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A Conjoint Analysis of New Food Products Processed from Underutilized Small Crawfish

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ABSTRACT

Attributes for two value-added seafood products derived from underutilized crawfish are analyzed using conjoint data from seafood restaurants in the southern region of the United States. Preferences for the products' form, price, and flavor attributes were tested. Statistical tests revealed that the attribute interactions were not significant, and part-worth utilities for all main effects were estimated using an additive preference model. Results indicate that the new crawfish products should be marketed as a high-quality fresh soup base or seafood stuffing, priced between 30% and 50% of the cost of fresh crawfish tail meat.

Key Words: conjoint analysis, minced meat, seafood, value added.

The United States fishery and aquaculture industries yield numerous by-products that have the potential for further processing into value-added food products. In 1990, the United States produced some 300 million pounds of surimi, which is used to make a variety of mince-based seafood products such as stuffings and dips, battered and breaded seafood products, seafood patties, and soup bases (Meyers). These products can be derived from a number of sources. For example, commercial fishing creates large amounts of underutilized fish species, which are caught when more desirable species are netted. In other cases, fishing and aquaculture enterprises often yield undersized grades that simply may be too small to process normally (Regenstein).

The Louisiana crawfish industry provides an example of how smaller grades can go underutilized. The primary products of the crawfish industry are live crawfish and hand-peeled tail meat. Most of the crawfish harvested in Louisiana either come from the Atchafalaya Basin or are farm-raised. After harvesting, most crawfish are sorted into three or four grades. The larger grades are exported to European markets or sold on the domestic live market at a premium price. The smallest grades typically are not suitable for processing or for sale on live markets. These smaller crawfish, which account for as much as 20% of the catch in some years, are by-products of the grading process and usually are priced well below the current market price or discarded by the processing plant (Özayan). Moreover, the crawfish industry generates some 80 million pounds of peeling by-product during recovery of only 15% of edible tail meat (Meyers).

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Numerous studies in the food science literature demonstrate the technical feasibility of mechanical processing of underutilized by-products into edible minced meat. Lee, Meyers, and Godber report that edible minced meat can be extracted from blue crab processing by-products using mechanical meat-shell (or meat-bone) separators. A study by Gates and Parker also confirms the feasibility of deriving food-grade minces from blue crab processing by-products. Pigott summarizes research on the further processing of fish frames into mince meat. While these analyses have documented the technical feasibility of minced meat seafood, little or no research has been conducted on the market potential for these products.

A few studies have addressed the marketing of traditional crawfish products. Dellenbarger, Schupp, and Zapata report that on-farm area devoted to crawfish production decreased by about 5,000 acres in 1990. They concluded that the decrease could have resulted from a decline in demand for crawfish caused by an economic recession or lower priced substitute products. Their study emphasizes the need to develop new markets, or expand existing markets, to increase the demand for crawfish. In a later analysis, Yen, Dellenbarger, and Schupp investigated the determinants of crawfish consumption in Houma, Louisiana, for the same reasons. Although the above works have contributed to the understanding of the crawfish industry's current markets, little effort has been made to examine markets for new value-added products derived from crawfish. The current study differs from previous research in this respect.

The primary objective of this analysis is to investigate the market potential for minced meat products derived from underutilized small crawfish. The specific objectives are to: (*a*) identify potential markets for crawfish mince-based products and the product attributes needed for the products' acceptance in these markets, and (*b*) estimate the market's preferences for new minced meat food products derived from undersized crawfish.

Methods

Conjoint analysis (CA) is widely used in market research because it allows for a buyer's total utility for a multidimensional product to be decomposed into combinations of part-worth utilities for each attribute of the product. CA is useful because it provides a technique for measuring and evaluating the relative importance of the individual characteristics of a product. It also provides a means to determine the preferred combination of product characteristics.

Numerous studies have used conjoint analysis to examine buyer or user preferences. Huang and Fu used conjoint analysis to examine individual consumer preferences for various Chinese sausage attributes. Gan and Luzar applied conjoint analysis to the problem of waterfowl hunting in Louisiana. They used ordered logit to estimate willingness to pay for recreation experience attributes. Yoo and Ohta applied conjoint analysis to determine the optimal pricing and product planning for automobiles. An application similar to that used in this study was employed by Halbrendt, Wirth, and Vaughn. They used conjoint analysis to determine the utility values for nine different hybrid striped bass products. The authors also added variables for market-level and attribute-market interactions to allow for inter-industry comparisons. Anderson and Bettencourt applied the conjoint approach to model preferences in the New England market for fresh and frozen salmon.

There are essentially three steps involved in a conjoint study. First, relevant product attributes and their levels must be defined in a manner that is consistent with the buyer's understanding of the product. Second, an experimental design and a survey instrument must be constructed to collect the conjoint data. At this stage, a set of hypothetical products is defined by combining product attributes at various levels. Subjects then are asked to evaluate their overall preference rating or ranking of the hypothetical products. The final step of CA involves choosing an appropriate composition model and estimating the buyer's part-worth

utilities. Each of these steps is discussed in detail below.

Selection of Product Attributes

To identify a product's attributes and its associated levels, Louviere recommends the use of unstructured focus group interviews, combined with a series of semi-structured, open-ended questions. Focus group interviews can be described as small groups in which the researcher guides a group discussion on the topic of interest. Since our study involves new product development and there was no a priori knowledge about the products, focus group interviews were used to obtain information about the possible use of crawfish mince and to determine the relevant attributes of the minced meat products.

The focus groups consisted of seafood processors, seafood wholesalers, distributors, seafood restaurant and delicatessen managers, and chefs from south Louisiana. Two focus group discussions were conducted, one in each of two major cities in Louisiana. The first was conducted in Baton Rouge with two delicatessen managers and two restaurant chefs. The second group discussion was held in New Orleans and included two seafood wholesaler/distributors, one restaurant owner/chef, a representative from the Louisiana Seafood Promotion and Marketing Board, and two seafood processors.

The results of the group interviews indicated that crawfish mince might best be marketed to restaurants for use either as a base and/or a stuffing ingredient for various menu items. The consensus was that a base or stock type product could be used to flavor soups and chowders. The stuffing product would be used as a meat substitute for various recipes for crawfish bisques, sausages, and other items that require a stuffing ingredient. The respondents also noted that the mince's price would need to be discounted relative to seasonal prices for fresh tail meat. Depending on the season, the price range for fresh tail meat is between $3 and $9 per pound (Gillespie and Capdeboscq). In addition, the form of the minced product was discussed and felt to be important. The discussion focused on various forms such as a completely fresh product that had never been frozen, a frozen product that could be stored for later use, and a dehydrated bouillon cube form. The respondents further reported that the strength or concentration of the product's flavor was important.

In summary, the focus group discussions revealed that the most relevant attributes for either a soup/chowder base or stuffing product are the price, form, and flavor of the product. Specifically, the attributes and their associated levels are the product's price, which is expressed as a percentage of the current price of fresh crawfish tail meat (at levels of 30%, 50%, and 70%); the product's form (with levels defined as fresh/never frozen, frozen, and dehydrated/semi-moist bouillon cube); and the product's flavor (with levels identified as concentrated/strong and mild). The respondents also indicated that their preferences for each attribute level would vary depending on whether the minced meat is used to make a base or a stuffing. Therefore, the preferences for the selected attributes were tested independently for both a base and a stuffing product.

Experimental Design

In this study, there are two three-level attributes (price and form) and one two-level attribute (flavor). A full profile approach would involve 18 ($3 \times 3 \times 2$) profiles for the soup/chowder base product and an equal number for the stuffing product. Subjects would have difficulty in rating 36 product profiles using a mail survey. To address this problem, the number of treatments was reduced using a mixed ($3 \times 3 \times 2$) confounded block design. This procedure reduces the number of profiles a subject must evaluate to six, and allows for a test of all main effects plus all two-way and three-way attribute interactions. The design used here was adapted from a design discussed in Cochran and Cox (p. 174). (Readers interested in a detailed discussion of this adaptation are referred to Özayan, pp. 26–30).

The Survey and Conjoint Data Collection

A questionnaire/mail survey was constructed to collect the conjoint data. A mailing list was

purchased from American Business Information Marketing, Inc., that included 1,599 seafood restaurants from the Gulf South region of the United States (Louisiana, Mississippi, Alabama, and Texas). The experimental design called for 12 different configurations for the conjoint questions (Özayan, pp. 26–30). Hence, the total sample was divided at random into 12 groups with a sample size of 133 for nine groups, and 134 for three groups. The respondents also were asked questions about their willingness to buy minced crawfish products. The questionnaires then were mailed to the seafood restaurants in their respective groups. Dillman's total design method was followed for implementation of the mail survey.

A total of 260 responses were received, resulting in a 16.3% response rate. Of these responses, 69 of the respondents did not answer the conjoint section of the questionnaire, and 36 questionnaires had incomplete conjoint responses. Although there were 155 questionnaires with complete conjoint responses, the confounded design requires a common number of observations for the 12 groups. Since eight was the highest common number within all the groups, 96 questionnaires were used to test for the presence of all main and interaction effects. After testing for attribute effects, all main effect part-worth values were estimated using the 155 usable questionnaires.

Tests for Attribute Effects

Analysis of variance (ANOVA) is used to determine if main and interaction treatments significantly affect respondents' preferences for the selected products. If interaction effects are not significant, then an additive model can be used to estimate part-worth values for all main effects. The ANOVA model used to test treatment effects for both the soup/chowder base and stuffing products is specified as follows:

$$R_{ijkn} = G + P_i + F_j + L_k + (PF)_{ij} + (PL)_{ik} + (FL)_{jk} + (PFL)_{ijk} + B_s + T_r + e_{ijkn},$$

where R_{ijkn} is the nth respondent's rating for the ijkth combination of attribute levels for the soup/chowder base and the stuffing product; G is the overall response mean; P_i is the ith price treatment effect (i = 30%, 50%, and 70% of the crawfish tail meat price); F_j is the jth form treatment main effect (j = fresh, frozen, and dehydrated form); L_k is the kth flavor treatment main effect (k = mild or concentrated crawfish flavor); $(PF)_{ij}$ is the ijth two-way price-form treatment interaction effect; $(PL)_{ik}$ is the ikth two-way price-flavor treatment interaction effect; $(FL)_{jk}$ is the jkth two-way form-flavor treatment interaction effect; $(PFL)_{ijk}$ is the ijkth three-way price-form-flavor treatment interaction effect; B_s is the sth block effect (s = 1, 2, 3); T_r is the rth replication effect (r = 1, 2, 3, 4); and e_{ijkn} is the error associated with the ijkth combination of the product for the nth respondent.

In addition to price, form, and flavor main and interaction effects, the experimental design called for four replications with three blocks within each replication. Hence, block and replication effects are additional sources of variation that must be accounted for in the model. The null hypothesis for the model is that each main and interaction effect is equal to zero. This is tested using an F-statistic to compare the within-treatment means for each source of variation in the model. For example, the null hypothesis for the main effect of price is H_0: $\mu_{30\%} = \mu_{50\%} = \mu_{70\%}$, where $\mu_{30\%}$ is the mean response for the 30% price level, $\mu_{50\%}$ is the mean response for the 50% price level, and $\mu_{70\%}$ is the mean response for the 70% price level. Rejection of the null hypothesis implies that the treatment effect for price (P_i) is significantly different from zero.

The ANOVA results for both the soup/chowder base and the stuffing product are presented in table 1. The significance level chosen for the analysis was $\alpha = 0.05$. The main effects for product form and price are significant for both the soup/chowder base and stuffing products. Therefore, product form (i.e., fresh, frozen, and dehydrated forms) affects the restaurants' preference for both the base and stuffing products. Similarly, price affects the restaurants' preference for these products as well.

Table 1. ANOVA Results for the Soup/Chowder Base and Seafood Stuffing Ingredients Derived from Southern Crawfish

Source of Variation	Degrees of Freedom	Soup/Chowder Base			Seafood Stuffing		
		Sum of Squares	Mean Square	*F*-Value	Sum of Squares	Mean Square	*F*-Value
Replications	31	47.65	1.54	0.140	74.15	2.39	0.236
Blocks w/in Replication	64	395.00	6.17	0.559	486.44	7.60	0.752
Main Effect Price (*P*)	2	69.57	34.79	3.154*	73.40	36.70	3.630*
Main Effect Form (*F*)	2	482.29	241.15	21.863*	734.18	367.09	36.310*
Main Effect Flavor (*L*)	1	22.56	22.56	2.045	0.03	0.03	0.003
PF Interaction	4	4.11	1.03	0.093	36.21	9.05	0.895
PL Interaction	2	38.64	19.32	1.752	33.30	16.65	1.647
FL Interaction	2	12.67	6.33	0.574	15.85	7.92	0.783
PFL Interaction	4	70.55	17.64	1.599	21.26	5.32	0.526
Error	463	5,107.40	11.03		4,679.02	10.11	
Total	575	6,250.44	10.87		6,153.83	10.70	

Notes: An asterisk (*) indicates the effect is significant at the $\alpha = 0.05$ level. *PF*, *PL*, and *FL* represent the price-form, price-flavor, and flavor-form two-way interactions, respectively; *PFL* represents the price-form-flavor three-way interaction.

Other results suggest that there is no statistical difference between preference ratings for the flavor attribute for either of the two products. Also, the replication and blocks within replication effects were not significant for either base or stuffing products. Moreover, the two-way and three-way interaction effects were not significant for either of the two products. The insignificance of interaction effects implies that the respondents evaluate product attributes independently from one another. Therefore, an additive preference model can be used to estimate respondents' part-worth utilities.

Estimation of Part-Worth Utilities

In conjoint measurement, a customer's total utility for a product is a function of his/her part-worth utilities. In order to determine a customer's total utility for a product, part-worth utilities for each product attribute must be estimated. If an additive preference function is assumed, then part-worth values can be estimated using linear regression and mean deviation dummy variable coding. The model used to estimate the part-worth utilities for both the soup/chowder base and stuffing products is:

$$R_i = G + W_1D_1 + W_2D_2 + W_3D_3 + W_4D_4 + W_5D_5 + e_i,$$

where R_i is the preference rating for the ith respondent; $D_1 = 1$ and $D_2 = 0$ represent the 30% price level; $D_1 = 0$ and $D_2 = 1$ represent the 50% price level; $D_1 = -1$ and $D_2 = -1$ represent the 70% price level; $D_3 = 1$ and $D_4 = 0$ represent the fresh product form; $D_3 = 0$ and $D_4 = 1$ represent the frozen product form; $D_3 = -1$ and $D_4 = -1$ represent the dehydrated bouillon cube product form; $D_5 = 1$ or -1 represent the mild and concentrated flavor, respectively; and e_i is the error term.

This type of coding yields part-worth estimates that represent deviations from the overall mean preference rating. The intercept G is the overall mean response, and the coefficients W_1, W_2, W_3, W_4, and W_5 are the part-worth estimates associated with the respective levels of price, form, and flavor. Some investigators have found heteroskedasticity to be a problem in conjoint data, and therefore estimated part-worth parameters using weighted least squares regression (Halbrendt, Bacon, and Pesek). White's procedure was used to test for the presence of heteroskedasticity in the data for this study (Kmenta). The test failed to reject the null hypothesis of homoskedastic errors at

Table 2. OLS Estimates of Part-Worth Utilities for Main Effects of the Soup/Chowder Base and Seafood Stuffing Ingredients Derived from Southern Crawfish

	Soup/Chowder Base			Seafood Stuffing		
Variable	Part-Worth Estimate	Standard Error	*t*-Statistic	Part-Worth Estimate	Standard Error	*t*-Statistic
Grand Mean	5.349	0.10	53.49*	5.336	0.10	53.56*
30% Price Discount	0.413	0.14	2.95*	0.341	0.14	2.44*
50% Price Discount	−0.003	0.14	−0.02	0.135	0.14	0.96
70% Price Discount	−0.410	0.14	−2.93*	−0.476	0.14	−3.40*
Fresh Form	1.055	0.14	7.54*	1.053	0.14	7.52*
Frozen Form	0.233	0.14	1.66	0.471	0.14	3.36*
Dehydrated Form	−1.288	0.14	−9.20*	−1.525	0.14	−10.89*
Mild Flavor	−0.016	0.10	0.16	0.119	0.10	1.19
Concentrated Flavor	0.016	0.10	−0.16	−0.119	0.10	−1.19
F-Statistic	20.383			27.580		
Adjusted R^2	0.095			0.125		

Notes: An asterisk (*) indicates the effect is significant at the $\alpha = 0.05$ level. Sample size is equal to 155 observations.

a 1% significance level. Therefore, the part-worth values were estimated using ordinary least squares (OLS) regression.

Results

The part-worth estimates relate the preference rating to combinations of various attribute levels. Table 2 presents the OLS part-worth estimates for the soup/chowder base and stuffing ingredient products. As before, the significance level chosen for the analysis was $\alpha = 0.05$. The *F*-statistics show that both models are significant, and the adjusted R^2s are 0.095 and 0.125 for the soup/chowder base and stuffing products, respectively. The primary cause for the somewhat low R^2s is that aggregating responses across individuals introduces additional variation due to differences in each respondent's subjective rating for the same product.

A *t*-test is used to test the null hypothesis that the part-worth estimate for each attribute level is equal to zero. The part-worth utilities for 30% and 70% price, and dehydrated and fresh forms are statistically significant for the soup base product. Similarly, part-worth utilities are significant for the 30% and 70% price, and the dehydrated, frozen, and fresh forms for the stuffing product. The relative effect of each attribute level on the respondent's preference rating can be determined by comparing the part-worth utilities. For both products, the lowest price has a positive effect on buyer preferences, whereas the highest price has a negative effect. Fresh and frozen forms have positive effects, and the dehydrated bouillon form has a negative effect. The highest contribution to customer preferences comes from a fresh product with a part-worth utility of 1.055 for the base product. A dehydrated product had a negative effect of −1.288 on the buyer's preference for the soup base product. The results for the stuffing ingredient are similar to the soup base product with part-worth utilities of 1.053 for a fresh product and −1.525 for a dehydrated bouillon product (table 2).

These results indicate that the target market has a relatively strong preference for a fresh (never frozen) crawfish minced meat product. However, even though the fresh product is the most preferred form, the frozen product's effect is significant and positive for the stuffing product—indicating some preference for a storable product. Hence, a frozen stuffing product may be acceptable to buyers if the quality characteristics of a fresh product are retained. This has implications regarding the seasonal supply of smaller crawfish and food processing technologies to produce frozen

products that satisfy the customer's desire for a fresh product.

Measure of the Relative Importance of Product Attributes

Part-worth utility values also can be used to compute the relative importance of the product attributes. The relative importance weights are calculated in a manner described by Halbrendt, Wirth, and Vaughn. First, the highest and the lowest part-worth utilities are determined for each attribute. The difference between the highest and lowest part-worth establishes the utility range for the attribute. Once a range for each attribute has been determined, the relative importance of the *i*th attribute is calculated as follows:

$$RI_i = \left[Utility\ Range_i \div \sum \text{utility ranges } \forall \text{ attributes} \right] \times 100,$$

where RI_i is the relative importance measure for the *i*th attribute.

The most important attribute is product form, contributing over 70% to the preference rating for a soup/chowder base product. Following form, price is the second most important attribute, accounting for 26% of the preference rating. Similarly, for the seafood stuffing product, form is the most important attribute, contributing 70% to the preference rating; price is the second most important, with a contribution of 23%. Conversely, flavor in both cases is the least important attribute. For the stuffing ingredient, flavor has a 7% contribution to the preference rating, whereas for the soup/chowder base the contribution is negligible.

These results imply that form is the most important characteristic in developing minced meat products from undersized crawfish. This finding is not surprising given that these products are entirely unknown to the buyer. This result also demonstrates the importance of developing minced meat products that maintain the quality associated with fresh crawfish tail meat. It should be noted that even though price is secondary, it is still a significant factor. The potential buyer's preference for a discounted price creates challenges for food scientists and/or industry to develop products that can be marketed below current prices for crawfish tail meat.

Calculation of Total Utility

Since interaction effects were found to be insignificant, the additive decision model was used to find the market's overall utility for specific product profiles. This allows for a ranking of the 18 products tested by conjoint analysis. The total utility for each profile is calculated using the OLS part-worth estimates. The following formula is used:

$$U_{ijk} = G + \sum W_{ijk},$$

where U_{ijk} is the total utility for the product profile defined by the attribute combination given by levels *ijk*, G is the overall mean preference rating given by the OLS intercept, and $\Sigma\ W_{ijk}$ is the summation of all part-worth utilities associated with the product profile defined by levels *ijk*. The market's rankings of the soup/chowder base and seafood stuffing products are presented in table 3.

The rankings show that the most preferred product for the soup/chowder base product is a fresh product, with a price discounted 30% of that for crawfish tail meat, and with a concentrated crawfish flavor. The lowest utility is assigned to the 70% price in combination with a dehydrated bouillon product and a mild flavor. Similarly, the most and least preferred stuffing products have the same form and price characteristics as those for the base product; however, they differ in flavor characteristics. The most preferred seafood stuffing product has a mild flavor, whereas the least preferred product has a concentrated flavor.

Summary and Conclusions

The overall objective of this study was to investigate the market potential for minced meat products derived from underutilized small

Table 3. Estimated Utility Rankings for the Soup/Chowder Base and Seafood Stuffing Products

Price			Form			Flavor		Rank[a]	
30%	50%	70%	Fresh	Frozen	Dehydrated	Mild	Concentrated	Base	Stuffing
X[b]			X				X	1	3
X			X			X		2	1
	X		X				X	3	4
	X		X			X		4	2
X				X			X	5	8
		X	X				X	6	10
X				X		X		7	5
		X	X			X		8	7
	X			X			X	9	9
	X			X		X		10	6
		X		X			X	11	12
		X		X		X		12	11
X					X		X	13	15
X					X	X		14	13
	X				X		X	15	16
	X				X	X		16	14
		X			X		X	17	18
		X			X	X		18	17

[a] The highest estimated total utility is assigned a ranking of 1, and the lowest utility is assigned a ranking of 18.
[b] A particular combination of X's defines a hypothetical product.

crawfish. Specific objectives were to: (*a*) identify potential markets for crawfish mince-based products and the product attributes needed for the products' acceptance in these markets, and (*b*) estimate the market's preferences for new minced meat food products derived from undersized crawfish.

Focus group discussions indicated that a potential market for the crawfish mince meat would be seafood restaurants where the mince could be utilized as ingredients for various menu items. Among the most promising uses were as a crawfish soup/chowder base and as a stuffing ingredient for various recipes like bisques, boudin, and sausage (where chopped crawfish currently are used). The relevant attributes for these products were determined to be the product's price, form, and flavor.

Conjoint analysis revealed that all interaction effects were not significant and that the main effects of product form and price were the most important attributes. The strongest effects for both of the products were associated with the product's form, with the highest preference being a fresh/never frozen product. The least preferred form was a dehydrated bouillon product for both the base and stuffing products. The highest utility for the soup/chowder base was assigned to a combination of a fresh product with a price discounted 30% from crawfish tail meat, and concentrated crawfish flavor. However, it should be noted that the flavor attribute was not significant.

The frozen product form was significant for only the seafood stuffing product. However, in both product cases, the part-worth utility for frozen form was positive and there was only a slight difference between the market's preference for a fresh product and the frozen product, given the same levels for the price and flavor attributes. That is, the estimated utility for a fresh soup/chowder base product with a combination of 30% price and concentrated flavor is 6.831, whereas a frozen soup/chowder base product with the same combination is 6.013. This suggests that even though the potential market has a relatively strong preference for a fresh (never frozen) product, a frozen product may be acceptable if it retains most of the quality characteristics attributable

to a fresh product. This has implications for the ability of food processing technologies to produce frozen products that satisfy the customer's desire for a fresh product. Another important finding of this study is the market's desire for base and stuffing products that are priced well below the price of crawfish tail meat. The profitability of these new products depends upon whether they can be produced economically. Further research is needed to determine the costs of processing such products.

Both the soup/chowder base and seafood stuffing products look promising, since 65% of the respondents expressed a willingness to purchase them. However, producing products with the characteristics desired by the potential market is challenging and calls for further technical and economic analysis. Additional research is needed to determine whether these products can be produced commercially meeting government and industry food safety requirements, accompanied by a cost analysis to determine financial feasibility.

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