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Scoping Review: Analysis of Alcohol Levels in Food and Beverages Using Gas Chromatography

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Abstract

Islamic teachings explain that food or beverage should not be consumed with more than 0.5% alcohol because it is categorized as *khamr*, which is unlawful. In determining the levels of foods or beverages that contain alcohol, one of which is the gas chromatography method with several aspects of the method validation used. So that it can be seen how halal food or beverage is. The purpose of this scoping review is to map the available evidence related to the optimum conditions of analysis of alcohol content in a food product by gas chromatography and obtain a method of analyzing alcohol content in food products with several parameters validation methods, including selectivity, linearity, the limit of detection, precision, and accuracy. This scoping review has followed the framework of Arksey and O'Malley, which consists of identifying the problem formulation from the literature review; seeking relevant evidence; completing studies of relevant scientific articles; mapping data; conclude and reporting results. PRISMA flowchart diagram is used for the flow of evidence search. The results of this review show that there are 6 research articles obtained from the database. This review shows that the analysis of alcohol content using the gas chromatography method has high sensitivity, accuracy, validity, and recovery. It is hoped that this scoping review can be used as a reference and theoretical basis in analyzing food products using the gas chromatography method with several aspects of validity.

***Keywords**: Alcohol, Halal products, gas chromatography, scoping review*

Background

Indonesia, as a Muslim-majority country, should place a greater emphasis on halal food. The government established Law Number 33 of 2014 about Guaranteed Halal Products as a foundation for offering guarantees to the Muslim people in order for them to access halal products that are Sharia-compliant. Alcohol is one of the issues with halal meals. Alcohol is a colorless liquid produced by the fermentation of carbohydrates and yeast. It is volatile and can be blended with

water, ether, or chloroform (Iskandar, 2012). According to Islamic beliefs, food or beverages containing more than 0.5% alcohol should not be consumed since they are classified as khamr, which is haram (Sudarma & Parwata, 2017). Ethanol is a common alcohol analyte that can be found in fermented foods and beverages (Destanoglu & Ismail, 2019).

Alcohol use has a significant and complex impact on a variety of ailments, including cardiovascular disease. Furthermore, alcohol can harm the central nervous system and lead to dependence (alcoholism). Hallucinations, headaches, hypertension, sleeplessness, excessive perspiration, and other symptoms are among them (Sudarma & Parwata, 2017). While ethanol concentrations greater than 55% can cause toxicity and even death (Suaniti, 2012). As a result, it is vital to create a simple and selective analytical method for determining alcohol concentration that is also time and cost-efficient.

The level of alcohol in food or beverage can be determined using a variety of methods, one of which is gas chromatography. The gas chromatography method has the advantages of being fast (usually in minutes), efficient, having a high resolution, being sensitive, being able to detect in ppm (parts per million) and even ppb (parts per billion), quantitative analysis with high accuracy, using small amounts of samples, being relatively simple and inexpensive, performing dynamic separation, identifying volatile organic compounds, having high sensitivity, and performing qualitative and quantitative analyses (McNair *et al*., 2019).

The sample was quantified using the gas chromatography method by comparing it to standard ethanol and using n-butanol as the internal standard (Anghelescu *et al*., 2017; Tiscione *et al*., 2011; Fu *et al*., 2015; Hong *et al*., 2015). The gas chromatography approach employs numerous features of the validation procedure to determine how halal a meal or beverage is. Method validation is performed to get outcomes that are as close to the truth as possible. Selectivity, linearity, distance, precision, accuracy, LOD, and LOQ are all validation methods. The goal of this scoping review is to map the available evidence about the best conditions for analyzing the amount of alcohol in a food product using gas chromatography, as well as to find a method for validating the amount of alcohol in a food product based on things like accuracy, precision, linearity, detection limit, limit quantification, and estimation of uncertainty.

Materials and Methods

The literature review study used is a scoping review, which is a method used to identify literature in depth and comprehensively obtained through various sources with various research methods and has relevance to the research topic (Arksey & O'Malley, 2005). So, we get a systematic study, identify the types of research evidence relevant to the topic, get an overview of how research is carried out on a particular topic or field, and identify key characteristics or factors related to the concept (Munn *et al*., 2018). The stages in conducting a scoping review include a focus review, using the PEOS framework (Problem, Exposure, Outcome, and Study design), identifying relevant studies, describing processes, identifying literature with PRISMA flowcharts, data extraction and mapping or scoping (Arksey & O'Malley, 2005).

Identify the focus of the review

This study is guided by the question "How to analyze the alcohol content of various foods using gas chromatography?" So, the literature review is defined as a research synthesis that aims to map the literature on the topic of analyzing the alcohol content of various foods with the gas chromatography method to determine the halalness of a food as a source of evidence to inform research on the analysis of alcohol content.

Develop a review focus

At this stage, to develop the review focus and search strategy, the PEOS (Population, Exposure, Outcome, and Study Design) framework is used to manage and solve the review focus (**Table 1**).

The use of this framework is useful for identifying key concepts in the focus of the review, developing appropriate search terms to describe the problem, and determining inclusion and exclusion criteria. The focus of the search for articles is quantitative research, so PEOS is considered appropriate to use (Bettany-Saltikov, 2010).

Table 1. PEOS chart

Population and Problem	Exposure	Outcomes of Themes	Study Design
Food and beverages with alcohol content	- Analysis of ethanol content - Gas chromatography	- Experience - View - Perspective	Perspective Anything related to the analysis of alcohol/ethanol content by gas chromatography

Find relevant studies

The article search strategy was developed using the PRISMA flowchart to assist authors in reporting on systematic reviews (SR) and meta-analyses (MA). PRISMA is considered appropriate to use because, in its use, it can improve the quality of publication reporting (Peters *et al*., 2015). The keywords used in the search for research articles are alcohol content, halal, and gas chromatography. Journal databases used include ScienceDirect, PubMed, and Google Scholar with inclusion and exclusion criteria (**Table 2**).

Table 2. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
a. Publication of articles in the last 10 years b. Speaks English and Indonesian c. Original article	a. Review article b. Book

Compile, summarize, and report the results and discussion

At this stage, the authors take a three-phase approach, namely: descriptive numerical analysis of research articles found covering the year of publication and type of study; literature strengths and weaknesses defined through thematic analysis of the studies included in the report; and reviewing the implications of the findings for future research, practices, and policies. front (Levac *et al*., 2010).

Table 3. Mapping results of scientific articles

No	Article	Object	Desain	Design	Topic	Result
1.	Hermanto *et al*., 2020	Determination of alcohol content in some traditional fermented foods (*tuak* and *brem*)	Quantitative	1. Internal standards are used to influence accuracy in analysis. 2. Method validation is carried out to provide results that are close to the truth. 3. The results of the GC measurement are compared with the alcohol content listed on the beer packaging (value	Testing the alcohol content of palm wine and *brem*	The ethanol content of palm wine is 25.5±0.2 and *brem* is 30.1±0.2% (v/v)

				declared by the producer)		
2.	Aryasa *et al*., 2019	Determination of alcohol content in palm wine by gas chromatography method	Quantitative	The sample used was seven samples of palm wine so that seven data were obtained.	The alcohol content test was compared with the determination of the alcohol content based on the Supreme Court decision no. 42P/HUM/2012.	Ethanol content obtained Day I (4.839%), Day II (5.076%.), Day III (5.233%), Day IV (5.173%), Day V (4.971%), Day VI (4.954%), Day VII (4.927%)
3.	Sudarma & Parwata, 2017	Knowing the ethanol content of the wine sold in Merita Village, Karangasem Regency, was carried out using gas chromatograph.	Quantitative	Samples are used as many as 5 samples	Determination of alcohol content is compared with the decision by the Minister of Health of the Republic of Indonesia number 86/Menkes/Per/IV/77	Ethanol content obtained: sample a with a level of 18.47%, sample b with a level of 25.28%, sample c with a level of 16.11%, sample d with a level of 11.68%, and sample e with a level of 25.94%.
4.	Pulungan *et al*., 2018	Analyze alcohol content consisting of vinegar	Quantitative	1. The validation methods used are selectivity, linearity, distance, precision, LOD and LOQ. 2. The analytical instrument is chromatography gas Agilent 6890 Series GC System, with Flame Ionization Detector (FID). 3. Optimal conditions are obtained by using the inlet temperature. 4. The sample used is vinegar from Indonesia and Saudi Arabia	Determination of the alcohol content of vinegar	The ethanol content of vinegar from Saudi Arabia is 2,28,10-2% v/v and the brand of vinegar "x" from the market in Surabaya is 1,17.10-2 v/v
5.	Muchtardi *et al*., 2012	Determination of alcohol content on tape using gas chromatography	Quantitative	The sample used is black sticky rice tape	Determination of tape alcohol content	The alcohol content obtained from 3 days of

						fermentation was 4.295-5.34 % v/v.
6.	Astuti *et al*., 2018	Validate the gas chromatography method with a flame ionization detector to determine ethanol content in wine	Quantitative	1. The sample used is arak that has been diluted 10 times 2. The selected chromatographic conditions are injector temperature 250°C, detector temperature 300°C, with a split ratio of 20 3. The validation methods used are selectivity, linearity, distance, precision, LOD and LOQ.	Determination of ethanol content	The results obtained are 17.88%

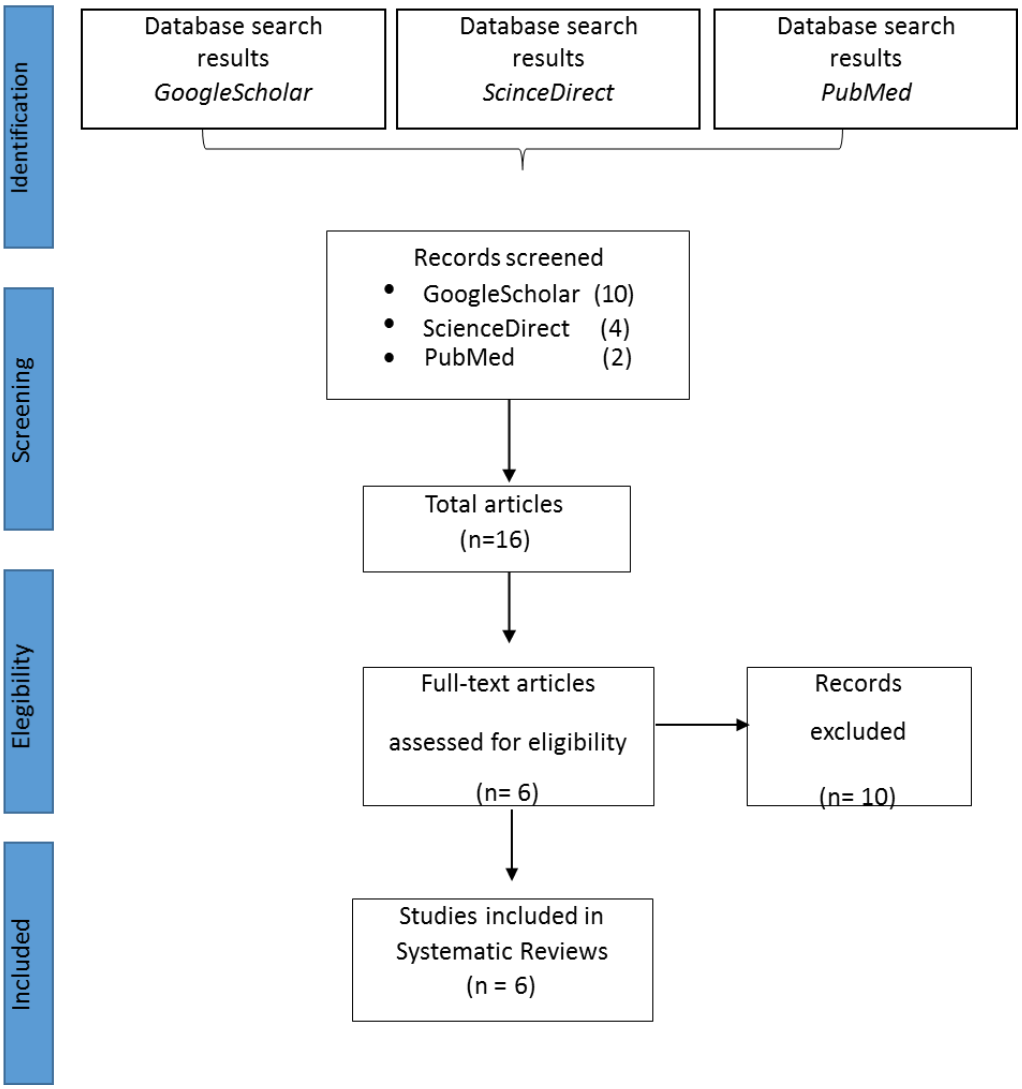

Figure 1. PRISMA Diagram

Result and Discussion

This review will look at how the alcohol level of various meals and beverages is verified using gas chromatography analysis for halal purposes. Before calculating the alcohol concentration with gas chromatography, the method must be validated. Even though the method to be employed has been published in journals, textbooks, and official books, an analytical approach can be used if validation has been performed. It is likely that the analytical results acquired will diverge from the actual situation if the experimental settings are not validated. Method validation seeks to produce outcomes that are as close to the truth as possible. The GC-FID method's analysis features are linearity, selectivity, accuracy, and precision (Astuti *et al*., 2018; Ortega *et al*., 2001).

Selectivity

If there is a separation on the chromatogram with a value of Rs ≥1.5, the selectivity is considered good. The experiment was carried out by injecting a portion of the solvent into the chromatographic injector. According to the results of the selectivity value calculation from the research of Pulungan *et al*. (2018), the six mixed analyses have a value of Rs >1.5. The selectivity value of Rs > 1.5 was reached for each standard in the research of Astuti *et al*. (2018) and Hermanto *et al*. (2020).

Linearity

This test is performed by evaluating the peak area and then converting the data into a linear regression equation y = bx + a. Each injection was performed three times, and the coefficient of determination was calculated. If r^2 ≥0.95, the procedure satisfies the linearity parameter. The correlation between ethanol and vinegar sample preparation was 0.834 in Pulungan *et al*. (2018)'s linearity test. According to Hermanto *et al*. (2020), the correlation coefficient (r) is 0.9984. The linearity value in the research of Astuti *et al*. (2018) is represented by the methanol correlation coefficient of 0.9998; ethanol 0.9998; and acetic acid 0.9274.

Limit of detection

The detection limit is the smallest analyte concentration in a sample that can be detected and produces a meaningful reaction when compared to the blank. The detection limit is calculated using the data from the regression equation. Pulungan *et al*. (2018) discovered that the detection limit for vinegar sample preparation was 0.9997 ng. According to Hermanto *et al*. (2020), the detection limit is 0.15 ng. The detection limit for methanol is 0.1059 ng, ethanol is 0.1688 ng, and acetic acid is 0.0837 ng.

Accuracy and precision

The accuracy and precision were validated by injecting the mixed solution with 3x replication. The standard deviation (SD), coefficient of variation (KV), and area under curve (AUC) of the ethanol chromatogram were determined after the data was collected. The results show a coefficient of variation of 2%, an accuracy (K) of 5%, and a recovery rate of 98-102%. (Hermanto *et al*., 2020). According to the research of Astuti *et al*. (2018), the accuracy value is methanol 0.7%, ethanol 1.8%, and acetic acid 1.8%. The accuracy value is 3.54% for methanol, 3.53% for ethanol, and 0.79% for acetic acid.

Food and beverage determination of alcohol levels

Because alcohol is a volatile molecule, the GC method can be used to determine its content. Because of its simplicity of analysis, sensitivity, accuracy, relative specificity, quick measurement, and small sample size, the GC method is employed for alcohol analysis (Mohammed *et al*., 2018). Alcohol is a severe concern in food and beverage goods, and Muslims are not permitted to consume it. Alcoholic beverages that are *khamr* are those that include more than 0.5% alcohol. The law is

haram, a little or a lot. Food and beverage goods containing *khamr* are both legally haram (MUI Fatwa No. 10 of 2018 regarding food and beverage products containing alcohol/ethanol). No. 86/Menkes/Per/IV/77 of the Minister of Health of the Republic of Indonesia regarding the types of alcoholic beverages, including class A liquor with an alcohol content of 1-5%, class B liquor with an alcohol content of 5-20%, and class C liquor with an alcohol content of 1-5%. 20-55% alcohol Then, from a health standpoint, alcohol is harmful since it can induce relaxation, anxiety, loss of balance, and loss of control at low and moderate levels. Alcohol, at high dosages, can cause nerve damage and addiction (Yang *et al*., 2012). A calibration curve equation is used to calculate alcohol content: (sample area) / (standard area) x standard (Sudarma & Parwata, 2017; Aryasa *et al*., 2019). The MUI fatwa says that Muslims can't beverage alcohol with a content of more than 0.5, which is what this review of six research journals shows.

Conclusion

Based on the results of the scoping review, it can be concluded that method validation (selectivity, linearity, limit of detection, accuracy, and precision) in gas chromatography is required in order to provide results that are close to the truth. Then the alcohol content obtained using the gas chromatography method from several kinds of food and beverage products has a value of more than 0.5, which is in accordance with the MUI fatwa for consumption by Muslims.

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