JOURNAL
OF HALAL QUALITY AND CERTIFICATION

Application of Rapid Enzyme Tests for Detecting Ethanol in the Validation of Halal-Certified Products

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Original scientific paper

ABSTRACT

Halal quality represents the totality of characteristics of products and services that meet the fundamental attributes of quality, such as health and hygiene safety, as well as compliance with halal standard requirements and Islamic dietary regulations. Halal product certification is carried out proactively using a preventive method to prevent the mixing or occurrence of any amount of ingredients that may have haram status. The modern food production process necessitates the use of rapid methods and techniques for analyzing the origin and quality of food, which is particularly emphasized in the production of halal products.

The aim of this study was to validate rapid enzymatic tests for detecting ethanol in prepared samples and finished products and to determine their applicability and reliability in analysis.

For the detection of alcohol in products and samples, the XEMATest Alco – an enzymatic test for the semi-quantitative determination of ethanol in samples, produced by XEMA Co. Ltd., was used.

For the purpose of this research, 90 analyses were conducted on 18 samples, of which 10 samples were prepared with different ethanol contents ranging from 0.02% to 10%, while 8 samples consisted of commercial alcoholic and non-alcoholic beverages.

The rapid enzymatic tests confirmed the presence of alcohol in the samples where alcohol was added, as well as in two alcoholic beverages whose labels stated that they contained 5% and 5.5% alcohol.

Out of all samples, ethanol was detected in 55 analyses, while 35 analyses showed no ethanol presence. The tests did not produce any false positive or false negative results. The determined sensitivity and specificity of the enzymatic test were 100%, with a false positive rate of 0%, error $\alpha < 5\%$, false negative rate of 0%, and error $\beta < 5\%$.

Keywords: *rapid tests, detection, ethanol, halal products.*

Introduction

The word halal refers to all things and actions that are permitted according to Islamic regulations. In modern usage, this term is most commonly associated with food. Halal food includes foods and beverages that are permissible for consumption according to Islamic rules and meet

the requirements of halal standards (Jašić & Alihodžić, 2022).

For food or food products to be halal-certified, they must undergo a process of halal implementation, verification, and, in many cases, validation. Implementation involves adapting raw materials and processes to meet halal standard requirements.Verification follows implementation and entails assessing the products and production processes. This is conducted by a third-party certification body, which inspects production facilities to ensure compliance.

Verification of implemented halal standard requirements is performed in accordance with certification procedures for specific product types. This includes a certification audit, during which the halal certification body inspects all processes within the company's production facilities—from raw material procurement to packaging and storage. During or after verification, validation is often required, which involves laboratory analysis of raw materials, semi-finished, or finished products.

In the validation process of halal-certified products, the halal certification body conducts sampling and analysis of certified products or raw materials to detect non-halal ingredients. Validation involves sampling and analyzing products based on halal standard requirements. Laboratory tests can be mandatory or recommended, with the frequency and timing of mandatory analyses determined according to accreditation standard criteria, taking into account product nature, sensitivity, risk level, and other factors.

These tests can be performed using classical laboratory methods or rapid (screening) tests. Due to the fast-paced nature of production, analysis results need to be obtained as quickly as possible, making rapid methods essential for detecting certain ingredients. For example, raw materials may contain haram components such as ethanol (alcohol) found in flavorings, additives, or other raw materials. According to the requirements of halal standards OIC/SMIIC 1 and BAS 1049:2023 – Halal Food Requirements and Measures, all products or beverages containing alcohol are strictly prohibited in accordance with Islamic regulations, even if used for cooking or filling confectionery products.

Alcohol (from the Arabic *al-kuḥl* – „kohl“)[1] is a type of organic compound that contains at least one hydroxyl (−OH) functional group attached to a saturated carbon atom (Patai, 1971). Alcohols range from simple compounds, such as methanol and ethanol, to more complex ones, such as sugar alcohols and cholesterol. The presence of an OH group significantly alters the properties of hydrocarbons, giving them hydrophilic characteristics. The OH group serves as a reactive site where various chemical reactions can occur[2]. There are many types of alcohols, including methanol, ethanol, isopropyl alcohol, butanol, propylene glycol, glycerol, erythritol, xylitol, mannitol, sorbitol, glycerol, inositol, menthol, and others. All these alcohols are used for different purposes, but only ethanol has intoxicating properties (Husaini, 2018). From the perspective of Islamic regulations, ethanol can be divided into two categories:

1. Ethanol derived from natural sources
2. Ethanol obtained through chemical synthesis

According to Islamic rulings, ethanol obtained from natural sources through fermentation and distillation is considered haram and impure (Arabic: *najis*). However, ethanol produced through chemical synthesis is not considered impure, and its use in the halal industry is permitted as long as its concentration does not cause intoxication (Alam, 2021).

Validation of Rapid Methods in the Analysis of Food Origin and Quality

Validation is the process of verifying the validity of a process or product, as well as determining whether a specific process or product fulfils its intended purpose.

The evaluation (validation) of a method involves testing and obtaining objective evidence that the specific requirements for the intended use have been met (Regulation on the Implementation of

[1]https://www.sciencefriday.com/articles/the-origin-of-the-word-alcohol/

[2]https://en.wikipedia.org/wiki/Alcohol_(chemistry)#cite_note-4

Analytical Methods and Interpretation of Results; Official Gazette of BiH No. 95/10).

The purpose of validation is to ensure that different data obtained from product analyses lead to consistent and high-quality results. Validation determines the reliability of a method. The simplest definition of analytical method validation is the process of demonstrating that a method serves the purpose for which it is intended. First and foremost, it is necessary to define the purpose of the method. After that, procedures are determined, i.e., experiments are planned and conducted, and their results are collected and presented as evidence of the method's validity.

Table 1. Overview of quality parameters for quantitative and qualitative analytical methods (Trullols et al., 2004).

Quantitative methods	**Qualitative methods**
Accuracy: truthfulness, precision	Sensitivity and specificity
Uncertainty	False positive and negative rates
Sensitivity and specificity	Selectivity
Selectivity	Detection limit
Range and linearity	Marginal limit
Limit of detection	Region of unreliability
Robustness	Robustness

The same procedures will not be applied to all methods-qualitative and quantitative methods are validated differently. The validation process differs for methods used to determine the main analyse in a sample versus those used to detect trace components in a complex matrix. Each method is approached individually, and an assessment is made to determine the necessary steps for proving its effectiveness (Lazarić, 2012).

The validation of analytical methods is a process that includes laboratory testing of specific analytical parameters to determine the method's reliability in relation to its intended use. Both practice and regulations have accepted the fundamental parameters that need to be determined for quantitative and qualitative methods.

By combining the parameters presented in Table 1, a validation plan is formulated for each method.

Enzymatic Test for Semi-Quantitative Determination of Ethanol in Products

In recent years, various analytical methods have been developed to identify specific substances in products intended for human consumption. Some analytical methods aim to protect products from potential adulteration by manufacturers while simultaneously safeguarding end consumers from possible fraud in the food market (Gvozdanović et al., 2017).

Additionally, there is often a need to detect other unwanted substances in food. For this purpose, immunochromatographic and enzymatic tests can be used to detect mycotoxins (Lai et al., 2009), allergens, GMOs (Holst-Jensen, 2009), residues of veterinary drugs, the presence of ethanol alcohol residues, and similar contaminants.

Alcohol detection can be performed using an enzymatic test for the semi-quantitative determination of ethanol traces in non-alcoholic beverages, food products, and within kitchens and equipment in the food industry.

Ethanol from the sample is converted by a specific enzyme attached to the test pad. During this conversion, the colour on the pad changes proportionally to the amount of ethanol present. The test sensitivity in solution is 0.02% vol., which represents the first stage of colour change on the test. These tests also show the same sensitivity in detecting methanol, while they are less sensitive to other alcohols such as propanol, isopropanol, butanol, and isobutanol. They are not applicable for detecting higher alcohols, aldehydes, or ketones (including acetone). The analysis result is read based on the colour change on the test pad. This test is semi-quantitative and can be used for detecting alcohol (ethanol) in beverages. Additionally, it is applicable for detecting alcohol in certain food products and raw

materials, such as kefir, yogurt, flavours, colorants, and similar liquid products.

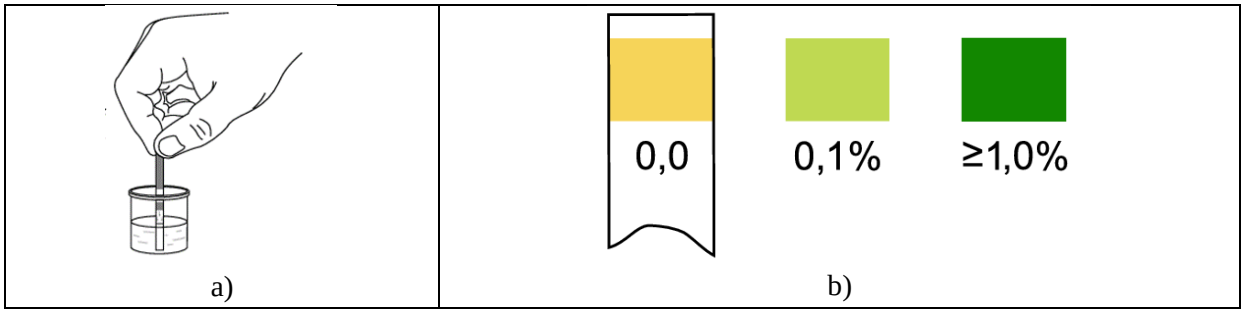

Figure 1. a) Sample testing process; **b)** Indicator and interpretation of the analysis results for the semi-quantitative determination of ethanol traces (adapted from the manufacturer's instructions for Xema test Alco).

Research Method

For alcohol detection in products and samples, the commercial XEMATest Alco - Enzymatic Test for semi-quantitative determination of ethanol in food and beverages from XEMA Co. Ltd. was used.

Materials

Materials for ethanol detection in products included 96% concentrated ethanol. The samples were prepared by diluting the 96% ethanol with distilled water according to previously designed ratios.

Table 2. List of raw materials and products taken for analysis and sample preparation for ethanol detection in products and samples.

No.	Materials / Samples	Declared alcohol in the product
1.	Ethanol	96% ethanol
2.	Methanol	Methanol
3.	Non-alcoholic beer	0,0% Ethanol
4.	Non-alcoholic beer	0% Ethanol
5.	Soft malt drink	-
6.	Beer 1	5% Ethanol
7.	Beer 2	5,5% Ethanol
8.	Kefir 1	-
9.	Kefir 2	-
10.	Kefir 3	-

Sample Preparation

For ethanol detection, nine samples with varying ethanol concentrations were prepared: 10%, 5%, 3%, 2%, 1%, 0.5%, 0.1%, 0.05%, and 0.02%. To prepare the samples with different ethanol concentrations, 96% vol. concentrated ethanol was used as a reference. The samples were prepared by diluting the concentrated ethanol according to the following ratio:

$$C_1 \cdot V_1 = C_2 \cdot V_2$$

Where:
C_1 – ethanol concentration in the sample,
V_1 – volume of the sample,
C_2 – ethanol concentration in the solution,
V_2 – volume of the solution.

Since concentrated ethanol with a concentration of 96% was used, the amount required for the desired ethanol content in the samples was calculated. The desired ethanol content in the samples is obtained from the previous equation as follows:
For a sample containing 10% ethanol, the calculation is as follows:

$$V = \frac{10\% \cdot 100ml}{96\%} = 10{,}41\ ml$$

In a 100 ml volumetric flask, 10.41 ml of 96% ethanol was pipetted and transferred, then the flask was filled to the mark with distilled water.
For a sample containing 5% ethanol, the required amount is:

$$V = \frac{5\% \cdot 100ml}{96\%} = 5{,}20\ ml$$

In a 100 ml volumetric flask, 5.20 ml of 96% ethanol was pipetted and transferred, then the flask was filled to the mark with distilled water.
For a sample containing 3% ethanol, the calculation is as follows:

$$V = \frac{3\% \cdot 100ml}{96\%} = 3{,}12ml$$

In a 100 ml volumetric flask, 3.12 ml of 96% ethanol was pipetted and transferred, then the flask was filled to the mark with distilled water.
In the same way, the required volume was calculated for the 1%, 0.5%, 0.1%, 0.05%, and 0.02% samples, pipetted and transferred into the volumetric flask, and then filled to the mark with distilled water.

Table 3. List of samples prepared for ethanol detection.

No.	Sample	Ethanol Content (ml)	Wather Content (ml)	Percentage of ethanol in the sample (%)
1.	Sample 0%	0	100	0
2.	Sample 0,02%.	0,0208	≈ 99,98	0,02
3.	Sample 0,05%,	0,052	≈ 99,95	0,05
4.	Sample 0,1%,	0,104	≈ 99,89	0,10
5.	Sample 0,5%,	0,52	99,48	0,50
6.	Sample 1%,	1,04	98,96	1,00
7.	Sample 2%,	2,03	97,97	2,00
8.	Sample 3%,	3,13	96,87	3,00
9.	Sample 5%,	5,20	94,80	5,00
10.	Sample 10%,	10,41	89,59	10,00

*ND – non-declared

In addition to the prepared samples with varying ethanol content, alcohol detection was performed on finished commercial products sampled from a supermarket. Out of a total of eight sampled commercial products, six did not have alcohol declared. Kefir, a dairy food product, can contain 0.2 – 2% alcohol (ethanol) depending on the production method. Three kefirs from three different manufacturers were sampled.

Depending on the regulations in certain countries, non-alcoholic beer can contain 0 – 0.5% alcohol (ethanol). Two non-alcoholic beers and a "Kvas" product – a non-alcoholic refreshing beverage based on barley malt – were sampled for the study. In addition to the alcohol-free products, two alcoholic beers from different manufacturers were sampled, with alcohol content declared as 5% and 5.5% on their labels.

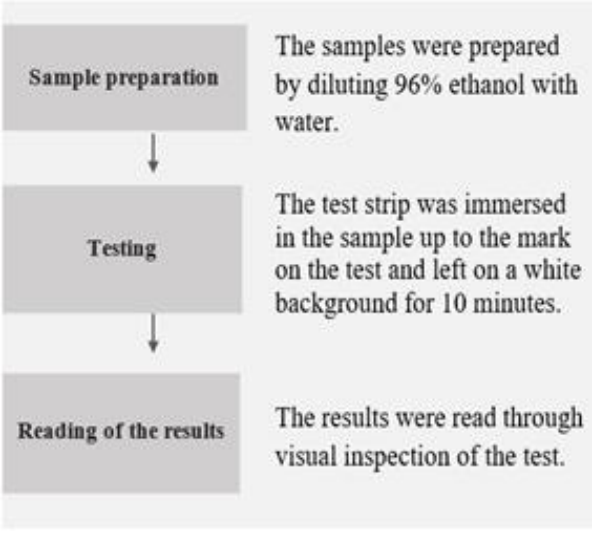

Figure 2. Flow diagram of ethanol detection in the solution.

Table 4. List of finished commercial products used for ethanol detection.

No.	Sample	Ethanol Content (ml)	Percentage of ethanol in the sample (%)
1.	Beer		5%
2.	Beer		5,5%
3.	Non-alcoholic beer	*ND	Unknown
4.	Non-alcoholic beer	ND	Unknown
5.	Non-alcoholic refreshing beverage based on barley malt	ND	Unknown
6.	Kefir 1	ND	Unknown
7.	Kefir 2	ND	Unknown
8.	Kefir 3	ND	Unknown

Results and Discussion

According to the manufacturer's instructions for this enzymatic test, the volumetric alcohol content in the analyzed sample can be assessed based on the color intensity ranging from light yellow to dark green. The initial color on the test pad before analysis is light yellow.

In the sample containing 0% ethanol, there was no color change on the test strip pad, indicating that the sample does not contain alcohol (Figure 3).

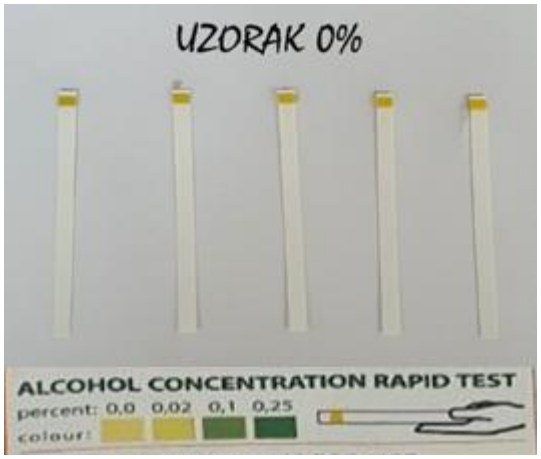

Figure 3. Display of results for a sample containing 0% ethanol.

On the test part of the strip of the analyzed sample containing 0.02% alcohol, a color change occurred on the pad, indicating that the sample is positive for the presence of ethanol (Figure 4). The color on the pad changed from the initial yellow to light green, indicating that the sample contains more than 0.02% alcohol.

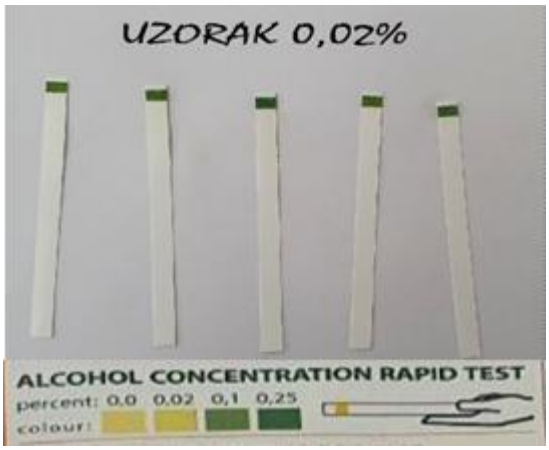

Figure 4. Display of results for a sample containing 0,02% ethanol**.**

In Figure 5, it is visible that on the test part of the strip with a sample containing 0.05% ethanol, a color change occurred on the pad, indicating that the sample contains alcohol.

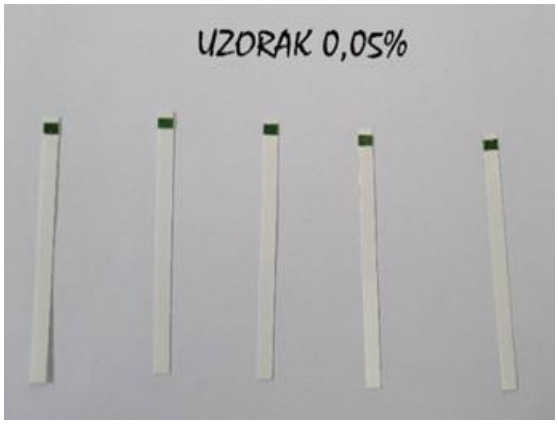

Figure 5. Display of results for a sample containing 0,05% ethanol.

On the test part of the strip of the analyzed sample with a content of 1% ethanol, a color change occurred on the pad, indicating that the sample is positive for the presence of ethanol.

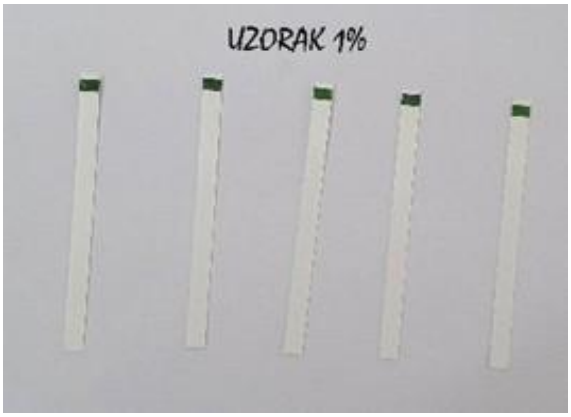

Figure 6. Display of results for a sample containing 1% ethanol.

On the test part of the strip with a sample containing 2% ethanol, a color change occurred on the pad, indicating that the sample is positive for the presence of ethanol.

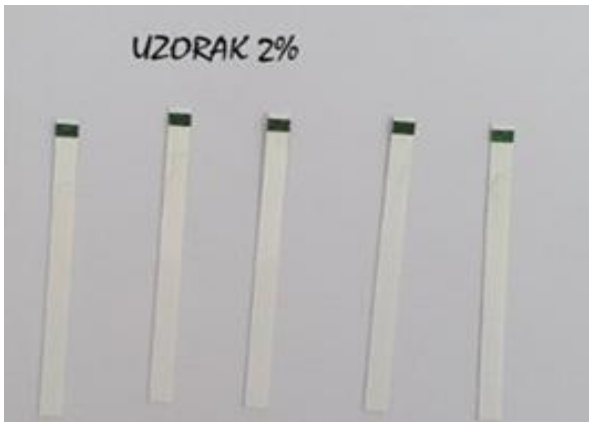

Figure 7. Display of results for a sample containing 2% ethanol**.**

On the test part of the strip with a sample containing 3% ethanol, a color change occurred on the pad, indicating that the sample is positive for the presence of ethanol.

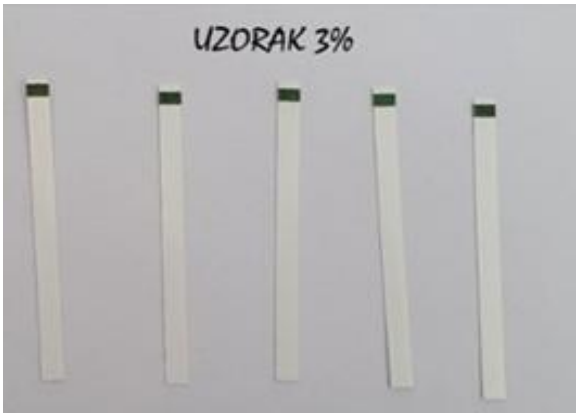

Figure 8. Display of results for a sample containing 3% ethanol.

On the test part of the strip with a sample containing 5% ethanol, a colour change occurred on the pad, indicating that the sample is positive for the presence of ethanol.

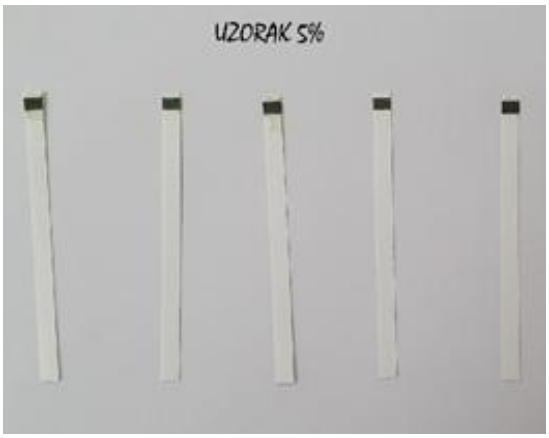

Figure 9. Display of results for a sample containing 5% ethanol**.**

On the test part of the strip with a sample containing 10% ethanol, a colour change occurred on the pad, indicating that the sample is positive for the presence of ethanol.

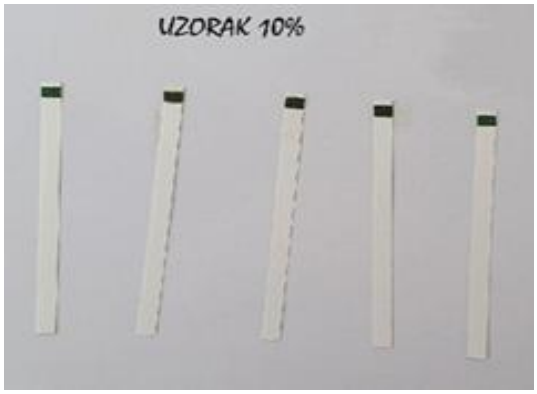

Figure 10. Display of results for a sample containing 10% ethanol.

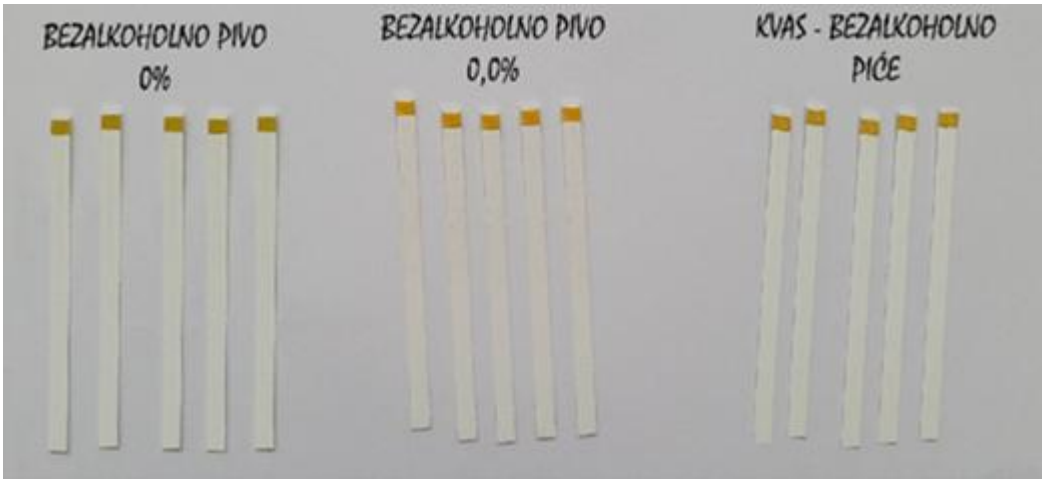

Figure 11. Display of results for products with undeclared alcohol-ethanol.

Results of the Enzymatic Test for Alcohol (Ethanol) Detection in Samples

A total of 18 samples were analyzed, and 90 tests were conducted using the enzymatic rapid test for alcohol detection. The analyses were performed on prepared samples containing alcohol concentrations of 0%, 0.02%, 0.05%, 0.1%, 0.5%, 1%, 2%, 3%, 5%, and 10%. All tests that contained alcohol showed positive results for the presence of alcohol. The result is read by the color change on the test pad, ranging from light green to dark green. In addition to the analyses performed on the prepared samples, tests were also conducted on finished products, both those with declared alcohol content and those with no declared alcohol content.

Table 5. Results of the Enzymatic Test for Alcohol (Ethanol) Detection in Samples

No.	Tested Samples	Conducted Analysis No.	Analysis Results	
			Positive	Negative
1.	Sample with 0% ethanol	5	0	5
2.	Sample with 0,02% ethanol	5	5	0
3.	Sample with 0,05% ethanol	5	5	0
4.	Sample with 0,1% ethanol	5	5	0
5.	Sample with 0,5% ethanol	5	5	0
6.	Sample with 1% ethanol	5	5	0
7.	Sample with 2% ethanol	5	5	0
8.	Sample with 3% ethanol	5	5	0
9.	Sample with 5% ethanol	5	5	0
10.	Sample with 10% ethanol	5	5	0
11.	Beer	5	5	0
12.	Beer	5	5	0
13.	Non-alcoholic beer	5	0	5
14.	Non-alcoholic beer	5	0	5
15.	Non-alcoholic refreshing beverage based on barley malt	5	0	5
16.	Kefir 1	5	0	5
17.	Kefir 2	5	0	5
18.	Kefir 2	5	0	5
	Total number of analysis	**90**	**55**	**35**

Accuracy of the Enzymatic Test for Alcohol Detection

The results of the enzymatic test were not confirmed by a reference method for alcohol detection, but by using a reference material and diluting it to different alcohol percentages in the sample.

Accuracy shows the agreement between the mean values of the obtained results and the actual values in the sample. Every tested sample containing alcohol showed a positive result in each repeated analysis, so it can be concluded that the test is accurate for alcohol detection in products.

Table 6. Overall representation of true positive, false positive, false negative, and true negative results for alcohol detection (adapted from: Guidelines for the validation and verification of quantitative and qualitative test methods, National Association of Testing Authorities, Australia 2012).

		Samples with different contents of genetically modified soy and corn	
		Positive	**Negative**
Test resutls	**Positive**	True Positive *TP=55*	False Positive *FP = 0*
	Negative	False Negative *FN= 0*	True Negative *TN = 35*

The sensitivity of the enzyme test for alcohol detection

Within the framework of qualitative analysis, sensitivity and specificity represent the ability of a test to distinguish truly positive from truly negative samples. Sensitivity is the ability of a method to correctly identify true positive samples as positive, so the sensitivity rate is the probability that for a given concentration, the tested sample will be classified as positive, given that the tested sample is already known to be positive (O'Rangers et al., 2000). Sensitivity can be calculated according to the formula:

$$Sensitivity = \frac{TP}{(TP + FN)}$$

Where: T*P – True Positive results; FN – False Negative results*.

The results of the experiment showed that 55 analyses yielded true positive results, and no analysis showed false negatives. By incorporating the results into the formula for determining sensitivity, the following will be obtained:

$$Sensitivity = \frac{TP}{(TP + FN)} = \frac{55}{(55 + 0)} \cdot 100 = 100\%$$

In the context of qualitative analysis, sensitivity represents the ability of the test to differentiate between truly positive and truly negative samples.

Based on the conducted analyses and calculations, it was determined that the enzymatic test for alcohol detection is highly sensitive, as a sensitivity rate of 100% was achieved.

Specificity of the enzymatic test for alcohol detection

Specificity is defined as "the ability of a method to correctly identify true negative samples as negative." The specificity rate is the probability that, for a given concentration, the method will classify the tested sample as negative, assuming that the tested sample is previously known to be negative (O'Rangers et al., 2000). Specificity can be expressed according to the following relation:

$$Specificity = \frac{TN}{(TN + FP)}$$

Where: *TN – True Negative results; TP – True Positive results; FP – False Positive results;*
The results of the experiment showed that 35 analyses showed true negative results, and no analysis showed false negatives. By including these results in the formula for determining specificity, we get:

$$Specificity = \frac{TN}{(TN + FP)} = \frac{35}{(35 + 0)} \cdot 100 = 100\%$$

By inserting the results into the formula for determining specificity and performing the calculation, it can be determined that the method/test is capable of accurately identifying true negative samples as negative. This confirms the effectiveness of the test in distinguishing between positive and negative samples.

Determination of the false positive rate of the enzymatic alcohol detection test

The false positive rate is the probability that a test sample known to be negative is classified as positive by the test method. The false positive rate can be expressed by the following formula (Feldsine et al., 2002):

$$False\ Positive\ Rate = \frac{FP}{(TP + FP)}$$

Where: *FP – False Positive results; TP – True Positive Results;*
By inserting the analysis results into the formula for determining the false positive rate, the false positive rate of the semi-quantitative alcohol-ethanol detection test in the sample will be obtained.

$$False\ Postive\ Rate = \frac{FP}{(TP + FP)} = \frac{0}{(55 + 0)} \cdot 100 = 0\%$$

Given that the false positive rate is 0%, meaning the error rate is $\alpha < 5\%$, it can be stated that this test does not produce false negative results for alcohol-ethanol detection.

Determination of the false negative rate of the enzymatic alcohol detection test

The false negative rate is the probability that a test sample known to be positive is classified as negative by the test method. The false negative rate can be expressed with the following formula (Feldsine et al., 2002):

$$False\ Negative\ Rate = \frac{FN}{(TP + FN)}$$

Where: *FN – False Negative results; TP – True Positive results.*
By including the analysis results in the formula for determining the false negative rate, the false negative rate of the semi-quantitative alcohol-ethanol detection test in the sample will be obtained.

$$False\ Negative\ Rate = \frac{FN}{(TP + FN)} = \frac{0}{(55 + 0)} \cdot 100 = 0\%$$

Out of a total of 90 conducted analyses, 55 were true positive, and 0 were false negative. By including the results in the formula for the false negative rate, the calculated value for the false negative rate was 0%, meaning the error is $\beta<5\%$. Based on the analyses performed, it can be concluded that this test does not produce false negative results for ethanol detection.
During the experiment, it was determined that this enzyme test, in addition to ethanol, can also detect methanol and isopropanol, allowing the determination of the type of alcohol present in the sample or product being analysed. A drawback of this method is its non-selectivity in alcohol detection, so validation is recommended using procedures like GC-MS or another standardized method. The application of this rapid method in acidic solutions is not possible, such as in the case of alcohol presence in acetic acid.

Conclusion

A total of 90 analyses were conducted using the rapid enzyme test for alcohol detection, with 55 true positive and 35 true negative results. The results were validated based on the detection of previously prepared samples with varying ethanol concentrations as reference material.

The enzyme tests did not show any false positive or false negative results. The calculations determined that the enzyme test for alcohol detection has 100% sensitivity and specificity. The false positive rate is 0%, meaning the error is less than 5% ($\alpha < 5\%$), while the false negative rate is also 0%, with an error of $\beta < 5\%$.

Based on experimental data and the obtained parameters, it can be concluded that the enzyme test is accurate and reliable for detecting alcohol—ethanol in samples and commercial finished products.

The enzyme test for alcohol detection can be reliably used to detect alcohol in raw materials, semi-finished products, and non-alcoholic beverages for the detection of ethanol in halal-certified products.

The enzyme test for alcohol detection can be used to detect ethanol in raw materials, alcoholic and non-alcoholic beverages, and liquid food products, such as kefir, yogurt, and similar products that may contain ethanol.

Although it was not the focus of the study, during the experiment, it was observed that the alcohol detection test reacts positively not only to ethanol in samples but also to methanol, detecting it as well. On the other hand, the product "Alcoholic Vinegar," labelled as containing 0.5% alcohol (ethanol), could not be detected by the test. After this discovery, a smaller quantity of ethanol was added to the sample, which the test also failed to detect. Further investigation is needed to determine which type of acid, concentration, or pH value interferes with alcohol detection in acidic media.

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Časopis za halal kvalitet i certificiranje (2024) 2 (2) 77 - 89
Journal of halal quality and certification (2024) 2 (2) 77 - 89

Primjena brzih enzimskih testova za detekciju etanola u validaciji halal certificiranih proizvoda

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Originalni naučni rad

Sažetak

Halal kvalitet predstavlja ukupnost karakteristika proizvoda i usluga koji zadovoljavaju osnovne atribute kvaliteta, kao što su zdravstvena i higijenska ispravnost, te usklađenost sa zahtjevima halal standarda i islamskih propisa o hrani.

Halal certificiranje proizvoda provodi se proaktivno - preventivnom metodom sa namjerom prevencije miješanja ili nastanka bilo koje količine sastojaka koji mogu imati haram status. Savremeni način proizvodnje hrane nameće potrebu za primjenom brzih metoda i tehnika u analizi porijekla i kvaliteta hrane. Posebno je to izraženo u području proizvodnje halal proizvoda.

Cilj rada je bio izvršiti validaciju brzih enzimskih testova za detekciju etanola u pripremljenim uzorcima i gotovim proizvodima, te odrediti njihovu primjenjivost i pouzdanost u analizi.

Za detekciju alkohola u proizvodima i uzorcima korišten je XEMATest Alco - Enzimski test za semi-kvantitativno određivanje etanola u uzorcima proizvođača XEMA Co. Ltd.

U svrhu ovog istraživanja provedeno je 90 analiza na 18 uzoraka od kojih je 10 uzoraka pripremljeno sa različitim sadržajem etanola od 0,02% do 10%, a 8 uzoraka komercijalnih alkoholnih i bezalkoholnih pića.

Brzim enzimskim testovima utvrđeno je prisustvo alkohola u uzorcima u koje je dodan alkohol, te u dva alkoholna pića na čijim deklaracijama je navedeno da sadrže 5 i 5,5% alkohola. Od svih uzoraka u 55 analiza je detektovano prisustvo etanola, a u 35 nije. Analize nisu pokazale lažno pozitivne i lažno negativne rezultate. Utvrđena osjetljivost i specifičnost enzimskog je testa 100%, a lažno pozitivna stopa od 0%, gdje je pogreška $\alpha<5\%$, lažno negativna stopa od 0% i pogreška $\beta<5\%$.

Ključne riječi: *brzi testovi, detekcija, etanol, halal proizvodi.*