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# Internet-orientated Hungarian car drivers' knowledge and attitudes towards biofuels

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ABSTRACT

The respondents rated the most important questions of the questionnaire on a Likert scale. The responses greatly deviated from the normal distribution; therefore, the Kruskal–Wallis *H* and Mann–Whitney *U* were used to test the differences of knowledge about and interest in biofuels and of differences between the most important characteristics of the analysed clusters. As opposed to other studies in this topic, respondents' self-knowledge and real awareness about biofuels were examined jointly. As a result, it was concluded that 78% of those who rated their knowledge appropriate are relatively realistic about the depth of their knowledge. Significantly less respondents had practical experience with biodiesel than ethanol, but the results of the crosstable analysis suggest that these respondents know biofuels more than those who had practical experience with ethanol. Although respondents are basically positive about biofuels, there are significant differences between them. Based on the result of the attitude analysis, respondents were classified into three typical clusters: the indecisive, the supporters and the sceptics. The three clusters can be clearly distinguished from each other in terms of their ways of thinking and they probably represent the opinions of the drivers about biofuels well. Compared with other countries' surveys, the results suggest that there are many similarities and differences between Hungarian car drivers' perceptions to biofuels. It is our opinion that the findings of our examinations are capable of focusing decision-makers' attention, as they corroborate the singificance of conveying knowledge and influencing others online.


**Contents**



## 1. Introduction

Biofuel production and use dramatically increased in the last years. In 2006, 39 billion l bioethanol and 5760 thousand t biodiesel were produced globally, increasing to 86 billion l bioethanol and 18,500 thousand t biodiesel by 2012 [1–3]. The development of the sector was accompanied by the need for energetic independence, the significant role of diesel (60%) in the EU's fuel consumption, as well as the fact that several oil companies and transport enterprises

*Abbreviations:* GHG, greenhouse gases; WWF, World Wide Fund for Nature; ACEA, European Automobile Manufacturer's Association; COPA-COGECA, The united voice of farmers and their co-operatives in the European Union; USDA, United States Department of Agriculture; B-10, fuel with 10% biodiesel and 90% fossil diesel content; DDGS, Dried Distillers Grains with Solubles; RED, Renewable Energy Directive (EU); ILUC, Indirect Land Use Change; DLUC, Direct Land Use Change E-85, fuel with 85% bio-ethanol and 15% gasolin content

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started to take part in research and development. As a matter of course, this sudden development causes changes in land use, trade and industry, thereby placing the entire biofuel sector in the crossfire between serious debates. The scientific interest elicited by these debates is still present in the areas of environmental protection [4–6], land use [7,8], food administration [5,9], as well as economy and trade [10–14] arguments from these scientific fields are used to prove or disprove the necessity of biofuels. For this reason, the mainstream of research left consumers unaffected and there were only a few surveys aiming at their knowledge of and opinions regarding this topic. Therefore, the objective of this paper is to fill the gap and examine the knowledge and attitudes of Hungarian car drivers concerning biofuels. Even though there are numerous studies dealing with car drivers' knowledge, no one has ever performed the simultaneous examination of their self-knowledge and real knowledge. There is a vast amount of information of various quality about biofuels on the Internet which greatly influence consumer preferences; therefore, we considered it to be important to ask those respondents who regularly visit online car portals. It is our opinion that the findings of our examinations are capable of focusing decision-makers' attention, as they corroborate the singificance of conveying knowledge and influencing others online.

Today, almost all of the commercially available biofuels are produced from either starch or sugar-rich crops (for bioethanol), or oilseeds (for biodiesel). Recent research has found that these bioenergy sources have their drawbacks [15,16] and turned attention to the use of ligno-cellulosic feedstocks, such as perennial grasses and short rotation woody crops for bioenergy production [17,18]. Removing $CO_2$ from the atmosphere (negative emissions) implies that human-induced uptake of $CO_2$ would have to be larger than the amount of human-induced GHG emissions. One of the few technologies that may result in negative emissions is the combination of bioenergy and carbon capture and storage [19].

This section offers a brief overview of biofuels, the development of the biofuel sector, the current anxieties and a non-exhaustive description of the main studies targeting consumer knowledge.

### 1.1. Brief presentation of biofuels

The transport sector is responsible for about 20% of world primary energy demand. Transport biofuels are currently the fastest growing bioenergy sectors even they represent just around 3–4% of total road transport fuel and only 5% of total bioenergy consumption today. They also are seeing small but increasing use in the aviation and marine sectors [20]. The increasing prices and environmental impacts of fossil fuels have made the production of biofuels to reach unprecedented volumes over the last years. Bioethanol- and biodiesel production raised from 39 billion litres to 85 billion litres and from 6 billion litres to 18 billion litres, respectively, between the period of 2006–2012 [3].

Growth in biofuels markets, investment, and new plant construction has slowed in several countries in response to a number of factors: policy uncertainty, increased competition for feedstock, impacts of drought conditions on crop productivity, concerns about competition with food production for land and water resources, and concerns about the sustainability of production more broadly. Currently, around 80% of the global production of liquid biofuels is in the form of ethanol. The two world's top ethanol producers, the U. S. and Brazil, account for around 85% of total production. Biodiesel production is far less concentrated than ethanol. The European Union remained the centre of global biodiesel production, with 7.9 million tonnes litres and representing 43% of total output in 2012 [3].

To drive development of biofuels that provide considerable emission savings and at the same time are socially and environmentally acceptable, support measures need to be based on the sustainable performance of biofuels. Recent years have also seen increased attention to biofuels sustainability and environmental standards. However, neither specific advanced biofuel quota, nor performance based support measures on their own seem to be effective to address the higher production costs of advanced biofuels in the short term [21].

As regards the utilisation of biomass for energetic purposes, optimisation from environmental and economic aspects is also important [22]. Environmental and social aspects, and sometimes economic advantages, are often particularly emphasised, but sustainability can only be provided with the complex evaluation of these factors. Of economic factors, the role of logistic approach is more preferred in the process of biofuel production [23], since it cannot be neglected that the energy and cost input of the production of energy resources greatly depend on logistic parameters (e.g., distances of feedstock transport, characteristics of vehicle fleet) and the poorly developed (non-optimised) logistic system may reduce or defeat all other advantages of biofuels.

A key requirement for all biofuels to get access to the market will be compliance with international fuel quality standards. This will ensure vehicle and infrastructure compatibility among different regions and promote consumer acceptance for new fuels. End-use infrastructure requirements also need to be addressed to avoid bottlenecks caused by incompatibility with deployed biofuels. Evolution of fuel specifications and new fuel grades are taken into account in the developing of future vehicles, such as compatibility of vehicles in the fleet with higher biofuels blends or new limits for existing specifications. Backward compatibility of fuel changes is a very difficult issue, because it is extremely difficult to cover all the vehicle generations and models combined with reliability risks for the customers and a risk for vehicle manufacturers in meeting legal commitments ($CO_2$ emissions). Furthermore, this issue is costly. Automotive manufacturers need sufficient protection for the existing fleet at any point in time and a sufficient lead-time and clear fuel specifications for the future. At least 5 years lead-time should enable the automotive industry to adapt to new fuel standards. Electric vehicular solutions seem to be viable for light vehicles and short distances [3].

### 1.2. Consumer environmental awareness vs. knowledge

The consumers of developed countries became increasingly environmental-conscious during the last two decades [24–27]. This phenomenon has become a serious factor in the consumer attitude seen on the market of both food and other products, resulting in the development of the so-called "green market" segment [28–30]. The examined biofuels constitute a special sub-field of the green market segment, as the level of their acceptance is determined by numerous factors: crude oil prices, the renewable energetic objectives of each country and the EU, politics (also including the political views of consumers [31], as well as the press coverage of policy, intellectual and emotional debates around them.

The evaluation of biofuels shows a lot of diversity among the players of this sector. Conservationists, environmentalists, professionals involved in food administration, as well as automotive manufacturers, express their negative opinions, while agricultural producers and biofuel producers usually emphasise positive impacts in accordance with the following typical standpoints [32,33].

Based on the highly controversial paper of Pimentel et al. [34], 75% of the food price increase is caused by bioethanol. Furthermore, ethanol production from maize results in 10–30% price increase of basic food products in the US. WWF supports biofuel aid packages to developing countries, second generation biofuels and the tightening regulations of car manufacturers' emission reduction. According to Hungarian Energy Club, first generation

biofuels cannot be considered a real alternative on their own; therefore, the EU's target values for 2020 have to be reconsidered, since they have significant environmental and social risks and there are more effective technologies available for the mitigation of climate change. Greenpeace demands that first generation fuels be totally phased out by 2020. Based on their estimations, supporting railroad traffic and using more efficient engines could further decrease $CO_2$ emissions by 15% by 2020. According to ACEA the car industry needs enough time for the necessary modifications [35].

COPA-COGECA supports the import quotas on ethanol and the energy crop subsidisation in order to provide the safety of crop production in the EU. Based on an USDA survey (2009), 55% of US farmers would offer part of their maize yield as feedstock for the ethanol industry. One main reason for doing so is that the price of DDGS in the US used within the country in 2008 was 10% lower than the maize price and its use in foraging reduced forage costs by 4–7% [36]. The European Renewable Ethanol [37] and the European Biodiesel Board [38] support the introduction of minimum values in blending, the standardisation of B-10 and that the carbon dioxide emission spared by using biodiesels be part of the official calculations of the EU. According to the Hungarian Bioethanol Association, the Hungarian biofuel industry cannot be accused of depriving people of food. On the contrary, biofuel production could finally become a stable outlet for the Hungarian agriculture which has been struggling with overproduction for decades. Furthermore, a large number of additional jobs could be created, mainly in rural Hungary, with all associated sectors [39].

The approach of the EU has significantly changed: as opposed to its unconditional support, as seen in earlier times, currently, there are strict sustainability and energy efficiency expectations and these are expected to narrow the market of first generation biofuels through quantitative restrictions in the future [40–42]. The focus of the sustainability criteria in the EU Directive is on biofuels for transport, particularly liquid biofuels, such as ethanol or biodiesel, and gaseous fuels, such as biomethane. Furthermore, the criteria also apply to bio liquids, generally used in other applications such as for heating, cooling and electricity. The EU has introduced regulations under the RED that lay down sustainability criteria that biofuels must meet before being eligible to contribute to the binding national targets that each Member State must attain by 2020 [40]. The EU is the global frontrunner on sustainability, other continents may follow. In December 2008, the EU adopted a new policy on biofuels as part of a new RED [42], an ingredient of the EU Climate and Energy Package. This Directive details on the EU objective of a 20% overall share of energy from renewable sources by 2020 and includes 10% energy from renewable sources in transport. Bioenergy is an important option for meeting these goals, and specifically biofuels for transport. The debate on the sustainability of biofuels set off relatively late during the process of political decision-making. This discussion also influenced the negotiations on the renewed Fuel Quality Directive [41], which includes a 10% reduction target for GHG emissions for 2020 for transport fuels. Under time pressure and in close cooperation between the European institutions, it was decided to include a set of sustainability criteria for biofuels, both in the RED and in the Fuel Quality Directive. However, this set of criteria does not cover all issues and there is no guarantee of sustainability. Moreover, the ILUC emission factor was criticised for lacking a proper scientific foundation and it was decided to keep the effects of ILUC out of the sustainability criteria included in the Directives. In order to count towards the RED target, biofuels must provide 35% GHG emissions saving compared to fossil fuels. This threshold will rise to 50% as of 2017, and to 60% as of 2018 for new plants. However, there is a loophole, as only DLUC emission is accounted and ILUC emission is not calculated.

### *1.3. Examination of consumers' attitude and knowledge concerning biofuels*

According to various surveys, it is a serious problem that consumers are rather under-informed and unaware of the field of renewable energetics and biofuels [43,44]. However, it has to be noted that consumers do not rely solely on their knowledge when they form opinions about political or scientific events. However, US consumers basically show a positive attitude to biofuels [44,45].

Delshad et al. [46] examined the opinions of biofuels in the state of Indiana (USA) by involving 119 people in 34 focus groups. The overwhelming majority of respondents were aware of the concept of biofuels, mainly bioethanol and E-85, but only around half of them used them and less than 40% knew about the regulatory background and technology of biofuels. After the focus group discussions, respondents supported biofuels to a significantly higher extent than before the discussions. The advantage of this study was that it examined the social support of measures aiming at first generation biofuels, the cellulose-based next generation technologies and the use of biofuels (due to their economic and environmental advantages and the related ethical obligations). The disadvantage is that the survey mainly focuses on attitude examination and the assessment of knowledge is superficial—but it showed the opinion-changing role of conveying knowledge.

Zhang et al. [47] interviewed 192 car users and 182 truck users in Nanying, China. They found that nearly 80% of car users think that the use of biofuels increases energy safety, while reducing energy crisis and GHG emission. However, it is remarkable that the majority could not answer the questions related to the impact of biofuel production on land and water use, as well as food prices and they did not know about production costs either. Furthermore, the survey also focused on what parameters customers consider to be important when buying a new car and which factors make them choose biofuels. It is a serious shortcoming of the survey that it is limited to only one city, while the regulation and support of biofuels usually takes place at the national and provincial levels. While most international literature does not strive to be representative in the case of attitude examinations concerning biofuels, narrowing down the sample to this extent greatly restricts the practical usability of findings.

The results of another Chinese comprehensive survey has been conducted for 226 private diesel vehicle owners in Beijing indicate that the most important factor affecting consumers' selection of biodiesel is price. Since the transportation expense occupies a large part in household expenditure in China, therefore, appropriate policies are necessary to regulate price to promote the biodiesel market [48].

Savvanidou et al. [49] interviewed 571 consumers about biofuels in Northern Greece. Yes or no questions were used (agrees–does not agree) and the support of the following statements was examined: the use of fossil fuels is related to climate change; climate change is an important problem; the reduction of forested areas is a result of biofuels gaining ground; the production of biofuels increases employment in agriculture. More than 90% of respondents thought that one of the causes of climate change is the use of fossil fuels, but only 23.8% of them knew what the difference is between biodiesel and bioethanol and less than 54% of them agreed that biofuels are an efficient solution for energetic problems. More than four fifths of car users were ready to fuel biofuels, but only 45% of them would have been willing to pay an extra charge of 0.06 € for them in practice. Based on the respondents' answers, the correlations between answers were analysed with logit/probit regression models and with the involvement of several socio-economic variables. The advantages of the questionnaire were the used sample size (one of the largest in the related technical literature) and its easy evaluability (yes or no questions), which was also its disadvantage, since there was no possibility to objectively verify the answers (the questionnaire did not contain any questions

which measure real knowledge). For this reason, the questionnaire only aimed at the self-evaluation of consumers.

Van de Velde et al. [50] distributed 1200 questionnaires at five fuel stations in Belgium with stamped reply envelopes, of which 363 were sent back with evaluable answers. More than 80% of respondents knew biodiesel (such as B-7) blended with conventional diesel fuel, 55% knew pure biodiesel, ethanol blended with gas (E-85) was known to 51.5% of respondents, while slightly more than 40% of them knew pure bioethanol. Only a negligible proportion of respondents (0.7–2%) had practical knowledge in this field. This is a low proportion, especially if one considers the biofuel policies of the neighbouring countries (e.g., Germany). The based on the answers given to the questions about the importance of the characteristics of biofuels (e.g., price, availability, safety, performance, smell), consumers were classified into four clusters: performance-focused, social oriented, environment-focused and convenience-focused. It was shown that each cluster significantly differed from the other in terms of age composition, educational level, average distance driven and attitude towards biofuels. However, no significant difference was shown in terms of income status, gender and the awareness of biofuels. The research had a relatively high cost and only a modest willingness to answer (around 30%) was shown. Respondents' average attitude to biofuels was not examined; therefore, it can be assumed that only those more committed to biofuels replied. This means that the sample is distorted, even if not intentionally.

Cacciatore et al. [31] evaluated a telephone questionnaire research study involving 556 adults in Wisconsin, USA. One half of the respondents were asked about biofuels and the other half about ethanol, in order to examine the impact of the name of the given type of biofuel on opinion forming. It was concluded that those considering themselves to be Democrats have a much more positive attitude to the question if they were told the word 'bioethanol' instead of 'ethanol'. On the contrary, Republicans were not influenced by the name at all. According to the survey, socio-demographic variables were not in correlation with the attitudes towards biofuels, but ideological affiliation did. The survey did not focus on knowledge about biofuels, although it would be interesting to compare these findings to real knowledge, to see whether they affect the impact of relevant knowledge on attitude.

Several surveys were performed about the evaluation of biofuels in Hungary, too. According to the survey done by Simkó [51], mostly among Budapest citizens with higher education degrees, respondents mostly consider fuel cost and quality aspects whenever they fuel their vehicles. The environmental friendly character was ranked the last and was mentioned by those who do not have a car. 85% of them have already heard about bioethanol and 65% about biodiesel, which is less than the awareness ratio of wind, solar and water power ( $>90\%$), but is more than the awareness of other forms of bioenergy. The statistically significant survey performed by Tóth [52], mostly among consumers with primary school educations, shows much lower awareness (30% and 40%, respectively) and especially low acceptance (15%). In 2008, 2400 l biodiesel was used by the public transport in the city of Debrecen, in blended in various mixtures into diesel (10%, 20%, 50%) and fuelled into 2 IKARUS-260 and 2 IKARUS-280 buses. The drivers of these buses did not observe any noticeable change in the operation of the bus engines, but the increased consumption was obvious [32] as opposed to the examinations of Farkas [53], who showed notable difference in all important operation technological parameters.

## 2. Methods

The applied methods are described in two subsections. First, the sampling and questionnaire methodologies are presented, followed by the procedures used in evaluating results.

### 2.1. Sampling and questionnaire methods

The aim of the examination was to survey the knowledge and opinions of car users who constantly improve their knowledge by following the press dealing with cars; therefore, they probably know more about biofuels and are able to form a more firmly grounded opinion and are more open to innovation. Therefore this research did not set the goal of performing a nationally representative survey. Furthermore, the international body of literature on consumer attitudes and knowledge on biofuels emphasises representativeness either [48]. With the consideration of these aspects, the subjects of the survey were the professional sites/journals dealing with cars. Eventually, the readers of the Hungarian Internet portal "Totalcar" were selected as the target group of our research, since this is the largest online magazine dealing with cars in Hungary (around 100,000 clicks per day) and it investigated the Hungarian situation of biofuels several times from the viewpoint of drivers (car modification, FFV tests, transport economy issues of E-85 fuel). The readers of the portal were contacted with an online questionnaire. Web surveys are used for collecting answers on various topics such as health, social and economic behaviours, as well as voting intentions and consumer preferences [54].

The journalists of the site were very helpful and supportive in carrying out the survey [55] and the questionnaire part of the research was done in February 2012. In order to increase readers' willingness to reply, a small model tractor prize was drawn. The post which led to the questionnaire was clicked on 6240 times and 404 readers filled out the questionnaire properly. Number of respondents conforms with the sample sizes of the official Hungarian public-opinion polling companies. Two methods were used to make sure that there is no redundancy in the sample: in order to participate in the prize game, respondents had to use their user name and password and the questionnaire could be filled out only once on a given computer.

Web surveys are widely used for collecting answers on preferences and are described by low level of sample control and control of data collection environment, as well as response rate; while high flexibility of data collection, high speed and low costs are observable [56]. Web surveys are suffering less from the "warm-glow effect" and are less influenced by the interviewer. Contrary, disadvantages of web surveying are the lower response rate and representativeness [57].

Altogether, the questionnaire contained 28 questions and 3 main sections. The first part focused on respondents' knowledge about biofuels, the source of this knowledge and respondents' practical experience, if any. The second part dealt with opinions and attitudes regarding biofuels and the third section served the purpose of identifying respondents (by gathering socio-demographic data). The questions focusing on biofuel-related knowledge had to be answered only by respondents whose knowledge about biofuels was rated at least average on a scale from 1 to 5, but the attitude analysis involved all respondents.

### 2.2. Procedures used in evaluation

After the descriptive statistics, the self-evaluation of respondents was verified. Towards this end, the results of respondents who rated their knowledge to be at least 3 which made them eligible to take part in surveying their knowledge were compared to the knowledge index formed from the weighted average of their answers reduced to binary variables (1—right, 0—wrong). Real knowledge was measures with questions referring to extra fuel consumption, feedstock, substitutability and the main producer. The knowledge index was determined strictly on the basis of professional aspects, considering the press coverage the given question or subquestion had and how relevant it is for Hungarian consumers. Each question

**Table 1**
Socio-demographic distribution of respondents.

| Variable | Category | No. of people | Distribution (percentage) |
|---|---|---|---|
| Gender | Male | 392 | 97.0 |
| | Female | 12 | 3.0 |
| | *Total* | *404* | *100.0* |
| Highest educational degree | Elementary | 7 | 1.8 |
| | Vocational school | 87 | 21.5 |
| | High school | 64 | 15.8 |
| | Higher vocational education | 43 | 10.6 |
| | College/university | 195 | 48.3 |
| | Scientific degree | 8 | 2.0 |
| | *Total* | *404* | *100.0* |
| Age | 0–18 years | 4 | 1.0 |
| | 19–25 years | 100 | 24.8 |
| | 26–40 years | 246 | 60.9 |
| | 40–60 years | 53 | 13.1 |
| | 61– years | 1 | 0.2 |
| | *Total* | *404* | *100.0* |
| Distance driven per year | Does not drive/did not reply | 9 | 2.2 |
| | < 10,000 km/year | 87 | 21.5 |
| | 10,000–20,000 km/year | 182 | 45.1 |
| | > 20,000 km/year | 126 | 31.2 |
| | *Total* | *404* | *100.0* |
| Do you have a car of your own? | Yes | 328 | 81.2 |
| | No | 75 | 18.8 |
| | *Total* | *404* | *100.0* |
| Citizenship | Hungarian | 395 | 97.8 |
| | Other | 9 | 2.2 |
| | *Total* | *404* | *100.0* |

*Source*: Own results.

was weighed 6, 4, 2 or 1. (Originally, questions were planned to be weighed between 1 and 3, but the press coverage of certain questions was so low that could only be considered with a weight factor not higher than 0.5. Therefore, instead of using fractions, the original weights were multiplied by 2.) Questions of practical significance (extra consumption, what is substituted by biodiesel) were assigned the highest weights, while the information often covered by the media (e.g., ethanol from maize, biodiesel from rape) had medium weights and the information irrelevant in the wide range of society (bioethanol and biodiesel production in the world, main producer countries) were assigned the lowest values. As a next step, a weighted average was formed from the answers and the knowledge index was determined which showed the real knowledge on a scale from 1 to 5.

404 people were involved in the initial database. Respondents who do not drive a car at all, those who did not reply to the question about the distance driven per year and non-Hungarian citizens were excluded from the rest of the survey (18 people altogether). Therefore, 386 people were involved in the final sample, which contained seven questions focusing on the opinions of respondents about biofuels. Respondents specified their opinions using five-point Likert scales.

Crosstable analyses were used to examine the correlation between practical experience with and knowledge about biofuels. Respondents who had practical experience with bioethanol and biodiesel were involved in the analysis, since the number of respondents who gained practical experience with the other examined biofuels was very low.

The chi-square test was employed to investigate the differences in perceptions and attitudes among the sample population [58,59]. The chi-square test is used to investigate statistical association between variables [60]. This is done primarily by testing the null hypothesis of no association between a set of groups and outcomes for a response. Pearson's chi-square tests were conducted using SPSS 17.0 to identify the differences. For large values of $\chi^2$, this test rejects the null hypothesis in favour of the alternative hypothesis of general association. We use the standard 5% or 0.05 cut-off for defining what is a statistically significant difference. Therefore, an associated $p$-value $< 0.05$, means that there is significant evidence of an association between variables [59,61–63]. Cronbach's alpha coefficient was used for the verification of construct reliability of the questionnaire [64]. The Cronbach alpha indicator is the most frequently used test in assessing reliability (reliability in quantitative research can be translated into legitimate corresponding operations for qualitative research) [48]. The overall reliability of the 28 items that measured drivers' perceptions and attitudes related to biofuels showed adequate level of internal consistency (Cronbach's $\alpha = 0.709$).

Kruskal–Wallis $H$ and Mann–Whitney $U$ were used to test the differences of knowledge about and interest in biofuels and of differences between the most important characteristics of the analysed clusters because we could not transfer data into normally distributed data like in the paper published in the RSER by Cai and Jiang [65]. At this point, it should be acknowledged that the Likert scale data and survey based perceptions studies are criticised by some researchers [66]. Transforming Likert-scale responses into interval-scale variables and computing averages and products is statistically not correct [67]. However, based on the literature review, it was found that many renewable energy perception surveys applied this technique for their study in order to draw conclusions [68].

Before forming clusters, Spearman's rank correlation coefficients were used to examine the correlation between each question used for forming clusters. Based on the correlation matrix, it was established ($r = -0.220 - +0.483$) that there was no close correlation between the answers of questions focusing on opinions about biofuels. For this reason, all seven variables could be used to form the clusters. As a next step, in accordance with [69], the squared Euclidean distance was selected (at the $r = 2$ value of Minkowski metric) from among the different distances. Of the potential clustering methods, Ward's method – which belongs to the group of space conserving procedures – was used as the improvement of the target function is monotonous. In this method, mean value and squared sum of differences are calculated for the points within the cluster and the point or cluster which results in the lowest increment of squared sum of differences will be involved in forming a larger cluster [70].

As a next step, the stability and validity of the resulting clusters were examined: various similarity values and merging algorithms were used, different cluster numbers were analysed, one of the variables involved in the analysis was always left behind from step to step and results were compared to each other [71]. Based on professional considerations, the three-cluster solution was chosen from among the clusters formed with Ward's method. Significant differences between clusters were sought in consideration of socio-demographic aspects, knowledge index, the evaluation of respondents' own knowledge, the extent of interest in biofuels, as well as the importance of the Internet, as a source of knowledge. Since we could not transfer the five-point Likert-scale data into normally distributed data, a non-parametric statistical method (Kruskal–Wallis test) was used to analyse the data [72–74].

## 3. Results and discussions

Table 1 shows respondents' socio-demographic characteristics. The overwhelming majority (97.8%) of respondents are Hungarian citizens and men (97%). Respondents of foreign citizenship were mostly people of Hungarian ethnicity living outside the border. The

reason for the dominance of men in the sample is explained by the main topic of the website, since the sample was drawn from a car-themed site which specifically targets male readers. Nevertheless, it can be taken for granted that the extreme gender proportion does not affect the value of this survey negatively, since the maintenance, development and servicing of cars is traditionally a "male task"; therefore, women typically rely on men's opinions in these issues. The majority of respondents belong to the active age of the population, more specifically the younger age class (19–40 years of age). This was expected based on the data disclosed on the website of Eurostat [75], which show that this age class use the Internet to a significantly higher extent than older people. Around half (50.2%) of respondents had at least college degrees. 2.2% of respondents do not drive a car at all or did not give any answer the question about their driving habits. For this reason, as written above, these people were excluded from the rest of the survey.

Respondents' self-evaluation concerning biofuels can be characterised by the following values: 161 outstanding (41.8%), 138 better than average (35.8%), 62 average (16%), 20 below average (5.2%), 5 no knowledge (1.2%). Altogether, 220 people rated their knowledge to be at least average; therefore, this sample was taken as a basis when determining the knowledge index.

It is interesting to note that more than half of those respondents who rated their knowledge at least 3 have already used some kind of biofuels—most (54.2%) tried E85. 19.1% have experience with biodiesel, while crude, or refined rape oil was used by

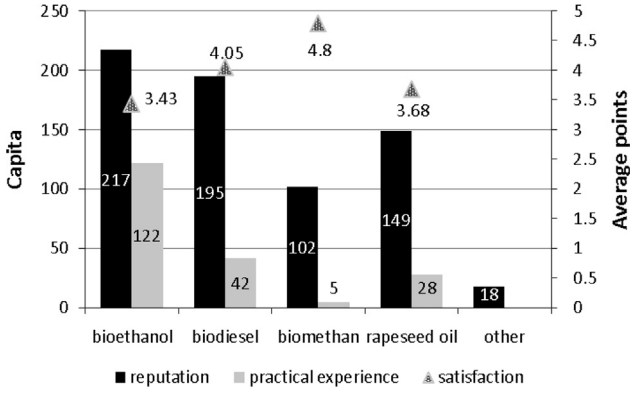


**Fig. 1.** Awareness of each biofuel among respondents. Reputation and practical experience are shown in capitas (left *y*-axis), satisfaction of biofuel-consumers is indicated in a number between 1 and 5 (right *y*-axis).

13.3%. Biomethane was tried by the lowest amount (2.2%) or respondents which may be partially due to the underdeveloped character of the Hungarian fuel station network (which also refers to biodiesel and rape oil) and the significant mechanical modifications necessary for biomethane (bio-CNG) use. The awareness of various biofuels can also be considered rather high, especially in comparison with the findings of Delshad et al. [46] and Van de Velde et al. [50]: the awareness of bioethanol was 98.2% and that of biodiesel was 88.5%, while biomethane (bioCNG) (53.1%) and rape oil (31.9%) had lower awareness (Fig. 1).

The reason for the relatively high awareness rate in comparison with those published in international technical literature is that this question was only posed to respondents who rated their knowledge at least 3. If it is assumed that those who rated their knowledge 2 or 1 do not know biofuels at all, then the awareness of biofuels would be the following in terms of the total population of 386: bioethanol: 56.2%, biodiesel: 50.6%, biomethane (bio-CNG): 26.8%, rape oil: 39%. The obtained values would be closer to the results of the above written source, but they would not be realistic, as it is not granted at all that those rating their knowledge about biofuels low have never even heard about them. For this reason, the most realistic values are somewhere in between.

Crosstable analyses were performed to determine whether respondents who have practical experience about each biofuel type are more informed in terms of the questions focusing on the given biofuel than other respondents. Those who have experience with E-85 (bioethanol) were aware of the specific extra consumption typical of this biofuel significantly more and there were several more respondents who knew about maize as feedstock for ethanol production than those who have no experience (Tables 2–3). Knowing about maize as feedstock and the clear distinction between uses for ethanol and biogas purposes (they were aware that silo maize is a biogas feedstock) can be explained by the fact that the Hungarian ethanol industry is built on maize; therefore, maize production was inevitably mentioned if there was any press release about ethanol. However, it is important to note that the examination of the question about which traditional fuel can be substituted by ethanol did not show any significant difference between the groups of those who have practical experience and those who do not, since they knew the right answer independently of whether they had experience or not.

A Mann–Whitney *U* test was performed to examine whether there is any correlation between the experience gained with bioethanol and biodiesel and respondents' knowledge index and

**Table 2**
Descriptive statistics of awareness of and interest in biofuels.

| Awareness of bioethanol | Statistical indexes | Bioethanol | | | Biodiesel | | |
|---|---|---|---|---|---|---|---|
| | | Knowledge index (1–5)[a] | Interest in biofuels (1–5)[b] | How much would you like to work in the biofuel sector? (1–5)[c] | Knowledge index (1–5)[a] | Interest in biofuels (1–5)[b] | How much would you like to work in the biofuel sector? (1–5)[c] |
| Yes | Mean | 2.48 | 3.53 | 3.24 | 2.52 | 3.63 | 3.37 |
| | Number | 98 | 98 | 98 | 178 | 178 | 178 |
| | Std. deviation | 0.91 | 0.90 | 0.91 | 0.93 | 0.86 | 0.93 |
| No | Mean | 2.71 | 3.84 | 3.54 | 2.98 | 3.98 | 3.57 |
| | Number | 122 | 122 | 122 | 42 | 42 | 42 |
| | Std. deviation | 0.98 | 0.75 | 0.96 | 0.98 | 0.68 | 1.04 |
| Total | Mean | 2.61 | 3.70 | 3.41 | 2.61 | 3.70 | 3.41 |
| | Number | 220 | 220 | 220 | 220 | 220 | 220 |
| | Std. deviation | 0.95 | 0.83 | 0.95 | 0.95 | 0.83 | 0.95 |

*Source*: Own results.

[a] 1: Worse value; 5: best value.
[b] 1: Not interested at all; 5: very interested.
[c] 1: Not at all; 5: I would be very happy to.

the attitude to biofuels (Table 4). As it was expected, those who have practical experience are more open to biofuels, i.e., they are more interested in this topic and would be more willing to work in this sector than respondents who have no practical experience. Also, their knowledge index is significantly higher. There is also a methodological reason for the significant difference in knowledge indexes, namely that pieces of information which are more important from the practical aspect and those which had more media coverage were taken into consideration with more weight. As regards biodiesel, the Mann–Whitney *U* test had similar results as in the case of bioethanol, but not significant difference was shown in terms of willingness to get employed in the biofuel sector (Table 4).

Significantly less respondents had practical experience with biodiesel, but the results of the crosstable analysis suggest that these respondents know biofuels more than those who had practical experience with ethanol, since the crosstable analysis showed significant difference in several questions (Table 5). One of the reasons for this phenomenon can be that pure biodiesel is not available at Hungarian fuel stations; therefore, those who would like to use it in their vehicles have to get hold of it abroad. Consequently, these drivers probably investigate biofuels more thoroughly before switching from conventional fuels. The difference between the two groups is obvious in the case of rape oil and jatropha, while sunflower shows various results. Since Western Europe mostly uses rape as biodiesel feedstock, it was expected that those who have already used biodiesel would know it. The reason for the awareness of jatropha can mainly be explained by following the news about biodiesel, since there are great debates about the use of this crop which were covered also by the Hungarian media. Even though Hungary has outstanding endowments for sunflower production, the biodiesel standard of the EU was developed for rape; therefore, sunflower can be used only to a 30–35% proportion. This may be the reason why sunflower as feedstock is mostly known to those who became more immersed in this topic due to their practical experience. Similarly to ethanol, there was no difference in terms of knowing conventional fuels in the case of biodiesel between the two groups—obviously, the name 'biodiesel' is already a hint. However, significant difference was shown in knowing the largest biodiesel producing country and region. The possible reason for this is that the EU has been maintaining it stable leading position in production since the beginning. Unfortunately, very few respondents knew the difference between crude or refined rape oil and biodiesel, but the group which had practical experience performed significantly better in this question, too (Table 5).

The difference between the knowledge index developed with the above written method and the self-evaluation values is shown in Fig. 2. Although the majority of respondents overrated their knowledge (negative values), the extent of this overrating was only 1 in comparison with their real knowledge in most cases. 77.3% of respondents rated their knowledge within the $\pm 1$ range. Spearmann's rank correlation of self-evaluation and the knowledge index was 0.307 ($p < 0.001$), i.e., only weak statistical significance can be shown. However, considering the fact that the questions focusing on real knowledge were much more detailed than those in international technical literature and that knowledge had to be rated before reading the questions, it is safe to assume that the self-evaluation of the survey can be considered realistic.

The source of knowledge was also examined by asking respondents to rate the importance of various media on a five-point scale. Unsurprisingly, the Internet was rated the highest, followed by professional journals, specifically car-themed and economic periodicals which have already dealt with the topic of biofuels. The low rank of education can probably be explained by the fact that the majority of respondents already finished school and also that the education of renewable energetics-related subjects in Hungary first started only a few years ago only in a limited number of scientific fields (agriculture, mechanics, energetics, Fig. 3).

Driver attitude to biofuels was examined through seven statements which were previously covered by the press. Respondents had to rate each statement from 1 to 5 in terms of how much they agree with them. Three statements with positive indication and four of negative indication were formulated. The statements and the average scores of answers are shown in Table 6.

**Table 3**
Crosstable analysis of awareness of and interest in biofuels.

| Description | Practical experience with bioethanol | | $\chi^2$ | $p$ |
|---|---|---|---|---|
| | No | Yes | | |
| *Extra consumption in the case of E85* | | | 4.714 | 0.030 |
| Unaware | 27 | 19 | | |
| Aware | 71 | 103 | | |
| *Which biofuel's feedstock is grain* maize? | | | 13.936 | 0.001 |
| Unaware | 44 | 26 | | |
| Aware | 54 | 96 | | |
| *Which biofuel's feedstock is silo maize?* | | | 4.89 | 0.030 |
| Unaware | 89 | 98 | | |
| Aware | 9 | 24 | | |
| *Which biofuel's feedstock is cassava?* | | | 2.899 | 0.089 |
| Unaware | 87 | 98 | | |
| Aware | 11 | 24 | | |
| *Usability of bioethanol to run engines* | | | 1.615 | 0.204 |
| Unaware | 8 | 5 | | |
| Aware | 90 | 117 | | |

*Source*: Own results.

**Table 4**
Examination of the difference between knowledge about and interest in biofuels.

| Description | | Bioethanol Knowledge index (1–5)[a] | Interest in biofuels (1–5)[b] | How much would you like to work in the biofuel sector? (1–5)[c] | Biodiesel Knowledge index (1–5)[a] | Interest in biofuels (1–5)[b] |
|---|---|---|---|---|---|---|
| Unaware | Rank average | 101.12 | 96.96 | 100.32 | 105.82 | 104.68 |
| | Number | 98 | 98 | 98 | 178 | 178 |
| Aware | Rank average | 118.03 | 121.37 | 118.68 | 130.33 | 135.17 |
| | Number | 122 | 122 | 122 | 42 | 42 |
| Mann–Whitney *U* | | 5059 | 4652 | 4980 | 2905 | 2702 |
| *p* | | 0.039 | 0.002 | 0.025 | 0.016 | 0.003 |

*Source*: Own results.

[a] 1: Worse value; 5: best value.
[b] 1: Not interested at all; 5: very interested.
[c] 1: Not at all; 5: I would be very happy to.

**Table 5**
Crosstable analysis of awareness of and interest in biodiesel.

| Description | Practical experience with biodiesel | | $\chi^2$ | $p$ |
|---|---|---|---|---|
| | No | Yes | | |
| Extra consumption with biodiesel | | | | |
| Unaware | 108 | 8 | 23.623 | 0.001 |
| Aware | 70 | 34 | | |
| Which biofuel's feedstock is rape? | | | | |
| Unaware | 65 | 6 | 7.684 | 0.006 |
| Aware | 113 | 36 | | |
| Which biofuel's feedstock is sunflower? | | | | |
| Unaware | 50 | 6 | 3.413 | 0.065 |
| Aware | 128 | 36 | | |
| Which biofuel's feedstock is jatropha? | | | | |
| Unaware | 175 | 38 | 6.778 | 0.009 |
| Aware | 3 | 4 | | |
| Usability of biodiesel to operate engines | | | | |
| Unaware | 15 | 1 | 1.842 | 0.175 |
| Aware | 163 | 41 | | |
| The largest biodiesel producing country in the world | | | 7.533 | 0.006 |
| Unaware | 165 | 33 | | |
| Aware | 13 | 9 | | |
| Difference between biodiesel and rape oil | | | 18.419 | 0.001 |
| Unaware | 156 | 25 | | |
| Aware | 22 | 17 | | |

*Source*: Own results.

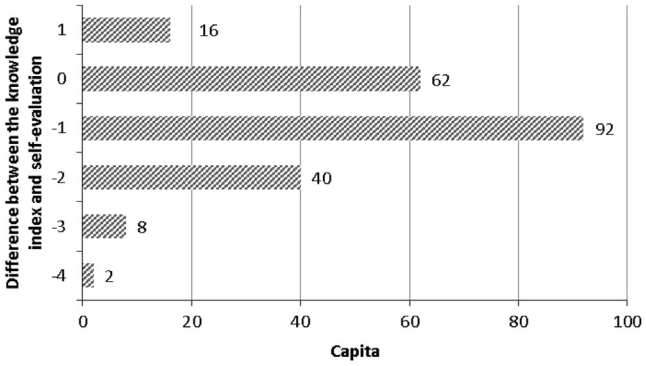


**Fig. 2.** Difference between the knowledge index and self-evaluation.

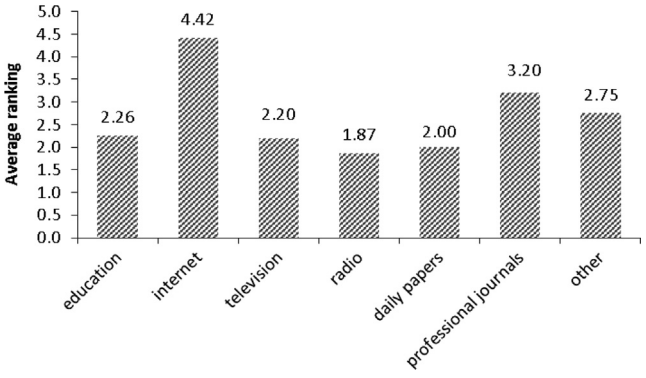


**Fig. 3.** Evaluation of the importance of various sources of knowledge.

In general, it can be stated that respondents have a relatively positive approach to biofuels, which means that they tend to support the statements about biofuels with positive indication and they tend to refuse those with a negative indication (except for the 6th statement), but there are 3 well deliniable groups behind the uniform average opinion which was shown. For this reason, based on the results of the attitude analysis, respondents were classified into three clusters. No significant difference was shown between the clusters from the socio-demographic aspect with the Kruskal–Wallis test, similarly to the findings of Cacciatore et al. [31]. There were no significant differences in terms of self-evaluation and knowledge index either, while significant difference was shown in the interest in biofuels (Interest), the extra purchase price of cars running on biofuels (Willingness to pay) and in the evaluation of getting employed in the biofuel sector (Career, Table 7).

The 1st cluster is the group of supporters who have clearly positive attitude to biofuels. This is the largest group (206 people), representing 53.4% of the whole sample. They agreed with the positive statements about biofuels the most and they refused the negative statements the most, too. This cluster had the highest values from the aspect of interest, willingness to pay and career.

The 2nd cluster could be named the group of irresolute people. Even if there is no significant difference, their educational degree is the highest, while their interest, willingness to pay and to get employed in the sector can be considered average. They do not really support biofuels, but they do not even refuse them sharply either. Typically, the average value of their opinions is between 2.2 and 3.7.

The 3rd cluster is the group of sceptics. Based on their answers to the questions of the attitude analysis, they show increased environmental and social sensitivity. They almost extremely refuse biofuels and they support the critical statements the most. Their interest and willingness to pay and to get employed in the biofuel sector are the lowest.

## 4. Conclusions and policy implications

Compared with other countries' surveys the results suggest that there are many similarities and differences of Hungarian car drivers' perception to biofuels. The survey results give rise to some consideration about the experiences and attitudes towards biofuels among different cluster groups.

The target group of examination was represented by drivers who always keep their knowledge up-to-date. The main source of their knowledge about biofuels is the Internet, followed by car-themed and economic journals, as these deal with biofuels in a form that is the most intelligible to the general public. Basically, it is favourable that many of the respondents obtain information

**Table 6**
Statements and results of the attitude analysis.

| No. and indication of statement | Statement | 1st Cluster | 2nd Cluster | 3rd Cluster | Average |
|---|---|---|---|---|---|
| 1. (+) | The biofuel sector can be positively evaluated, since it creates jobs and contributes to the maintenance of pre-existing jobs | 3.67 | 3.46 | 3.25 | 3.52 |
| 2. (+) | The biofuel sector contributes to the stabilisation of agricultural markets and is an efficient tool of managing overproduction | 3.61 | 3.46 | 2.56 | 3.40 |
| 3. (−) | Biofuels are allowed to be produced only if they are competitive with conventional energy resources, no other aspect matters | 2.13 | 2.21 | 3.08 | 2.31 |
| 4. (+) | The use of biofuels is environmental friendly, as it contributes to the reduction of greenhouse gas emission | 3.80 | 3.24 | 2.69 | 3.45 |
| 5. (−) | The feedstock needed by the biofuel industry can only be produced with intensive agricultural production which significantly damages biodiversity; therefore, biofuel production is a threat to the environment. | 2.07 | 2.87 | 4.30 | 2.66 |
| 6. (−) | Agricultural production for biofuel purposes is in competition with food production for production areas; therefore, biofuel production causes food prices to increase. | 2.19 | 3.74 | 4.43 | 3.02 |
| 7. (−) | Feedstock production for biofuel purposes leads to or increases social injustice (e.g., starvation in Africa) | 1.69 | 3.16 | 1.26 | 2.55 |

*Source*: Own result.

**Table 7**
Differences between each cluster.

| Clusters | | Highest educational degree | Age | Distance driven per year | Interest | Willingness to pay | Career |
|---|---|---|---|---|---|---|---|
| 1. | Mean rank | 182.90 | 195.23 | 197.43 | 217.44 | 209.18 | 212.55 |
| | *N* | 206 | 206 | 206 | 206 | 206 | 206 |
| 2. | Mean rank | 209.08 | 191.88 | 199.13 | 187.18 | 183.85 | 183.20 |
| | *N* | 119 | 119 | 119 | 119 | 119 | 119 |
| 3. | Mean rank | 198.91 | 190.81 | 195.02 | 174.12 | 199.05 | 149.47 |
| | N | 61 | 61 | 61 | 61 | 61 | 61 |
| | $\chi^2$ | 4.497 | 0.146 | 1.501 | 8.933 | 15.546 | 19.037 |
| | *p* | 0.084 | 0.930 | 0.472 | 0.011 | 0.000 | 0.000 |

*N*: number of respondents.
*Source*: Own results.

from the Internet, since they can have access to fresh information most quickly this way, but the often unverified source and doubtful reliability of these pieces of information is a disadvantage as well, which is shown when evaluating real knowledge.

78% of respondents who rated their own knowledge appropriate turned out to be realistic when doing so. This survey focused on significantly deeper knowledge than the related international surveys referred to in the literature review. For this reason, it can be assumed that the obtained results are more reliable than those of the currently available international surveys on knowledge of biofuels.

In general, respondents have positive opinions about biofuels and they are interested in the topic, but there are three clusters behind the average. These three clusters can be clearly distinguished from each other in terms of their ways of thinking and they probably represent the opinions of the drivers about biofuels well. However, the refining of this model calls for the incorporation of currently unsurveyed other variables (e.g., political affiliation, income, evaluation of the car engineering characteristics of biofuels) with the inclusion of international technical literature resources.

It should be emphasized that the energy policy to promote the use of biofuels – however well-established and reasonable it might be – can easily fail due to the resistance of the consumers. Our research has undoubtedly proven that the attitude of tested segment of Hungarian car drivers towards the biofuels is essentially positive, thus, resistance is very unlikely in the further implementation of biofuels policy in Hungary. Based on our results, governmental decision-making bodies can be recommended to show credible information about biofuels also on Internet sites if possible and also to develop a closer cooperation with the relevant professional organisations in order to make sure that information appearing on the Internet is credible.

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