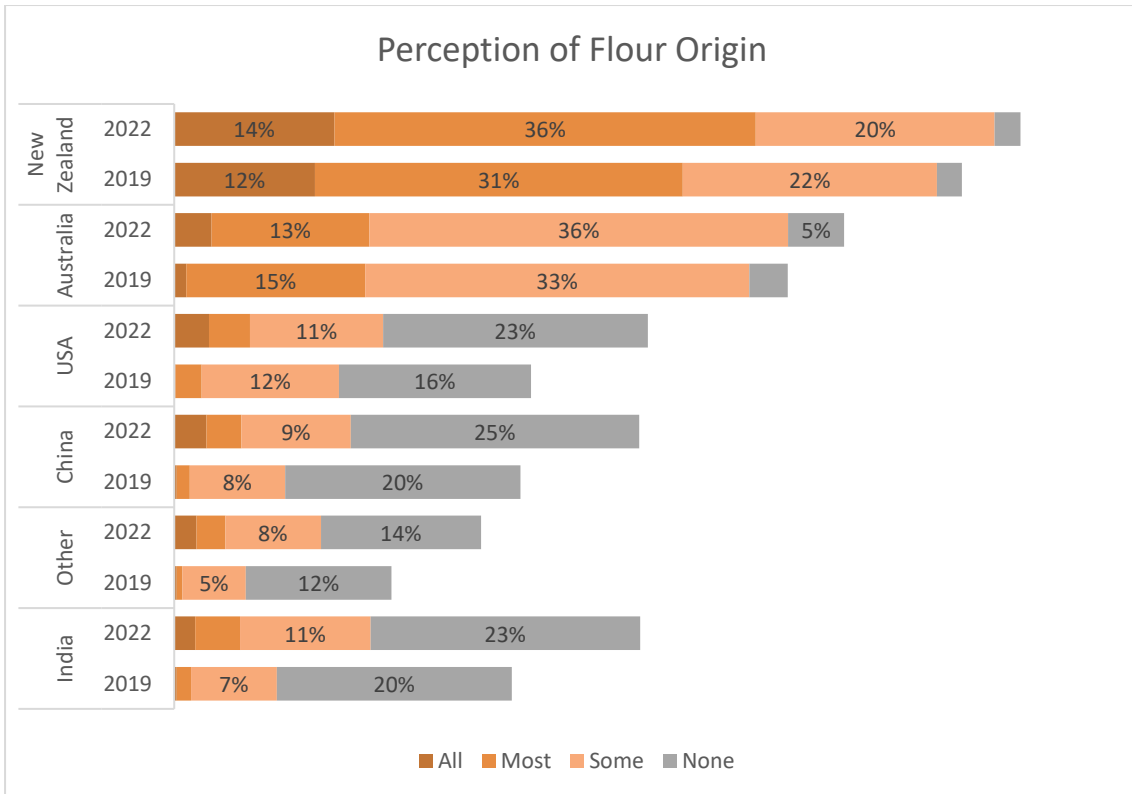


Figure 37. Perception of flour origin (2022 cf. 2019)

- The relative importance of reasons for New Zealand origin flour has remained consistent between surveys (Figure 38). However, the ability to support local producers has increased substantially.

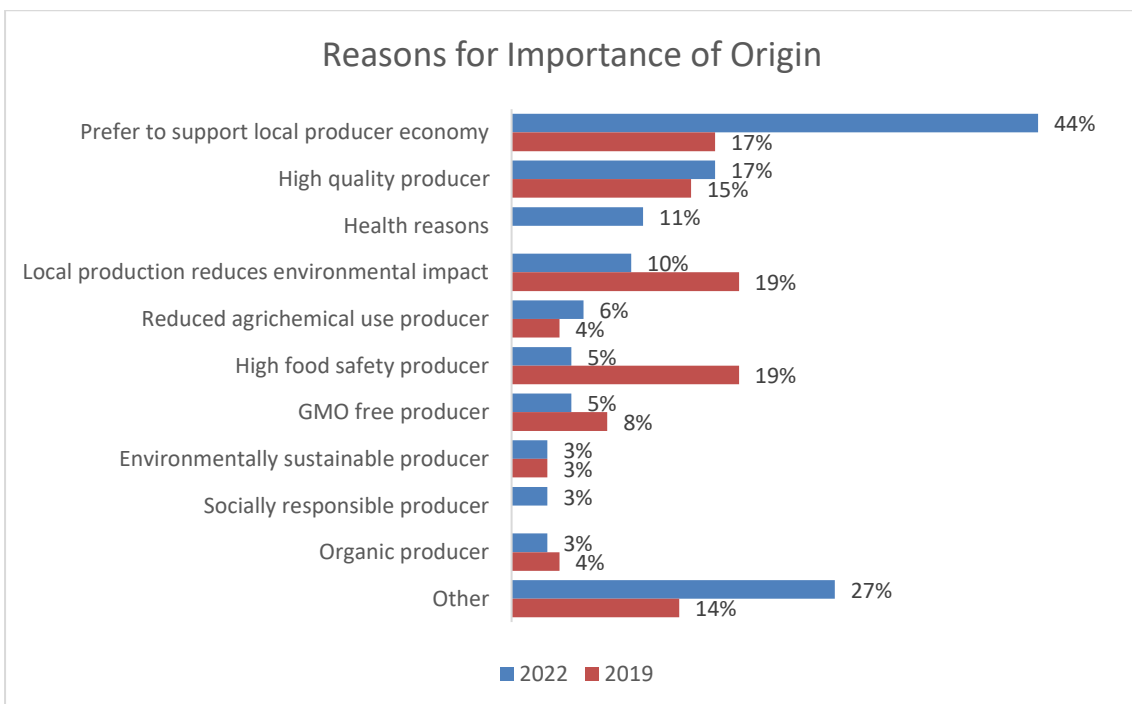


Figure 38. Reasons for importance of origin (2022 cf. 2019)

- The ranking of importance of a range of bread loaf attributes remains consistent between surveys (Figure 39).

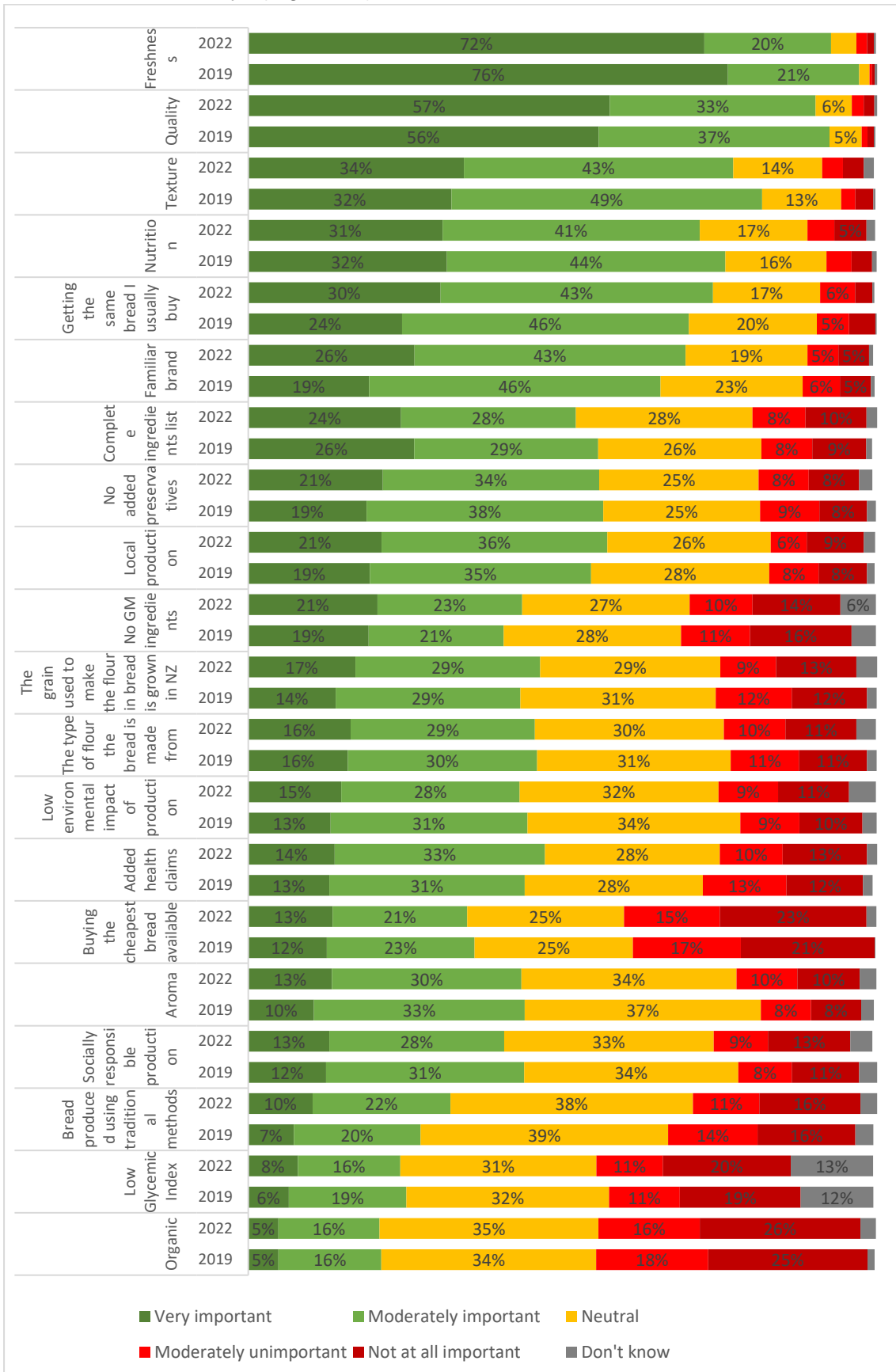


Figure 39. Importance of various bread attributes (2022 cf. 2019)

- Respondents' bread label awareness remains consistent between surveys, with some slight increases in ease of use, information content perception, and interest in expanded information labels (Figure 40).

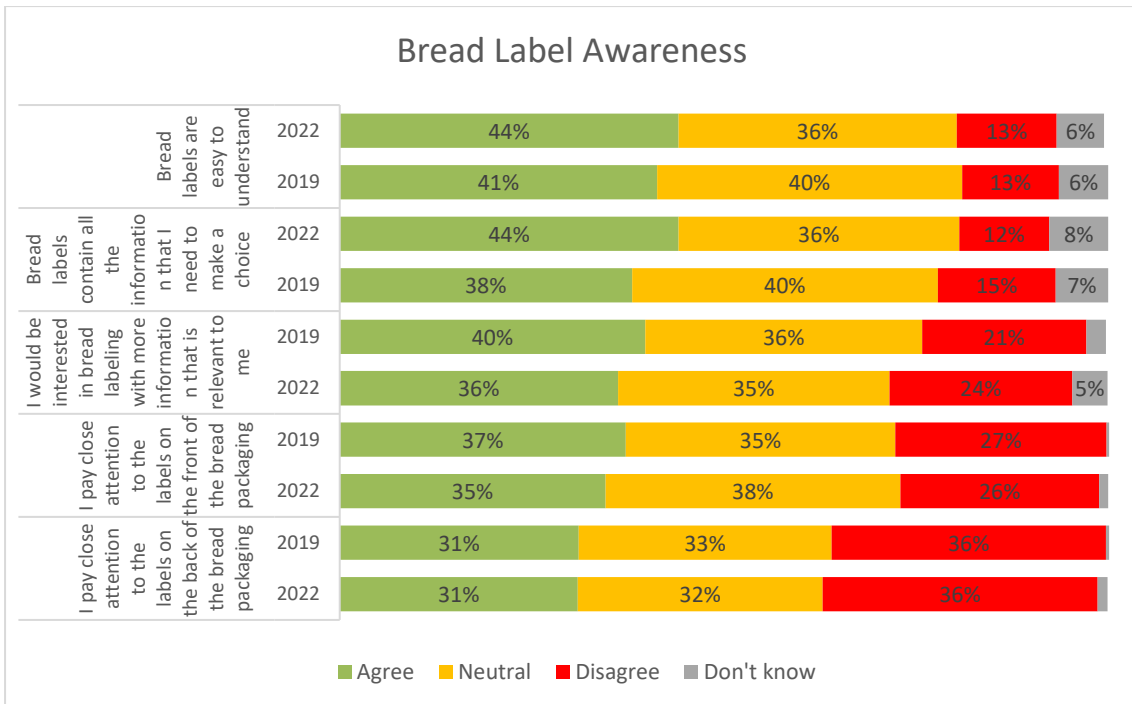


Figure 40. Bread label awareness (2022 cf. 2019)

- Across both the 2019 and 2022 surveys, consumers in Class One exhibit the broadest and strongest overall preferences for the types of bread attributes considered in the Choice Experiment (Table 7).
- The makeup of this group of consumers has remained relatively consistent across both surveys.

Table 7. Willingness-to-pay estimates for bread attributes (2019 cf. 2022)

	2019			2022		
	Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
New Zealand Origin	\$0.49*** (\$0.24, \$0.83)	\$0.23*** (\$0.07, \$0.39)		\$0.56*** (\$0.41, \$0.72)	\$0.14*** (\$0.06, \$0.22)	\$0.55*** (\$0.23, \$0.87)
NZ Organic				\$0.32*** (\$0.03, \$0.61)		
NZ Carbon Neutral	\$0.15* (-\$0.01, \$0.31)		\$0.41*** (\$0.17, \$0.66)	\$0.41*** (\$0.31, \$0.50)		
NZ Biodiversity Enhancement	\$0.35* (-\$0.12, \$0.83)		\$0.57*** (\$0.33, \$0.82)	\$0.48*** (-\$0.36, \$0.62)		\$0.39*** (-\$0.06, \$0.81)
NZ Water Quality Protection				\$0.16*** (\$0.08, \$0.24)		
Added Health Claim	\$0.37*** (\$0.14, \$0.59)			\$0.21*** (\$0.13, \$0.27)		\$0.28*** (\$0.11, \$0.44)

- Consumer preferences for NZ origin flour have strengthened (Table 8). With a significant increase in the number of respondents who indicate a positive willingness-to-pay for this bread attribute. And a moderate increase in the overall amount they are willing-to-pay.
- Preferences for NZ Organically produced flour is now significant compared to 2019 where they were not.
- Preferences for NZ Carbon neutral produced flour have fallen slightly but remain consistent with 2019.
- Preferences for NZ biodiversity enhancing produced flour remain consistent with 2019.
- Preferences for NZ water quality protection produced flour is now significant compared to 2019 where they were not.
- Preferences for flour with added health claims has expanded with a significant increase in the number of respondents with positive willingness-to-pay.

Table 8. Class attributes comparison (2022 cf. 2019)

	2019				2022		
	Class 1	Class 2	Class 3		Class 1	Class 2	Class 3
Class size (% of participants)	51%	13%	36%		54%	11%	35%
Age (average age bracket)	35-44	45-54	35-44		35-44	55-64	45-54
Income (average income bracket)	\$70k-\$100k	\$40k-\$70k	\$70k-\$100k		\$70k-\$100k	\$40k-\$70k	\$40k-\$70k
Proportion of females	54%	41%	48%		52%	61%	52%
Proportion with University Degree or higher	58%	37%	52%		47%	22%	33%
Proportion in paid employment	56%	52%	61%		70%	46%	54%
Number of loaves usually bought per fortnight	4.6	5.3	4.4		5.6	5.0	4.7
Average price per loaf usually paid	\$3.30	\$2.80	\$2.90		\$5.34	\$3.22	\$3.35
Use non-supermarket supply channel	22%	23%	19%		36%	32%	34%
Average number of adult household members	2.2	1.9	2.3		2.2	2.2	2.1
Average number of children household members	0.6	0.4	0.5		0.6	0.4	0.6
Proportion with dietary requirements (GF/DF/Vegan)	7%	14%	7%		13%	20%	7%
Added health claims are important	47%	33%	43%		49%	43%	46%
Low GI is important	28%	18%	24%		29%	14%	21%
Low environmental impact of production is important	43%	42%	45%		47%	33%	40%
Buying the cheapest bread available is important	33%	36%	41%		34%	32%	36%

Buying their usual bread is important	69%	76%	70%		70%	84%	77%
Organic production is important	43%	42%	44%		25%	17%	16%
The grain used to make the flour in bread is grown in NZ is important	50%	38%	40%		46%	40%	48%

5 Conclusions

Currently, country of origin labelling is absent from the vast majority of bread loaves sold in New Zealand, particularly in mainstream retailers such as supermarkets, where most people buy their bread. In the absence of market signals, estimating the value that consumers place on New Zealand grown flour in bread loaves is therefore difficult. This report applied the economic non-market valuation approach of choice experiments to estimate the value that New Zealand residents place on New Zealand grown grain as a flour ingredient in bread loaves.

The 2022 survey process achieved a sample of 941 respondents broadly demographically representative of the NZ population. The willingness-to-pay results found indicate significant public support for New Zealand grown flour ingredient. It is important to note that value can be much higher than cost – the willingness to pay estimates are a measure of the maximum benefit accruing to individuals and therefore is the most they would pay, but they would prefer to pay less if that were possible.

A comparison with the 2019 survey indicates that the samples are consistent across demographic measurements. And the results find that consumers preferences for New Zealand origin flour have remained significant, with a slight increase in willingness-to-pay, and a significant increase in the number of consumers with positive willingness-to-pay.

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Appendix A: 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 utility⁹ 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 utility¹⁰ providing the behavioural rule underlying choice analysis:

$$U_j > U_i \tag{1.1}$$

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).

$$U_{nj} = V_{nj} + \varepsilon_{nj} \tag{1.2}$$

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

⁹Related terminology used in psychology discipline is *the level of satisfaction* (Hensher et al. 2015).

¹⁰In choice analysis, utility is considered as *ordinal utility* where the relative values of utility are measured (Hensher et al. 2015).

and their preference weights (coefficient estimates).

$$V_{nsj} = \sum_{k=1}^K \beta_k x_{nsjk} \quad (1.3)$$

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 :

$$\Pr_{nsj} = \Pr(U_{nsj} > U_{nsi}) = \Pr(V_{nsj} + \varepsilon_{nsj} > V_{nsi} + \varepsilon_{nsi}) = \Pr(\varepsilon_{nsi} - \varepsilon_{nsj} < V_{nsj} - V_{nsi}) \quad \forall j \neq i \quad (1.4)$$

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:

$$\Pr_{nsj} = \frac{\exp(\beta'_n x_{nsj})}{\sum_J \exp(\beta'_n x_{nsj})} \quad (1.5)$$

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:

$$L_{njs} = \int_{\beta} \Pr_{nsj}(\beta) f(\beta | \theta) d\beta \quad (1.6)$$

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:

$$L_{nsj} = E(\Pr_{nsj}) \approx \frac{1}{R} \sum_R f(\beta^{(r)} | X) \quad (1.7)$$

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:

$$\beta_n = \sigma_n \beta + \gamma \eta_n + (1 - \gamma) \sigma_n \eta_n \quad (1.8)$$

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):

$$\sigma_n = \exp\{\bar{\sigma} + \tau\omega_n\} \quad (1.9)$$

where $\bar{\sigma}$ 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:

$$WTP_i^j = - \left(\frac{\beta_j + \varepsilon_{ij}}{\beta_{price} + \varepsilon_{ip}} \right) \quad (1.10)$$

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):

$$CS = \frac{-1}{\beta_{cost}} \left[\ln \sum_{j=1}^J \exp\{V_j^0\} - \ln \sum_{j=1}^J \exp\{V_j^1\} \right] \quad (1.11)$$

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 β_{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 respond 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.



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