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Plant-Based versus Animal-Based Proteins: Does It Have to Be Either/Or?

Saroj Adhikari, Brandon R. McFadden, Trey Malone, and Jayson L. Lusk

This paper investigated consumer preferences for hybrid blends consisting of 50% and 75% plant-based ingredients relative to burgers comprised of 100% beef or plant-based ingredients. Latent class models with four latent classes identified four consumer segments: "Meat Purist," "Meat-Forward Flexitarian," "Plant-Forward Flexitarian," and "Price Sensitive." 100% beef burgers were most preferred, while hybrid meat burgers, particularly 50% beef with 50% soy or pea blends, were preferred over the 100% plant-based burgers. The study findings provide insight into the potential of hybrid blends to bridge between 100% meat and plant-based options and provide information about promoting hybrid meat products.

Key words: consumer preference, consumer segmentation, flexitarian, hybrid meat, latent class model, market share

Introduction

As global food systems face mounting pressures from increased demand, environmental sustainability concerns, and health considerations, the protein pivot toward plant-based meat alternatives is experiencing unprecedented coverage in the media (Fiorentini, Kinchla, and Nolden, 2020; Lang, 2020; Grasso, Asioli, and Smith, 2022). This shift is underpinned by a growing body of academic literature debating the nutritional and ecological costs and ethical ramifications of animal-based protein demand (Hoek et al., 2011; Van Loo, Caputo, and Lusk, 2020; Ortega, Sun, and Lin, 2022; Caputo, Sogari, and Van Loo, 2023; Zhao et al., 2023). Yet there is a tendency within public discourse and the scientific community to frame the protein conversation as a dichotomous choice—either animal or plant-based—and overlook the potential of hybrid blends that combine animal and plant-based proteins.

The potential of hybrid meat products lies in their appeal to a segment of consumers who find themselves at a crossroads of dietary traditions and modern dietary consciousness (Spencer and Guinard, 2018; Grasso and Jaworska, 2020; Grasso and Goksen, 2023). These consumers are willing to replace part of their meat- or plant-based diets and try new products. While recently developed plant-based meat alternatives have sought to disrupt the food industry, integrating plant proteins (i.e., pea and soy) into meat products may be a promising compromise. This study examines consumer preferences for burgers with varying proportions of beef and plant-based ingredients. The selection of burgers as a case study is relevant for a large proportion of U.S. consumers, given the wide appeal and significant role of ground beef consumption.

Saroj Adhikar is a postdoctoral researcher, Brandon R. McFadden (corresponding author, mcfadden@uark.edu) is a professor and the Tyson Endowed Chair in Food Policy Economics in the Department of Agricultural Economics and Agribusiness at the University of Arkansas. Trey Malone is an associate professor and the Boehlje Chair in Managerial Economics for Agribusiness in the Department of Agricultural Economics at Purdue University. Jayson L. Lusk is a vice president and dean in the Division of Agricultural Sciences and Natural Resources at Oklahoma State University.
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The objective of this study is to examine possible demand for hybrid meat products and determine the consumer segments most likely to purchase hybrid meat products. Specifically, we employed a latent class analysis to shed light on the nuanced choices of the contemporary consumer. The research presented here offers a granular view of how different consumer segments respond to hybrid burgers, with a particular focus on the meat-to-plant ratios that find favor among diverse consumer segments. Our results suggest that a sizable market segment would reduce their animal-based consumption by substituting for a hybrid option. As such, this article argues for further investigation that de-emphasizes the binary view of plant versus animal protein.

While prior research has shed light on the potential of hybrid meat products, few studies have focused on the extent of the market opportunity represented by beef–soy and beef–pea blends. Our study bridges this gap by investigating consumer preferences for hybrid meat products in the United States. Specifically, we seek to (i) evaluate consumer preferences for burgers with hybrid beef–soy and beef–pea blends and (ii) identify market segments based on preference heterogeneity for hybrid blends. While a steadfast segment still prefers 100% beef burgers, our data indicates a trend toward accepting hybrid alternatives among some consumer segments. Such insights are valuable for market positioning, message crafting, and devising strategic promotions that align with the complex and evolving landscape of consumer preferences in meat consumption.

Background

Dietary reductions are difficult, in general, because changes in food habits usually occur very slowly (Lentz, 1999). A large reduction in meat consumption is particularly difficult considering meat consumption is a formed habit (Pollak, 1970), and people continue eating meat due to a formed attachment (Graça, Calheiros, and Oliveira, 2015). There is a growing interest in a "flexitarian" diet, a relatively new term used to refer to meat eaters who are also cognizant of ongoing issues around meat consumption (Derbyshire, 2017; De Marchi et al., 2021). Flexitarians may seek to increase the proportion of plant-based foods in their diets for several reasons, including concerns about environmental sustainability (Garnett, 2011; Hartmann and Siegrist, 2017), human health (Cheskin et al., 2008; Wang and Beydoun, 2009), or animal welfare (Graça, Calheiros, and Oliveira, 2015). If consumers are divided into three broad categories—meat consumers, meat reducers, and meat avoiders—flexitarians are most closely associated with the meat-reducers category (Derbyshire, 2017). Plant-based meat alternatives that seek to imitate the taste, texture, and overall experience of animal meat are considered an attractive choice for those seeking to adhere to a flexitarian diet (Selinske et al., 2020; Aschemann-Witzel et al., 2021).

While plant-based alternatives are readily available in major US grocery stores, hybrid meat products are rarely available. Alternative meat products like Beyond Burger, which uses pea protein, and Impossible Burger, which uses soy protein, showed promising starts by attracting significant attention from consumers and investors (Caputo, Sogari, and Van Loo, 2023). However, despite the initial surge in popularity and consumer curiosity, sales of these products have been declining. For instance, sales for all Beyond Meat products decreased by 34.3% from the second quarter of 2022 to the second quarter of 2023 (Beyond Meat, 2023). The observed decline in sales prompts the question of whether the current approach of promoting entirely plant-based meat products is the most effective strategy for encouraging dietary reductions of animal meat consumption (Shanker, 2023).

A plant-based transition can be viewed as a range of dietary changes occurring as a result of various substitutes and forms (Hoek et al., 2011; Sirimuangmoon et al., 2016). Flexitarians (meat reducers), the likely targets in the context of the plant-based dietary transition, might find some combination of meat and plant-based proteins most appealing (Profeta et al., 2020). This raises the possibility of hybrid meat, a product with some proportion of the meat replaced with plant-based options (Spencer and Guinard, 2018; Grasso and Jaworska, 2020; Grasso, Asioli, and Smith, 2022; Caputo, Sogari, and Van Loo, 2023). Hybrid meat products may penetrate the meat category faster

than entirely plant-based alternatives for two reasons. First, hybrid meat may reduce the negative connotation of unfamiliarity often linked to meat substitutes currently on the market (Elzerman et al., 2011; Hoek et al., 2011; Graça, Calheiros, and Oliveira, 2015; Hartmann and Siegrist, 2017; Spencer and Guinard, 2018). Second, it is behaviorally easier to reduce meat consumption rather than shift to an entirely or primarily plant-based diet (Graça, Calheiros, and Oliveira, 2015; Hartmann and Siegrist, 2017; Spencer and Guinard, 2018).

Recent studies provide a compelling background on the potential of hybrid meat products (Fiorentini, Kinchla, and Nolden, 2020; Grasso and Jaworska, 2020; Lang, 2020; Sogari et al., 2021; Asioli et al., 2023; Caputo, Sogari, and Van Loo, 2023; Grasso and Goksen, 2023). Some European studies found that consumers were willing to try and buy hybrid meat products as they thought they were a healthier option (Grasso, Asioli, and Smith, 2022; Asioli et al., 2023). While these studies provide some useful insights for the US market, they did not examine any specific plant-based ingredients that can be blended with meat to create a hybrid meat product. Soy and pea, two excellent protein sources, have been explored as plant-based food products to some extent (Aschemann-Witzel et al., 2021; Bakhsh et al., 2021), but no study has ever carried out a consumer study to examine consumer preference for hybrid meat products prepared by blending soy and/or pea with beef. A few studies have that shown beef can be blended with mushrooms to enhance flavor while maintaining consumer acceptability (Myrdal Miller et al., 2014; Guinard et al., 2016; Caputo, Sogari, and Van Loo, 2023). However, additional research is needed to determine the consumer acceptability and market feasibility of hybrid meat products incorporating soy or pea protein to provide educated leads for producers and policy makers.

Methods and Materials

Discrete Choice Experiment Details

The outcome variable of interest for this study was product selections from a hypothetical discrete choice experiment (DCE) that simulated purchasing decisions for 1-lb packages of burger patties. A hypothetical DCE is necessary as no hybrid products are currently marketed; however, hybrid alternatives have been developed and tested (Just Food, 2020). Before completing the DCE questions, respondents were shown a cheap talk script, which has been shown to reduce hypothetical bias associated with nonbinding purchasing decisions (Cummings and Taylor, 1999; Penn and Hu, 2019).[1] The cheap talk script (see Appendix for details) informed respondents about hypothetical bias in layman's terms and asked them to make decisions that matched actual selections as if they were shopping at a grocery store. After the cheap talk script, respondents were informed that they would be making selections between 1-lb packages of burger patties that varied by ingredients and price.

In the DCE, respondents selected between 1-lb packages of burger patties. The burger patties varied by the percentages of meat and plant-based food ingredients they contained. Eight types of burger patties were presented: (i) 100% beef, (ii) 100% soy, (iii) 100% pea, (iv) 50% soy blended with 50% beef, (v) 50% pea blended with 50% beef, (vi) 75% soy blended with 25% beef, (vii) 75% pea blended with 25% beef, and (viii) black bean blended with mushroom. Beef burgers were selected as the product of interest for reasons raised in previous literature, as discussed by (Asioli et al., 2023). Beef consumption remains high and demand is increasing (Sheng and Song, 2019), yet there are some concerns about the greenhouse gas (GHG) contribution of beef (Clune, Crossin, and Verghese, 2017). At the same time, healthy meat alternatives are gaining popularity and industry interest and investment in new plant-based foods continue to increase (Barone et al., 2021; Lang,

[1] Hypothetical bias refers to the difference between stated preferences (decisions made in a hypothetical scenario) and revealed preferences (decisions made in a real-world scenario). Different approaches, like cheap talk scripts, minimize the bias. However, hypothetical bias is less of a concern when the focus of analysis is marginal willingness to pay rather than overall willingness to pay for a product (Lusk and Schroeder, 2004).

Figure 1. An Example Choice Set Shown to Respondents in the Discrete Choice Experiment

2020). The black bean and mushroom option, which is relatively expensive due to the mushrooms, was included to determine the relative preferences of more economical plant-protein alternatives (e.g., soy and pea). Mushrooms, which are fungi, are specialty crops with higher cash value than row crops because the mushroom production process is intensive and costly, making it difficult to scale up production. Additionally, despite being an expensive alternative, the mushroom is the only plant-like food that has been studied widely and proven to work well when blended with beef in a hybrid meat product (Myrdal Miller et al., 2014; Guinard et al., 2016; Lang, 2020; Caputo, Sogari, and Van Loo, 2023). Therefore, knowing consumer preferences for soy and pea alternatives relative to a black bean and mushroom burger would provide valuable insights into their market potential.

Prices in the DCE varied across the burger options at $7, $10, $13, and $16. The prices were selected to reflect a major retailer's price for beef, plant-based, and black bean with mushroom burger patties when data were collected. A fractional-factorial design was used to determine the number of choice sets (choice questions) and combinations of choice options (alternatives) shown to respondents, given the eight types of burger patties and four price levels. The DCE design included eight choice sets with four product choice options and an opt-out option (no buy) to indicate an unwillingness to purchase any of the burgers provided in a choice set, with a D-efficiency of 94.02. Respondents were asked to choose a package of burger patties from among a set of given alternatives, presented in textual multiple-choice questions as shown in Figure 1, imagining that they were grocery shopping.

Respondent Sampling Details

This study was approved by the Institutional Review Board at Purdue University. Data were collected from 1,200 US respondents using a web-based survey in January 2023 to complete the study objectives. The survey was designed in Qualtrics online software, and respondents were recruited and compensated by Dynata using a quota-based sampling to match the US population on the characteristics of age, gender, ethnicity and race, income, and region of residence (e.g., Midwest). After completing the demographic questions necessary for the quotas, respondents completed the DCE questions. After completing the DCE, respondents answered additional questions about their demographic characteristics (e.g., marital status, highest level of education completed, household size, political identity). Respondents were also asked questions to include as moderating variables, including current consumption of beef and plant-based products and individual health status.

Appendix Table A1 reports descriptive statistics of the respondents' sociodemographic characteristics. The proportions of age groups by generation were similar to the US population; the proportion of individuals in the Baby Boomer generation (i.e., Boomers) was a little higher in our study (US Census Bureau, 2023). We observe that Boomers made up the largest portion of respondents (30.67%), followed by Generation X (24.67%), Millennials (23.5%), Generation Z (14.67%), and Silent Generation (6.50%). In terms of gender distribution, 52.42% of respondents were female. Nearly half of respondents (46.00%) were of Hispanic origin, and the racial composition of the sample was mostly White (58.17%), followed by Black (12.17%). Household

income was relatively evenly distributed, with a mean of 1.95 measured in three levels: 1 = < $35,000 (30.17%), 2 = $35,000–$99,999 (44.33%), and 3 = >$99,999 (25.50%). Respondents reported their health status with a mean of 2.66, indicating generally good health. Geographically, 35.00% of respondents were in the South, 27.33% in the West, and 18.67% in the Northeast. A substantial portion of the sample (28.08%) had completed a 4-year college degree, while 15.92% had a graduate degree. Nearly 45% of respondents were politically affiliated as Democrats and about 24% as Republicans. Last, respondents' consumption habits were measured through 5-point Likert scale (1 = did not consume in last 6 months, . . . , 5 = consume daily), with a mean frequency of 3.15 for hamburgers and 1.92 for plant-based burgers. The average household size of the respondents was 2.72.

Empirical Framework

According to the random utility maximization (RUM) theory, individuals make choices by maximizing their utility, which is the satisfaction or preference they derive from the chosen alternative. However, utility is not directly observable but is represented as a combination of systematic and random components:

$$\boldsymbol{U}_{nij} = \boldsymbol{V}_{nij} + \boldsymbol{\epsilon}_{nij}, \tag{1}$$

where $\boldsymbol{U}_{nij}$ is the total utility that individual n derives from choosing alternative i in choice task j; $\boldsymbol{V}_{nij}$ is the systematic component that is deterministic and observable; and $\boldsymbol{\epsilon}_{nij}$ is the unobserved component, including unmodeled preferences and measurement error.

If $\boldsymbol{\epsilon}_{nij}$ follows a Type I extreme value distribution and is *i.i.d.* across n, i, and j, then the probability of consumer n choosing alternative i can be expressed by a multinomial logit (MNL) model:

$$\text{Prob}(n \text{ chooses } i \text{ in choice set } j) = \frac{e^{\hat{\boldsymbol{V}_{nij}}}}{\sum_{k=1}^{I} e^{\hat{\boldsymbol{V}_{njk}}}}, \tag{2}$$

where I is the total number of alternatives provided in a choice task.

The MNL model assumes that all respondents have the same preference, which is unlikely to hold in a real-world scenario, and imposes the Independence of Irrelevant Alternatives (IIA) assumption. In contrast, a latent class model (LCM) assumes that there are several distinct consumer segments and that consumer preferences are heterogeneous across the segments but homogeneous within a segment (Boxall and Adamowicz, 2002; Ikiz et al., 2018), and relaxes the MNL assumption of IIA. Similar to equation (2), the probability of respondent n choosing i in choice set j in an LCM is

$$\text{Prob}(n \text{ chooses } i \text{ in choice set } j) = \sum_{c=1}^{C} P_{nc} \frac{e^{\hat{\boldsymbol{V}_{nijc}}}}{\sum_{k=1}^{I} e^{\hat{\boldsymbol{V}_{njkc}}}}, \tag{3}$$

where C is the total number of classes, P_{nc} is the estimated probability of respondent n being in class c, and $\hat{\boldsymbol{V}_{nijc}}$ is as in equation (2), except parameters are now class-specific, as indicated by the subscript c.

We estimated three separate LCM, each differing from the other on product combinations. The main model, Model 1, was estimated using all eight products included in the DCE separately. Similar products were combined to estimate Models 2 and 3 as robustness checks. In Model 2, burgers with similar proportions of soy or pea were combined as a single product; for example, the 75% soy and 75% pea burgers were combined. In Model 3, burgers with the same plant-based protein were combined as a single product regardless of blend proportions; for example, burgers with 100%, 75%, and 50% soy were combined. Table 1 presents detailed descriptions of the types of burgers used in three LCM.

Table 1. Descriptions of Different Types of Burgers Used in Three Latent Class Models

Burger Type	Description of Burgers
Model 1 (main model)	
100%Beef	Burger with 100% beef patty
BlackBean/Mushroom	Burger with patty made up of black bean and mushroom, no meat
100%Soy	Burger with 100% soy patty
100%Pea	Burger with 100% pea patty
50%Beef/50%Soy	Burger with patty made up of 50% beef and 50% soy
50%Beef/50%Pea	Burger with patty made up of 50% beef and 50% pea
25%Beef/75%Soy	Burger with patty made up of 25% beef and 75% soy
25%Beef/75%Pea	Burger with patty made up of 25% beef and 75% pea
Model 2 (blend-level combined)	
100%Beef	Burger with 100% beef patty
BlackBean/Mushroom	Burger with patty made up of black bean and mushroom, no meat
100%Soy/100%Pea	Burger with 100% soy or pea patty
75%Soy/75%Pea	Burger with patty made up of 75% soy or pea and 25% beef
50%Soy/50%Pea	Burger with patty made up of 50% soy or pea and 50% beef
Model 3 (plant-protein combined)	
100%Beef	Burger with 100% beef patty
BlackBean/Mushroom	Burger with patty made up of black bean and mushroom, no meat
AllSoy	Burger with patty made up of 100%, 75% or 50% soy
AllPea	Burger with patty made up of 100%, 75% or 50% pea

Selection of Latent Classes

Although there is likely heterogeneity in preferences across individuals, a key marketing strategy is to group individuals who share similar preferences into distinct market segments. The LCM identifies individuals with similar preferences and classifies them to the same segment of consumers. Identifying consumer segments helps differentiate the marketing campaigns so that different consumer segments are reached differently, theoretically improving consumer welfare (McFadden, Bovay, and Mullally, 2021). Therefore, selecting an optimal number of classes in latent class analysis is vital, although the optimal number of classes cannot be endogenously determined since it is not a model parameter (Pacifico and Yoo, 2013; Matyas and Kamargianni, 2021).

Different performance estimates are considered to determine the optimal number of classes (Matyas and Kamargianni, 2021). We used three performance estimates: the Akaike information criterion (AIC) (Aflaki, Vigod, and Ray, 2023), the Bayesian information criterion (BIC) (Roeder, Lynch, and Nagin, 1999), and likelihood ratio tests (Greene and Hensher, 2003). We conducted the latent class choice model in Stata SE (version 18) using the lclogit command to get the starting values and the lclogitml command to get the standard errors and confidence intervals for the coefficients (Pacifico and Yoo, 2013).

We analyzed latent classes 2–10 for in-depth observations before estimating performance indicators. Convergence was achieved for latent classes 2–4, but the convergence was not achieved for any latent class above 4. Although convergence was not achieved, latent classes 5 and 6 still produced the coefficients but gave a few skewed (very large) coefficients, indicating overfitting or small class sizes (Lusk, 2019). Therefore, performance estimates for models with 2–4 latent classes were estimated to select the optimal number of classes. Both AIC and BIC values decreased with the increasing number of latent classes, indicating the model with four latent classes as the best model (Appendix Table A2). Further, we conducted likelihood ratio tests: two latent classes versus three (χ^2: 1,038.76, p-value: 0.00) and three latent classes versus four latent classes (chi-square: 833.66,

Table 2. Latent Class Estimates for Model 1 (Main Model)

	Consumer Segment			
Variable	**Meat Purist**	**Meat-Forward Flexitarian**	**Plant-Forward Flexitarian**	**Price Sensitive**
Price	−0.230**	−0.074**	−0.071**	−0.420**
	(0.031)	(0.011)	(0.007)	(0.037)
100%Beef	5.607**	4.032**	1.790**	3.113**
	(0.458)	(0.163)	(0.174)	(0.350)
BlackBean/Mushroom	−0.342	1.203**	2.724**	0.691
	(0.456)	(0.181)	(0.156)	(0.254)
100%Soy	−1.677**	−0.021	2.373**	0.082
	(0.480)	(0.216)	(0.161)	(0.392)
100%Pea	−3.000**	−0.886**	2.095**	−1.362
	(0.680)	(0.270)	(0.159)	(0.911)
50%Beef/50%Soy	−1.046**	2.352**	2.308**	−0.057
	(0.370)	(0.165)	(0.164)	(0.427)
50%Beef/50%Pea	−1.650**	1.926**	2.073**	−0.553
	(0.385)	(0.159)	(0.166)	(0.503)
25%Beef/75%Soy	−3.859**	0.810**	2.158**	−0.573
	(0.874)	(0.164)	(0.165)	(0.456)
25%Beef/75%Pea	−2.635**	0.160	2.106**	−0.584
	(0.696)	(0.209)	(0.161)	(0.502)
Class sizes	0.297	0.264	0.248	0.191
Log-likelihood function	−8,628.161			

Notes: Single and double asterisks (*, **) indicate p-values of <0.05 and <0.01, respectively. Values in parentheses are standard errors. The model was estimated using 48,000 observations.

p-value: 0.00), which showed that a model with three latent classes was a significantly better model than that with two latent classes and four latent classes was a significantly better model than that with three latent classes. Thus, four latent classes were selected for Models 1–3.

Unconditional and Conditional Market Share Calculations

Estimated results from Model 1 and the midprice ($11.5) of the prices used in the DCE (i.e., $7, $10, $13, $16) were plugged in to equation (3) to estimate the unconditional market shares of the eight types of burgers used in the DCE for each latent class. Conditional market shares were also estimated, with the condition that no hybrid products were available; thus, conditional market shares were estimated for 100% beef, 100% soy, 100% pea, black bean with mushroom, and the opt-out option.

Last, we calculated the difference in market share between the unconditional and conditional market shares for each latent class to determine the "overall beef market share" by introducing hybrid blends. We refer to this as the overall beef market share because a 1-lb package of 50% blended burger patties (e.g., 50% soy blended with 50% beef) still constitutes a half pound of beef. Thus, the overall beef market share is the sum of the market share for 100% beef, the 50% beef products market shares weighted by 50%, and the 25% beef products market shares weighted by 25%. The difference in overall beef market share for each latent class was then multiplied by the respective class size to calculate a weighted difference in overall beef market share across the four latent classes.

Empirical Results

Latent Class Logit Models

As mentioned previously, we estimated three LCMs, with each model including four classes (consumer segments). The four segments identified by all LCMs had similar preference characteristics; therefore, the same names were used for the consumer segments across the three models. In order of class size, the four segments were "Meat Purist," "Meat-Forward Flexitarian," "Plant-Forward Flexitarian," and "Price Sensitive."

Table 2 presents LCM estimates from Model 1. Approximately 30% of respondents were in the Meat Purist segment, characterized by strongly preferring 100% beef burgers and relatively negative preferences for plant-based alternatives. Around 50% of respondents were classified in a flexitarian segment (i.e., Meat-Forward or Plant-Forward). About 26% of respondents were in the Meat-Forward Flexitarian segment, characterized by mostly preferring 100% beef but also amenable to some plant-based alternatives, particularly the 50% blends. Nearly 25% of respondents were in the Plant-Forward Flexitarian group, characterized by strong preferences for plant-based alternatives and the lowest preference estimate for 100% beef burgers. Finally, the Price Sensitive segment had a class size of 19%, which included people with high price sensitivity, a preference for 100% beef, and no significant preference for hybrid or plant-based burgers. While the preferences for different mixes for the four classes generally followed the expected trend, there were a few deviations. For example, the marginal utility of Meat Purists for 100% soy was greater than 75% soy–25% beef blends. Also, the marginal utility of the Plant-Forward Flexitarian segment for 50% soy–50% beef blends was greater than that for 75% soy–25% beef blends. This highlights the nuances in preferences for the hybrid blends, such that preferences were not linear in the ratio of meat/plant in the mixes.

Table 3 presents the estimates from Models 2 and 3, used as robustness checks. As a reminder, burgers with similar proportions of soy or pea were combined for Model 2, and Model 3 combined burgers containing the same plant-based protein. The estimates and class sizes for the consumer segments in Models 2 and 3 were similar to those in Model 1, providing some validation for the results estimated by the main model. Preferences for the 100% beef, hybrid, and 100% plant products followed similar trends as in Model 1. For both Models 2 and 3, preference estimates for the 100% beef burger were the highest across all products and segments except for the Plant-Forward Flexitarian segment, where consumers preferred 100% plant-based and hybrid burgers over the 100% beef burger. In Model 2, hybrid burgers with 50% soy or pea were preferred over hybrid burgers with 75% soy or pea. Among the plant-based options in Model 3, the black bean with mushroom burger was most preferred, followed by burgers using soy protein. Similar to Model 1, results from Models 2 and 3 showed the expected trend with few exceptions, again highlighting the nuances in preferences between different blend ratios.

Table 4 presents the associations between respondent sociodemographic characteristics and segment affiliation. The Price Sensitive segment was used as the base in estimation, so coefficients are interpreted relative to that segment. Millennial and Generation X respondents were likelier to be in the Meat Purist, Meat-Forward Flexitarian, or Plant-Forward Flexitarian segments than respondents in the Silent Generation (p-value < 0.10). Estimates for the Boomer Generation were not different from those in the Silent Generation, indicating that the older respondents were affiliated with the Price Sensitive segment. Generation Z respondents were likelier to be in the flexitarian segments but less likely to be in the Meat Purist segment. Besides age, few characteristics were significantly associated with the segments at a p-value of less than 0.05. People of Hispanic origin were more likely to be Meat Purists, Meat-Forward Flexitarians, and Plant-Forward Flexitarians than non-Hispanic individuals. Respondents who indicated having poor health status were less likely to be Plant-Forward Flexitarians. Perhaps unsurprisingly, those who consumed meat more often were likelier to be in the Meat Purist and Meat-Forward Flexitarian segments. Those who consumed plant-

Table 3. Latent Class Estimates for Model 2 (blend-level combined) and Model 3 (plant-protein combined)

Panel A: Model 2 (blend-level combined

Variable	Meat Purist	Meat-Forward Flexitarian	Plant-Forward Flexitarian	Price Sensitive
Price	−0.215**	−0.071**	−0.070**	−0.410**
	(0.028)	(0.010)	(0.007)	(0.035)
100%Beef	5.383**	4.023**	1.840**	3.010**
	(0.411)	(0.159)	(0.174)	(0.330)
BlackBean/Mushroom	−0.291	1.048**	2.780**	0.664**
	(0.445)	(0.188)	(0.151)	(0.343)
100%Soy/100%Pea	−2.410**	−0.308	2.285**	−0.324
	(0.390)	(0.189)	(0.151)	(0.348)
75%Soy/75%Pea	−3.372**	0.571**	2.196**	−0.617
	(0.558)	(0.160)	(0.155)	(0.385)
50%Soy/50%Pea	−1.428**	2.176**	2.236**	−0.271*
	(0.311)	(0.153)	(0.156)	(0.384)
AllSoy				
AllPea				
Class sizes	0.301	0.261	0.245	0.193
Log-likelihood function		−8,668.723		

Panel B: Model 3 (plant-protein combined)

Variable	Meat Purist	Meat-Forward Flexitarian	Plant-Forward Flexitarian	Price Sensitive
Price	−0.249**	−0.111**	−0.069**	−0.398**
(0.035)	(0.010)	(0.008)	(0.034)	
100%Beef	5.936**	4.223**	1.943**	2.912**
(0.494)	(0.167)	(0.238)	(0.323)	
BlackBean/Mushroom	−0.839	1.767**	2.870**	0.576
(0.550)	(0.151)	(0.172)	(0.334)	
100%Soy/100%Pea				
75%Soy/75%Pea				
50%Soy/50%Pea				
AllSoy	−1.654**	1.452**	2.510**	−0.302
(0.382)	(0.127)	(0.185)	(0.320)	
AllPea	−2.201**	1.100**	2.326**	−0.715*
(0.412)	(0.160)	(0.184)	(0.359)	
Class sizes	0.285	0.276	0.244	0.195
Log-likelihood function		−9,034.233		

Notes: Single and double asterisks (*, **) indicate *p*-values of <0.05 and <0.01, respectively. Values in parentheses are standard errors. All models were estimated using 48,000 observations.

Table 4. Sociodemographic Characteristics Associated with Segment Classification (relative to the price-sensitive base class)

	Model 1 (main model)			Model 2 (blend-level combined)			Model 3 (plant-protein combined)		
Variable	**Meat Purist**	**Meat-Forward Flexitarian**	**Plant-Forward Flexitarian**	**Meat Purist**	**Meat-Forward Flexitarian**	**Plant-Forward Flexitarian**	**Meat Purist**	**Meat-Forward Flexitarian**	**Plant-Forward Flexitarian**
Boomer	0.487	0.387	0.486	0.476	0.381	0.403	0.554	0.577	0.040
	(0.339)	(0.466)	(0.560)	(0.338)	(0.468)	(0.553)	(0.345)	(0.503)	(0.520)
Generation X	1.245**	1.597**	2.066**	1.227**	1.590**	1.997**	1.309**	1.789**	1.617**
	(0.396)	(0.502)	(0.575)	(0.395)	(0.502)	(0.565)	(0.401)	(0.536)	(0.529)
Millennial	1.060*	1.946**	2.584**	0.998**	1.881**	2.439**	1.058*	2.002**	2.226**
	(0.472)	(0.553)	(0.627)	(0.456)	(0.543)	(0.606)	(0.468)	(0.584)	(0.574)
Generation Z	1.157	2.858**	3.082**	1.105*	2.803**	2.922**	1.145	2.956**	2.509**
	(0.599)	(0.647)	(0.729)	(0.595)	(0.645)	(0.717)	(0.587)	(0.669)	(0.687)
Female	0.027	−0.115	−0.379	0.050	−0.126	−0.344	0.005	−0.035	−0.496
	(0.209)	(0.232)	(0.254)	(0.208)	(0.231)	(0.253)	(0.210)	(0.231)	(0.257)
Hispanic	1.110**	1.523**	0.825**	1.115**	1.521**	0.847**	1.107**	1.539**	0.900**
	(0.253)	(0.267)	(0.284)	(0.252)	(0.267)	(0.284)	(0.251)	(0.265)	(0.288)
White	0.180	−0.456	−0.481	0.180	−0.459	−0.477	0.196	−0.328	−0.623*
	(0.253)	(0.262)	(0.285)	(0.251)	(0.261)	(0.284)	(0.252)	(0.262)	(0.287)
Black	0.974*	0.618	0.205	0.987*	0.636	0.234	0.989*	0.676	−0.017
	(0.408)	(0.425)	(0.458)	(0.409)	(0.428)	(0.465)	(0.405)	(0.422)	(0.466)
Incomer	−0.063	−0.176	−0.231	−0.046	−0.151	−0.182	−0.027	−0.106	−0.261
	(0.157)	(0.173)	(0.191)	(0.155)	(0.171)	(0.186)	(0.156)	(0.171)	(0.189)
Poor health	−0.163	−0.250*	−0.352**	−0.150	−0.241*	−0.344**	−0.157	−0.245*	−0.320**
	(0.106)	(0.113)	(0.122)	(0.105)	(0.113)	(0.121)	(0.106)	(0.113)	(0.123)
Northeast	0.500	0.457	0.548	0.504	0.463	0.560	0.540	0.469	0.719
	(0.310)	(0.348)	(0.371)	(0.309)	(0.348)	(0.369)	(0.312)	(0.350)	(0.379)

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Table 4. – continued from previous page

	Model 1 (main model)			Model 2 (blend-level combined)			Model 3 (plant-protein combined)		
Variable	**Meat Purist**	**Meat-Forward Flexitarian**	**Plant-Forward Flexitarian**	**Meat Purist**	**Meat-Forward Flexitarian**	**Plant-Forward Flexitarian**	**Meat Purist**	**Meat-Forward Flexitarian**	**Plant-Forward Flexitarian**
South	0.419	0.310	0.397	0.443	0.312	0.380	0.430	0.364	0.440
	(0.278)	(0.310)	(0.335)	(0.277)	(0.310)	(0.334)	(0.278)	(0.305)	(0.345)
West	0.686*	0.689	0.477	0.661*	0.651*	0.371	0.661*	0.587	0.421
	(0.297)	(0.327)	(0.367)	(0.294)	(0.326)	(0.364)	(0.295)	(0.326)	(0.374)
4-year degree	−0.454	−0.113	0.221	−0.453	−0.122	0.210	−0.462	−0.166	0.328
	(0.243)	(0.268)	(0.291)	(0.243)	(0.269)	(0.292)	(0.244)	(0.269)	(0.295)
Graduate degree	−0.228	−0.554	0.246	−0.301	−0.582	0.165	−0.201	−0.594	0.171
	(0.348)	(0.304)	(0.373)	(0.345)	(0.301)	(0.365)	(0.339)	(0.305)	(0.369)
Democrat	0.248	0.136	0.377	0.231	0.120	0.324	0.273	0.116	0.333
	(0.257)	(0.241)	(0.280)	(0.255)	(0.239)	(0.278)	(0.256)	(0.240)	(0.278)
Republican	0.024	0.306	0.071	0.008	0.308	0.058	0.140	0.309	−0.146
	(0.298)	(0.260)	(0.332)	(0.299)	(0.260)	(0.331)	(0.249)	(0.260)	(0.345)
Meat frequency	0.678**	0.595**	−0.025	0.695**	0.597**	−0.027	0.665**	0.614**	−0.015
	(0.120)	(0.106)	(0.128)	(0.120)	(0.105)	(0.122)	(0.119)	(0.106)	(0.127)
Plant-based frequency	0.440**	−0.125	1.164**	0.424**	−0.124	1.153**	0.464**	−0.123	1.179**
	(0.130)	(0.140)	(0.128)	(0.130)	(0.141)	(0.128)	(0.131)	(0.139)	(0.130)
Household size	0.137	0.136	0.199	0.153	0.150	0.213	0.141	0.123	0.232*
	(0.100)	(0.097)	(0.105)	(0.100)	(0.097)	(0.105)	(0.099)	(0.097)	(0.106)
Constant	−3.768**	−2.557**	−3.237**	−3.884**	−2.656**	−3.271**	−4.175**	−2.719**	−3.018**
	(0.826)	(0.721)	(0.892)	(0.824)	(0.719)	(0.878)	(0.852)	(0.723)	(0.874)
Log-likelihood function		−8,628.16			−8,668.72			−9,034.23	

Notes: Single and double asterisks (*, **) indicate *p*-values of <0.05 and <0.01, respectively. Values in parentheses are standard errors. All models were estimated using 48,000 observations.

based alternatives were much more likely to be in the Plant-Forward Flexitarian segment; however, they were also likely to be affiliated with the Meat Purist segment, highlighting the diversity of preferences for meat and plant-based alternatives. These associations were similar across the three models, which provides some confidence in the estimated results.

Unconditional and Conditional Market Shares Across Segments

Table 5 reports the unconditional and conditional market shares for products. Hybrid blends are removed from calculations to estimate the conditional market shares, which allows us to determine the differences in consumption patterns from the introduction of hybrid blends across the consumer segments. The unconditional market share of 100% beef was the highest among the eight products in the Meat Purist, Meat-Forward Flexitarian, and Price Sensitive segments, while the unconditional market share of 100% beef was lowest among the eight products in the Plant-Forward Flexitarian segment. Unconditional market shares for hybrid blends and plant-based alternatives combined were less than 1% and 5% for the Meat Purist and Price Sensitive segments, respectively. The unconditional market shares for hybrid blends and plant-based alternatives combined were about 31% for the Meat-Forward Flexitarian segment, with 21 of the percentage points coming from the 50% hybrid blends. Nearly 91% of the unconditional market shares for the Plant-Forward Flexitarian segment was associated with hybrid blends and plant-based alternatives combined, with black bean with mushroom having the highest market share, followed by 100% soy. The opt-out option market share for the Price Sensitive segment was over 80% in both unconditional and conditional estimates, which may be due to the range of prices used in the DCE to reflect current market conditions and higher prices associated with plant-based alternatives.

After removing the hybrid blends, the conditional estimates had little effect on the market share for 100% beef in the Meat Purist and Price Sensitive segments due to the low unconditional shares for hybrid blends in the unconditional estimates. However, differences in market shares between the unconditional and conditional market shares were more distinct for the Meat-Forward Flexitarian and Plant-Forward Flexitarian segments. Removing hybrid blends increased the market share estimates for 100% beef by around 22% and 6% in the Meat-Forward Flexitarian and Plant-Forward Flexitarian segments, respectively.

The differences between overall beef consumption by introducing hybrid blends were estimated using the conditional and unconditional market shares, presented in Table 6. First, we calculated total beef consumption for each class when hybrid blends were available by adding beef consumption from 100% beef and hybrid burgers using results from Table 5. For example, the total beef consumption for Meat-Forward Flexitarian (78.17%) was calculated by adding 66.73% for 100% beef, 6.22% for 50% soy-50% beef, 4.21% for 50% pea-50% beef, 0.67% for 75% soy-25% beef, and 0.34% for 75% pea-25% beef burgers. Second, we subtracted the total beef consumption when there were no hybrid options (conditional market share for 100% beef burger given in Table 5) from the total beef consumption when hybrid blends were available. Thus, the overall reduction in beef consumption when hybrid blends were available for the Meat Purist and Meat-Forward Flexitarian segments was 0.11% and 10.69%, respectively. Overall beef consumption increased by 11.14% and 0.42% for the Plant-Forward Flexitarian and Price Sensitive segments, respectively. After adjusting for the class sizes of the segments, the overall decline in beef consumption by introducing hybrid blends was only 0.01% across the four segments.

Discussion

This study contributes to the literature regarding reducing or substituting meat consumption by embracing a diet with plant-based ingredients. These hybrid and plant-based alternatives that mimic meat characteristics have gained popularity among researchers, producers, and policy makers

Table 5. Market Shares (%) With (unconditional) and Without Hybrid Blends (conditional) Across the Four Consumer Segments

	Meat Purist		Meat-Forward Flexitarian		Plant-Forward Flexitarian		Price Sensitive	
Burger Type	With Hybrid Blends	Without Hybrid Blends	With Hybrid Blends	Without Hybrid Blends	With Hybrid Blends	Without Hybrid Blends	With Hybrid Blends	Without Hybrid Blends
100%Beef	94.56	94.77	66.73	88.87	7.98	14.14	14.63	14.89
BlackBean/Mushroom	0.25	0.25	3.94	5.25	20.07	35.99	1.3	1.32
100%Soy	0.06	0.07	1.16	1.54	14.13	25.34	0.71	0.72
100%Pea	0.02	0.02	0.49	0.65	10.7	19.19	0.61	0.17
50%Beef/50%Soy	0.12		12.44		13.24		0.61	
50%Beef/50%Pea	0.07		8.42		10.46		0.37	
25%Beef/75%Soy	0.01		2.66		11.39		0.37	
25%Beef/75%Pea	0.02		1.39		10.82		0.36	
Opt-out	4.89	4.9	2.77	3.69	1.32	5.34	81.48	82.9

Table 6. Differences in Overall Beef Consumption Without (conditional) and With (unconditional) Hybrid Blends Across the Four Consumer Segments

	Beef Market Share		Difference in Beef		Weighted Difference in
Consumer Segment	With Hybrid Blends (%)	Without Hybrid Blends (%)	Market Share (percentage pts)	Class Size (%)	Beef Consumption (percentage pts)
Meat Purist	94.66	94.77	−0.11	29.7	−0.03
Meat-Forward Flexitarian	78.17	88.87	−10.69	26.4	−2.82
Plant-Forward Flexitarian	25.29	14.14	11.14	24.8	2.76
Price Sensitive	15.31	14.89	0.42	19.1	0.08
Total decline in beef market share by introducing hybrid blends				−0.01%	

(Apostolidis and McLeay, 2016; Slade, 2018). However, the recent struggle for entirely plant-based alternatives to penetrate the meat industry has raised questions about the approach and paved the way for hybrid alternatives. These hybrid alternatives could potentially better meet the preferences of flexitarians because it is easy, in terms of behavioral change, to reduce meat consumption rather than entirely replace meat from the diet (Lang, 2020). Mushrooms have proven acceptable to consumers when blended with meat, but mushroom production is intensive, making it difficult to scale up. Our study explored preferences for hybrid beef burgers blended with soy or pea, which are excellent protein sources with relatively lower production costs.

We estimated the latent class model (LCM) with four classes, which divided consumers into four segments according to similar preference characteristics. Meat Purist consumers were unlikely to adopt hybrid blends due to strong preferences for beef (Grasso and Goksen, 2023). Meat-Forward Flexitarian consumers are a major potential market for hybrid blends. Most relevant to our objectives, results for the Meat-Forward Flexitarian segment indicated that a 50:50 plant-to-meat ratio made with soy and pea would appeal to consumers. This segment highlights how some consumers with strong preferences for meat will adopt hybrid blends with a desirable meat-to-plant ratio. This result aligns with results from Grasso and Jaworska (2020), Profeta et al. (2020), and Caputo, Sogari, and Van Loo (2023) indicating that many consumers are still committed to traditional meat options and are likely to switch to hybrids rather than choosing entirely plant-based products.

Plant-Forward Flexitarian consumers' flexibility in food choices aligns with the concept of flexitarian diets discussed in Derbyshire (2017) and Hartmann and Siegrist (2017). However, it important to note that introducing hybrid blends reduced not only consumption of 100% beef but also of 100% plant-based alternatives. The Price Sensitive segment shows a high sensitivity to price, with only a strong preference for 100% beef burger. Previous studies (e.g., Katare et al., 2023; Van Loo, Caputo, and Lusk, 2020) have emphasized the significance of price in consumer decisions regarding meat and plant-based alternatives, which resonates with economic theories of consumer choices, as discussed by Pollak (1970) and Greene and Hensher (2003).

Regarding consumers' sociodemographic characteristics, younger generations were likelier to adopt diets that reduce meat consumption. People of Hispanic origin have a strong preference for hybrid products, indicating that understanding the cultural nuances in food preferences is essential (Graça, Calheiros, and Oliveira, 2015,?; Sogari et al., 2021). Black men are considered to consume higher amounts of processed meat (Rodriguez et al., 2006), which supports our findings that Black individuals were more likely to be in the Meat Purist segment. People with poor health status were more likely to avoid hybrid and plant-based products, and higher meat consumption may negatively affect health (Wang and Beydoun, 2009). Some consumers who frequently eat beef burgers may be more open to hybrid blends because of similar sensory attributes (Spencer and Guinard, 2018; Fiorentini, Kinchla, and Nolden, 2020), which is the case in our study for the Meat-Forward Flexitarian segment.

The presence or absence of hybrid products did not matter to the Meat Purist or Price Sensitive segments, which indicates that targeting these two consumer segments to adopt hybrid blends would be a major challenge. This is particularly true for consumers in the Price Sensitive segment, who did not select any products at the higher price levels. Although there were differences between the market shares with and without hybrid products for the Meat-Forward Flexitarian and Plant-Forward Flexitarian segments, the overall market share of beef remained constant after accounting for the proportion of the beef used in the hybrid products. This shows that introducing hybrid blends is unlikely to disrupt beef production. However, hybrid meat blends allow flexitarians to add some plant-based options to their diets in a convenient and appealing way.

Conclusion

This study provides valuable insights for understanding consumer behavior and guiding marketing strategies for companies aiming to tap into the growing demand for meat alternatives. The strong affinity for traditional meat products suggests that the development process of hybrid products should consider preserving the sensory attributes of meat products. Given the strong sensitivity to price, companies should focus on competitive pricing strategies and promotional offers to attract cost-conscious consumers. Marketing should highlight the appeal of hybrid meat products as a bridge between traditional and plant-based options.

As consumer preferences evolve, the meat industry must adapt and innovate, and hybrid blends represent a promising avenue for meeting these changing demands. The segments identified by this study offer valuable guidance for marketers, enabling them to develop targeted campaigns that resonate with each segment's specific preferences. By recognizing the diversity within the consumer base and customizing marketing strategies accordingly, companies can position their products more effectively in the competitive landscape of meat alternatives. Different consumer segments represent opportunities to tailor marketing campaigns.

Further, the study identified the potential of hybrid meat products as a viable middle ground between traditional meat and entirely plant-based alternatives. Consumers demonstrated a preference for hybrid options over entirely plant-based products, indicating that these hybrid products have the potential to cater to a broader consumer base. The study also recognized the significance of the type and proportion of plant-based ingredients in hybrid meat products. Understanding the trade-offs and synergies between soy and pea and how they influence consumer choices provides valuable insights for product development and marketing. Last, our findings contribute to the broader discussions on sustainability and the shift toward more environmentally friendly dietary choices. By offering meat enthusiasts and those inclined toward plant-based diets a compromise in the form of hybrid meat products, we have the potential to promote a more sustainable and adaptable food system.

There are, however, limitations to this study. Hybrid burgers are not currently marketed to consumers; thus, respondents made product selections without knowing the taste or nutritional facts associated with the products. While a cheap talk strategy was used to mitigate hypothetical bias, unfamiliarity with hybrid products or even 100% plant-based currently sold at retailers could possibly introduce some bias. It is possible that information about the nutritional contents or environmental costs associated with the products could affect selection, which could be an area for future research. If hybrid products are ultimately developed, future research using sensory analysis could provide more insight into the taste and texture performance of hybrid products relative to meat and completely plant-based alternatives.

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Appendix A: Prompts Shown to Respondents Before the Discrete Choice Experiment

Cheap Talk Prompt

Next, you will be asked to make hypothetical purchasing decisions. Below is important information about making hypothetical purchasing decisions in surveys. Please read the information below.

Studies show that people tend to act differently when they face hypothetical decisions. In other words, they say one thing and do something different. For example, some people would say they would choose an item in a hypothetical situation, but when faced with non-hypothetical or real choices (e.g., in a supermarket), they will not actually choose the item that they said they would choose. We want you to behave in the same way that you would if you really had to choose between food options in a supermarket.

Now imagine you are grocery shopping while making the following purchasing decisions. Thank you.

Product Selection Prompt

Imagine you are grocery shopping for a 1-pound package of burger patties, and there are several types of burger patties to choose from.

In the following questions, you will be asked to select which package of burger patties you would choose if grocery shopping. The packages will vary by the type of burger patties and price.

Table A1. Descriptions and Descriptive Statistics of Respondents' Sociodemographic Characteristics (N = 1,200)

Variable	Description	Proportion or Mean
Boomer	Takes a value of 1 for respondents with age of 59–77 years, else 0	30.67%
Generation X	Takes a value of 1 for respondents with age of 43–58 years, else 0	24.67%
Millennial	Takes a value of 1 for respondents with age of 27–42 years, else 0	23.5%
Generation Z	Takes a value of 1 for respondents with age of < 27 years, else 0	14.67%
Female	Takes a value of 1 for respondents who identified as female, else 0	52.42%
Hispanic	Takes a value of 1 for respondents who identified as Hispanic, else 0	46.00%
White	Takes a value of 1 for respondents who identified as White, else 0	58.17%
Black	Takes a value of 1 for respondents who identified as Black, else 0	12.17%
Income	Respondent's household income level: 1 ≤ $35,000, 2 = $35,000–$99,999, 3 = > $99,999	1.95 (0.74)
Poor health	Respondent's self-reported health status: 1 = excellent, 2 = very good, 3 = good, 4 = fair, 5 = poor	2.66 (1.05)
Northeast	Takes a value of 1 for respondents living in the Northeast region, else 0	18.67%
South	Takes a value of 1 for respondents living in the South region, else 0	35.00%
West	Takes a value of 1 for respondents living in the West region, else 0	27.33%
Four-year degree	Takes a value of 1 for respondents who have completed a 4-year college degree, else 0	28.08%
Graduate degree	Takes a value of 1 for respondents who have completed graduate degree, else 0	15.92%
Democrat	Takes a value of 1 for respondents who self-identify as Democrats, else 0	44.83%
Republican	Takes a value of 1 for respondents who self-identify as Republicans, else 0	23.58%
Meat frequency	Respondent's frequency of consuming hamburgers rated on a scale of 1–5, where a higher number represents more frequent consumption	3.15 (1.02)
Plant-Based Frequency	Respondent's frequency of consuming plant-based burgers rated on a scale of 1–5, where a higher number represents more frequent consumption	1.92 (1.25)
Household size	Total number of people living in respondent's household	2.72 (1.46)

Notes: Proportions are provided for dummy variables and means are provided for continuous variables, with standard deviations in parentheses.

Table A2. Performance Estimates for Models with Two, Three, and Four Latent Classes (N = 48,000)

Latent Classes	Degrees of Freedom (df)	Akaike Information Criterion (AIC)	Bayesian Information Criterion (BIC)	Log-Likelihood
2 classes	19	19,922.48	20,089.28	−9,942.24
3 classes	29	18,903.72	19,158.31	−9,422.86
4 classes	39	18,090.06	18,432.44	−9,006.03