Trends in Food Science & Technology 58 (2016) 14–20

Contents lists available at ScienceDirect

Trends in Food Science & Technology

journal homepage: http://www.journals.elsevier.com/trends-in-food-science-and-technology

Review

Ethanol and its Halal status in food industries

Jawad Alzeer [a, b, *], Khaled Abou Hadeed [a, b]

[a] Department of Chemistry, University of Zurich, Winterthurerstrasse 190, 8057 Zurich, Switzerland
[b] Halal Certification Services, Salinenstrasse 18, 4310 Rheinfelden, Switzerland

ARTICLE INFO

Article history:
Received 21 April 2016
Received in revised form
5 August 2016
Accepted 26 October 2016
Available online 5 November 2016

Keywords:
Ethanol
Vinegar
Halal
Haram
Fermentation
Food

ABSTRACT

Background: Ethanol is an important organic solvent and substrate which extensively used in research and industries. It is the main ingredient produced during fermentation of carbohydrates derived from fruits and other biomass substances. Halal status of ethanol is controversial and it is rational use is ambiguous.

Scope and Approach: In this review the issue of ethanol in food industries is addressed. Ethanol is a sensitive, controversial and main issue in the production of Halal (Permitted, Allowed) products. Setting the limit of ethanol in Halal food industries is needed to facilitate food production and complied with certain religious demands. This review gives an overview of ethanol, types, application, advantages and disadvantages. An attempt to set a limit of ethanol in food industries, supported by scientific facts and Islamic rules, is described.

Key Findings and Conclusion: Halal status of ethanol is highly controversial but rarely classified based on its source and concentration. Any ethanol produced by anaerobic fermentation and ranging between 1 and 15% is considered to be Haram (non-Halal, Forbidden), whereas ethanol produced by natural fermentation and less than 1% is considered as preserving agent and its Halal status is allowed. Any ethanolic solution higher than 15% is treated as a toxic solution but still could be used in industries, meanwhile ethanolic solution prepared by dilution from absolute or denatured ethanol is allowed for industrial used but toxic for human consumption. However, any concentration varied from 0.1 to 100% prepared with intention to be used as beverage drink is consider non-Halal.

1. Introduction

Since the beginning of recorded history, a complex relationship between human and ethanol was developed. This complex relation continues today, probably because of its being the essence of wine and the intoxicating ingredient in many beverages, and one of the most important chemicals available to industry. The solvent power of ethanol makes it particularly useful for extraction of valuable natural products from plant and animal tissues (Park, Kim, Kim, & Song, 2015). As an industrial raw material, ethanol is involved in the manufacture of adhesives, toiletries, detergents, explosives, inks, chemicals, hand creams, plastics, paints, thinners, textiles, vinegar and other (Equistar, 2003). Two types of ethanol are produced worldwide, namely fermented and synthetic ethanol. Fermented ethanol (bioethanol) is produced from corn or other biomass material (Erdei, Hancz, Galbe, & Zacchi, 2013; Gnansounou & Dauriat, 2005; Vijayalaxmi, AnuAppaiah, Jayalakshmi, Mulimani, & Sreeramulu, 2013), mainly used for fuel, though a small part is used by the beverage industry. Synthetic ethanol is produced from ethylene, a petroleum by-product (Chu, Echizen, Kamiya, & Okuhara, 2004), and is used mainly in industrial application (Yue, Ma, & Gong, 2014). As alcohol is extensively applied in food, pharmaceutical, cosmetic and other industrial applications, therefore Halal status of alcohol used in industries need to be subjected for discussion. Ethanol is a controversial and main issue in the production of Halal products (Khattak et al., 2011). Traditionally, consumers and Islamic jurist have identified ethanol as non-Halal (Haram, forbidden) substance, and hence Halal certified products are usually alcohol free. In this review, we will highlight the advantages and disadvantages of ethanol, meanwhile compare the alcohol content in fruits and deduce alcohol limit for Halal production. Quran was revealed that, alcohol contains some good and some evil, but the evil is greater than good: “They ask you about intoxicants and games of chance. Say: In both of them there is a

* Corresponding author. Department of Chemistry, University of Zurich, Winterthurerstrasse 190, 8057 Zurich, Switzerland.
E-mail address: jawad.alzeer@chem.uzh.ch (J. Alzeer).

http://dx.doi.org/10.1016/j.tifs.2016.10.018
0924-2244/

great sin and means of profit for men, and their sin is greater than their profit" (Chapter (2) Surat al-baqara). Although the above verse does not prohibit ethanol directly, but it expresses the harmful effect of intoxicant to human, and advice for abstaining from the usage of alcohol. "O you who have believed, indeed, intoxicants, gambling, [sacrificing on] stone alters [to other than Allah], and divining arrows are but defilement from the work of Satan, so avoid it that you may be successful" (Chapter (5) Surat al-maidah). In this review, we describe the various types of ethanol, why ethanol is a potential risk (Gulbinat, 2009), and correlate science with Shariah to explain why not all ethanol types can be treated as Khamr (alcoholic beverage, non-Halal) and propose a set of limits for ethanol use in food industries.

2. Ethanol production

Ethanol is the most common volatile compound produced since ancient times by the fermentation of sugars. All beverage ethanol and more than half of industrial ethanol is still made by the same process. Zymase is an enzyme from yeast, which is responsible for the changes of simple sugars into ethanol and carbon dioxide. The fermentation reaction, represented by the simple equation, Fig. 1:

During the process of fermentation, in the absence of oxygen, ethanol concentration is increased until it is reached about 15%, above this concentration, yeast is toxified and zymaze enzyme is inhibited and fermentation process stopped (Thamilvanan & Selvi, 2013).

Ethanol used for industrial purpose, not for drinking, is commercially prepared from one of the following starting materials: ethylene (Chu et al., 2004), ethane (Kawakami, Shoji, & Watanabe, 2013), ethylacetate (Fuentes et al., 2015), ethylperoxide (Arasasingham, Balch, Cornman, & Latos-Grazynski, 1989), ethylene oxide (Ushakov, 1937), ethylene glycol (Kaneda & Hirokazu, 2014), acetic acid (Xu, Chunli, Fengyi, Chunlei, & Yonggang, 2015), acetaldehyde (Morooka, Wakai, Matubayasi, & Nakahara, 2008), aceticanhydride (Walsh, Mertel, & Miwa, 1983), acetylene (Radloff, 2014), carbon mono oxide (Wang, Ang, Liu, Zhang, & Liu, 2016), carbon dioxide (He et al., 2016), dimethylether (Tan, Qingde, Yizhuo, Hongjuan, & Caihong, 2012), propylene glycol (Samson et al., 2015), cellulose (Gunasekar, Apoorva, Sailaja, & Ponnusami, 2014), glucose (Keera, Foukia, Kahil, Fadel, & Abedo, 2014). Synthetic ethanol is chemically and physically indistinguishable from ethanol produced by fermentation. Ethanol concentrations above 15% is normally obtained by distillation of aqueous solutions, but at 95.6% concentration, water and ethanol form a constant boiling mixture and distilled together even though they have different boiling points. A common method to produce ethanol with concentration higher than 95% is to use either dehydrating agents or additives that disrupt the azeotrope composition and allow further distillation. Absolute ethanol is hygroscopic (it attracts water), therefore 100% ethanol is expected to decrease overtime (Gil, Uyazan, Aguilar, Rodríguez, & Caicedo, 2008).

3. Energy source

The simple structure of ethanol molecule makes it appropriate alternative biofuel energy source to fossil fuel. The main raw materials used for bioethanol production are wheat straw in Europe, corn stover in the USA, and straw in China. Use of either sugar cane or corn to produce ethanol is problematic, because of their high production cost and the competition with food and feed production. To increase the productivity and cost effectiveness of ethanol production, many process and cheap raw materials have been investigated and developed (Dong, Zhao, & Zhang, 2012). Ethanol is an efficient energy source compared to fossil fuel. Fossil fuel required more energy for its production and has a finite resource, not renewable and will no longer be able to rely on as our source of supply whereas ethanol fuel, with high oxygen content (35% oxygen by weight), it allows the engine to achieve more combustion, resulting in fewer emissions. Ethanol fuel is more useful and renewable and could be reproduced chemically and biologically from different raw materials. Ethanol emits lower levels of greenhouse gasses, which in turn reduce global warming. However the atmospheric oxidation of ethanol produces acetaldehyde, which is a very dangerous substance at high levels of exposure (Andradea & Miguela, 1985).

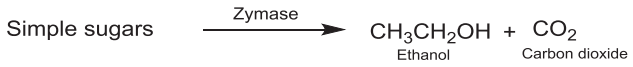

Fig. 1. Zymase convert carbohydrates into ethanol and carbon dioxide.

4. Ethanol types

There are several types of ethanol, but not all types of ethanol are suitable for all tasks:

A 95% (95.6%) ethanol: This is the highest concentration of ethanol one can obtain by distillation, 95.6% ethanol is an azeotrope, which means the vapour state has the same ethanol:water ratio as the liquid state. This alcohol could be obtained either synthetically in the lab from a variety of starting materials or by fermentation process of different biomasses. The quality of this alcohol is considered to be compatible with food industries and could be used in flavours, candy, personal care products and as a carrier for a wide spectrum of medicines such as cough, decongestants and iodine solutions.

Absolute (99–100%) ethanol: Certain experiments are sensitive to water, therefore absolute ethanol is required. A common method to produce ethanol with concentration higher than 95% is to use additives, such as toluene, heptane, cyclohexane, and 2-butanone that disrupt the azeotrope composition and allow further distillation. For this reason, absolute ethanol contains trace amounts of these additives. As ethanol is hygroscopic, water can be easily absorbed by ethanol therefore absolute ethanol need to be prepared freshly or kept over magnesium metal and distilled when it is needed.

Denatured ethanol: It is made to be unhealthy for human consumption by adding one or more chemicals. Denatured ethanol (either 95% or absolute) contains chemical, such as methanol and isopropanol, therefore it is not safe to drink. Usually it is cheaper than pure ethanol, as it is exempted from beverage taxes and frequently used as cleaning and disinfectant agents. Ethanol is an effective disinfectant at concentrations between 70 and 90%, aqueous ethanol is a more effective protein denaturant than absolute ethanol. Denatured ethanol is commonly used in perfume industries.

5. Relative risks of ethanol

Ethanol is completely soluble in water, when drank as beverage, the ethanol molecules are rapidly absorbed through the stomach by small intestines and bloodstream then supplied to tissues such as brain. Small amounts of alcohol act as a stimulant to many organs, but with increasing levels it begins to act as a depressant in the body and increase the risk of developing disease.

5.1. Alcoholism

Alcoholism is a disease affect many tissues and can be classified