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A Preliminary Study on *Halal* Limits for Ethanol Content in Food Products

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Abstract: *Halal* food market holds the promise of rapid and sustained growth from its present USD $80 billion industry. However, problems in the certification of *Halal* products have been identified as a key issue in the development of the world market for *Halal* foods. One such issue is the inconsistent limits of ethanol permitted in *Halal* food certification due the absence of a globally verified standard limit. This preliminary study will seek to provide a way to achieve a consensus on the permissible limit of alcohol based on a simulated fermentation of *nabidh*, a grape or date juice as was found in the tradition of the Prophet Muhammad (peace and blessings be upon him). Preliminary results suggested that 0.78% alcohol might still be permissible for *Halal* certification of foods and drinks.

Key words: *Halal* · Nabidh · Alcoholic drinks · Ethanol · Permissible levels

INTRODUCTION

International and domestic *Halal* markets remain attractive and potential sources of huge revenue with at least 1.66 billion Muslim consumers around the world [1]. Over the years, the demand for *Halal* food products has increased considerably, making *Halal* certification far more important than before. *Halal* certification not only helps consumers gain confidence but it also expands existing *Halal* market and enhances sales strategies [2]. However, as shared at the World *Halal* Forum 2007 in Malaysia [3] despite of *Halal* certification being a platform to expand *Halal* market, inconsistent requirements for the certification has remained as one of the issues inhibiting the global *Halal* market potential. One of the revolving issues is the absence of a global standard allowable limit of ethanol for *Halal* certification of foods.

As a reference, alcoholic drinks or beverages are totally prohibited in Islam, and even a small amount of the drink added into foods or drinks will render the products *haram* [4]. This however does not apply to ethanol, given that trace amounts of ethanol (naturally present or ethanol used in food processing) is allowed if the amount is insufficient to cause intoxication. Regenstein *et al.* [5] stated that synthetic or grain alcohol is permitted in food processing such as for extraction, precipitation and dissolving process provided the remaining ethanol in the final product is negligible. Permissibility of ethanol is based on the concept of *Al Istihlak* (assimilation or consumption), that is, if a small amount of a prohibited substance mixed with a dominant permissible substance and the prohibited substance loses all its attributes such as taste, colour and smell, this substance loses the qualifications of being impure [6]. Furthermore, if the impurity is not detectable by taste, smell, or sight, the *Halal* status of foods will not be nullified [7]. This conclusion is also recommended by the Ninth Medical *Fiqh* Seminar of the Islamic Medical Science Organization, which met in Ad-Dar Al-Bayda', Morocco in June 1997 [6].

According to Riaz and Chaudry [7], generally 0.5% residual ethanol is acceptable in food ingredients but the acceptable limit for food products differs for various countries and organisations. The Islamic Food and Nutrition Council of America accepts a level of 0.1%, or a 1:1000 dilution of alcohol as permissible. Thai-FDA has set 0.5% (added-in or natural) ethanol in non-alcoholic beverages as *Halal* [8]. The Malaysian Islamic Development Department (JAKIM), on the other hand has loosely stated that as far as the amount of ethanol in foods is insignificant and causes no effect of intoxication, then it is permissible to be used in food processing [9]. On the other hand, a food survey carried out showed the

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amounts of ethanol present to be 0-0.13% in vinegar, 0.01-0.35% in sterilised fruit juices, 0.20-0.30 in soft drinks and 2-3% in naturally fermented soy or starch sauces [8]. The absence of a global standard allowable limit of alcohol for *Halal* certified foods prompts the need to establish one that is accepted by all *Halal* certification bodies and Muslim authorities. In line with this, the objective of this study is to use a scientific approach to identify the permissible level, based on authentic Islamic sources of law, which is the Quran and the traditions of the Prophet, peace and blessings be upon him (pbuh).

Thus, the premise of this study is based on a *hadith* (sayings of the Prophet, pbuh) that allowed *nabidh* (drink traditionally made from fruits such as raisins, grapes or dates) [10] to be consumed within three days. The transition state between *Halal* to *haram* of *nabidh* was made clear in the following *hadith*.

Ibn Abbas reported that Nabidh was prepared from raisins for Allah's Messenger (may peace be upon him) in the waterskin and he would drink it on that day and on the next day and the day following and when it was the evening of the third day, and he would drink it and give it to (his Companions) and if something was left over, he threw that away [11].

Consequently, this paper reports on a tentative study carried out by simulating the natural fermentation of *nabidh,* and the monitoring of the concentration of ethanol throughout 5-day storage, with the determination of the ethanol concentration on the third day of fermentation to be considered as the limit of ethanol permitted in *Halal* foods.

MATERIALS AND METHOD

Samples: Eight samples from a variety of grapes, dates and raisins were randomly chosen and bought from the nearest hypermarket, Tesco Extra Sungai Dua, Penang for screening purpose. Dried samples consisted of two varieties of dates (China and Egyptian) and raisins (golden and black raisins) while fresh samples consisted of four varieties of grapes (red seedless grape, Crimson grape, black seedless grape and Sugarone grape respectively).

Preparation of Nabidh: Prior to preparation of nabidh, samples were kept in refrigerator overnight. Samples with seeds were pitted, crushed and blended with distilled water in a ratio of 1:2 (w/w sample to water) to form a suspension. The suspension was filtered through a piece of Muslin cloth, aliquoted (200 mL) into 250 mL plastic bottles, capped and incubated as *nabidh* at 30°C which is the average mid-October temperature of the primary harvest season in Madinah, Saudi Arabia [12]. Each of nabidh samples was prepared in a single 250mL plastic bottle. Two bottles (7mL Favorit bijou bottle) of *nabidh* from each sample was withdrawn daily for analyses. All analyses were done in duplicate for 5 successive days and results were expressed as the main value.

Effect of Initial Sugar Concentration and Storage Temperature on Alcohol Levels Produced During Storage: After the initial screening for *nabidh* producing the highest concentration of ethanol by the third day of fermentation had been done, the effect of fermentation temperature and the initial sugar concentration on the amount of ethanol produced in *nabidh* was studied. The *nabidh* sample with the highest amount of ethanol content in the initial screening was selected and 100mL of *nabidh* (18°Bx) in 250 mL bottles were incubated static at three different temperatures (25°C, 30°C and 37°C). Another set of *nabidh* from the same sample was diluted with distilled water to produce *nabidh* with different initial sugar concentration (10°Bx, 15°Bx and 18°Bx), and then was incubated static at 30°C. Duplicate bottles (7mL Favorit bijou bottle) of *nabidh* from each set were withdrawn daily from a bottle of 250mL nabidh for analysis of ethanol and reducing sugar. All determinations were done in duplicate for five successive days.

Analyses: The *nabidh* were analyzed for soluble solids content, reducing sugar content and ethanol concentration. The amount of soluble solids was measured using a Refractometer (Atago Pellete PR-101) and reducing sugar content in the *nabidh* was analyzed using the DNS method [13] with the absorbance measured using a spectrophotometer (Thermo Spectronic Genesis IDUV). The method of ethanol analysis in wine using gas chromatography [14] was followed for the determination of ethanol in *nabidh*. Analysis was carried out using GC (Shimadzu GC 17A) equipped with Flame ionization detector (FID) and computer integrator software. The temperature of the FID detector and the injection port was set at 150°C and 250°C respectively. Helium with the flow rate of 3°C/min was used as the carrier gas. A capillary column (SGE ID-BP20, 30 m, 0.25 mm id) was used. Oven temperature was initially set at 60°C and then increased to 80°C by programming at 20°C/min.

Statistical Analysis: ANOVA analyses were performed on the data using SPSS version 17.0 for Windows. Significance was accepted at $P < 0.05$.

RESULTS AND DISCUSSION

Alcoholic fermentation is a biological process in which sugars are converted into cellular energy and thereby producing ethanol and carbon dioxide as metabolic waste products [15]. Numerous papers concerning sugar utilization by yeast have been published and it has been reported that ethanol production rate by yeast is limited primarily by the rate of sugar intake [16]. In this study, sugar utilization was monitored through reducing sugar and soluble solids (apparent brix) measurement (Table 1). Although apparent brix (soluble solids) is not an exact measurement of sugar content, it allows one to easily observe the trend of fermentation and have been used in most parts of the world to express sugar content during fermentation [17]. The decrease in soluble solids corresponding to decreases in reducing sugar content in medium as shown in Table 1 was also reported by Ocloo and Ayernor [18]. A decrease in the reducing sugar with concomitant increase in the ethanol content of the *nabidh* over the storage period observed is due to the fact that sugar is utilized by yeast as a source of energy and thereby producing ethanol. These changes indicated the evidence of fermentation in progress.

Putative Halal Limits for Ethanol Content in Foods: In order to determine the limit of ethanol in *Halal* food, analysis of ethanol content in *nabidh* samples was carried out for five successive days. Results (Table 1) showed no significant increase in ethanol content in the first two days of fermentation. However, on day 3 of fermentation, significant increases of ethanol started to be observed in *nabidh* samples of dates (Egypt) and grapes (Red, Crimson and Sugarone). By day-4, significant increases of ethanol content were observed for all samples except for *nabidh* from date (China). The fact that significant changes only started on day-3 of fermentation suggests a scientific explanation behind the reason day-3 of fermentation was chosen as the limit in the *hadith* of the Prophet (pbuh). In addition, Pramanik and Rao [19] have also reported day-3 as an optimum fermentation time since nearly 98.5% of the initial sugar contained in grape waste juice was utilized at 30°C. On the other hand, Torija *et al*. [20] in their study on the effects of fermentation temperature on the strain population of *Saccharomyces cerevisiae* described that at temperatures of 20, 25 and 30°C, yeast reached its maximal population at day-3 of fermentation. From the results (Table 1), the highest concentration of ethanol on day-3 was 0.78% in *nabidh* from Red grapes and thus, in the light of the *hadith* quoted earlier, that level of ethanol may be suggested as still acceptable for *Halal* certification of foods and drinks.

Effect of Storage Temperature on Ethanol Levels Produced in Nabidh: The effect of storage temperature on the ethanol limit suggested in the first part of the work was then investigated. There are some factors that strongly affect alcoholic fermentation and hence, the production of ethanol. One of these factors, the fermentation temperature exerts a pronounced effect on growth, metabolism and survival of the fermenting organism [21]. However, the optimum temperature of fermentation is strongly strain dependent [22]. According to Pramanik and Rao [19], alcoholic fermentation using conventional baker's yeast increased as temperature increased to optimum value between 30°C to 40°C. In contrast, Fleet and Heard [23] suggested a much lower optimum range of between 20°C to 25°C. *Nabidh* samples kept in static 25°C, 30°C and 37°C incubators also showed that the rate of fermentation increased as temperatures increased. However, although ethanol formation at 30°C was significantly higher than that at 25°C by day-3 of the fermentation, there was no significant difference with that at 37°C except for days 2 and 4 (Table 2) indicating an optimum temperature of 30°C to 37°C for the fermentation of *nabidh* by indigenous flora.

Effect of Initial Sugar Concentration on Ethanol Levels Produced in Nabidh: Initial sugar concentration also has a significant effect on fermentation time [19, 24], and thus, the amount of ethanol produced within a stipulated time. The optimum initial substrate concentration is reportedly the function of the amount of sugar in the samples and the limit of tolerance of the yeast strain to ethanol [22]. Thus, the initial sugar concentration of the *nabidh* may have some bearing on the ethanol limit proposed. Previous studies on the effect of initial sugar concentration showed that ethanol concentrations increased as higher sugar concentration were used, with an adverse effect observed beyond a certain level of sugar [19, 25, 26] attributable to osmotic pressure [27]. Gaur [21] reported that generally, osmotic pressure becomes pronounced beyond 16-18% of sugar.

Table 1: Ethanol, reducing sugar and soluble solids contents in *nabidh* from different sources, measured during a static fermentation at 30°C for 5 days.

Samples Type	Specification	Day	Ethanol Content (%)	Reducing Sugar (mg/mL)	Soluble Solids (°Bx)
Date	(Egyptian)	1	0.003^{a}	30.795^{e}	26.3^{b}
		2	0.011^{a}	26.546^{d}	21.6^{a}
		3	0.636^{b}	21.644^{c}	28.9^{d}
		4	2.254^{c}	13.857^{b}	27.4^{c}
		5	2.834^{c}	2.177^{a}	28.6^{d}
Date	(China)	1	<0.001	21.936^{c}	23.3^{d}
		2	<0.001	21.674^{c}	22.9^{d}
		3	<0.001	24.843^{c}	21.4^{c}
		4	0.010^{a}	17.425^{b}	19.0^{b}
		5	0.130^{b}	12.565^{a}	16.8^{a}
Raisin	(Black)	1	0.010^{a}	25.504^{c}	24.1^{c}
		2	0.009^{a}	22.061^{b}	24.3^{c}
		3	0.008^{a}	25.754^{c}	24.3^{c}
		4	1.047^{b}	21.586^{ab}	22.6^{b}
		5	3.677^{c}	20.950^{a}	20.2^{a}
Raisin	(Golden)	1	0.004^{a}	15.048^{a}	23.2^{cd}
		2	0.005^{a}	27.613^{d}	23.0^{c}
		3	0.019^{a}	26.435^{d}	23.5^{d}
		4	1.576^{b}	20.289^{b}	20.0^{b}
		5	9.301^{c}	23.772^{c}	17.0^{a}
Grape	(Black)	1	0.041^{a}	22.110^{b}	19.7^{c}
		2	0.039^{a}	21.212b	15.0^{a}
		3	0.050^{a}	18.192a	18.4^{b}
		4	0.201^{b}	16.870a	19.1^{c}
		5	0.720^{c}	16.021^{a}	18.0^{b}
Grape	(Crimson)	1	0.072^{a}	14.761^{c}	15.0^{c}
		2	0.040^{a}	14.400^{c}	14.7^{c}
		3	0.418^{b}	12.565^{b}	14.6^{c}
		4	1.356^{c}	12.141^{b}	13.3^{b}
		5	2.291^{d}	7.462^{a}	11.4^{a}
Grape	(Red)	1	0.048^{a}	17.182^{c}	17.6^{d}
		2	0.042^{a}	16.700^{c}	17.1^{cd}
		3	0.777^{b}	14.387^{b}	16.7^{c}
		4	1.141^{c}	14.175^{b}	15.6^{b}
		5	2.078^{d}	10.032^{a}	13.8^{a}
Grape	(Sugarone)	1	0.004^{a}	14.998^{d}	15.8^{c}
		2	0.003^{a}	12.952^{b}	15.7^{c}
		3	0.001^{b}	14.025^{c}	16.0^{c}
		4	0.012^{c}	13.426^{bc}	15.1^{b}
		5	0.040^{d}	10.418^{a}	14.2^{a}

Values in the same column from the same sample having the same superscripts are not significantly different ($P < 0.05$).

Table 2: Effect of fermentation temperature on ethanol concentration and reducing sugar concentration in *nabidh* (18°Bx) during a static fermentation for 5 days

	Ethanol concentration (%)			Reducing sugar concentration (mg/mL)		
Fermentation Temperature (°C)	25°C	30°C	37°C	25°C	30°C	37°C
Day						
1	0.040^{a}	0.040^{a}	0.040^{a}	24.793^{a}	24.793^{a}	24.793^{b}
2	0.108^{a}	0.161^{a}	0.868^{b}	15.497^{a}	15.273^{a}	16.720^{b}
3	2.299^{a}	3.849^{b}	3.690^{b}	13.124^{b}	7.377^{a}	7.103^{a}
4	3.932^{a}	4.656^{b}	5.850^{c}	6.692^{b}	3.004^{a}	3.060^{a}
5	4.506^{a}	5.851^{b}	6.221^{b}	5.786^{c}	1.959^{a}	3.004^{b}

Values in the same row from the same analysis having the same superscripts are not significantly different ($P < 0.05$)

Table 3: Effect of initial sugar concentration on ethanol concentration and reducing sugar concentration in *nabidh* during a static fermentation at 30°C for 5 days

	Ethanol concentration (%)			Reducing sugar concentration (mg/mL)		
Initial Sugar Concentration (°Bx)	10°Bx	15°Bx	18°Bx	10°Bx	15°Bx	18°Bx
Day						
1	0.038^{a}	0.045^{b}	0.040^{a}	12.540^{a}	14.786^{b}	24.793^{c}
2	0.138^{a}	0.246^{b}	1.105^{c}	7.611^{a}	13.451^{b}	16.270^{c}
3	2.319^{a}	3.321^{a}	2.619^{a}	2.127^{a}	3.782^{b}	9.255^{c}
4	3.105^{a}	4.424^{b}	4.994^{b}	1.525^{a}	4.534^{b}	4.360^{b}
5	4.443^{a}	4.760^{a}	7.216^{b}	0.337^{a}	0.137^{a}	4.973^{b}

Values in the same row from the same analysis having the same superscripts are not significantly different ($P < 0.05$).

The effect of the initial sugar concentration on the amount of ethanol produced in *nabidh* during storage was studied with initial sugar concentrations set based on soluble solids concentration of 10°Bx, 15°Bx and 18°Bx respectively. Results (Table 3) showed that ethanol concentrations in the *nabidh* increased as with increase in initial sugar concentration used. However, since 18°Bx was the natural concentration of the sugars in the crushed grapes used to make the *nabidh*, the concentration of ethanol at the third day (and hence the alcohol limit suggested) may only be increased if the *nabidh* was made from a much sweeter variety of grape. Complete sugar utilization by the fifth day of fermentation was noticed for *nabidh* with initial sugar concentrations of 10°Bx and 15°Bx.

CONCLUSION

This preliminary study on the limit of allowable ethanol in *Halal* foods provides an alternative on how the setting of limit could be scientifically carried out based on authentic religion scriptures. An initial screening of *nabidh* from different sources suggested that 0.78% ethanol in foods and its products are still permissible for *Halal* certification. The limit suggested could probably an underestimate if the effects of temperature and initial sugar concentration were to be taken into account. In addition, if the standard global limit is to be suggested, additional studies on method validation and measurement of uncertainty are necessary to precisely state a reliable figure.

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