Consumer preferences for ground beef packaged under a modified atmosphere

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Abstract

The main objective of this paper is to identify factors that determine consumers' purchase decisions for ground beef offered with different packaging technologies. Consumers' increasing knowledge about food technologies and changes in food labeling regulation influence agribusiness' future product development and marketing strategies. Non-hypothetical choice experiments with ground beef, conducted in the USA, are used to quantify consumers' valuation of technology-related attributes namely shelf life, color and packaging. How alternative types of information affect consumers' WTP is of particular importance to processors and food safety analysts. This paper's methodological contribution lies in applying advanced methods to elicit consumers' estimates of WTP for product attributes. Results aim to benefit food producers and retailers who make decisions about investing in new packaging methods, food control and food safety.

Key Words: non-hypothetical choice experiments, modified atmosphere packaging, ground beef

JEL Code:
Q13 - Agricultural Markets and Marketing; Cooperatives; Agribusiness
C9 - Design of Experiments
D12 - Consumer Economics: Empirical Analysis

Q13, C9, D12

1. Introduction

Nowadays, consumers express concerns about and demand healthy and safe meat products, as well as products that meet higher quality standards and are more convenient to use. In this context, keeping color attractive is of primary importance since color is the first attribute consumers use to evaluate overall meat quality (GREBITUS, 2008). Color plays a major role in influencing purchase decisions (VIANA ET AL., 2005). In purchasing fresh retail meat, color has a significant impact on consumers' quality expectations and especially freshness expectations, even if the color does not affect taste or shelf life (SØRHEIM ET AL., 2001).

While meat color is very important, establishing a bright cherry red and maintaining it during retail display is still a challenge. Improved but still limited color stability is achieved by packaging meat in modified atmosphere. This so-called modified atmosphere packaging (MAP) refers to the replacement of air in the package with a single gas or mixture of gases such as high oxygen (O_2) atmosphere, with minimum 60% O_2 (SØRHEIM ET AL., 2001). Another gas used to preserve meat color is carbon monoxide (CO) in concentrations between 0.3% and 0.5%. This gas strongly binds myoglobin to form carboxymyoglobin, producing a stable bright red color to the muscle meat. MAP with low concentrations of CO and high concentrations of carbon dioxide (CO_2) has been shown to improve beef and pork color. Additionally, MAP extends shelf life (VIANA ET AL., 2005). Overall, MAP is commonly used to maintain and improve the quality of foodstuffs.

Advantages of MAP containing CO (MAP/CO) for consumers are stable and attractive color, increased shelf-life and little or no need for the use of chemical preservatives. Food producers might profit from the reduction in distribution costs as there are fewer deliveries over longer distances and less waste. Meat color changing from cherry red to grey reduces revenue because it is sold cheaper or has to be thrown away as it is no longer accepted by consumers.

Retailers might question the contribution of the added cost of packaging (PHILLIPS, 1996). Hence, investigating consumers' willingness to pay (WTP) for MAP and MAP/CO supports improved decisions by food producers and retailers, as well as analysts concerned about the benefits and value of the new technology for consumers.

MAP and MAP/CO do have other effects on food safety – both actual and perceived. Regarding food safety, growth of spoilage and pathogenic bacteria are generally reduced by using MAP with increased levels of CO_2 and/or removal of O_2 (SØRHEIM ET AL., 2001). Nevertheless, several consumer groups claim that use of MAP/CO has negative effects on consumers' health, because it could mask spoilage since CO stabilizes the meat color longer than the shelf-life. There is a certain risk that pathogens such as *Listeria Monocytogenes* grow while fresh color is maintained. Consumers who do not pay attention to the expiration date might be at risk (PHILLIPPS, 1996).

Against this background, consumers' stated preference and WTP for color, shelf life and packaging technologies are analyzed. Using non-hypothetical choice experiments this paper reveals how these characteristics affect retail ground beef prices in the U.S.. We investigate consumer response towards ground beef packaged with MAP and particularly CO as the color stabilizer in MAP. MAP is an innovative technology. While in scientific literature many studies exist on technological effects and characteristics of MAP (e.g. CLIFFE-BYRNES AND O'BEIRNE, 2005; ALLENDE ET AL., 2004; ROCCULI ET AL., 2004; JAYAS AND JEYAMKONDAN, 2002), there is no economic assessment of consumers' preferences regarding MAP and MAP/CO. We develop a data set based on experimental, consumer-based study and apply mixed logit models to analyze the data. This analytical approach provides a flexible econometric method for economic discrete choice that is postulated to come from utility maximization (e.g. MCFADDEN AND TRAIN, 2000). Finally, marketing recommendations for the agribusiness can be derived.

The remainder of the paper is as follows. Section 2 gives an overview regarding previous research. Section 3 describes the methodology. Section 4 presents the results and section 5 concludes.

2. Previous research

A number of empirical studies contributed to the better understanding and evaluation of the retail value of major meat product attributes. For example TONSOR ET AL. (2005) used choice experiments to investigate consumer preferences for beef steak attributes in Europe. The study confirms that consumers are on average willing to pay a premium for a labelled steak (USDA Choice No Hormones or GMOs) as opposed to their "Domestic Typical" steak. NAYGA ET AL. (2005) used choice experiments in U.S. grocery stores to measure consumers' WTP for irradiated ground beef. In 2004, irradiation of retail meat products was the new technology that created public discussion and concern; today, other technologies such as MAP, the subject of our analysis, are at the center of some controversy.

With respect to color, ALFNES ET AL. (2006) studied Norwegian consumer preferences for different salmon colors using choice experiments. Participants were informed about the nature of salmon coloring (e.g. for farmed salmon, synthetically produced astaxanthin is added to the feed). Results revealed that consumers use color as a quality indicator and are willing to pay more for salmon fillets with normal or above-normal redness, as compared to paler fillets. Additional consumer information about the salmon color did not affect the WTP for pale and normal red fillets but consumers' WTP for above-normal red fillets decreased. This indicates a weak reaction to labeling and response to information, when product appearance remains in boundaries perceived to be "natural".

This paper extends the experiments by ALFNES ET AL. (2006) and examines consumer response to MAP and MAP/CO technologies. We extend the previous study by including shelf

life as a third choice attribute. Unlike the ALFNES ET AL. study, we use three-level attributes and not five because we have three attributes and needed to avoid a design that is too large.

3. Methodological background

3.1. Non-hypothetical choice experiments

Main objective of this research project is to measure the premiums consumers are willing to pay for shelf-life extension resulting from MAP as well as for color of ground beef stabilized by MAP/CO. In addition, we test the effect of different information types regarding MAP and MAP/CO on their WTP.

Choice experiments deliver the most appropriate tool set to isolate individual product characteristics and their specific influence on price, and provide insight into consumers' WTP. In choice experiments, respondents are asked to make repeated choices between different consumption bundles which include different attributes and the respective levels of these attributes. The respondents' utility depends on attribute levels of the choices made from these sets. This procedure enables the researcher to determine the attributes which influence the choice significantly and the marginal WTP for an increase/ decrease in the significant attributes (GOLDBERG AND ROOSEN, 2005).

Following ALFNES ET AL. (2006) we run a non-hypothetical choice experiment to collect data that provide stated preferences of U.S. consumers for pre-packaged ground beef (1 lb). Ground beef is a staple in the diet of industrialized countries (AMI, 2002). Our experimental design is as follows. The ground beef was packaged on white Styrofoam trays wrapped in transparent foil. We took nine trays sitting on a table. Each of the trays represented one scenario. On each tray we displayed two consumer packages of ground beef. The group size was 8-12 participants. We ran the experiments with 10 groups of participants. Participants received $20 each entering the experiment. They chose between the exact products they could obtain. After the

last treatment of the experiment one of all choices was drawn randomly. To induce real economic incentives, each participant had to buy one of the packages, i.e. a randomly chosen product of the *m* products. In fact, for safety reasons after finishing the experiments participants purchased a coupon for ground beef, which is a limitation regarding the set up of non-hypothetical choice experiments.

The two alternatives of ground beef on each tray were referred to as Alternative 1 and Alternative 2. We had three treatments.[1] The ground beef presented had three different colors. The information that was posted in our experiments were price and shelf life in Treatment 1; additionally MAP in Treatment 2; additionally MAP/CO in Treatment 3.

Our experiments were conducted as follows. In each treatment nine trays with 2 packages of ground beef each were displayed. The ground beef was characterized by different combinations of the following attributes (see Table 1). For example a ground beef package might have a cherry red color, a shelf life of 5 days and cost $3.05 in the first treatment. In the third treatment this ground beef would be labeled 'modified atmosphere packaging with carbon monoxide' because of the cherry red color. The light red ground beef was packaged at the university meat lab with pure air. The brownish red ground beef was packaged at the meat lab with pure air but irradiated with 1 kG to achieve the brownish red. The cherry red ground beef packaged in MAP/CO was purchased in a grocery store.

Table 1: Attributes of the ground beef

Attribute	**Price**	**Shelf life**	**Color**
Level	$2.85/lb	3 days	Light red
	$3.05/lb	5 days	Cherry red
	$3.25/lb	14 days	Brownish red

Participants received different information during the experiment. Before Treatment 2 we gave information about the shelf life, i.e. the role of MAP in extending the shelf life. Before

[1] Note, there was a fourth treatment which will not be referred to in this paper regarding natural packaging methods such as rosemary extract.

Treatment 3 we gave information about the role of CO in stabilizing the color. All information was technical information, and neutral without risk or benefit information included (see Table 2).[2]

Table 2: Information provided and labels used in the treatments (T)

	Information provided	Label
T 1	None	None
T 2	Detailed/neutral on MAP for extending shelf life	"modified atmosphere packaging" (on packages with 14 day shelf life)
T 3	Detailed/neutral on MAP/CO for stabilizing color	"modified atmosphere packaging with carbon monoxide" (on packages with cherry red ground beef)

3.2. Sample structure

The study took place in 2007 in the Midwest, U.S.. The sample consists of randomly recruited 106 participants. The sample is characterized by a higher share of female participants (77%). As women are usually responsible for household grocery shopping this should not bias results in a negative way. The average age of participants is 45 years. The household size counts between two and three persons. The sample is characterized by a rather high education level. The income classes are almost equally distributed except for a lower share of the income class of less than $10,000 annual income.

3.3. Mixed logit model

To analyze the data a multinomial mixed logit model with individual specific, random and independent parameters to capture taste variations is used. Compared to the fixed coefficient multinomial logit and its extensions (e.g. nested logit), the mixed logit has the relevant advantage of allowing for taste heterogeneity unconditional on socio-economic covariates (MENAPACE ET AL., 2008). Moreover, the mixed logit obviates three limitations of the standard logit model by allowing for random taste variation, unrestricted substitution patterns, and correlation in

[2] To generate a fractional factorial design SAS was used.

unobserved factors over time (TRAIN, 2003). This is particularly relevant because several studies have shown (e.g. BAKER AND BURNHAM, 2001) that taste variation is only partially linked to and poorly explained by socio-economic variables such as age and income.

The mixed logit can be defined as any model whose choice probabilities are integrals of standard logit probabilities over the density of parameters to be estimated. It can be specified via random parameters in the utility function and the goal is to estimate the *moments* of the distributions of individual-specific taste parameters.

The following example explains this point. One of the explanatory variables used in the model is the color 'cherry red'. It is reasonable to assume that consumers differ in their level of appreciation for a specific color of ground beef. Some consumers may prefer cherry red while others may prefer a lighter color produced with pure air. In this model, the random behavior of taste for the variable 'cherry red' is described by a normal distribution with a certain mean and variance. The mixed logit task is to estimate mean and variance, which completely describe the normal distribution.

An important implication of the mixed logit is that probability statements can be attached to the values of these parameters. The mixed logit produces efficient parameter estimation when the same individual makes repeated choices since it considers the correlation over sequential choices induced by the variability in the individual-specific parameters.

Model specification and estimation

Each decision maker, $i (i = 1,...,106)$, faces $T = 9$ choice situations $(t = 1,...,T)$. At each choice situation, the decision maker is presented with a set of alternatives. Each set contains 3 elements: 2 ground beef alternatives and the 'no purchase' alternative. In total, there are $J = 19$ alternatives, indexed by $j, j = \{1,...,J\}$, including 18 ground beef packages and the 'no purchase' (j_{19}). J_t represents the set of alternatives at time t, for $t = 1,...,T$, $\mathrm{J}_t = \{j_{2t-1}, j_{2t}, j_{19}\}$.

The choice probabilities of a mixed logit for panel data and with linear utility function can be specified as shown in the following. The utility of individual *i* from alternative *j*, in choice scenario t, is denoted by

$$U_{ijt} = \beta_i x_{ijt} + \varepsilon_{ijt}, \qquad (1)$$

where ε_{ijt} is distributed iid extreme values over individuals, alternatives and time, and x_{ijt} is a vector of observed variables relating to alternative j, which is described below in details. β is a vector of unobserved coefficients that vary over individuals but not over alternatives (representing the individuals' tastes). It varies over individuals with density $g(\beta|\theta)$, where θ represents the parameters of this distribution. For example, if β is normally distributed in the population θ represents the mean and covariance (REVELT AND TRAIN, 1999).

Within a choice set, an individual chooses the option that maximizes utility within the given set. Let y_{it} denote the individual's chosen alternative in situation t, and let $y_i = y_{i1},...,y_{iT}$ denote the person *i*'s sequence of chosen alternatives. Since the ε_{ijt}'s are distributed extreme value, the probability conditional on β_i that the individual chooses alternative j in situation t is standard logit (MCFADDEN, 1973, IN REVELT AND TRAIN, 1999):

$$L_i(j,t|\beta) = \frac{e^{\beta_i X_{jt}}}{\sum_j e^{\beta_i X_{jt}}} \qquad (2)$$

and since the ε_{ijt}'s are independent over choice situations, the probability of the individual's sequence of choices, conditional on β_i, is the product of logits:

$$P(y_i|\beta_i) = L(y_{i1},1|\beta_1)\cdot...\cdot L(y_{iT},T|\beta_i)\ . \qquad (3)$$

We do not observe β_i, and so these conditional probabilities are integrated over all possible values of β_i, using the population density of β_i,

$$P(y_i|\theta) = \int P(y_1|\beta_1) g(\beta_i|\theta) d\beta_i \,. \qquad (4)$$

$P(y_i|\theta)$, which is called the mixed logit choice probability, is the probability of the individual's sequences of choices conditional on the parameters of the population distribution, $g(\beta_i|\theta)$. The integral in the mixed logit probability generally does not have a closed form, and so it is approximated numerically through simulation. The parameter estimation is obtained by maximizing the simulated log-likelihood function. The estimated coefficients in the (linear) utility function vary over people but are constant over choice situations for each individual. Properties of the maximum simulated likelihood estimator are given by Hajivassiliou and Ruud (1994) and Lee (1992) (see REVELT AND TRAIN, 1999).

We estimate three models. The parameter distributions are assumed to be independent normal distributions. Across individuals the price coefficient is fixed. The advantage of having a fixed coefficient for price is that the WTP for each non-price attribute has the same distribution as the attribute's coefficient. As suggested by TRAIN (2000) the mixed logit estimates presented in this paper are obtained via simulated maximum likelihood using 125 Halton draws. As optimization routine we use Paul Ruud's routine. In the models ten explanatory variables are included. Table 3 gives a summary of the included variables.

Table 3: Summary of variables used in the analysis

Variable	Variable Definition
Price	Continuous variable indicating price of $2.85, $3.15 or $3.25
Shelf life	Continuous variable indicating shelf life of 3, 5 or 14 days
Color light	Dummy variable equal to 1 if ground beef alternative is Light red (aerobic)
Color cherry	Dummy variable equal to 1 if ground beef alternative is Cherry red (MAP/CO). Brown was excluded because of multicollinearity.
GBcons*price	Interaction effect between frequency of ground beef consumption[3] and Price
Infoshelflife*cherry	Interaction effect between knowledge about shelf life[4] and Cherry red
Info CO*cherry	Interaction effect between knowledge about CO[5] and Cherry red
EDU*cherry	Interaction effect between education level[6] and Cherry red
MassMediaMAP* shelf life	Interaction effect between having recently heard something about MAP in the mass media and Shelf life
NOT	1 if the none-of-these option was chosen for a choice set

To estimate the model we use the mixed logit code for Gauss written by Train. The code is designed for panel data and accounts explicitly for the correlation over time in unobserved utility that arises when there are repeated choices by a given individual.[7] We use the panel version of the mixed logit code because each participant gives rise to a panel of 9 choices. In the model nine random coefficients and one fixed coefficient (price) are used.

4. Results

The results of the mixed logit estimates of our models for Treatment 1 to Treatment 3 are presented in Table 4. The price coefficient in all three rounds is significantly negative as expected. The value for the coefficient is expressed in US $. WTP indicates the marginal WTP.

The estimated models show the following results and effects on consumers' WTP for ground beef:

[3] Daily, 5 to 6 times a week, 3 to 4 times a week, 1 to 2 times a week, 1 to 3 times a month, less than once a month.
[4] Question: How knowledgeable do you consider yourself about 'Shelf Life'? (1 = no knowledge to 5 = very knowledgeable).
[5] Question: How knowledgeable do you consider yourself about 'Carbon Monoxide in Food Packaging'? (1 = no knowledge and 5 = very knowledgeable).
[6] Question: What is your educational background? E.g. Some college, Bachelor, Master, Doctorate.
[7] See http://elsa.berkeley.edu/~train/software.html.

Price had a negative effect on product choice in all three treatments. The higher the price, the less likely were participants to choose the product. The effect of price was less negative for more frequent consumers of ground beef (Ground beef consumption*price).

With regard to shelf life there are no significant coefficients to state in all three rounds. The industry introduced MAP to increase shelf life of ground beef. This has a benefit for producers and retailers as mentioned in the introduction. This should be a benefit for consumers as well in terms of storage. However, the results indicate that consumers do not value this benefit. MAP/CO was introduced to stabilize color of ground beef. The results in the three treatments suggest that participants preferred light red meat over brownish red meat in all three treatments. The WTP for this color was lower under Treatments 2 and 3, compared with Treatment 1. The cherry red ground beef resulting from MAP/CO had a significantly positive coefficient on product choice in Treatments 1 and 2 only. However, the participants' WTP for the cherry red color decreased 23% (from $1.04 to $0.80) after they received information on the use of MAP. This result leads to the conclusion that provision of information on MAP and MAP/CO in packaging affect participants' choice of ground beef. Consumers WTP for attractive color of ground beef declines if MAP or MAP/CO are applied. Signaling the use of these technologies decreases consumers' WTP for color.

Other variables had little effect on WTP, including education level related to cherry red and shelf life, respectively, or whether participants had heard about MAP in relation to shelf life in the mass media. When participants chose to buy neither package (the NOT variable), it negatively affected WTP for ground beef. This negative effect was measured across all treatments.

Table 4: Parameter estimates

	TREATMENT 1				TREATMENT 2				TREATMENT 3			
	Coeff[1]	Std-error	t-value	WTP	Coeff[1]	Std-error	t-value	WTP	Coeff[1]	Std-error	t-value	WTP
Price (mean)	-3.256***	0.722	-4.509		-4.817***	1.053	-4.575		-6.279***	1.069	-5.876	
Shelf life (mean)	0.083	0.090	0.927	0.026	0.056	0.137	0.409	0.012	-0.002	0.093	-0.016	0.000
(std.-dev.)	0.015	0.104	0.141	0.004	0.046	0.072	0.639	0.010	0.006	0.072	0.081	0.001
Light (mean)	2.128***	0.193	11.039	0.654	2.844***	0.233	12.224	0.590	1.856***	0.192	9.649	0.296
(std.-dev.)	0.610**	0.275	-2.220	-0.187	1.147***	0.257	4.466	0.238	0.760***	0.240	3.170	0.121
Cherry red (mean)	3.384***	1.225	2.763	1.039	3.874***	1.281	3.023	0.804	1.927	1.687	1.142	0.307
(std.-dev.)	-0.789	0.629	-1.254	-0.242	0.074	0.651	0.114	0.015	1.189**	0.487	-2.440	-0.189
GBcons*price (mean)	0.416**	0.173	2.406	0.128	0.573**	0.241	2.374	0.119	0.560**	0.250	2.239	0.089
(std.-dev.)	0.084	0.068	1.239	0.026	0.217***	0.061	3.581	0.045	0.325***	0.073	-4.458	-0.052
Infoshelflife*cherry (mean)	-0.338*	0.180	-1.874	-0.104	0.190	0.171	1.113	0.040	-0.291	0.242	-1.203	-0.046
(std.-dev.)	0.043	0.251	-0.172	-0.013	0.123	0.163	0.754	0.026	0.111	0.338	-0.327	-0.018
Info CO*cherry (mean)	-0.083	0.298	-0.278	-0.025	-0.314	0.377	-0.831	-0.065	0.055	0.397	0.139	0.009
(standard deviation)	0.186	0.451	0.413	0.057	0.021	0.428	-0.050	-0.004	0.171	0.450	0.381	0.027
EDU*cherry (mean)	0.039	0.070	0.556	0.012	-0.102	0.082	-1.238	-0.021	0.069	0.102	0.682	0.011
(std.-dev.)	0.038	0.047	0.814	0.012	-0.037	0.034	-1.094	-0.008	0.072***	0.028	-2.577	-0.012
MassMediaMAP*shelf life (mean)	0.025	0.038	0.649	0.008	-0.061	0.053	-1.147	-0.013	0.011	0.043	0.254	0.002
(std.-dev.)	0.006	0.118	0.052	0.002	0.004	0.293	0.013	0.001	0.054	0.054	-1.002	-0.009
EDU*shelflife (mean)	-0.004	0.006	-0.673	-0.001	0.001	0.008	0.149	0.000	0.003	0.006	0.505	0.000
(std.-dev.)	0.002	0.004	0.509	0.001	0.004*	0.003	1.562	0.001	0.000	0.004	-0.064	0.000
NOT (mean)	-7.107***	1.180	-6.024	-2.183	-11.457***	1.437	-7.974	-2.378	-16.746***	1.341	-12.485	-2.667
(std.-dev.)	2.293***	0.866	-2.647	-0.704	2.021***	0.762	-2.650	-0.420	2.637***	0.790	-3.338	-0.420

[1] Significance level: ***p<0.01, * p<0.05, *p<0.1 std.-dev.=standard deviation

5. Discussion and conclusion

This paper deals with consumers' purchase decisions for ground beef packaged under modified atmosphere with and without Carbon Monoxide. As so far no studies have analyzed consumers' response and economic valuation of this technology we applied non-hypothetical choice experiments to uncover consumers' WTP for ground beef attributes related to the packaging technology. We examine response to shelf life which is extended by MAP and color which is stabilized by MAP/CO. The choice experiments contained three treatments providing consumers with alternative types of information. Results from mixed logit models reveal that there is no significant WTP for shelf life. The WTP for the different colors – light (from a pure air packaging) and cherry red (from MAP/CO) compared to the brownish red colored ground beef – show a significant preference of ground beef with a brighter red. Not much variation in WTP exists for the color light red across Treatments 1 and 2, but it did occur for the color cherry red. After the introduction of Carbon Monoxide as color stabilizer in Treatment 3 we find a large decrease in WTP for both colors. In contrast, WTP for cherry red is not significant at conventional levels of statistical significance.

To conlcude:

- Shelf life extension barely affects consumers' WTP for ground beef.
- Consumers have clear preferences for light and cherry red colors adding about $0.30-$1.00 per pound in value. This result emphasizes the importance of color stabilization.
- Information on MAP extending shelf life and MAP/CO stabilizing color, significantly decreases consumers' WTP for the preferred color.
- Consumers' knowledge (education, mass media) has little effect on WTP for ground beef.

Consumers' WTP for new technologies in fresh meat production has important implications for public health policy, marketing and R&D. Perceived benefits of red color and higher WTP for

products may dissipate when consumers are informed about the packaging technologies used. Regarding the meat industry, our results indicate the importance for industry of developing a clear communication to improve consumers' education and change (improve) consumers' attitudes regarding MAP. Such communication might highlight the advantages of MAP such as shelf life extension and increasing food safety for consumers, at the same time as providing information on the technology.

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