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UNDERSTANDING CONSUMERS' PERCEPTIONS TOWARD BIOTECHNOLOGY AND LABELING

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Risk perceptions about biotechnology and genetically modified (GM) foods drive the choices made by many consumers. In this paper, we address two important issues; namely, consumer preferences for mandatory labeling of products using biotechnology, as well as consumer response toward three different types of genetically modified processes (biotechnology applications to increase the nutritional content of potatoes, increase potato flavor, and a decrease in pesticide use). We identify socio-demographic characteristics that affect consumer preference for mandatory labeling as well as the support level that might be associated with biotechnology techniques that could improve upon potato characteristics identified as important by the consumer.

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Keywords: Genetically Modified , Biotechnology, Labeling, Potato.

1. Introduction

Biotechnology and its impact on our food supply has been a concern for many years as a result of different risk perceptions among groups of people in different countries. In Europe, this concern reached hysteria levels in February 1999, with the British media's almost panic-like reaction to these "Frankenstein Foods" (Economist, 1999). In spite of this European reaction and growing consumer concern in the U.S.—Starbucks is the most recent firm under attack for refusing to guarantee that the milk, beverages, chocolate, ice cream, and baked goods they are serving or selling are free of genetically engineered ingredients—many U.S. firms continue to explore the potential uses of genetically modified (GM) foods. This is being accomplished through research programs that include trial work on variety/seeding evaluations from traditional breeding and biotech programs, pest control management, fertility practices, and the focus on the importance of improved nutritional food values.

In the case of the potatoes (a pesticide intensive crop), herbicides for weed control, insecticides for insect control (Colorado Potato Beetles, aphids, flea beetles), and fungicides are routinely used each year. As Coffin et al. pointed out, potato growers often apply 10 to 12 applications of protective fungicides each year to prevent infection by late blight. In this regard, biotechnology offers opportunities to develop crops resistant to pests. For example, researchers have developed a potato containing a specific protein from *Bacillus Thuringensis* (BT) that is resistant to the Colorado Potato Beetle. This same application has been used with corn, producing the already widespread (BT) corn. According to McBride and Books (2000), 17% of the acreage in 17 survey states was planted with the herbicide-resistant seed. However, risk perceptions about GM products containing BT genes can have severe impacts on production agriculture and can affect many food outlets. In general, consumers may have concerns about some adverse health outcome (such as an allergic reaction) resulting from the consumption of a good produced with biotechnology, or some welfare concerns, or general ethical concerns about the implications of biotechnology. The most recent case—StarLink—involved Kraft Foods, Safeway, and Taco Bell.

In recent years, the intense debate over introducing biotechnology products has been increasing, and research in the field is flourishing. New research questions include what type of labeling scheme should be used for products that use biotechnology processes in their production or transformation. Genetically modified products are classified as credence goods with respect to the information level that they provide to the consumers for consumers cannot verify even after consumption whether a particular product is GM or GM-free. Thus asymmetric information problems occur between consumers and producers, since only the latter group knows precisely what type of technology or products they are using. Labeling policies are supposed to reduce the asymmetric information problem between producers and consumers about the use of GM practices (Hobbs and Plunkett). As McCluskey pointed out, there are mainly three types of labeling schemes: labeling ban (the product does not satisfy certain requirements), voluntary labeling (used by companies which do not use biotechnology methods—GMO-free labels), and mandatory labeling (which obligates the use of a label if the product uses biotechnology methods).

According to Caswell (2000), the different labeling policies depend on factors associated with risk assessment, management, communication, and with consumers' basic right-to-know what they are buying. Therefore, as a consequence of a more skeptical audience about biotechnology in Europe, the EU chose a mandatory labeling policy for those products made using biotechnology processes. Meanwhile in the US, the USDA chose a voluntary labeling policy with an accompanying disclaimer noting no difference in terms of safety between regular products and those containing biotechnology manipulations. However, it has been found that many consumers would prefer to have GM food labeled. Therefore, in the context of this study, we focus our attention on whether or not consumers find mandatory labeling an important issue in biotechnology applications in the food industry, and whether or not consumers would support the use of biotechnology that could improve upon the food attributes, which they ranked as important.

Specifically in this paper, we studied the socio-demographic factors that affect the selection of mandatory labeling of GM foods, and the support level that might be associated with different biotechnology techniques that could improve upon the nutritional value of the potato, reduce pesticide applications, or increase the level of flavor of potatoes. The remainder of this paper will be divided as follows: Section 2 provides a summary of previous studies conducted in this area; Section 3 includes a description of the data used for the study. Sections 4 and 5 include the hypotheses and methods used in the analysis of the data, and Sections 6, 7, and 8 include the empirical models, and statistical results.

2. Previous Studies

The first studies about consumer response toward biotechnology are related to the use of PST (porcine somotropine) and BST hormones (bovine somatotropin) in porcine and milk production, respectively. Lemieux and Wohlgenant valuated *ex-ante* the impact on the new growth hormone porcine somatotropin in the U.S. pork industry predicting large surpluses for both producers and consumers. Kaiser et al. studied the potential impact of the approval of BST in milk consumption, showing that if its use was approved, milk consumption could go down between 5-15% in the state of New York. McGuirk et al. assessed consumer concerns and potential demand reactions toward the introduction of BST in Virginia. As in the Kaiser study, sizable reductions in consumption were predicted if BST were to be used. However, after years of investigation, the FDA (U.S. Food and Drug Administration) did not find scientific evidence that milk coming from cows treated with BST would pose a health risk for humans, since the BST hormone is naturally produced in cows. As Caswell (1998) pointed out, the FDA allows a voluntary labeling scheme but also requires a disclaimer that prevents consumers from being mislead about the benefits of nonuse of artificial BST in milk production. Therefore, the demand for milk produced with BST cows never shifted as much as originally expected.

On the other hand, if consumers feel that they will receive a positive benefit from the use of something like PST, it has been shown that they will indeed use the product. For example, Buhr et al. show that students were actually willing to pay a premium for pork produced using PST because the pork was reported to have 30% to 60% fewer calories and was 10% to 20% leaner. Heiman et al. studied consumer responses toward GM meats when alternative choices of meat produced with hormones or dyes were given. They concluded that consumers were more receptive toward GM meats than those produced using hormones or dyes. However, concerns about biotechnology exist, nonetheless, and many producers are responding to these consumers' concerns by offering GMO-free products. Loureiro and Hine studied consumer willingness to pay for GMO-free potatoes in comparison with organic and Colorado Grown potatoes. They found that although consumers are willing to pay a premium for GMO-free potatoes (about six cents/lb), this premium is smaller than the one for organic and Colorado Grown potatoes.

3. Data

One of the primary objectives of this survey was to gather information about the consumer attitudes about biotechnology issues associated with the purchase of potatoes. Data were gathered from a survey conducted during the fall of 2000 in different locations of the state of Colorado. Students from the National Agribusiness Marketing Association (NAMA) at Colorado State University (CSU) conducted 437 useable in-person surveys in supermarkets such as King Soopers, Albertsons, Super Wal-Mart, and Safeway in different locations of Colorado including Fort Collins, Greeley, Parker, and Denver.

The survey was divided into four sections. Section I focused on general consumption patterns and potato attributes that consumers found important including the premium that these consumers were willing to pay for these characteristics. Section II dealt with nutrition issues and what would prompt consumers to purchase more potatoes. Section III asked questions about biotechnology and consumers' general attitude associated with genetically modified foods. The last section provided demographic information with which to develop a target audience. As summarized in Table 1, 60% of the respondents are female, and the mean age of the sample is 44 years. The mean education level includes some years of college, with almost one third (31%) of the respondents earning a bachelors degree or higher, and 46% of the respondents had at least one child in their household. Finally, 60% of those responding to the income question (out of a total of 378) reported a household income of $50,000 or more in the year 2000. When comparing these figures with the Colorado Census (U.S. Census Bureau) as in Table 2, we see that our sample is a bit older, with higher income levels and a higher percentage of females. Although the higher percentage of females is desirable since they are the ones making most of the purchasing decisions in the household, it's difficult to assess the effects associated with an older population with higher incomes in our results. Given the preceding observations, we acknowledge that our findings are limited in their ability to be applied to a fully generalized broader population.

With respect to the biotechnology questions, consumers were asked about their knowledge of biotechnology issues and their support of biotech methods for the improvement of certain important characteristics of their potato purchases. As shown in Table 3, consumers show a strong support for biotechnology techniques that would improve upon nutritional value, with 63% of respondents willing to support its use. Other attributes ranked high by consumers were flavor (56%), storability, and improved farmer efficiency (both at 53%). Less than one-forth of the respondents indicated that they would not support biotechnology for improving these attributes. In addition, over one-half of the respondents feel that biotechnology is important to the sustainability of agriculture. Consumers were also asked about their willingness to purchase a product modified by biotechnology to provide protection against pests, which would result in less use of pesticides and 80% said they would support this. However, concerns about the use of biotechnology still exist. These concerns are reflected in the fact that 78% of the consumers said that labeling of GM products should be enforced.

4. Research Hypotheses

Using the information provided by the survey, we developed two hypotheses to test both the desire for mandatory labeling and support of biotechnology for improved potato characteristics. We would expect these hypotheses to be applicable to other studies or industries.

Hypothesis 1: The more informed consumers are about biotechnology, the less likely it is that they support mandatory labeling of genetically modified foods.

Hypothesis 2: In the case of our specific study, consumers who give more importance to nutritional properties, flavor, and pesticide-free foods will be more supportive of biotechnology practices that improve upon these attributes.

5. Methods

In assessing the desire for mandatory labeling programs and the support of biotechnology depending on its potential use or benefit, respondents provided a "Yes," "No" answer to the questions about whether they think that GM foods should carry labels, and whether or not they support the use of biotechnology in order to have certain characteristics that they ranked important. To analyze these dischotomous choices, we used independent logit models based on the following logistic probability function:

(1) $$P_i = F(Y_i) = \frac{1}{1+e^{-Y_i}} = \frac{1}{1+e^{-(\alpha+\mathbf{X}_i\beta)}},$$

where P_i is the probability that the ith consumer will make a certain choice (answer = "Yes"), given the observed level of certain socio-demographic characteristics and information conditions contained in $\mathbf{X_i}$. Therefore, if (1) represents the probability that a consumer will answer "Yes" to the question regarding labeling, then 1-P_i will be the probability associated with answering "No." Thus,

(2) $$1 - P_i = \frac{1}{1+e^{Y_i}}$$

As a consequence, if we want to estimate the odds ratio in favor of saying “Yes,” versus saying “No,” then we need to calculate the ratio of both probabilities.

(3) $$\frac{P_i}{1-P_i} = \frac{1+e^{Y_i}}{1+e^{-Y_i}} = e^{Y_i} = e^{\alpha + x_i \beta_i}$$

When linearizing (3) by taking the natural log, we obtain the odds ratio in favor of those respondents answering “Yes” to any specific question given $\mathbf{X_i}$, where $\mathbf{X}_i$ is a $(n \times K)$ matrix of subjective values about biotechnology, subjective information, and socio-demographic characteristics. This can be shown as:

(4) $$Log\left(\frac{P_i}{1-P_i}\right) = Y_i = \alpha + \mathbf{X_i}.\beta,$$

where Y_i is the dichotomous response $(n \times 1)$ vector related to a $(n \times K)$ matrix of observable explanatory variables $\mathbf{X}_i$. Notice that the meaning of the coefficients cannot be interpreted as the direct effects on the probability of supporting mandatory labeling for GM products; rather, they measure the change in the odds ratio by a change in a unit of X. In order to estimate the effects on the probabilities directly, as Maddala explains, we need to estimate the marginal effects.

It’s convenient to remember that the underlying statistical model is based on a latent and continuous unobservable (Y_i^*) variable unknown to the researcher, which in the context of the labeling analysis could be the general consumers' concerns about biotechnology. The observable variable, which is modeled by the researcher, is the response to the dichotomous choice. Thus, the latent model is represented by:

$$(5) \qquad Y_i = I_{(0,\infty)}(Y_i^*), \qquad \text{where} \quad Y_i^* = \alpha + \mathbf{X_i}.\beta + \varepsilon_i.$$

Therefore,

$$(6) \qquad Y_i = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \quad \text{iff} \quad \mathrm{Y_i^*} = \alpha + \mathbf{X_i}.\beta + \varepsilon_i \begin{Bmatrix} > \\ \leq \end{Bmatrix} 0.$$

Notice that we are assuming that the ε_i are iid unobservable random variables, which follow a logistic distribution with mean 0 and a variance of $\pi^2 / 3$.

We observed a "Yes" response if and only if the latent unobservable variable is greater than 0. On the other hand, we observed a "No" response when the latent variable (consumers' concerns) is less than or equal to 0.

6. Support of Mandatory Labeling

As mentioned above, 78% of the respondents believe that products using biotechnology practices should be labeled. In order to empirically model the consumers' desire for mandatory labeling of GM products, the following logit model has been empirically estimated:

$$(7)\, Y_i^* = \beta_0 + \beta_1 Age_i + \beta_2 Female_i + \beta_3 Children_i + \beta_4 Educat_i * Income_i + \beta_5 Information_i + \varepsilon_{i,}$$

where Age_i is the age of the ith consumer; $Female_i$ denotes whether the respondent is a female; $Children_i$ denotes the number of children living in the household; $Educat_i$*$Income_i$ is the cross-product of consumer's individual education and income levels (See Table 1 for socio-demographic variable descriptions); $Information_i$ represents the respondent's subjective information level about biotechnology, and ε_i is the error term that follows a logistic distribution.

7. Support of Biotechnology

In addition, we focused our attention on biotechnology applications that could result in an immediate and private benefit to the consumer (such as the increase of nutritional value, the increase in potato flavor and the decrease of pesticides) , although consumers also ranked other applications such as an increased potato size and storability as very high—with more than 50% level of acceptance.   Empirically, the following three independent logit models were estimated:

$$(8)\, Y_{ij}^{*} = \beta_{0j} + \beta_{1j} Age_i + \beta_{2j} Female_i + \beta_{3j} Children_i + \beta_{4j} Educat * Income_i + \beta_{5j} Attribute_i + \varepsilon_{ij},$$

where j=1,2,3 corresponding respectively with each biotechnology application.

Notice that $Attribute_i$ refers respectively to the importance of nutrition, flavor, and pesticide-free attributes. We hypothesized that the acceptance toward biotechnology practices depends on socio-demographic characteristics such as the consumer's age, the consumer's gender, whether there are children under 18 years of age in the household and the cross product of consumers' education and income, as well as the importance of certain attributes in potatoes. In particular, if the nutrition, flavor, or pesticide-free attributes are important to consumers, they would be willing to support the use of biotechnology in order to achieve higher values of those desirable attributes. The inclusion of these socio-demographics also provides a comparison with the above model that tests support for labeling of biotechnology products. Note that the variable denoting consumer's information regarding biotechnology was dropped, because it was not statistically significant for any of the regressions.

8.1 Results: Support towards Mandatory Labeling

Statistical results on whether or not the consumer agrees with mandatory labeling are presented in Table 5. All the variables have the expected relationship with the dependent variable, acceptance of mandatory labeling. With the exception of the variable *Children*, and the coefficient *Educat*Income* all coefficients are significant at either the 90 or 95 percentile. The variables *Children* and the cross product *Educat*Income* were included in the specification model, not only as socio-demographic characteristics, but also because in the case of the children variable, it served as a food safety proxy. We expected that respondents who had children in their household would be more supportive of the use of labels to identify genetically modified products. It's interesting to note that the presence of children, although not significant, still has a positive sign showing that perceptions play a very important role with respect to mandatory labeling. A mother may be more concerned about her children (than herself) when it comes to GM foods.

According to the coefficients of the logit model in Table 5, subjective information (*Information*) about biotechnology significantly decreases the log of the odds ratio in favor of mandatory labeling. This is related to the fact that consumers already informed about biotechnology do not desire labels to decrease the asymmetric information problem.

8. 2. Acceptance of biotechnology to increase nutritional value of potatoes

Empirical results from equation (9) are presented in Table 6. At first glance, it's interesting that the female coefficient carries a positive (although not statistically significant coefficient) for the acceptance of biotechnology to increase the nutritional value of potatoes. The respondents' importance level for nutrients in food *(Nutrition)* has a positive, although not statistically significant effect on the odds of supporting the use of biotechnology. This finding could be explained by the fact that consumers may perceive biotechnology processes as risky, even if they could potentially benefit from these practices. In other words, the benefits are outweighed by the risks. The variable *Age* also has a positive effect, which can be explained by the fact that many middle-aged Americans are concerned with the nutritional value of their diets. For example, Variyam et al. showed that dietary fiber intake increases significantly with respondent's age. On the other hand, the number of children in the household (*Children)* has a negative although not significant effect, which can represent a food safety concern about practices involving biotechnology.

8.3. Acceptance of Biotechnology to increase Potato's Flavor

Again, all coefficients have the expected signs and relationships with the dependent variable. As in the above regression, the cross product of income and education is positive and statistically significant on the odds of accepting this biotechnology application. Also, the variable denoting consumer's age (*Age)* is positive and statistically significant. Thus, our results infer that older people with higher social status are more likely to accept biotechnology applications that increase the nutritional content and flavor of potatoes. Other variables such as the number of children in the household, and the dummy denoting female respondents carry negative (although not statistically significant) signs, denoting that there is a negative relationship between these aforementioned variables and the acceptance of biotechnology practices.

8.4. Acceptance of Biotechnology to decrease Pesticide Applications

All coefficients have the expected sign with the dependent variable, acceptance of biotechnology. Age has a negative effect, which may be explained by the fact that as people age, they are generally less concerned about the impacts of pesticides in the environment or food**;** instead, they consider their food supply to be safe**.** Older people tend to be less worried about food safety and more concerned about the nutritional level of their food. Female respondents are also less likely to support biotechnology applications, which reflect the fact that biotechnology may be perceived as a risky application. This finding is also expressed by the fact that the number of children *(Children)* has a negative and significant effect, which may indicate the concerns that families with small children may have about biotechnology. The subjective importance of pesticide free attributes in food consumption *(PestF)* has a positive-although not significant-effect. This can be explained by the fact, that even when consumers rank the importance of pesticide-free foods as high, on average if they are concerned about pesticides, they are less likely to support the use of biotechnology processes. An example of a target group made of pesticide-concerned consumers who aren't likely to support biotechnology is the organic market segment.

9. Conclusions

In this paper, we look at socio-demographic factors affecting consumer acceptance of mandatory labeling of GM products. Our results indicate consumers who are well informed do not appear to be as concerned about the mandatory labeling of GM foods as those who are less informed, which may indicate that better education would help the GM situation. In addition, we also analyzed consumer response toward biotechnology manipulations that may increase the nutritional content of the potatoes, its flavor, or reduce the pesticide usage. Our results indicated that female with children, are still uneasy about GM purchases—the perception may be that GM foods could be risky for our children. It is also interesting to note that risk perceptions associated with biotechnology may be playing a significant role with respect to the support consumers are willing to give for more nutritious, more tasty, and pesticide-free food. Although there are positive relationships between the support of biotechnology and the attributes reflecting the importance of nutrition, flavor, and pesticide-free attributes, we were unable to show a statistically and positive relationship between the importance of the mentioned attributes and biotechnology applications.

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Table 1: Socio-Demographic Characteristics of the Sample

Variable	Description	Mean	Standard Deviation
FEMALE	Dummy variable, 0=Male, 1=Female	0.603	0.537
CHILDREN	Number of children in the household	1.516	5.016
INCOME	Household's income level: 1=<$25,000 2=$25-50,000 3=$50-75,000 4=$75-100,000 5=>$100,000	2.941	1.266
AGE	Age of interviewee	44.38	15.180
EDUCATIONAL LEVEL	Highest Level of Education completed; 1=Non-Graduate 2=High School 3=Some College 4=Associates Degree 5=Bachelors Degree 6=Masters Degree 7=Doctorate	3.147	1.454

Table 2: Comparison of Sample Socio-demographic versus Colorado Population

	Sample	Colorado Population
% Female	60.3%	49.6%
% Household with Children under 18 years of age	31.6%	35.3%
% High School Graduates	79.58%	41,36%[1]
Median Income	3 ($50,000-$75,000)	$40,853
Median Age	44	34.2

Source: Consumer Survey and US Census Bureau (2000).

[1] Persons 25 years and over, 1990

Table 2: Variable Description related to Perceptions of Biotechnology and other Food Attributes. Used likert scale ranking from 0 to 5, with 5 being most important)

Variable Name	Definition	(Min., Max.)	Mean	Stdv.
INFORMATION	Personal Information Level about Biotechnology 0-No information, 5=Very well informed	(0,5)	2.296	1.300
FLAVOR	Importance of good flavor	(0,5)	4.176	2.253
NUTRITION	Subjective Importance of Nutrition Contents of Food when making purchasing decisions	(0,5)	4.308	0.976
PESTF	Subjective Importance of Pesticide-Free attributes when making purchasing decisions	(0,5)	3.183	1.365

Table 4: Support of Biotechnology Depending on Associated Benefit

Enhanced Characteristic	Support	Do not Support	Don't Know
NUTRITIONAL VALUE	63%	21%	16%
REDUCTION OF PESTICIDES	50%	13%	37%
FLAVOR	56%	21%	23%
STORABILITY	53%	21%	26%
SUSTANABILITY OF AGRICULTURE	53%	25%	22%
APPEARANCE	36%	23%	41%
SIZE	38%	22%	40%

Table 5: Modeling Support towards Mandatory Labeling. Y={0,1}

Variables	Coefficients	T-ratio	Marginal Effects	T-ratio
Constant	1.9019**	2.5323	0.1265**	2.399
AGE	0.0273*	1.8145	0.0018*	1.864
FEMALE	0.9597**	2.2805	0.06384**	2.350
CHILDREN	0.1280	0.7663	0.0085	0.786
EDUCAT*INCOME	-0.0062	-0.2205	-0.0004	-0.221
INFORMATION	-0.5008***	-3.3986	-0.0333***	-3.484

(*) significant at $\alpha = 0.1\%$, and (**) significant at $\alpha = 0.05\%$.
N=303
% of Correct Predictions=89.43%
Restricted Log-Likelihood=-86.70
Unrestricted Log-Likelihood=-97.83
$\chi_{(5)}$ Test=22.27, p-value=0.0046

Table 6: Support toward Biotechnology Applications

	Acceptance of Biotechnology to increase Nutritional Value		Acceptance of Biotechnology to increase Flavor		Acceptance of Biotechnology to decrease Pesticide	
	Coefficients	T-ratio	Coefficients	T-ratio	Coefficients	T-ratio
Constant	-0.2143	-0.27867	-0.8200	-1.1389	2.7229**	3.27305
AGE	0.0268**	2.07646	0.0262**	2.4130	-0.0156	-1.290
FEMALE	0.1602	0.439069	-0.3874	-1.2549	-0.0153	-0.0415
CHILDREN	-0.0196	-0.71385	-0.0055	-0.2045	-0.0688*	-1.881
EDUCAT* INCOME	0.0561*	1.89844	0.0447*	1.9227	0.0341	1.248
ATRIBUTE (NUTRITION)	0.0723	0.501509	/	/	/	/
ATRIBUTE (FLAVOR)	/	/	0.162598	1.2673	/	/
ATRIBUTE (PESTICIDE-FREE)	/	/	/	/	-0.2292*	-1.663
N=	253		257		213	
% of Correct Predictions	82.1%		77.43%		85.37%	

Table 7: Marginal Effects

	Acceptance of Biotechnology to increase Nutritional Value		Acceptance of Biotechnology To increase Flavor		Acceptance of Biotechnology to Decrease Pesticide	
	Coefficients	T-ratio	Coefficients	T-ratio	Coefficients	T-ratio
Constant	-0.2487	-0.2790	-0.1433	-1.1320	0.3929	3.499
AGE	0.0031**	2.1220	0.0045**	2.451	-0.0022	-1.296
FEMALE	0.0186	0.4390	-0.0677	-1.262	-0.0022	-0.0420
CHILDREN	-0.0228	-0.7100	-0.0009	-0.2040	-0.0099*	-1.840
EDUCAT* INCOME	0.0065**	1.9650	0.0078**	1.949	0.0049	1.259
ATRIBUTE (NUTRITION)	0.0084	0.6155	/	/	/	/
ATRIBUTE (FLAVOR)	/	/	0.0284	1.2710	/	/
ATRIBUTE (PESTICIDE-FREE)	/	/	/	/	-0.0330*	-1.696