Biodiesel: Awareness, Use and Perceptions of Students at Four U. S. Universities

D.M. Johnson[1], D.W. Edgar[2] and L.D. Edgar[3]
University of Arkansas
Fayetteville, AR

M. Pate[4]
Utah State University
Logan, UT

R.W. Steffen[5]
Illinois State University
Normal, IL

Abstract

Knowledge about renewable energy is limited and a lack of information pertaining to biofuels is prevalent. If consumers believe there are negative consequences towards use of biofuels then they are less likely to use biodiesel. Based on perceptions portrayed through media formats, the battle between food and fuel has been formulated and presented to the public. This study sought to examine selected college students' awareness, use and perceptions of biodiesel and determine if there was variance between selected regions based on gender, major (agriculture vs. non-agriculture), type of area where students were raised (farm, rural non-farm, town or city), or political orientation (conservative, moderate, or liberal). Findings indicated that one in five (20.9%) participants reported owning or driving a vehicle fueled by diesel while over three-fourths (76.4%) had heard of biodiesel. Furthermore, males, agriculture majors, and students raised on a farm were significantly more likely to have heard of biodiesel than females, non-agriculture majors, and students raised in a town or city. Illinois State University students tended to be more likely to have purchased biodiesel, be more positive about the benefits of biodiesel and have a lower level of concern about the effects of biodiesel.

Introduction

Liquid biofuels have received renewed interest among the public, government, and industry due to diminishing petroleum supplies, increasing energy demands, the geographical concentration of known petroleum reserves, and concerns about the environment (Koonin, 2006; Rojey et al., 2010). The U.S. Energy Independence and Security Act of 2007 mandated that 136 billion liters of renewable biofuels be in use by 2022 (Schnepf et al., 2010). Furthermore, the National 25 x '25 Committee, comprised of U.S. leaders in agriculture and forestry, has set a goal that farms and ranches will produce 25% of U.S. energy by 2025 (Acker, 2008).

Although there is strong political and agricultural industry support for first generation biofuels, not all critics have been convinced of the net benefits of increased production and use. Some question the performance (Skipper, 2007), environmental and economic impacts (Lehrer, 2010), and food availability and cost effects (Pimentel et al., 2009) of first generation biofuels. According to Acker (2008), research and education must play key roles in meeting the U.S. National 25 x '25 Committee's renewable energy goals. One research priority (Acker, 2008) is to "assess consumer behavior and attitudes towards renewable energy" with the goal of understanding perceived advantages and concerns (p. 57). Evidence has further been found that political affiliation may predispose persons to oppose biofuels (Cacciatore et al., 2012).

Research has shown that individual judgments often depend on how an issue is framed by the news media and other opinion leaders (Chang, 2009; Druckman, 2001; Van de Velde et al., 2010). Additionally, Chang (2009) identified fuel vs. food as a commonly used media frame for reporting on biofuels. The food vs. fuel frame portrays increased biofuel production resulting in decreased food production and/or increased food

[1]Professor, Agricultural Education, Communications and Technology, Tel: 479-575-2039, Fax: 479-575-2610, Email: dmjohnso@uark.edu
[2]Associate Professor, Agricultural Education, Communications and Technology, Tel: 479-575-2037, Fax: 479-575-2610, Email: dedgar@uark.edu
[3] Associate Professor, Agricultural Education, Communications and Technology, Tel: 479-575-6770, Fax: 479-575-2610, Email: ledgar@uark.edu
[4]Assistant Professor, Applied Sciences, Technology and Education, Tel: 435-797-3508, Fax: 435-797-4002, Email: Michael.pate@usu.edu
[5]Professor, Department of Agriculture, Tel: 309-438-8084, Fax: 309-438-5653, Email: rwsteff@ilstu.edu

prices. The acceptance of biodiesel could be improved by utilizing alternative communication channels that may overcome national, geographic, social and cultural, or other boundaries (Jensen et al., 2011).

The theory of reasoned action (TRA) (Ajzen et al., 1980) posited that human actions, such as using biodiesel, are guided by three considerations: (a) beliefs about the consequences of an action (behavioral beliefs), (b) beliefs about the normative expectations of others (normative beliefs), and (c) beliefs about the presence of factors that may promote or hinder the behavior (control beliefs). Taken as a whole, these beliefs lead to the formation of behavioral intentions which serve as precursors to behavior (such as use or non-use of biodiesel).

The purpose of this study was to determine selected college students' awareness, use, and perceptions of biodiesel. Specific objectives were to:

Determine students' awareness of biodiesel and determine if awareness differed by university or the demographic variables of gender, major (agriculture vs. non-agriculture), residence (farm, rural - nonfarm, town or city), or political orientation (conservative, moderate or liberal);

Determine students' use of biodiesel and determine if biodiesel use differed by university or the demographic variables of gender, major (agriculture vs. non-agriculture), residence (farm, rural - nonfarm, town or city), or political orientation (conservative, moderate or liberal);

Determine students' perceptions of biodiesel and determine if a significant ($p < .05$) proportion of the variance in perceptions of biodiesel can be explained by a single or linear combination of predictor variables.

Methods

The population for this study was comprised of students enrolled in introductory agricultural economics courses at the University of Arkansas, Texas Tech University, Utah State University, and Illinois State University during the fall or spring semesters of the 2011-2012 academic year. These universities were purposively selected based on geographic diversity (Southeast, Southwest, Mountain West and Midwest U.S.) and willingness to participate. Introductory agricultural economics courses were selected because these courses meet general education (social science) requirements at these four universities and, consequently, enroll a mixture of agriculture and non-agriculture majors. All research protocols relating to human subjects were approved by the respective university institutional review boards prior to data collection.

The survey was administered in each class by the course instructor or one of the researchers during either the fall or spring semesters of the 2011-2012 academic year. At the University of Arkansas, 90 of 105 (85.7%) students enrolled were present and provided usable responses; at Texas Tech University, 200 of 235 (85.1%) provided usable responses; at Utah State University 318 of 470 (67.7%) provided usable responses; and at Illinois State University 90 of (154) (58.4%) provided usable responses. Overall response rate was 72.4%. The anonymous nature of responses precluded follow-up of absent or non-responding students.

The instrument was developed by the researchers based on a review of the literature related to consumer awareness, use, and perceptions of biofuels (Halder et al., 2011; Kinsey et al., 2003); Kulscar et al., 2011; Popp et al., 2009; Skipper et al., 2009; Selfa, et al., 2010; Vogt et al., 2008; Xue et al., 2011). The completed instrument contained three sections. Section one had three items to determine if the respondent owned or drove a diesel-fueled vehicle, had ever heard of biodiesel, or had ever purchased biodiesel. Section two contained 34 items on a 1 to 5 Likert-type scale (1 = "strongly disagree" and 5 = "strongly agree") designed to determine respondent perceptions about biodiesel. To prevent response set, 11 of these 34 items were negatively worded. Section three had five demographic items related to gender, age, type of area where the student was raised [farm, rural - nonfarm, town (< 10,000 population, or city (>10,000 population)], academic major and political views (conservative, moderate or liberal).

The test-retest procedure was used to determine instrument reliability (Gall et al., 2006). The survey was administered twice, at a 14 day interval, to seven undergraduate students not included in the main study. The coefficients of stability were 1.0, 0.81, and 0.99, for sections one, two and three, respectively. A panel of five individuals with expertise in survey methods (n = 2), biofuels research (n = 2), and biodiesel marketing (n = 1) reviewed the instrument and judged it to possess face and content validity.

Data were analyzed using descriptive and inferential statistics. Principal components analysis was used to identify the number and nature of the underlying factors responsible for covariance in the 34 items designed to measure perceptions of biodiesel (section two). Following principal components analysis, negatively worded items were reverse-coded and factor scores were constructed for each identified factor, factor reliabilities were assessed, and the resulting factor scores were used as criterion variables in subsequent multiple regression analyses (Hair et al., 1998, Hatcher, 1994).

Results and Discussion

A majority of all respondents were male (63.2%) and were raised in either a town (26.6%) or a city (39.4%). Respondents were almost evenly divided between agriculture (50.2%) and non-agriculture majors (49.8%). A majority reported their political views as conservative (51.3%), followed by moderate (39.3%) and liberal (9.4%). There were significant differences by university on the variables of gender, major, residence and political orientation (Table 1).

Pairwise Chi Square tests were used *post hoc* to identify significant ($p < .05$) differences by university for each variable (Cox et al., 1993). Utah State University

Table 1. Respondent Demographic Characteristics by University

	University A		University B		University C		University D		
Characteristic	*f*	%	*f*	%	*f*	%	*f*	%	χ^2
Gender									17.71***
Male	51	58.6	100	52.9	213	71.2	56	62.9	
Female	36	41.4	89	47.1	86	28.8	33	37.1	
Major									329.71****
Agriculture	71	81.8	175	93.6	42	14.1	42	48.3	
Other	16	18.4	12	6.4	255	85.9	45	51.7	
Residence									39.91****
Farm	30	35.3	50	27.3	45	15.5	13	15.3	
Rural/nonfarm	18	21.2	20	10.9	28	9.6	15	17.6	
Town (≤10,000)	16	18.8	45	24.6	93	32.0	17	20.0	
City	21	24.7	68	37.2	125	43.0	40	47.1	
Political orientation									44.74****
Conservative	36	43.9	116	63.7	152	52.4	18	24.3	
Moderate	38	46.3	46	25.3	121	41.7	42	56.8	
Liberal	8	9.8	20	11.0	17	5.9	14	18.9	

***p < .001; ****p < .0001

Table 2. Diesel Vehicle Ownership/Use and Awareness and Purchase of Biodiesel, by University

Question	Response		
University	Yes (%)[z]	No (%)	χ^2
Do you own or drive any vehicle that runs on diesel?			2.64
University of Arkansas (n = 89)	16.8_a	83.2	
Texas Tech University (n = 194)	23.7_a	76.3	
Utah State University (n = 314)	20.1_a	79.9	
Illinois State University (n = 88)	17.0_a	83.0	
Have you ever heard of biodiesel?			12.38**
University of Arkansas (n = 90)	85.6_a	14.4	
Texas Tech University (n = 199)	79.4_{ab}	20.6	
Utah State University (n = 311)	70.4_b	29.6	
Illinois State University (n = 90)	81.1_{ab}	19.9	
Have you ever purchased biodiesel?			15.93**
University of Arkansas (n = 74)	5.4_{ab}	94.6	
Texas Tech University (n = 155)	4.5_b	95.5	
Utah State University (n = 236)	5.9_{ab}	94.1	
Illinois State University (n = 71)	18.3_a	81.7	

[z]For each question, percentages in the "Yes" column that share a subscript letter are not significantly different (p < .05) by pairwise Chi Square analyses.

**p < .01.

Table 3. Purchase of Biodiesel by Students Driving/Owning Diesel Vehicles and Aware of Biodiesel, by University

	Have you ever purchased biodiesel?			
	Yes		No	
University	*n*	%	*n*	%
University of Arkansas	3	21.4_{ab}	11	78.6
Texas Tech University	4	11.8_b	30	88.2
Utah State University	8	16.0_b	42	84.0
Illinois State University	8	61.5_a	5	38.5

For each question, percentages in the "Yes" column that share a subscript letter are not significantly different (p < .05) by pairwise Fisher's Exact Test.

had a significantly higher percentage of males (p < .001) than Texas Tech University; no other pairwise comparisons were significant. Significant differences (p < .0001) were found between the percentages of agriculture and non-agriculture majors for all paired comparisons except between the University of Arkansas and Texas Tech University. The University of Arkansas had a significantly higher (p < .01) percentage of respondents raised on a farm than did Utah State University or Illinois State University; the percentage of farm-reared respondents at Texas Tech University was also significantly higher (p < .05) than at Utah State University.

A majority of students at Utah State University (52.4%) and Texas Tech University (63.7%) indicated having a conservative political view; the percentage of students that indicated conservative political views at both schools was significantly higher (p < .0001) than at Illinois State University (24.3%). Texas Tech University had a significantly larger (p < .01) percentage of students indicating a conservative political view than the University of Arkansas. Texas Tech University had a significantly smaller percentage of students (25.3%) indicating a moderate political view than the University of Arkansas (p < .05), Utah State University (p < .01), and Illinois State University (p < .0001). Fewer than 10% of total respondents indicated a liberal political view; there were no significant differences between universities regarding the percentage of students that indicated a liberal political view.

Overall, approximately one in five (20.9%) students reported owning or driving a diesel vehicle; this percentage did not differ significantly (p > .05) by university (Table 2). Over three-fourths (76.4%) of all respondents had heard of biodiesel. University of Arkansas students were significantly (p < .01) more likely to have heard of biodiesel than Utah State University students; there were no other significant (p > .05) differences in awareness of biodiesel by university. Of those students who had heard of biodiesel (n = 527), only 1 in 14 (7.1%) reported ever having purchased biodiesel. Illinois State University students were significantly more likely to have purchased biodiesel than Texas Tech University students; there were no other significant (p > .05) differences between universities in the percentage of students who had purchased biodiesel.

Data on the purchase of biodiesel was further examined for the subset of students who owned or drove a diesel vehicle and had heard of biodiesel (n = 111). Overall, 20.7% of these students had purchased biodiesel. The results of the Fisher's Exact Test indicated a significant (p < .01) difference in the percentage of students having purchased biodiesel by university. Based on pairwise analyses (Table 3), a significantly higher percentage of Illinois State University students had purchased biodiesel than Texas Tech University (p < .01) and Utah State University (p < .01) students. No other paired comparisons by university were statistically significant (p > .05).

Student awareness of and purchase of biodiesel were next examined by the demographic variables of gender, major, residence and political views (Table 4). Males were significantly (p < .05) more likely than females and agriculture majors were significantly (p < .0001) more likely than non-agriculture majors to have heard of biodiesel. Students raised on farms were significantly more likely to have heard of biodiesel than students raised in town (p < .05) or in the city (p < .0001). Students raised in a rural, nonfarm area were significantly (p < .05) more likely than students raised in the city to have heard of biodiesel. Conservatives, moderates and liberals were equally likely to have heard of bio-

diesel. The only significant difference by demographic variable in the purchase of biodiesel was for residence, where students raised on a farm were more likely ($p < .05$) than students raised in a city.

Students' responses for the 34 items measuring perceptions of biodiesel were analyzed using exploratory factor analysis with squared multiple correlations as prior communality estimates. The principal factor method was used to extract the factors followed by a varimax (orthogonal) rotation. The scree plot indicated the presence of two meaningful factors which were retained for rotation (Hair et al., 1998; Hatcher, 1994). In interpreting the rotated factor pattern, an item was determined to load on a given factor if the loading was .40 or greater on that factor and less than .40 on the other factor (Hair et al., 1998; Hatcher, 1994). Using this criterion, 15 items loaded on the first factor (Support for Biodiesel) and six items loaded on the second factor (Concerns about Biodiesel). The two-factor solution satisfied the requirements for interpretability as described by Hatcher (1994); a minimum of three items loaded on each factor, each factor had a unique and identifiable conceptual meaning, and the factors demonstrated simple structure. The two factors explained 74.3% of the variance associated with the original 34 items. Table 5 presents the two named factors, the items, loadings and the coefficient alpha reliability estimate for each factor.

Table 4. Association of Demographic Characteristics with Awareness of and Purchase of Biodiesel

	Have you ever heard of biodiesel?					Have you ever purchased biodiesel?				
	Yes		No			Yes		No		
Variable	*n*	%	*n*	%	χ^2	*n*	%	*n*	%	χ^2
Gender					5.78*					2.94
Male	327	78.6	89	21.4		29	8.8	301	91.2	
Female	170	70.2	72	29.8		8	4.6	166	95.4	
Major					37.7****					1.96
Agriculture	282	85.7	47	14.3		24	8.7	253	91.3	
Non-agric.	210	65.0	113	35.0		12	5.4	210	94.6	
Residence					24.0****					10.83*
Farm	120	87.6	17	12.4		16	13.6	102	86.4	
Rural - nonfarm	66	82.5	14	17.5		5	7.6	61	92.4	
Town (<10,000)	124	73.8	44	26.2		8	6.2	122	93.8	
City (>10,000)	168	66.4	85	33.6		6	3.5	165	96.5	
Political views					3.02					0.36
Conservative	248	77.7	71	22.3		18	7.3	229	92.7	
Moderate	176	71.8	69	28.2		13	7.3	172	93.0	
Liberal	42	71.2	17	28.8		2	4.8	40	95.2	

*p < .05, **p < .01, ***p < .001

Table 5. Student Perceptions of Biodiesel: Factor Structure, Item Loadings, and Coefficient Alpha Estimates for the Two-Factor Solution

Factor 1: Support for Biodiesel (alpha = .86)	Factor loading
By using biodiesel I can contribute to a cleaner environment	.70
The U.S. government should support research and development in biodiesel	.61
It is better to use biodiesel because it is made from renewable resources	.58
I am willing to go out of my way to purchase biodiesel	.55
Biodiesel can significantly reduce U.S. dependence on foreign oil	.54
Increased use of biodiesel will reduce global warming	.52
I believe that average global temperature is increasing	.50
Biodiesel produces fewer harmful emissions than does petroleum diesel	.50
It is worth paying extra for biodiesel	.50
If I had a diesel car or truck, I would use biodiesel	.50
Biodiesel is better for my engine than regular diesel	.48
Increased use of biodiesel will result in more jobs in rural areas	.45
Emissions from automobiles have no effect on average global temperature	-.44
Cars and trucks run better with biodiesel	.41
The U.S. is too dependent on foreign oil sources	.41
Factor 2: Concerns about Biodiesel (alpha = .74)	
Increased use of biodiesel will cause a shortage of food	.67
Increased use of biodiesel will cause an increase in the cost of food	.65
Increased biodiesel production will decrease food production	.56
Diesel engines will not run properly on biodiesel	.55
Using biodiesel results in increased engine repair and maintenance costs	.50
Using food crops for biodiesel is justified	-.41

After reverse-coding negatively-loaded items, composite factor scores were created by summing responses to all individual items in the factor and then dividing by the number of items comprising the factor (Hair et al., 1998; Hatcher, 1994), thus, retaining the original 1 to 5 item-scaling for each factor. These factor scores were used as dependent variables in subsequent analyses. In interpreting these scores, a higher score on Factor 1 indicated a higher level of support for biodiesel, while a higher score on Factor 2 indicated a higher level of concern about the potential negative effects of biodiesel.

The overall mean of 3.41 (SD = 0.53) on Factor 1 indicated students had a moderately positive level of support for biodiesel. The overall mean of 2.82 (SD = 0.60) on Factor 2 indicated that students were undecided to slightly unconcerned about the effects of biodiesel. Thus, overall the students had a somewhat positive perception of biodiesel. Bivariate and multiple regression analyses were used to examine the relationships between the predictor variables (university, owning/driving a diesel vehicle, purchasing biodiesel, type of place raised, political views and major) and the criterion variables (support for biodiesel and concerns about biodiesel).

Effect coding and dummy coding (Table 6) were used in order to prepare categorical predictor variables for correlation and regression analyses. Effect coding was used for predictor variables with three or more levels (university, type of place raised, and political views). With effect coding membership in one level of each categorical predictor is indicated by coding a "-1" in the "Yes" category. Effect coding, as opposed to dummy coding, allows each category of each predictor variable to be compared with the grand mean for the criterion variable instead of the mean for a defined reference group, as is the case with dummy coding (Hair et al., 1998). However, caution must be used in interpreting the sign of the correlation coefficient and the standardized multiple regression coefficient (Beta weight) for each variable effect coded as "-1." because of the negative coding, a positive relationship will carry a negative sign while a negative relationship will carry a positive sign (Hair et al., 1998).

Dummy coding was used to code binary categorical variables (own or drive a diesel vehicle, have purchased biodiesel, gender and major); only one category was coded since each variable could be fully described by membership (or non-membership) in the respective category. In interpreting results related to dummy coded variables, the comparison is to the un-coded reference group (Hair et al., 1998).

There were significant ($p < .05$) bi-serial correlations between 8 of 15 potential predictor variables and the criterion variable, support for biodiesel (Table 7). The correlations for these eight predictor variables and support for biodiesel ranged from -0.11 to 0.23. Using descriptors suggested by Davis (1971), the magnitude of all significant relationships was low. Multicollinearity among the eight predictors was assessed using variance inflation factors (VIF). All obtained VIF values (ranging from 1.04 to 1.44) were substantially less than 5, indicating low levels of multicollinearity between predictor variables (Hair et al., 1998).

The regression equation containing the eight predictor variables was statistically significant [F (df = 8, 458) = 8.05; $p < .0001$ (adjusted $R^2 = .1079$)] and explained 12.56% of the variance in support for biodiesel. Beta weights (standardized multiple regression coefficients) and squared semi-partial correlations (Table 8) were reviewed to assess the importance of each of the eight variables in predicting support for biodiesel. Being an Illinois State University student, owning or driving a diesel vehicle, being male, and having a liberal political view all had statistically significant Beta weights and squared semi-partial correlation coefficients. The positive sign associated with the Beta weights for Illinois State University students and liberal political view indicated students in these categories supported biodiesel to a greater extent than the average student. The negative Beta weights for owning or driving a diesel vehicle and being male indicate these students are less supportive of biodiesel than students not owning or driving a diesel vehicle or students whose gender is female. While the relative magnitudes of the squared semi-partial correlation coefficients were consistent with the Beta weights, the best predictor (having a liberal political view) explained only 2.36% of the unique variance in support for biodiesel.

Five of the 15 variables had significant ($p < .05$) bi-serial correlations with the criterion variable, concerns about biodiesel (Table 9). The correlations for these five

Table 6. Coding of Categorical Predictor Variables

Categorical variable Levels	Variable label	Dummy coding Yes	No
University			
Arkansas	D1[a]	-1	0
Texas Tech	D2	1	0
Utah State	D3	1	0
Illinois State	D4	1	0
Own or drive a diesel vehicle?	D5	1	0
Have purchased biodiesel?	D6	1	0
Gender			
Male	D7	1	0
Type of place raised			
Farm	D8[a]	-1	0
Rural - nonfarm	D9	1	0
Town (pop. ≤ 10,000)	D10	1	0
City (pop. > 10,000)	D11	1	0
Political views			
Conservative	D12[a]	-1	0
Moderate	D13	1	0
Liberal	D14	1	0
Major			
Agriculture	D15	1	0

[a]Category effect coded as "-1".

Table 8. Beta Weights and Squared Semipartial Correlations from Multiple Regression Analysis Predicting Support for Biodiesel

Variable	Variable name	Beta Weights[a] Beta	t[c]	Squared semipartial correlations[b] sR^2	F[d]
D3	Utah State University	-.039	-0.75	.0011	0.57
D4	Illinois State University	0.160	2.17*	.0091	4.75*
D5	Own/drive diesel vehicle	-0.166	-2.64**	.0134	7.00**
D7	Male	-0.120	-2.39*	.0110	5.74*
D8	Raised on farm	0.068	1.04	.0021	1.10
D11	City (pop. > 10,000)	.0305	0.57	.0006	0.31
D12[e]	Conservative	0.088	1.74	.0058	3.02
D14	Liberal	0.307	3.51***	.0236	12.32***

[a]Standardized multiple regression coefficients.

[b]Percentage of unique variance accounted for by each predictor when controlling for all other predictors. [c]For *t* tests determining significance of Beta Weights, df = 462. [d]For *F* tests determining the significance of ΔR^2, *df* = 1, 461. [e]Effect-coded as '-1". Model R^2 = .1226; Adj. R^2 = .1092.

*p < .05, **p < .01, ***p < .001, ****p < .0001

Table 7. Intercorrelations between Predictor Variables and Support for Biodiesel[a]

Variable	D1[b]	D2	D3	D4	D5	D6	D7	D8[b]	D9	D10	D11	D12[b]	D13	D14	D15	Support
D1[b]	-	.24****	.35****	.15****	.03	.02	.04	.13****	-.10***	.07	.11**	-.06	-.05	.00	-.25****	-.09
D2		-	-.57****	-.25****	.04	-.07	-.14***	-.09*	-.03	-.03	-.03	-.16****	-.17****	.04	.54****	-.07
D3			-	-.36****	.00	-.04	.15****	.13***	-.08*	.11**	.07	-.04	.06	-.10**	-.65****	-.11*
D4				-	-.03	.15****	.00	.06	.06	-.06	.05	22****	.08*	.20****	-.02	.16***
D5					-	.26****	.10*	-.38****	-.05	-.10**	-.19****	-.07	.04	-.08*	.20****	-.19****
D6						-	.08*	-.13***	.01	-.02	-.11**	.00	-.01	-.03	.07	-.02
D7							-	.00	.01	-.07	.04	-.09*	-.05	-.06	-.18****	-.13**
D8[b]								-	.19****	.30****	.40****	19****	16****	.11**	.33****	.15***
D9									-	-.22****	-.29****	-.02	.02	-.07	.08*	-.05
D10										-	-.46****	.04	.05	-.01	-.10*	.05
D11											-	.13***	.09*	.16****	-.23****	.10*
D12[b]												-	.75****	.30****	.13**	.19****
D13													-	-.24****	-.13***	.05
D14														-	-.04	23****
D15															-	-.05
Support																-

[a]Phi coefficients calculated between predictor variables; point biserial correlations calculated between predictor variables and support. [b]Membership in category effect coded as -1, therefore, negative coefficient indicates positive correlation and positive coefficient indicates negative correlation.

*p < .05, **p < .01, ***p < .001, ****p < .0001.

Table 9. Intercorrelations between Dummy Variables and Concerns about Biodiesel[a]

Variable	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	Concerns
D1[b]	-	.25****	.35****	.15****	.03	.02	.04	.13***	-.10**	.07	.11**	-.06	-.05	.00	-.25****	.04
D2		-	-.57****	-.24****	.05	-.07	-.14***	-.09**	-.03	-.03	-.03	-.16****	-.17****	.03	.54****	.08
D3			-	-.36****.	.00	-.04	15****	.13***	-.08*	.11**	.07	-.04	.06	-.10**	-.65****	.09*
D4				-	-.03	15****	.00	.06	.06	-.06	.05	.22****	.08*	.09*	-.02	-.19****
D5					-	26****	.10*	-.38****	-.05	-.10**	-.19****	-.07	-.05	-.09*	.20****	.00
D6						-	.08*	-.13***	.01	-.02	-.11**	.00	-.01	-.03	.07	-.11*
D7							-	.00	.01	-.07	.04	-.09*	-.05	-.06	-.18****	.00
D8[b]								-	.19****	.30****	.40****	.19****	.16****	.11**	-.33****	-.03
D9									-	-.21****	-.29****	-.01	.02	-.07	.08*	.01
D10										-	-.46]	.04	.l0*	-.01	-.10*	.04
D11											-	.13***	.09*	16****	-.23****	-.07
D12[b]												-	.75****	.30****	-.13**	-.11*
D13													-	-.24****	-.13***	-.04
D14														-	-.04	-.10*
D15															-	.04
Support																-

[a]Phi coefficients calculated between predictor variables; point biserial correlations calculated between predictor variables and support. [b]Membership in category effect coded as -1, therefore, negative coefficient indicates positive correlation and positive coefficient indicates negative correlation.

[b]Membership in category effect coded as -1, therefore, negative coefficient indicates positive correlation and positive coefficient indicates negative correlation.
*p < .05, **p < .01, ***p < .001, ****p < .0001.

Table 10. Beta Weights and Squared Semipartial Correlations from Multiple Regression Analysis Predicting Concerns about Biodiesel

		Beta Weights[a]		Squared semipartial correlations[b]	
Variable	Variable name	Beta	t[c]	sR^2	F[d]
D3	Utah State University	0.028	0.48	.0004	0.20
D4	Illinois State University	-0.260	-3.02**	.0182	9.14**
D6	Have purchased biodiesel	-0.197	-1.89	.0071	3.57
D12[e]	Conservative	-0.054	-0.93	.0017	0.85
D14	Liberal	-0.155	-1.48	.0044	2.21

[a]Standardized multiple regression coefficients. [b]Percentage of unique variance accounted for by each predictor when controlling for all other predictors. [c] For *t* tests determining significance of Beta Weights *df* = 462. [d]For F tests determining the significance of ΔR^2 *df* = 1, 477. [e]Effect-coded as '-1". Model R^2 = .0524; Adj. R^2 = .0425.
**p < .01.

predictor variables and concerns about biodiesel ranged from .09 (Utah State University student to -0.19 Illinois State University student. Using descriptors suggested by Davis (1971), the magnitude of each significant relationship was low. Multicollinearity among the five predictors was assessed using variance inflation factors (VIF). All obtained VIF values (ranging from 1.03 to 1.24) were substantially less than 5, indicating low levels of multicollinearity between predictor variables (Hair et al., 1998).

The regression equation containing the five predictor variables was statistically significant [F(df = 5,476) = 5.24; p < .0001 (adjusted R^2 = .0425)] and explained 5.24% of the variance in concerns about biodiesel. Beta weights (standardized multiple regression coefficients) and squared semi-partial correlations (Table 10) were reviewed to assess the importance of each of the five variables in predicting support for biodiesel. Being an Illinois State University student was the only predictor with a statistically significant Beta weight and squared semi-partial correlation coefficient. The negative Beta weight indicated Illinois State University students a lower level of concerns about biodiesel than the average student. Being an Illinois State University student explained 1.82% of the variance in concerns about biodiesel.

Summary

This study sought to examine selected college students' awareness, use and perceptions of biodiesel and determine if awareness, use, and perceptions varied by university, gender, major (agriculture vs. non-agriculture), type of area where students were raised (farm, rural non-farm, town or city), or political orientation (conservative, moderate or liberal). The results of this study have implications for educators, researchers, consumers and the U. S. biodiesel industry. Approximately one in five (20.9%) students reported owning or driving a diesel vehicle while over three-fourths (76.4%) had heard of biodiesel. Only about 1 in 14 (7.1%) of those having heard of biodiesel had ever purchased biodiesel. If one assumes that students unaware of biodiesel had never purchased biodiesel, then only 5.6% of all students surveyed had ever purchased biodiesel.

These observed differences in awareness and use may be due to differences in the concentration of biodiesel retail outlets in the four states where these universities are located. The concentration (km^2/retail outlet) of biodiesel outlets was highest in Illinois (1,445 km^2/outlet), followed by Arkansas (15,305 km^2/outlet), Texas (20,329 km^2/outlet) and Utah (21,990 km^2/outlet) (National Biodiesel Board, n.d.). A higher concentration of biodiesel outlets obviously provides greater purchasing opportunities through increased availability and may serve to increase awareness through observation and informal peer networks (Van de Velde et al., 2009).

Males, agriculture majors and students raised on a farm were significantly more likely to have heard of biodiesel than females, non-agriculture majors and students raised in a town or city. Students raised on a farm were more likely to have purchased biodiesel than students raised in a city. These results indicate a need to especially target consumer education efforts about biodiesel toward females, non-agriculture majors, and those raised in urban areas. These findings are consistent with Van de Velde et al. (2011).

The results of principal components analysis indicated that two factors were capable of explaining 73.4%

of the variance in the original 34 items assessing perceptions of biodiesel. These two factors were named "support for biodiesel" and "concerns about biodiesel." The support for biodiesel factor contained 15 items explicitly or implicitly comparing biodiesel to petroleum diesel on environmental, renewable, domestic and performance characteristics. The concerns about biodiesel factor contained six items related to the effects of biodiesel on food availability and cost and engine performance and maintenance and repair costs. Because items loaded on two broadly generic factors rather than on multiple specific factors, the researchers concluded these students have fairly unsophisticated knowledge and attitudes toward biodiesel and were most likely reacting to the overall perceived "goodness" of biodiesel as a renewable energy source without a deep level of technical knowledge. This is consistent with previous research demonstrating consumer attitudes are primarily developed through affective not cognitive processes (Bang et al., 2000; Hartman et al., 2012).

Regardless of the exact mechanism by which these attitudes were developed, students at these four U.S. universities had moderately positive levels of support for biodiesel. Results of regression analyses indicated that having liberal political views (sR^2 = .0236) was the best unique predictor of support for biodiesel, followed by owning or driving a diesel vehicle (sR^2 = .0134), being male (sR^2 = .0110), and being an Illinois State University student (sR^2 = .0091). However, the linear combination of these four predictor variables left 94.3% of the variance in support for biodiesel unexplained. This indicates that, while statistically significant, these four variables are weak predictors of support for biodiesel.

Students at these four U.S. universities were undecided to slightly unconcerned about potential negative effects of biodiesel production and use. The results of multiple regression analyses indicated that being an Illinois State University student was the only significant unique predictor of concerns about biodiesel (sR^2 = 0.182). The most consistent finding of this study was that Illinois State University students tended to be more likely to have purchased biodiesel, to be more positive about the benefits of biodiesel, and to have a lower level of concern about the effects of biodiesel production and use. While this "university effect" was not particularly strong, it was consistent and may be a result of the higher concentration of retail biodiesel outlets in Illinois. Greater availability likely leads increased use of biodiesel, which, in turn, may lead to more positive attitudes toward biodiesel.

The relationships between university and demographics and support for biodiesel and concerns about biodiesel were relatively small; overall students could be categorized as neutral to moderately positive in their perceptions of biodiesel. This, coupled with students' relatively unsophisticated perceptions of biodiesel, suggest a need for information about a wide range of issues related to biodiesel if these students are to be informed consumers and renewable energy leaders. This is consistent with previous research (Acker, 2008; Kinsey et al., 2003; Skipper, 2007; Van de Veld et al., 2011). Further research is also needed to better understand factors affecting college students' (and consumers') attitudes toward biodiesel.

Interpreted through the lens of Ajzen et al. (1980) theory of reasoned action, these results may explain the relative non-use of biodiesel by these students. Students are only moderately positive in their perceptions of the benefits of using biodiesel. When these factors are coupled with the lack of biodiesel availability, it is of little wonder that only about one in five (20.7%) students owning or driving a diesel vehicle and aware of biodiesel had ever purchased biodiesel. Thus, increasing biodiesel use will likely depend on both increasing consumer demand (through education) and increasing availability of biodiesel (through increased retail outlets).

Finally, future research should explore policies to increase biofuel use with consumption tax credits. It is very important to understand the effects of such policies on the markets for agricultural products, biofuels, and reduction of dependence on foreign oil and increased public awareness of biodiesel. Research for improving transportation and production infrastructure may assist increasing the availability of biodiesel leading to increased use of biodiesel, which, in turn, may lead to more positive attitudes toward biodiesel. Social marketing campaigns coupled with usage of QR-code stickers at businesses where diesel is sold may also increase public awareness and knowledge regarding biodiesel.

Literature Cited

Acker, D. 2008. Research and evaluation priorities in agriculture, forestry, and energy to achieve the 25x'25 renewable energy vision. NACTA Jour. 52(1): 55-59.

Aldridge, J.R. 2009. Ending america's dependence on foreign oil: Risk perceptions among Texans. http://digitalcommons.wku.edu/cgi/viewcontent.cgi?article=1086&context=theses. Western Kentucky University, unpublished master's thesis. June 5, 2012.

Ajzen, I. and M. Fishbein. 1980. Understanding attitudes and predicting social behavior. Englewood Cliffs, NJ: Prentice-Hall.

Bang, H.K., A.E. Ellinger, J. Hadjimarcou and P.A. Traichal. 2000. Consumer concern, knowledge, belief, and attitude toward renewable energy: An application of the reasoned action theory. Psychology & Marketing 17(6): 449-468.

Cacciatore, M.A., A.R. Binder, D.A. Scheufele and B.R. Shaw. 2012. Public attitudes towards biofuels. Politics and the Life Sciences 31 (1-2): 36 – 51.

Chang, S. 2009. The influence of media frames on the public's perception of biofuels. http://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=1619&context=etd. Iowa State University, unpublished master's thesis. June 5, 2012.

Cox, M.K. and C.H. Key. 1993. Post hoc pair-wise comparisons for the Chi-Square test of homogeneity

of proportions. Ed. and Psych. Measurement 53(4): 951-962.

Davis, J.A. 1971. Elementary survey analysis. Englewood Cliffs, NJ: Prentice-Hall.

Druckman, J.M. 2001. The implications of framing effects for citizens' competence. Political Behavior 23(3): 225-256.

Dunlap, R.E., K.D. Van Liere, A.G. Mertig and R.E. Jones. 2000. Measuring endorsement of the new ecological paradigm: A revised NEP scale. Journal of Social Issues 56(3): 425-442.

Gall, M.D., J.D. Gall and W.R. Borg. 2006. Educational research: An introduction (8th ed.). Columbus, OH: Allyn & Bacon.

Hair, J.F., R.E. Anderson, R.L. Tatham and W.C. Black. 1998. Multivariate analysis. Upper Saddle River, NJ: Prentice Hall.

Halder, P., P. Prokop, C.Y. Chang, M. Usak, J. Pietarinen, S. Havu-Nuutinen, P. Pelkonen and M. Cikar. 2011. International survey on bioenergy knowledge, perceptions, and attitudes among young citizens. Bioenergy Research 4: 1-15. DOI:10.1007/s12155-011-9121-y

Hartman, P. and V. Apaolaza-Ibanez. 2012. Consumer attitude and purchase intention toward green energy brands: The roles of psychological benefits and environmental concern. Jour. of Business Research 65: 1245-1263. DOI: 10.1016/j.jbusres.2011.11.001

Hatcher, L. 1994. A step-by-step approach to using the SAS® system for factor analysis and structural equation modeling. Cary, NC: SAS Institute.

Jensen, J.R., K.E. Halvorsen and D.R. Shonnard. 2011. Ethanol from lignocellulosics, U.S. federal energy and agricultural policy, and the diffusion of innovation. Biomass and Bioenergy 35: 1140-1453. DOI:10.1016/j.biombioe.2010.08.066

Kinsey, K., C. Peterson and D. Haines. 2003. A survey to understand the attitudes towards biodiesel in southwestern Idaho. In: Pacific Northwest American Association of Agricultural Engineers Ann University of Arkansas Meeting. http://elibrary.asabe.org/azdez.asp?JID=8&AID=15705&CID=smppnr&T=2. June 5, 2012.

Koonin, S.E. 2006. Getting serious about biofuels. Science, 311(5760), 435. DOI 10.1126/science.1124886

Kulscar, L. J. and B.C. Bolender. 2011. If you build it, will they come? Biofuel plants and demographic trends in the Midwest. Population and Environment 32: 318-331. DOI:10.1007/s11111-010-0122-0

Lang, K.B. 2011. The relationship between academic major and environmentalism among college students: Is it mediated by the effects of gender, political ideology, and financial security? The Jour. of Environmental Education 42(4): 203-215. DOI: 10.1080/00958964.2010.547230

Lehrer, N. 2010. (Bio)fueling farm policy: The biofuels boom and the 2008 farm bill. Agriculture and Human Values 27: 427-444. DOI:10.1007/s10460-009-9247-0

National Biodiesel Board. (n.d.). Biodiesel retailer listings. http://www.biodiesel.org/using-biodiesel/finding-biodiesel/retail-locations/biodiesel-retailer-listings. July 5, 2012].

Neumayer, E. 2004. The environment, left-wing political orientation and ecological economics. Ecological Economics 51: 167-175.

Petrolia, D.R., S. Bhattacharjee, D. Hudson and C.W. Herndon. 2010. Do Americans want ethanol? A comparative contingent-valuation study of willingness to pay for E-10 and E-85. Energy Economics 32(1): 121-128. DOI: 10.1016/j.eneco.2009.08.004

Pimentel, D., A. Marklein, M.A. Toth, M.N. Karpoff, G.S. Paul, R. McCormick, J. Kyriazis and T. Kruger. 2009. Food versus biofuels: Environmental and economic costs. Human Ecology 37: 1-12. DOI 10.1007/s10745-009-9215-8.

Popp, M., L. Van de Velde, G. Vickery, G. Van Huylenbroeck, W. Verbeke and B. Dixon. 2009. Determinants of consumer interest in fuel economy: Lessons for strengthening the conservation argument. Biomass and Bioenergy 33: 768-778.

REN21. 2011. Renewables 2011 Global Status Report (Paris: REN21 Secretariat). http://www.ren21.net/Portals/97/documents/GSR/REN21_GSR2011.pdf. July 9, 2012.

Rojey, A. and F. Monot. 2010. Biofuels: Production and applications. In W. Soetaert & E.J. Vandamme (Eds.), Industrial biotechnology: Sustainable growth and economic success (pp. 413-431). Hoboken, NJ: Wiley-VCH.

Schnepf, R. and B.D.Yucobucci. 2010. Renewable fuel standards (RFS): Overview and issues. Congressional Research Service: Washington, D. C.

Selfa, T., L. Kulscar, C. Bain, R. Goe and G. Middendorf. 2010. Biofuels bonanza?: Exploring community perceptions of the promises and perils of biofuel production. Biomass and Bioenergy 35(4): 1379-1389.

Sherburn, M. and A.S. Devlin. 2004. Academic major, environmental concern, and arboretum use. The Jour. of Environmental Education 35(2): 23-36.

Sims, R.E.H., W. Mabee, J.N. Saddler and M. Taylor. 2010. An overview of second generation biofuel technologies. Bioresource Technology 101: 1570-1580.

Skipper, D.H. 2007. Consumer attitudes concerning biofuels. Unpublished master's thesis, University of Arkansas, Fayetteville.

Skipper, D., L. Van de Velde, M. Popp, G. Vickery, G. Van Huylenbroeck and W. Verbeke. 2009. Consumers' perceptions regarding tradeoffs between food and fuel expenditures: A case study of U. S. and Belgian fuel users. Biomass and Bioenergy 33: 973-987.

U.S. Energy Information Agency. 2011. Petroleum and other liquids: Monthly U.S. product supplied of finished motor gasoline. http://205.254.135.7/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mgfupus1&f=m. July 5, 2012.

Van de Velde, L., V. Vandermeulen, G.Van Huylenbroeck and W. Verbeke. 2011. Consumer information (in) sufficiency in relation to biofuels: Determinants and impact. Biofuels, Bioproducts & Biorefining 5: 125-131.DOI: 10.1002/bbb

Van de Velde, L., W. Verbeke, M. Popp, J. Buysse and G.Van Hullenbroeck. 2009. Perceived importance of fuel characteristics and its match with consumer beliefs about fuels in Belgium. Energy Policy 37(8): 3183-3193.

Van de Velde, L., W. Verbeke, M. Popp and G.Van Huylenbroeck. 2010. Trust and perception related to information about biofuels in Belgium. Public Understanding of Science 20(5) : 295-608.

Vogt, R.J., R.L. Cantrell, M.A. Carranza, B. Johnson and D.J. Peters. 2008. Energy use and concerns of rural Nebraskans. Lincoln, NE: Center for Applied Rural Innovation. http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1070&context=caripubs. June 5, 2012.

Weins, J., J. Fargione and J. Hill. 2011. Biofuels and biodiversity. Ecological Applications 24(4): 1085-1095.

Xue, J., T.E. Grift and A.C. Hansen. 2011. Effect of biodiesel on engine performance and emissions. Renewable and Sustainable Energy Reviews 15: 1098-1116.

Zelezny, L.C., P.P. Chua and C. Aldrich. 2000. Elaborating on gender differences in environmentalism. Jour. of Social Issues 56(3): 443-457.