Application of Choice Modeling for Understanding Wheat User Preferences in Southeast Asia[1]

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ABSTRACT

Southeast Asia is the largest and fastest growing destination for global wheat exports and is projected to attract 27.6 Mt of wheat from Canada, the United States, Argentina, the Black Sea region, and Australia in 2019–2020. This article outlines how choice modeling can be applied to improve wheat breeding to ensure new varieties are better suited to end-user preferences in Southeast Asia. We describe a choice modeling study involving Southeast Asian wheat buyers and millers responsible for more than 70% of flour production in the region. Depending on the food produced from wheat flour, similarities and some differences in the trait preferences of wheat buyers and millers were revealed. The choice modeling approach illustrated here could be applied to other grains, other products, and other regions.

The export of agricultural commodities, like wheat, involves a multitude of decisions by buyers and providers of these commodities. The provision of wheat for export, for example, first involves decisions by plant breeders as to which parental materials to use in crossing programs and then later deciding which traits are worth selecting for in advanced plant lines (5,20). In the competitive world of grain export, being able to offer buyers fit-for-purpose wheat is an advantage. This article shows how use of choice modeling can aid wheat breeders to make better decisions to ensure their wheat varieties are truly fit-for-purpose in Southeast Asia, globally the largest outlet for wheat exports (11).

Although rice is a principal dietary staple (24) in Southeast Asia, a gradual dietary shift is underway in most Southeast Asian countries toward greater consumption of other grains, especially wheat (13). In many Southeast Asian countries, higher per capita incomes and continuing urbanization favor increased per capita consumption of wheat and a lesser role of rice in diets (4,27,28). However, Southeast Asian countries are climatically unsuited to wheat production, so they must rely on wheat imports to satisfy their wheat consumption needs. In Southeast Asia, wheat imports have risen from 1 Mt in 1961 to a projected 27.6 Mt in 2019–2020 (11).

Wheat-based foods such as instant noodles have rapidly become popular. For example, wheat-based instant noodles were first introduced in Indonesia in the 1970s, yet it is now the second largest instant noodle market globally (behind China), accounting for almost 15% of global consumption of instant noodles (16,17). Indonesia is also the fourth largest per capita consumer of instant noodles globally.

Such is the demand for wheat emanating from Southeast Asian countries that Southeast Asia is now the largest and fastest growing destination for wheat exports, attracting wheat from Canada, the United States, Argentina, the Black Sea region, and Australia. Indonesia, for example, is now the world's second-largest importer of wheat.

The logistics of wheat importation are well established, with wheat being an internationally traded commodity based on shipping contracts that specify the key required characteristics of the wheat cargo (e.g., moisture content, protein range, test weight, wheat class). Some contract characteristics, such as wheat class, are a proxy for a bundle of wheat quality characteristics required for particular end products (6).

Wheat quality is a complex issue (21,26). After being transformed into flour, wheat can be used to produce diverse end products ranging from breads to pastas, noodles, dumplings, cakes, pastries, and biscuits (cookies). Each end product, however, requires particular flour qualities usually derived from the blending wheat flours with different qualities, with the expression of wheat quality in any flour arising from the complex interplay of wheat plant genetics, the climate in the country of origin, and the grain processing systems used in the importing country. Often, wheat quality is approximated by indicators such as wheat class, grain hardness, grain protein content, test weight, falling number measurements, and moisture content—all of which are incorporated in shipping contract specifications. However, almost all shipping contracts incompletely specify the grain functionality requirements of the end user.

Rather than rely on limited indicators of wheat quality, as specified in trade contracts, it is possible to more directly and accurately identify the traits of wheat quality preferred by key wheat users when making particular end products. More complete and accurate knowledge of the trait preferences of end users can facilitate the decision-making of wheat breeders, who are charged with assembling a mix of traits in new varieties that will offer benefits to farmers and those subsequently reliant on that wheat to produce various end products. This issue is the focus of this article. Specifically, we identify what quality attributes are most valued by wheat buyers and milling technicians in major Southeast Asian markets when their end purpose is to make particular bread or noodle products. Objective information on their wheat preferences was collected through choice modeling experiments. More accurately, identifying end-user preferences and relaying that information back to wheat breeders can increase the efficiency and effectiveness of the wheat exporting country's response to Southeast Asian end-user needs. An implication for food producers in Southeast Asia is that they can share in the efficiency gains of better decision-making that more accurately matches the supply of wheat with desired qualities to meet the needs of end users.

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Empirical Methods

Choice modeling (22,23) has previously been applied to a variety of grain industry issues, including demand for grain transport services (31), consumer preferences for locally produced grain (8,9), and consumer preferences for quality assurance of grain production and storage (12,18). However, to our knowledge, the present study is the first to examine the stated preferences of grain purchasers and millers for specific quality attributes of a grain.

To illustrate the utility of applying choice modeling to more accurately match the supply of wheat quality to end users' needs, we use the example of wheat supply from Australia to Southeast Asia. Australia is one of the world's top five wheat exporters and annually exports 7.5 Mt of wheat valued at A$2.3 billion to Southeast Asia (1). Indonesia, Vietnam, Malaysia, Singapore, Thailand and the Philippines are major destinations for Australian wheat, with these exports facilitated by a few factors, such as their proximity to Australian grain ports and the generally reliable availability of Australian wheat (10).

Over the last few years, however, the Black Sea region and Argentina have emerged as cheaper sources of wheat, placing downward pressure on prices received by Australian wheat exporters (15). To help meet this competitive challenge, Australia's wheat industry has been keen to understand more accurately what characteristics of wheat are most valued or sought after by the majority of Southeast Asian customers. Such information would assist Australian wheat breeders in developing future varieties with traits highly desired by Southeast Asian customers.

To ensure that the findings of the choice experiments, described later, were useful to Australian wheat breeders, the wheat buyers and milling technicians who participated in the choice experiments needed to be from firms responsible for the bulk of wheat importation and flour sales in each country. Accordingly, the major firms in each country participated in this study, representing an aggregate market share, in each country, of more than 70%.

Discussions with the company executives revealed the key wheat-based products relevant to their particular market. Knowing which end products were most prevalent in each market allowed the subsequent choice experiments to be tailored to the wheat purchasers and milling technicians in each country. Examples of wheat-based products considered in the study include Hokkien-style noodles, fresh noodles (*mie basah*), fresh wet noodles, loaf breads, sweet buns, *pan de sal*, sandwich bread, and pastas.

Staff from 37 mills across the Southeast Asian region who participated in the study revealed their preferences and target levels of wheat quality characteristics for a range of wheat-based products, their willingness to pay for different attributes or combinations of attributes at different levels, and their technical service requirements.

The choice modeling investigations contained two parts. First, a best-worst scaling (BWS) survey was conducted to rank the quality and functional characteristics most important when a wheat purchaser or milling technician selected wheat for a particular end use. The ranked list identified the priority attributes for use in the study's second part—a series of discrete choice experiments (DCEs). The number of attributes to include in a DCE was limited as each additional attribute increased the size of the experiment design exponentially. Using the BWS survey helped identify which preferred attributes to consider.

Within each market, respondents completed two BWS surveys: one for a noodle product and one for a baked product. DCEs were then constructed for each of those products in that market.

BWS. The BWS methodology used follows that of Louviere et al. (19) and was a required step in this study, as a review of the previous literature on market quality requirements (2,7,14,25) provided inadequate information to assist in determining the willingness of wheat technicians and purchasers to pay for particular quality attributes.

Attributes selected for the BWS surveys represented those most likely to influence decisions by milling technicians and wheat purchasers regarding the suitability of wheat for use in particular food products. Examples of attributes are listed in Table A1 in the Appendix. Buyers and technicians completed separate surveys, with technicians considering 31 attributes and purchasers considering 25 attributes. The extra attributes considered by the technicians were a set of specific technical attributes that were unlikely to influence purchasers' decisions but that would be known by milling technicians and could affect their preferences. Also included in the list of attributes were five technical support services that could accompany wheat purchases and milling activity.

The BWS survey instrument for milling technicians consisted of 31 choice sets of 6 attributes per set, with the 6 attributes being drawn from the pool of 31 attributes. The experimental design ensured that each attribute was equally represented in the 31 choice sets, and all attributes were evaluated against each other. When faced with a particular choice set, each technician chose the most important and least important of the presented attributes based on their need to select grain for a particular end product. The most and least preferred of the attributes were then removed from the choice set, and the participants chose the most preferred and least preferred from the remaining four attributes. The same process was applied to wheat purchasers, except the survey consisted of 30 choice sets of 5 attributes per set, with those 5 attributes being drawn from a pool of 25 attributes.

After presenting each participant with a series of subsets and then undertaking appropriate analysis, a ranking of the full list of attributes was generated. The experimental design was a balanced incomplete block, an orthogonal fraction of the full factorial, and was amenable to analysis of choices by counting how many times each factor was chosen across all comparison sets as the best attribute, and subtracting how many times the attribute was selected as the worst attribute. These scores were then normalized by dividing the scores by the number of times they appeared in the survey. This method is based on that of Louviere et al. (19), using the normalized best-worst score. Analysis of the BWS results ranks the likelihood that a given attribute will influence a decision made by the participant when selecting wheat for a particular end use.

DCEs. For the DCEs in each country five quality attributes were selected from the attribute lists presented in Table I. These attributes were ranked as being of high importance in the BWS surveys. Price was also included as an attribute. In each country, milling technicians and wheat purchasers completed two surveys: one involving a noodle product popular in their country and the second for a popular bread product.

Although each attribute was evaluated at five levels within a market, there were some differences in attribute levels between markets. Restricting the number of included attributes to five

(excluding price) avoided participant fatigue, yet was a compromise to completeness. The levels at which attributes were set and varied were determined earlier as part of the BWS survey. At the mid-point of each BWS survey, participants completed a question set to define the minimum, maximum, and preferred values for a set of quality attributes for each product. These responses ensured that choice sets in the DCEs contained attribute levels set at credible and potentially influential levels, as revealed by respondents. Where the participants did not have an agreed, repeatable method for expressing the level of a particular attribute, the levels were presented using a subjective scale.

The DCEs were an orthogonal fraction of a 5^6 design of 6 attributes and 5 levels per attribute. The design was a paired design, whereby the profiles presented to each participant, being the set of levels for each attribute, were matched with their mirror profile. This meant, for example, that if the profile of levels in wheat parcel A was {1,5,1,2,4,3}, then the profile of levels in parcel B would be its mirror image of {5,1,5,4,2,3}. Also included was a third offer that was a constant, fixed with all attribute levels set at level two—a low level but not a zero likelihood of the availability of attributes. Inclusion of the third level is important; otherwise there is a symmetric effect in the results where it cannot be determined whether a decision is on the basis of the preference for one side of the paired level (high) or the low preference for the other side (low). Without the fixed third offer, it is difficult to estimate a model that accurately predicts preferences. The DCE format is illustrated in Table A2 in the Appendix.

Table I. Examples of attributes presented to participants in the discrete choice experiments for noodle and bread products

Noodles	Bread
Price	Price
Noodle texture	Bread volume
Noodle color	Water absorption
Noodle color stability	Dough strength
Milling yield	Milling yield
Wet gluten	Wet gluten
Gluten strength	Dough development time
Extensibility	

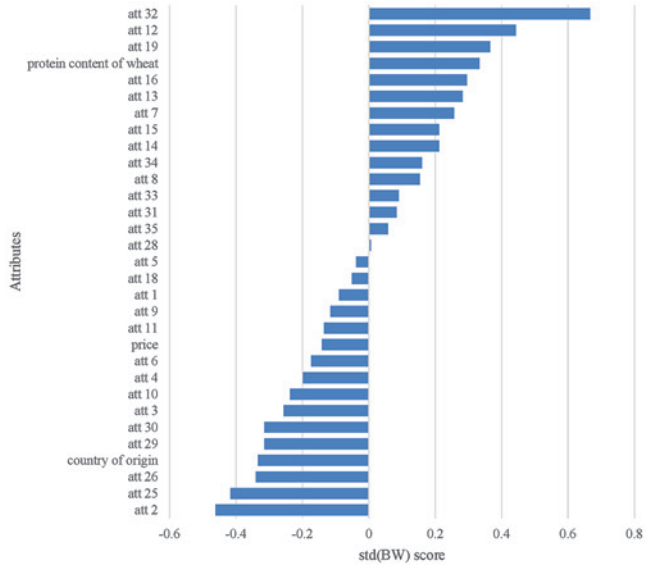

Fig. 1. Milling technicians' rankings of attributes influencing their wheat selection for making product A. BW = best-worst survey.

For each choice set of the DCE, participants were presented with three parcels of wheat described by five quality attributes and price. Participants were then asked to nominate which of parcel A, B, or C they would prefer if they were to select a parcel for use in making the nominated end product, as well as the parcel they would least prefer. Participants were not able to move to the next choice set until they entered a valid response. The data generated by the experiments indicated which of the three parcels of wheat were selected either as most or least preferred. A conditional logit model of the quality attributes was then estimated per Aizaki et al. (3), and estimates of willingness to pay for each attribute were generated. To economize on space, however, willingness-to-pay results are not presented here.

Results

Due to commercial sensitivities surrounding the results, the food products that were the focus of this research are presented as alphanumeric codes, and most of the attributes are presented as numeric codes. The exceptions are the characteristics of price, country of origin, and protein content. Not revealing the end-product name and each attribute is a requirement of the study's principal funder, who is charged with advancing the commercial interests of the Australian wheat industry. However, honoring the imposed commercial restrictions does not detract from the contribution of this article in illustrating how BWS and DCE surveys can accurately reveal wheat end-user preferences and, thereby, provide valuable information to any country's wheat breeders and marketers, leading to improvements in the effectiveness and efficiency of their wheat breeding and subsequent marketing of new varieties.

To further economize on space, results are presented here for the noodle product and bread product within one importing country. Attribute preferences are presented separately for each group of wheat buyers and milling technicians. The attributes of price, protein content, and country of origin are named, while the remainder are anonymized.

BWS Findings. ***Product A.*** The likelihood of a wheat attribute being selected as the most important, relative to other attributes when selecting wheat for product A, is presented in Figures 1 and 2 for milling technicians and wheat purchasers, respectively. For wheat purchasers, price and wheat protein content overwhelmingly dominated their selection of wheat when

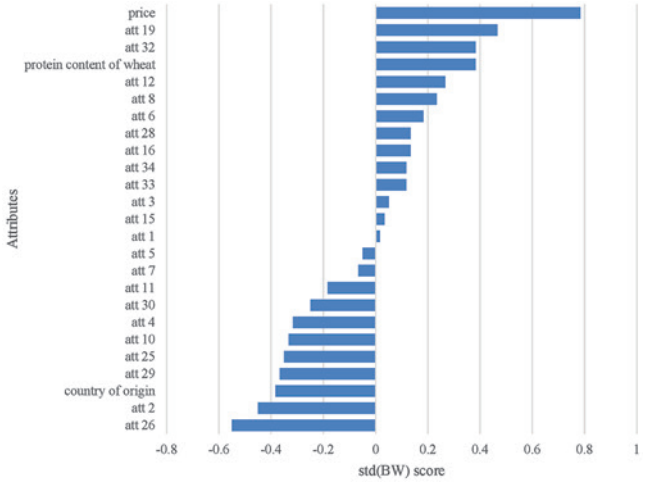

Fig. 2. Wheat purchasers' rankings of attributes influencing their wheat selection for making product A. BW = best-worst survey.

buying for product A. By contrast, milling technicians attached far less importance to price and wheat protein content in their ranking of desired attributes when sourcing wheat for product A.

A common and logical finding was that purchasers were more likely to value those attributes that could be negotiated within their purchasing contracts. Such a finding is consistent with earlier studies showing price differentials based on grain quality categories exist in various international markets (29,30). The exception to this rule concerning attributes in contracts were those attributes—usually regarding undesirable characteristics of a shipment—that could be fixed within the sale contract and once fixed were of no further concern and were then not a point of negotiation.

Attributes that technicians ranked as low in importance were also likely to be ranked as low in importance by purchasers. In each group's set of attributes that scored below 0.25, five attributes were common to each set. Hence, both groups mostly ranked a similar set of attributes as being relatively unimportant in their preferences for wheat used in making product A. The

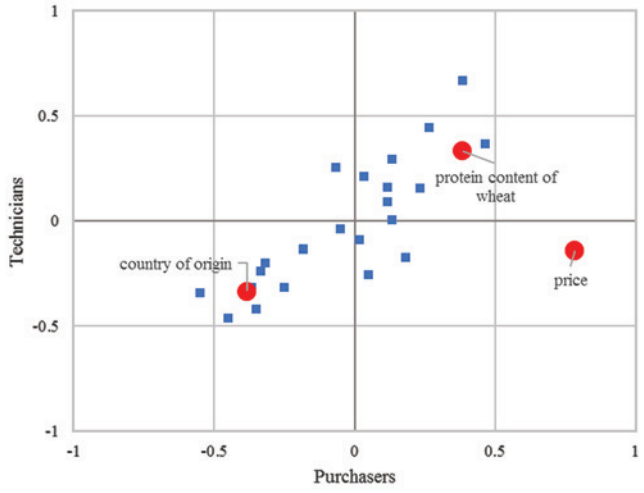

Fig. 3. Alignment of wheat quality preferences between wheat purchasers and milling technicians for product A. The labeled points are the round (red) symbols.

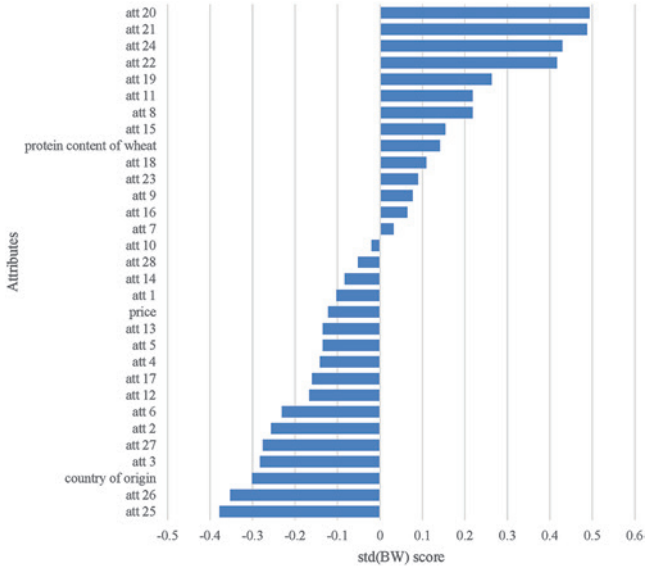

Fig. 4. Milling technicians' rankings of attributes influencing their wheat selection for making product B. BW = best-worst survey.

"country of origin" attribute was ranked lowly by both technicians and purchasers. This indicates that there is little allegiance to any one country when selecting wheat and that the performance of the wheat is the more important consideration. In some cases, however, such as wheat for baking bread, the country of origin, and especially the class of wheat from that country, were significant predictors of wheat performance.

The alignment of attributes common to purchasers and technicians is presented in Figure 3. Price is an outlier, being highly valued by purchasers but far less so by technicians. When price is not included in the results, the R^2 value is 0.72, while when price is included, the R^2 value falls to 0.48.

Product B. The characteristics that affect the manufacture of product B were ranked by their importance by milling technicians. Five attributes achieved importance index scores above 0.6 (Fig. 4). In contrast, yet consistent with findings for product A, wheat buyers highly ranked the price of the wheat and its protein content when selecting wheat for product B (Fig. 5). Only two attributes were commonly highly ranked above 0.6 by buyers and technicians.

There were 14 attributes with importance index scores less than 0.4 for technicians and 11 for buyers. Eight attributes that scored below 0.4 were common to rankings by technicians and buyers. Hence, similar to the findings for product A, both groups mostly ranked a similar set of attributes to be relatively unimportant in their preferences for wheat used in making product B.

As with product A, purchasers preferred price attributes, and protein also was higher in the rankings (Fig. 5). Within the purchasers' results, there was a general movement of all contract specifications up the rankings compared with the technicians' results.

For product B, the alignment of attributes common to purchasers and technicians was similar to product A (Fig. 6). Price was again an outlier, being highly valued by purchasers but of lesser importance for technicians. When price is not included in the results, the R^2 value is 0.72, while when price is included, the R^2 value falls to 0.38.

DCE Findings. As outlined previously in the section describing the DCEs, five quality attributes from the BWS survey for each product, along with price, were selected for the DCEs concerning Southeast Asian noodle and bread products. Although the selected attributes were ranked highly, they were not always

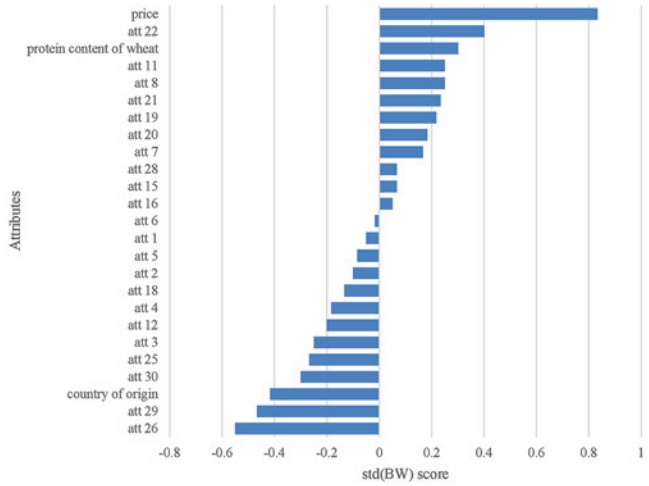

Fig. 5. Wheat purchasers' rankings of attributes influencing their wheat selection for making product B. BW = best-worst survey.

in the top five. There is high correlation between some of the attributes included in the BWS survey, and attributes for the DCE were chosen to minimize the correlation between attributes. The attributes for each end product reported here were included in surveys in multiple countries, and in each country, milling technicians and wheat purchasers completed the same survey, allowing comparison of their willingness to pay for similar attributes in different markets. Each attribute was evaluated at five levels within a market, although there were some differences in attribute levels between markets.

Product A. For product A, all five selected attributes had a positive effect on willingness to nominate a parcel of wheat as the preferred parcel (Table II). Although the coefficient for price was negative, this is an expected result, as it indicates more expensive parcels are less preferred.

Product B. The DCE for product B showed there were three key attributes with a significant effect on the decision to select a parcel of wheat (Table III). These included two flour characteristics and one end-product characteristic. The other characteristics included in the experiment were dough characteristics: dough characteristic 1 was not significant and should not be included in the model, and dough characteristic 5 had a $Pr(>|z|) < 0.01$, and so was significant at the 0.99 level.

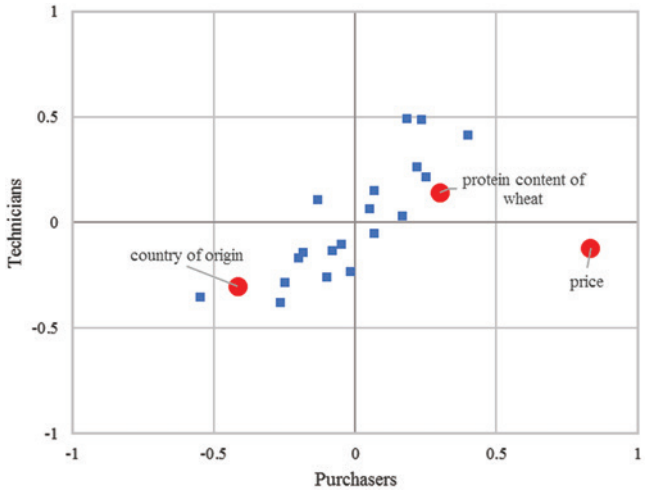

Fig. 6. Alignment of wheat quality preferences between wheat purchasers and milling technicians for product B. The labeled points are the round (red) symbols.

Discussion

Understandably, wheat buyers ranked price as the most important attribute governing their selection of wheat used in the manufacture of every end product considered in this study. Moreover, the focus of their selection and valuation of wheat often involved attributes specified in wheat purchasing contracts, such as protein content or wheat class. These wheat buyers were less familiar with dough rheology attributes, and so only a few of these properties figured highly in their rankings of wheat parcels for various end products.

Although the price of a wheat parcel and its protein content dominated buyers' preferences, more interesting was the revelation of technicians' preferences, which often differed from those of the buyers. In addition, technicians' preferences differed between noodle and bread products, with technicians valuing attributes that facilitated the manufacture of each particular end product.

For noodle products, a small number of attributes consistently were identified as very important when selecting wheat for noodle products across all markets. For bread products, again a small number of attributes were jointly valued by buyers and technicians. While wheat buyers always ranked price as the most important attribute, price was ranked as far less important by technicians. Price aside, the preferences of purchasers and technicians were aligned more closely for noodle attributes than for bread attributes. For bread products, technicians tended to place a greater emphasis on dough rheological characteristics than did buyers.

Implications for Wheat Breeders. The choice modeling experiments revealed what traits or attributes are valued by Southeast Asian wheat buyers and milling technicians. For example, when wheat is purchased and used for noodle products, then, in addition to price, a few key quality attributes are especially

Table II. Coefficients and significance for attributes included in the clogit model for product A

Attribute	Coefficient[a]	2.5%	97.5%	$Pr(>\|z\|)$	Significance[b]
Dough characteristic 1	0.017	0.012	0.023	0	***
End-product characteristic 2	0.273	0.208	0.338	0	***
End-product characteristic 3	0.267	0.205	0.328	0	***
End-product characteristic 4	0.231	0.167	0.296	0	***
Flour characteristic 5	0.079	0.059	0.1	0	***
Price	−0.032	−0.042	−0.021	0	***

[a] Due to commercial sensitivities, the units of these coefficients are not reported.
[b] *** indicates significance at 0.999.

Table III. Coefficients and significance for attributes included in the clogit model for product B

Attribute	Coefficient[a]	2.5%	97.5%	$Pr(>\|z\|)$	Significance[b]
Dough characteristic 1	0	0	0.001	0.29	
Flour characteristic 2	0.154	0.115	0.193	0	***
Flour characteristic 3	0.088	0.062	0.115	0	***
End-product characteristic 4	0.541	0.459	0.622	0	***
Dough characteristic 5	−0.034	−0.059	−0.009	0.008	**
Price	−0.059	−0.071	−0.048	0	***

[a] Due to commercial sensitivities, the units of these coefficients are not reported.
[b] *** indicates significance at 0.999; ** indicates significance at 0.99.

valued. Hence, when plant breeders develop new noodle wheat varieties, then in addition to selecting lines on the basis of their yield and disease tolerance, selections can also be made from lines that exhibit these other attributes that are highly desired in Southeast Asian markets. Aligning breeding objectives to deliver attributes that are highly valued by farmers (e.g., yield) and end-user noodle flour manufacturers ensures new wheat varieties are more likely to be grown and sold to be a principal component of flour blends used for noodle products.

In the case of wheat used for bread products, a small number of attributes were jointly valued by buyers and technicians. Hence, an implication for wheat breeders is that any bread wheat varieties they develop need to have not only the usual desirable characteristics of higher yield and disease resistance but also should feature these other strongly desired end-use properties.

When wheat breeders are aware of what traits or attributes are highly valued by end users, they can allocate their limited budgets on testing for those traits most valued by farmers and end users. In other words, the breeders can make better decisions that improve the efficiency of breeding, enabling varieties to be bred at lower costs that are better fit-for-purpose.

End users in Southeast Asia, in turn, can benefit from access to wheat varieties that are better tailored to their end users' needs, enabling more efficient production of noodle and bread products. Greater efficiency and effectiveness in the manufacture of these products reinforces the affordability and convenience of these products to consumers, further encouraging their consumption.

Other Implications. This study found differences between wheat buyers and millers regarding their ranking of the relative importance of various attributes. Such a finding is expected because buyers mostly focus on characteristics that feature in grain contracts with which they are familiar. In contrast, millers have a greater technical understanding of grain quality and traits that deliver end-use functionality. Hence, millers consider more attributes and display different preferences. One implication of these differences between buyers and millers is that there is likely to be merit in greater information exchange between buyers and milling technicians. Exposing buyers to the views of milling technicians ensures that buyers learn that, in addition to attributes such as price and protein content, there are other important attributes to discuss in any potential wheat trade. An outcome of such discussions could be that purchasers are better informed about what attributes deliver end-use functionality and, therefore, better serve end users of the grain they buy. The actions of buyers who are better informed about preferred traits would, in turn, reward the efforts of wheat breeders.

Conclusions

Decisions by wheat breeders are crucial in ensuring that the wheat varieties adopted by farmers benefit both growers and end users. This study illustrates how consumer choice surveys and experimental techniques can uncover what traits are of high and low value to wheat users when selecting wheat for particular Southeast Asian food products. The revealed preferences of Southeast Asian end users can be relayed to wheat breeders to improve their plant selection decisions and make breeding more effective and efficient.

In this study, BWS surveys revealed the preferences of wheat buyers and milling technicians when sourcing wheat for the manufacture of various Southeast Asian noodle and bread products. The buyers and millers ranked the relative importance of many traits or attributes of wheat used to create these products.

Highly ranked attributes featured in a second assessment of their preferences. DCEs revealed each group's willingness to pay for each highly ranked attribute when the wheat being purchased or milled was to be used to manufacture a particular food product.

When wheat is purchased and milled for noodle products, in addition to price, a few other attributes are especially valued. We conclude that when plant breeders are developing new noodle wheat varieties, then, in addition to selecting lines for their yield and disease tolerance, selection decisions should also consider these other highly desirable attributes.

Similarly, when wheat is purchased and milled for bread products, in addition to price, there are a few other attributes jointly valued by buyers and millers. These attributes could be incorporated in the plant selection and varietal development decisions of wheat breeders to improve the efficiency and effectiveness of providing a desired product to food producers in the globally important wheat market of Southeast Asia.

Appendix

Table A1. Attributes included in the best-worst scaling survey in each country

	Fresh Noodles		Bread	
Attribute	**Milling Technician**	**Wheat Purchaser**	**Milling Technician**	**Wheat Purchaser**
Economic	Price	Price	Price	Price
	Country of origin	Country of origin	Country of origin	Country of origin
Wheat quality	Protein content	Protein content	Protein content	Protein content
	Wheat grade	Wheat grade	Wheat grade	Wheat grade
	Grain color (white/red)	Grain color (white/red)	Grain color (white/red)	Grain color (white/red)
	Screenings/unmillable material	Screenings/unmillable material	Screenings/unmillable material	Screenings/unmillable material
	Test weight	Test weight	Test weight	Test weight
	Moisture content	Moisture content	Moisture content	Moisture content
	Wheat falling number	Wheat falling number	Wheat falling number	Wheat falling number
			Dark vitreous kernels 1	Dark vitreous kernels 1
Flour quality	Milling yield	Milling yield	Milling yield	Milling yield
	Flour ash	Flour ash	Flour ash	Flour ash
	Flour color – b^*		Flour color – b^*	
	Flour color – L^*	Flour brightness	Flour color – L^*	Flour brightness
	Water absorption	Water absorption	Water absorption	Water absorption
	Dough development time		Dough development time	
	Dough stability time		Dough stability time	
	Dough extensibility	Dough extensibility	Dough extensibility	Dough extensibility
	Dough strength	Dough strength	Dough strength	Dough strength
	Dough tolerance		Dough and fermentation tolerance	
	Starch viscosity		Starch viscosity	
	Wet gluten content	Wet gluten content	Wet gluten content	Wet gluten content
End product	Noodle texture firmness	Noodle texture firmness	Loaf volume 2	Loaf volume 2
	Noodle texture elasticity	Noodle texture elasticity	Bread crumb color	Bread crumb color
	Noodle color – L^*	Noodle color	Bread crust color	
	Noodle color – b^*		Bread crumb softness	Bread crumb softness
	Noodle color stability		Product resilience	
Support services	Quality inspection service and chemical/mycotoxin testing	Quality inspection service and chemical/mycotoxin testing	Quality inspection service and chemical/mycotoxin testing	Quality inspection service and chemical/mycotoxin testing
	Availability of on-farm quality assurance program	Availability of on-farm quality assurance program	Availability of on-farm quality assurance program	Availability of on-farm quality assurance program
	Availability of technical support and training	Availability of technical support and training	Availability of technical support and training	Availability of technical support and training
	Availability of seasonal crop quality report	Availability of seasonal crop quality report	Availability of seasonal crop quality report	Availability of seasonal crop quality report
	Uniformity of wheat shipment	Uniformity of wheat shipment	Uniformity of wheat shipment	Uniformity of wheat shipment

Table A2. Experimental design for the discrete choice experiments

Common	Parcel (Offer) 1 Attributes						Parcel (Offer) 2 Attributes					
Pairs	a1	a2	a3	a4	a5	a6	b1	b2	b3	b4	b5	b6
1	4	0	4	0	4	0	0	4	0	4	0	4
2	4	1	2	3	0	1	0	3	2	1	4	3
3	4	2	0	1	1	2	0	2	4	3	3	2
4	4	3	3	4	2	3	0	1	1	0	2	1
5	4	4	1	2	3	4	0	0	3	2	1	0
6	3	0	0	3	2	4	1	4	4	1	2	0
7	3	1	3	1	3	0	1	3	1	3	1	4
8	3	2	1	4	4	1	1	2	3	0	0	3
9	3	3	4	2	0	2	1	1	0	2	4	2
10	3	4	2	0	1	3	1	0	2	4	3	1
11	2	0	1	1	0	3	2	4	3	3	4	1
12	2	1	4	4	1	4	2	3	0	0	3	0
13	2	2	2	2	2	0	2	2	2	2	2	4
14	2	3	0	0	3	1	2	1	4	4	1	3
15	2	4	3	3	4	2	2	0	1	1	0	2
16	1	0	2	4	3	2	3	4	2	0	1	2
17	1	1	0	2	4	3	3	3	4	2	0	1
18	1	2	3	0	0	4	3	2	1	4	4	0
19	1	3	1	3	1	0	3	1	3	1	3	4
20	1	4	4	1	2	1	3	0	0	3	2	3
21	0	0	3	2	1	1	4	4	1	2	3	3
22	0	1	1	0	2	2	4	3	3	4	2	2
23	0	2	4	3	3	3	4	2	0	1	1	1
24	0	3	2	1	4	4	4	1	2	3	0	0
25	0	4	0	4	0	0	4	0	4	0	4	4

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