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Determination of permissible alcohol and vinegar in Shariah and scientific perspectives

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Abstract

The halal food production industry is gaining greater attention among Muslim and non-Muslim majority countries, particularly due to the increase of global market demand. One of the critical areas in issuing halal certified food is the determination of allowable alcohol content in food and drinks. The level of alcohol content has not standardized in several standards and fatwa of Islamic scholars. In Islam, the alcohol in several fruit products is produced through fermentation process such as takhammur (wine making) and takhallul (vinegar making). The fermentation process gives an impact to the status of the food products either permissible or prohibited. Therefore, the purpose of this paper is to discuss on the determination of permissible alcohol and vinegar by fermentation process content in selected food products from Shariah and science perspectives. In doing so, the views of authentic of Islamic Law in this issue are supported by lab work approached. As a result, in the first phase there are three types of by products from takhammur, while two types of takhallul. All the products can be determine of the alcohol content and give an implication of the status either permissible (halal) or prohibited (haram). Hence, in juice considered as halal due to lower of alcohol content. While cider or alcoholic beverage is haram due to above alcohol level permitted which is above of the 1%. Besides, cider vinegar or vinegar is halal by the interpretation of hadith of permissible conversion from alcoholic to vinegar itself.

Introduction

Alcohol is widely used in the food industry as solvents in flavours, colours and preservatives. Besides foods, alcohols are also widely used in cosmetics, pharmaceuticals and other industrial products. The total value of alcohol used in these industries amounts to billions of dollars and in the soft drink sector alone, Coca Cola reported sales of USD22 billion in its 2004 annual report (Azahari, 2010). Based on the amount of alcohol used in the food and other industries, it is difficult for any food industry to switch their industrial practices from using alcohol to alternative ingredients (Law *et al*., 2011). Currently, some of the issues related to the halalness of food products are the presence of alcohol in foods and beverages (Riaz, 1997). One of the critical parts in issuing halal certificates is the level of permissible alcohol content in food products. In some ASEAN countries such as Malaysia, Indonesia and Thailand, the permissible alcohol content is stated at 1% whilst Singapore benchmarked the level at 0.5% (Najiha *et al*., 2010). In other cases such as Brunei, United Kingdom and Canada, alcohol is not allowed to be present in Halal food products. The guideline which is set at 1% in Malaysia was established based on a fatwa of Islamic scholars and research conducted on the fermentation process of different substrates ranging from cereals, fruits and palm sugars (Vern *et al*., 2009). Applying the principle of analogy (qiyas) in this matter, Islamic jurists have concluded that other substances that have the same effect as ethanol i.e., intoxicating and harmful, for example drugs such as morphine, cocaine and heroin are also prohibited (Hamidah, 2009).

Fundamentally, alcohol or specifically ethanol is generated through the fermentation of fruits or

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grains, sugar or starch with the existence of yeast (Abdel Naser, 2000). If the amount of ethanol produced from fermentation is high enough, it could have an intoxicating effect and therefore not allowed for consumption by Muslims (Riaz and Chaudry, 2004). If the fermentation is allowed to continue in the presence of oxygen, the intoxicating alcohol is converted to acetic acid or vinegar (Mehaia and Cheryan, 1991; Tan, 2003). In Islamic law, for the first stage of the fermentation process, that is, the conversion of carbohydrate or sugar to alcohol (alcoholic fermentation) is termed takhammur while the second stage of the fermentation process, that is, the change from alcohol to vinegar (acidic fermentation) is known as takhallul (Jamaludin *et al*., 2012).

This article aimed to determine level of alcohol permitted in first and second stage fermentation process, covered from the conversion of sugar to alcohol and alcohol to vinegar. In line with this, this study proposed an integration method between Shariah and scientific perspectives to identify the permissible level, based on authentic Islamic sources of Law, which is the Quran and the tradition of Prophet, peace and blessing be upon him (pbuh), which is hadith. In carrying out this study, several products such as fruit juices from apples, grapes and oranges were used. The concentration of ethanol over the whole fermentation period was measured by looking into its permissibility according to the benchmark set by the Malaysian religious authorities which is 1% (E-fatwa, 2011).

Materials and Methods

An integration method between Shariah and science perspective of collecting and analyzed data were used as detailed in Farhan (1989) and Jamaludin *et al.* (2012). Literature review from the selected references and interviews session with the related field of expert also were conducted. All the data were compiled and analyzed according to deductive, inductive and comparative methods as detailed below to propose a comprehensive of permissible alcohol and vinegar by fermentation process content in selected food products from Shariah and science perspectives.

Materials

Apple, grape and oranges were used to produce alcoholic beverages. Apple-US Gala, Red Global and Sunkist varieties were obtained from a local hypermarket. The fruits chosen were at a mature stage with firm texture, uniform color and without any sign of spoilage. All fruits samples were stored at 4°C before used.

Preparation of fruits for fermentation

The fruits samples such as apple, grapes and oranges were washed, peeled and cut into slices before they were passed through a juice extractor to obtain the juice. A 300 mL portion of the fruits juice was then transferred into a sterilized 500 mL conical flask. Sugar was then added to adjust the °Brix to around 20%. The juice in the conical flask was seeded with a 10% by weight of juice with commercial yeast, Saccharomyces cerevisea. The flasks containing juice were incubated at 30°C for five days. All the experiments were carried out in triplicates.

Measurement of pH and total soluble solids

The pH and °Brix values during fermentation were determined daily (every 24 hours). All experiments were carried out in triplicates. The pH values of fruit juice during storage were determined using a pH meter (Mettler Toledo model Seven Easy) at room temperature (25°C) while °Brix was measured using a refractrometer. For the determination of titratable acidity, distilled water (25 mL) was added to fruit juice (5 mL), and then the pH was adjusted to 8.1 by adding 0.1 N NaOH. The volume (mL) required to bring the pH to 8.1 was recorded. The standards used for the analysis of titratable acidity in juices were malic acid for apple, tartaric acid for grape and citric acid for orange.

Analysis of ethanol content during fermentation

The ethanol content was performed using a Gas Chromatography (model 7897A) Mass Spectrometer (model 5975) with Head Space Analyzer (model G1888) using a DB-624 Agilent column (30 m X 0.25 mm, 1.4 μm thickness). The condition in the headspace analyzer was set at 75°C for the oven temperature, 90°C for the loop temperature and vial equilibration was 10 min. The GC injection port was set at 250°C with a split ratio 10:1. The oven temperature was maintained at 40°C at 6 min, and then increased from 80°C to 150°C for 0 min. The flow rate of the helium carrier gas was 1.2 ml/min. Total run time for each sample was 7.5 min. The analysis was carried out in triplicates

Results and Discussion

In Islamic law

From the viewpoint of Islamic law, the permissible of alcoholic fermentation is based on a hadith of the Prophet (pbuh) that permits the consumption

of nabidh fermented for up to three days (Siddiqui, 2013). It was narrated in a several hadith from the Prophet (pbuh) as bellow:

"Ibn 'Abbas reported that nabidh was prepared for Prophet (pbuh) in the beginning of the night and he would drink it in the morning and the following night and the following day and the night after that up to the afternoon. If anything was left out of that he gave it to his servant, or gave orders for it to be poured out."

(Sahih Muslim, Book 23, Hadith no. 4971)

"Ibn 'Abbas also narrated that nabidh was prepared from raisins for Prophet (pbuh) in water skin and he would drink it on that day and on the next day and following day. On the evening of the third day, he would drink it and give it to (his companions) and if something was left over, he would throw that away."

(Sahih Muslim, Book 23, Hadith no. 4974)

"Yahya Abu 'Umar al-Nakhai reported that some people asked Ibn Abbas about the sale and purchase of wine and its commerce. He asked (them): Are you Muslims? They said, Yes. Thereupon he said: Its sale and purchase and its trade are not permissible. They then asked him about nabidh and he said: Prophet (pbuh) went out on a journey and then came back and some persons amongst his companions prepared nabidh for him in green pitcher, hollow stump and gourd. He commanded it to be thrown away, and it was done accordingly. He then ordered them (to prepare it) in a water skin and it was prepared in that by steeping raisins in water, and it was prepared in the night. In the morning he drank out of that and on that day and then the next night, and then on the next day until the evening. He drank and gave others to drink. When it was morning (of the third night) he commanded what was left of that to be thrown away."

(Sahih Muslim, Book 23, Hadith no. 4975)

The term nabidh in hadith is literally derived from the word 'nabaza' which means whoever takes it or he takes dates or raisin and the word 'yanbuzu' is the act of putting something into a pot or something similar (seeka) and subsequently adding water and left to ferment (ya'furu) until it becomes an intoxicant (Manzur, 1997). At this juncture, it is important to clearly define the Arabic terms which are related to the fermentation process and to align the understanding of these terms with current terminologies or terms

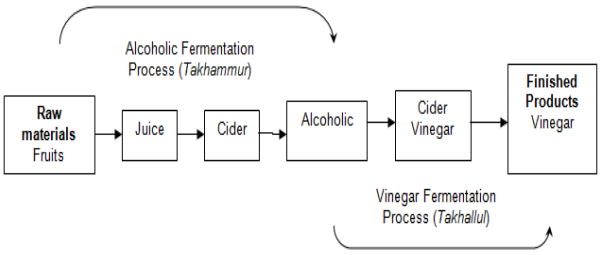

Figure 1. Fermentation process of takhammur and takhallul

related to fermentation or fermented products. Although there are different definitions ascribed to some of the terms found in the Arabic lexicon, for the purpose of this study the following definitions are adopted. Similar to nabidh, the terms 'asir' is defined as juice, obtained from grapes or other fruits (Hilal, 2005). Consequently, the term 'nabidh' is taken to mean the fermented juice, but which has not reached the intoxicating stage. On the other hand, fermented juice that has reached the intoxicating stage is known as 'khamr'.

From what have been described above, there is a transition stage during the early part of the fermentation process of dates or raisins before they become alcoholic (khamr) (Jamaludin *et al*., 2012). The product during this transition state, between juices to khamr is known as nabidh. In Islamic law perspective, is permissible and consumable. However, this permissibility is, from the understanding of the hadith, limited to nabidh not exceeding three days fermentation. In Islamic law, the first stage of fermentation, that is, the alcoholic fermentation is known as takhammur. Takhammur is a fermentation process involving a material containing carbohydrates such as dates, grape and raisin changing into alcohol, with a cider stage in between. While for the second stage of fermentation, which is conversion of alcohol or more specifically, ethanol to vinegar or acetic acid is known as takhallul (Figure 1).

In scientific perspective

Fermentation for preservation, flavour improvement, increasing of nutritive value and preparation of beverages has been used for a long time (Okafor, 2007; Sofos, 1993). Later on, fermentation using various fruits such as apple, pear and strawberry, pineapple and oranges were used to produce home wine (Fleet, 1993). Generally, fermentation is a kind of process that involves the production of organic products such as ethanol and acetic acid by converting the sugar or carbon source with the help of microorganisms such as bacteria, yeast and fungi. The fermentation process had been applied by humans since ancient time in making wine, beer, cheese and mead (honey wine)

Table 1. Change in pH, °Brix, per cent titratable acidity (%TA) and ethanol content (%) of apple, grape and orange juices during fermentation 5-days static fermentation at 30°C

Time (Day)		0	1	2	3	4	5
Sample Type							
pH	Apple	4.00 ± 0.05^{ax}	3.88 ± 0.02^{bx}	3.63 ± 0.08^{cy}	3.48 ± 0.09^{dx}	3.44 ± 0.10^{dx}	3.37 ± 0.15^{ex}
	Grape	3.98± 0.03^{ax}	3.94 ± 0.02^{bx}	3.94 ± 0.02^{bx}	3.58 ± 0.04^{cx}	3.22 ± 0.08^{ez}	3.08 ± 0.11^{ez}
	Orange	3.68 ± 0.02^{ay}	3.64 ± 0.04^{ay}	3.58 ± 0.02^{by}	3.50 ± 0.04^{cx}	3.37 ± 0.08^{dy}	3.20 ± 0.03^{ey}
°Brix	Apple	9.07 ± 0.15^{az}	8.67 ± 0.12^{az}	8.00 ± 0.20^{by}	7.73 ± 0.12^{cy}	7.40 ± 0.35^{cy}	7.13 ± 0.31^{dz}
	Grape	16.20 ± 0.20^{ax}	15.00 ± 0.20^{bx}	12.13 ± 0.61^{cx}	9.80 ± 0.40^{dx}	9.27 ± 0.46^{dx}	8.13 ± 0.12^{ex}
	Orange	10.13 ± 0.31^{ay}	9.73 ± 0.31^{by}	8.73 ± 0.61^{cy}	8.20 ± 0.35^{dy}	7.93 ± 0.42^{dy}	7.53 ± 0.50^{ey}
%TA	Apple	0.37 ± 0.06^{ay}	0.57 ± 0.06^{by}	0.74 ± 0.04^{cy}	0.86 ± 0.05^{dz}	0.91 ± 0.03^{ey}	0.96 ± 0.05^{ey}
	Grape	0.82 ± 0.04^{ax}	0.85 ± 0.04^{bx}	0.91 ± 0.01^{cx}	0.92 ± 0.02^{cy}	0.96 ± 0.02^{ey}	1.03 ± 0.07^{fy}
	Orange	0.81 ± 0.01^{ax}	0.91 ± 0.04^{bx}	0.97 ± 0.03^{bx}	1.06 ± 0.12^{cx}	1.20 ± 0.10^{dx}	1.27 ± 0.12^{dx}
Ethanol content (%)	Apple	0.13 ± 0.03^{az}	0.88 ± 0.17^{by}	2.17 ±0.08^{cz}	4.70 ± 0.16^{dy}	5.74 ± 0.15^{ey}	6.53 ± 0.24^{fy}
	Grape	0.49 ± 0.02^{ay}	2.20 ± 0.11^{bx}	4.72 ± 0.20^{cx}	5.81 ± 0.43^{dx}	6.81 ± 0.23^{ex}	7.42 ± 0.18^{ex}
	Orange	0.70 ± 0.02^{ax}	1.21 ± 0.23^{by}	3.16 ± 0.15^{cy}	4.23 ± 0.09^{dy}	5.14 ± 0.22^{ez}	6.79 ±0.11^{fy}

*The mean value within each column followed by different superscript letters (a, b, c, d, etc.) show significant (P<0.05) difference

*The mean value within each row followed by different superscript letters (x, y, z) show significant (P<0.05) difference

(Patrick *et al*., 2004). For fermentation, the fruit is macerated, where the fruit are softened and broken into pieces by pressing the fruit in order to extract the juice. The fermentation of fruit juices will yield several products based on the period of fermentation including cider, wine and cider vinegar. Cider, either in the form of soft cider or sweet cider is defined as an unfiltered, unsweetened, non-alcoholic fermented juice by adding yeast *(Saccharomyces cerevisiae)* and fermenting for a period of usually for 12 hours and above. The alcohol contents in cider vary from 2% to 8.5% (ABV of alcohol by volume). The classifications of cider vary from country to country. For example, in Spain the percentage of alcohol in cider is 4% to 8%, while in Sweden the cider must contain at least 15% of apple juice. In United States, the percentage of alcohol in cider is 0.15% (Wikipedia, 2013). According to the definition given above, cider is the product formed at the early stage of stage 1 (alcoholic) fermentation and the later middle stage of stage 2 (acetic acid) fermentation. The latter would usually known as cider vinegar.

In the stage 2 of fermentation the alcohol formed is converted to acetic acid and this is achieved through the addition of acetic acid bacteria. The vinegar bacteria are members of the genus Acetobacter and characterized by their ability to convert ethyl alcohol (C_2H_5OH) into acetic acid (CH_3CO_2H) by oxidation. This type of bacteria can live in an environment with temperatures between 25°C to 30°C, which is why the suitable incubation temperature for *Acetobacter* is between these temperatures. The amount of alcohol and acetic acid formed during fermentation will very much depend on the initial sugar content. As different types of fruits have different sugar contents, it is very important that the sugar contents of the fruit juices be known. The indicator of the sugar content is indicated through the value of °Brix which is the measurement of the total soluble solids in the fruit juice. The total soluble solid is normally referred to the sugar contents such as sucrose, glucose and fructose contained in the juice. Apart from the sugars, acids such as citrus acid, malic acid, tartaric acid and minerals also contribute to the value of total soluble solids. °Brix, is measured using a refractometer can also be expressed in terms of the value of Titratable Acidity (TA) which is the titration value of sodium hydroxide of fruit juice mixed with distilled water. To obtain the °Brix-acid ratio, °Brix is divided by the acid content. For fermentation, it is most preferable that the °Brix-acid ratio is around 20. For example, if the sugar content is 15% then a suitable acid content would be 0.75% or otherwise if the sugar content is 10%, a suitable acid content is 0.5%. From a standard and regulatory perspective, especially in relation to labeling, vinegar is defined as the final product of the two stage fermentation where the acetic acid content must be at least 4% (MDC, 2007; Regulations 1985, 2013) or at least 6% (WHO, 2001). It is also defined that wine vinegar cannot contain more than residual 0.5% alcohol or 1.0% for vinegars at large (WHO, 2001).

First stage fermentation

pH changes

The pH of different juices was produced from three different fruits (apple, grape and orange) over a five-day fermentation period are shown in Table 1. All juices showed a reduction in pH leading to an increase in acidity. At the start of fermentation, the pH of apple juice was approximately 4.00 ± 0.05ax compared to grape and orange which had values of 3.98 ± 0.03ax and 3.68 ± 0.02ay respectively. Acidification

is one of the important factor in fermentation as it has the advantage of limiting the growth of spoilage microorganisms. It can also contribute to a better flavour production at lower pH. Over the five-day fermentation period, the pH was gradually reduced to final values of 3.37, 3.08 and 3.2 for apple, grape and orange respectively. It is expected that a faster reduction in pH will indicate a higher breakdown of the substrates, and concomitantly leading to a more rapid increase of ethanol content. It can be observed from the values shown in Table 1, grape had relatively the lowest pH at day 5 fermentation and also relatively produced the highest ethanol content, that is 7.42 ± 0.18 ex% as shown in Table 1 compared to apple and orange. The production of lactic acid during fermentation will result in the lowering of the pH value (Ronald, 2008).

Changes in total soluble solids

The values of the total soluble solids (°Brix) throughout the 5 day fermentation are shown in Table 1. The °Brix value was found to reduce and this corresponded to the sugar consumption rate as fermentation progressed. At day 5, grape had the highest value of °Brix, that is 8.13 ± 0.12ex%, while apple had the lowest °Brix, 7.13 ± 0.31dz% and the value for orange was somewhere in between. At day 5, the ^{0}Brix values were significantly different ($P < 0.05$) between samples. Normally, the sugar contents in fresh fruit juice are 10% for apple, 9% for orange and 15% for grape (Girard and Fukumoto, 2000). Table 1 shows percentage sugar in fruit juices at 0 day for apple, grape and orange, which were 9.07 ± 0.15az%, 16.20 ± 0.20ax% and 10.13 ± 0.31ay% respectively. As fermentation progresses, small amounts of residual sugars can affect the microbial stability in an alcoholic beverage. To provide stability to the microbes, sugar need to be added in cases where there is insufficient sugar in the juice in order to increase the alcohol content (Zoecklein *et al*., 1998). According to Loesecke (1972), 55% of the sugars present in fruits were converted to alcohol at the completion of the fermentation process.

Change in titratable acidity (TA)

The acidity of fruits has an important role in maintaining the organoleptic properties of alcoholic beverages. It can be observed from the results shown in Table 1 that the titratable acidity in all fermenting juices increased with fermentation time. After five days of fermentation, orange was found to have the highest percentage of acidity, which is 1.27 ± 0.12dx%, compared to apple and grape, which were 0.96 ± 0.05ey%, 1.03 ± 0.07fy% respectively. There were no significant different, $P > 0.05$, between apple and grape and the end of the 5 day fermentation period. Although different types of fruits have different acid contents, there are certain major acids such as malic acid, citric acid and tartaric acid that will affect the sourness of the fermented product. It was observed that presence of acids besides affecting the flavour and aroma will also affect the colour and stability of the product (Anthony and Kate, 2009). These acids will also induce astringency in flavour (Fleet, 2003). Besides indicating the amount of total acids present in the fermented juices, titratable acidity can also be significantly related to the alcohol release in stored fermented juices during fermentation.

Change in ethanol content in fruit juices during fermentation

After 5 days of fermentation, grape contained the highest ethanol content, which was 7.42 ± 0.18ex% (Table 1). Fermented apple and orange had similar ethanol contents, 6.53 ± 0.24fy% and 6.79 ± 0.11fy% respectively. Thus, overall, at the first stage of fermentation, the amount of alcohol content was influenced by various factors for example pH value, percentage of sugar and amount of acid present.

Second stage fermentation

Changes in ethanol and acetic acid contents on mango vinegar

While the conversion of sugar to alcohol occurs during the first stage of fermentation, the conversion of ethanol to acetic acid occurs during the second stage fermentation (Maal, 2010). During the second stage fermentation of mango juice, the ethanol content started to decrease after reaching a maximum at 72 hours. In this particular case, even though the mango juice was not purposely inoculated with acetic acid bacteria, the conversion of ethanol still occurred and it is assumed that this must be due to the action of naturally occurring acetic acid bacteria in the mango juice as the bottle was exposed to the environment. As demonstrated by Ameyapoh *et al.* (2010), when the mango juice was inoculated with acetic acid bacteria at the maximum ethanol content, the reduction in ethanol content was found to be relatively more rapid (Figure 2). The reduction in ethanol content was accompanied by a concomitant increase in acetic acid (Figure 3). The standard for vinegar applied in many countries is that the acetic content must be at least 4% (Regulations 1985, 2013) or 6% (FAO/WHO, 2000) for it to be labeled as vinegar and with a maximum residual alcohol content of 0.5% v/v for wine vinegar and 1% v/v for other vinegars (FAO/WHO, 2000).

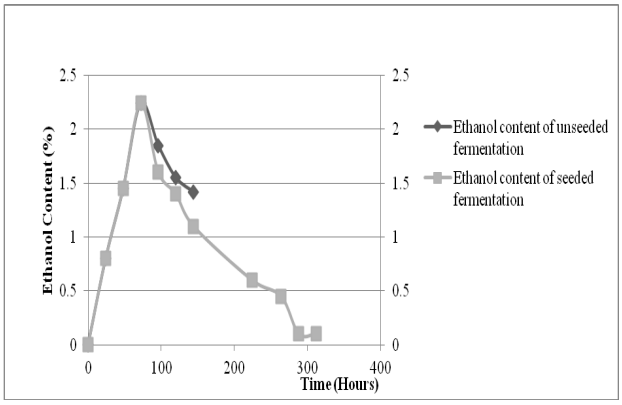

Figure 2. Evolution of ethanol content during mango vinegar productio

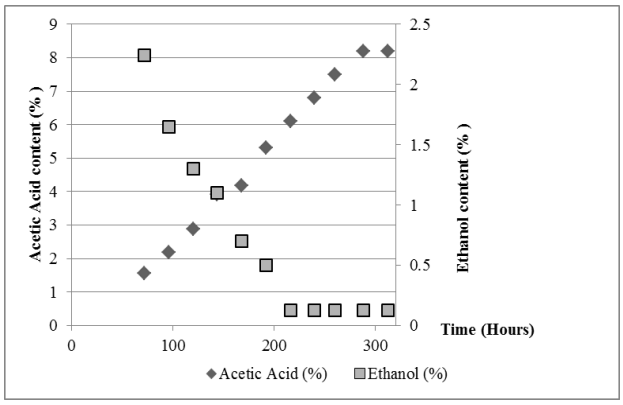

Figure 3. Evaluation of the acetic acid and ethanol content during the production of mango vinegar

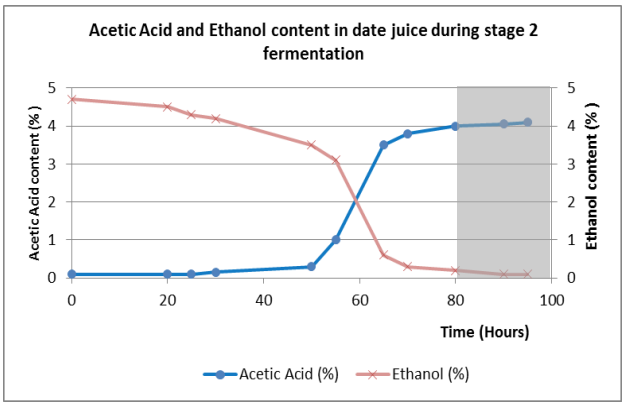

Figure 4. Evaluation of the acetic acid and ethanol content during the production of date juice

The data shown in Figure 3, concurred with this requirement and that is, when the acetic acid content is 3.92% or 4% the corresponding alcohol content is 1.1% or 1%. Mehaia and Cheryan (1991) added that in the case of fermentation of date juice (Figure 4), an alcohol content of 0.1% coincided with an acetic acid content of 4%.

Permissible alcohol and vinegar content in food products

The Islamic viewpoint of the fermentation process is where the first and second stages of fermentation are named as takhammur (or the wine making process) and takhallul (or the vinegar making process) respectively. While the consumption of khamr is prohibited due to its intoxicating effect, on the contrary the consumption of vinegar is allowed as vinegar does not cause any intoxicating effect (Auda, 2010; Sopyan, 2007). It has been an established principle of Islamic Law that the reason for the prohibition of khamr is due to its intoxicating nature (Qaradhawi, 2001). The Prophet Mohammad (pbuh) said about khamr and other intoxicants as followings:

"Anything that intoxicates is khamr and khamr is haram".

(Sahih Muslim, Book 23, Hadith no. 4962)

"Anything which intoxicates in large quantity is prohibited even in a small quantity".

(Sunan Ibn Majah, Book 30, Hadith no. 3392)

The demarcation point in terms of whether a drink containing a certain amount of alcohol or specifically ethanol is classified as khamr, as decided by the Malaysian National Fatwa Committee is 1% (v/v). If this particular principle is therefore applied to the products generated during both fermentation stages, it can be inferred that juices and fermented juices where the ethanol content has not gone beyond 1% (v/v) are permissible, while products such as alcohol cider, cider and alcoholic beverages such as beers and wines are prohibited. For products which are produced during the second stage of fermentation, vinegar or cider vinegar is considered to be permissible but for the case of cider vinegar, where the alcohol content is above 2% (v/v), from an Islamic perspective would be considered doubtful and is therefore prohibited.

Conclusion

It can be concluded that to ascertain the status of a fermented product, the consideration must be based on the fundamental principle of Islamic Law and supported through scientific evidence. Today, owing to the progress and advances made in analytical instrumentation and techniques, the precision of measurements have tremendously improved and this means that a better control and monitoring system can be put in place to determine the halal status of alcohol containing fermented products.

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