ADVANCED GLYCATION END PRODUCTS: THE KNOWLEDGE, ATTITUDE AND PRACTICE AMONG IIUM KUANTAN UNDERGRADUATE STUDENTS

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ABSTRACT

Introduction: Advanced glycation end products (AGEs) are group of compounds that are formed exogenously from diet and endogenously in our body. Generally, AGEs are produced through a non-enzymatic process known as Maillard reaction. The exposure of lipids and proteins with reducing sugar will result in the formation of these compounds. AGEs have been associated with the progression of many chronic diseases such as diabetes, cardiovascular diseases and neurodegenerative diseases when consumed in high amounts. The main objective of this research is to explore the level of knowledge, attitude and practice of IIUM Kuantan undergraduate students regarding the consumption of food containing high AGEs. **Methods:** A total of 164 undergraduate students have been recruited in this study that was conducted in International Islamic University Malaysia encompassing six kulliyyahs. A self-administered questionnaire has been distributed to the respondents to observe their extent of knowledge, attitude and practice regarding AGEs. Apart from their demographic data, various questions regarding the knowledge, attitude and the consumption practice of AGE-containing foods were asked. Based on the analysis of results, 77% of the respondents depicted poor knowledge related to AGEs statements. half of the students (51.8%) portrayed moderate attitude towards AGEs To assess the practice of the students, 26 high AGEs foods have been selected from an available database and respondents were classified into low and high AGE group based on their food frequency questionnaire. **Results:** The results showed that 89.6% of the respondents fell under the low AGE-consumption group. Furthermore, a significant positive correlation was found between knowledge and attitude scores of the respondents ($r = 0.532$, $P < 0.001$). However, no association was found between knowledge score and AGE consumption per day among students. **Conclusions:** In conclusion, more approach needs to be done to establish a good knowledge, attitude and practice towards AGE since this study is still new in Malaysia.

KEYWORDS: AGEs, Maillard reaction, Knowledge, Attitude, Practice

INTRODUCTION

Modern diets are mostly heat-processed which results in high levels of advanced glycation end products (AGEs). AGEs are a large and complex group of compounds that exists almost everywhere among tissues and organs of the human body that formed through the process of Maillard reaction. It is often associated with the complications of diabetes, kidney disease, metabolic disorders and degenerative diseases as their concentration rises with age (Axel, Celine, Eric & Frederic, 2016). Animal-based foods that are high in fat and protein are generally rich in AGEs whilst carbohydrate-rich foods such as fruits, wholegrains, and milk as well as vegetables consist relatively low AGEs. This may be due to the presence of higher water content or antioxidants and vitamins which will eventually prevent new AGE formation (Jaime et al., 2010). Generally, AGEs are formed endogenously in our body as part of the normal metabolism through non-enzymatic reactions between amino acids and sugars. However, if excessively high levels of AGE accumulated in tissues and circulation it will result in pathogenic compounds. Foods that are exposed to high temperature cooking techniques such as deep-frying, baking, broiling, roasting and grilling can elevate the total daily AGE intake by 25% compared to the average adult daily intake when consumed (Estifanos et al., 2017). Data on the average daily intake of dietary AGE in general population are currently limited. However, based on cohort study of healthy adults conducted in New York City found that the average dietary AGE intake is around 14,700±680 AGE kU/day (Jaime et al., 2010). Based on early findings, Western-style fast foods such as grilled and broiled meats and also French fries contain high levels of pro-inflammatory AGEs (Luanne, 2017). As noted by Abate et al. (2015), the level of AGEs is not only contributed by endogenous AGEs but dietary AGE intake also shows significant effect. Chronic diseases such as diabetes and cardiovascular diseases can be alleviated or even cured if the intake of dietary AGEs is low. According to studies conducted in rats, about 10% to 30% of dietary AGEs are absorbed intestinally and enter the circulation (Paraskevi & Markus, 2012). This can be supported by Abate et al. (2015) where the studies on mice and human reported that dietary AGEs can be absorbed at intestinal level and possess toxicity. A safe and optimal level of dietary AGE intake has yet to be concluded. However, it can be postulated that in people who consumed diet rich in grilled or roasted meats and highly processed foods could achieve up to 20,000 AGE kU/day excessively. On the contrary, those who consumed meat prepared with moist heat method like stews and soups regularly could reduce half of the daily intake. Animal studies also demonstrate that a reduction of dietary AGE by 50% of normal intake is correlated with reduced level of oxidative stress, increased lifespan and reduced risk of diabetes. In addition, mice that were fed with calorie restriction diet have low body weight as well as maintain normal insulin levels as been noted by Weijing et al. (2008).

METHODS

Subjects

Approximately 164 undergraduate students from International Islamic University Malaysia (IIUM) Kuantan campus were recruited through convenience sampling method to participate in this study. A self-administered questionnaire that also includes informed

consent form were distributed to the respondents through convenience sampling method. Ethical approval was obtained from Kulliyyah Postgraduate and Research Committee (KPGRC) and IIUM Research Ethics Committee (IREC) for this study to be conducted.

Self-administered questionnaire

The questionnaire consisted of 2 sections which are socio-demographic data including age, year of study and kulliyyah of the respondents. For the second parts, respondents were asked about their awareness, knowledge, attitude and practice on AGEs. As for the practice section, 26 high AGE foods were obtained from the food database from the study that had been conducted by Jaime et al. (2010) that analysed the AGE content for 549 foods by using different cooking methods. Based on literature review, meat and poultry are among the foods that contain high AGE, thus they are included in the food frequency questionnaire the most. The selection of foods is also based on its availability and commonly consumed food among the students.

Statistical analysis

All data were coded, entered and analysed by using Statistical Package for Social Science (SPSS) Version 12.0.1 for Windows. Descriptive statistics was applied to analyse the sociodemographic data, knowledge score, attitude score and practice of the respondents. Crosstabs test was used to determine the awareness regarding AGE among students in each kulliyyah. The response of the students for each item in the questionnaire were expressed in both frequencies and its corresponding percentages. Pearson's correlation test was used to find association between knowledge score and attitude score as well as association between knowledge score and AGEs content per day among students. The significant value was set at 95% confidence interval.

RESULTS

The Table 1 shows the number and distribution of students in the Kulliyyah.

Table 1 Distribution of undergraduate students according to Kulliyyah

Variable	N	%
Gender		
Male	60	36.6
Female	104	63.4
Kulliyyah		
Sciences (KOS)	49	29.9
Allied Health Sciences (KAHS)	41	25.0
Nursing (KON)	29	17.7
Medicine (KOM)	19	11.6
Dentistry (KOD)	14	8.5
Pharmacy (KOP)	12	7.3

The awareness regarding AGE among students

Based on Table II, almost of the respondents claimed that they have never heard about AGE with the percentage of 63.4% (n=104) prior to this study. However, there are 28.7% (n=47) out of all students that have heard about AGE primarily during lectures and friends. Only 7.9% (n=13) are unsure regarding AGE.

Table 2. The distribution of the awareness regarding AGE among students (n=164)

Question: Have you ever heard about AGE?	**Yes** % **(n)**	**No** % **(n)**	**Unsure** % **(n)**
KOS	2.0 (1)	87.8 (43)	10.2 (5)
KAHS	26.8 (11)	63.4 (26)	9.8 (4)
KON	13.8 (4)	82.8 (24)	3.4 (1)
KOM	94.7 (18)	0.0 (0)	5.3 (1)
KOD	35.7 (5)	50.0 (7)	14.3 (2)
KOP	66.7 (8)	33.3 (4)	0.0 (0)
Total	**47**	**104**	**13**

Knowledge regarding AGE

The knowledge on the statements regarding AGE were assessed by evaluating both true and false answers. Then, the total scores are classified into three categories, which are good (75% - 100%), moderate (51% - 74%) and poor (≤50%). As shown in Table III, most of the respondents (77.4%, n=127) falls in the 'Poor' category, while 21.3% (n=35) and 1.2% (n=2) were from moderate and good knowledge group respectively.

Table 3. Categories of knowledge among students

Knowledge group	**Frequency**	**%**	**Mean ± SD**
Good	2	1.2	2.76 ± 0.455
Moderate	35	21.3	
Poor	127	77.4	

Table IV Knowledge statements regarding AGE (n=164**)**

Statement	**True**	**False**	**Unsure**

1. Advanced glycation end products and Maillard reaction is the same process.	9.1% (n=15)	**8.5% (n=14)**	82.3% (n=135)
2. Diabetes and cardiovascular diseases are among the diseases that have been associated with AGE.	**50.6% (n=83)**	5.5% (n=9)	43.9% (n=72)
3. There are three sources of AGE that have been studied widely.	5.5% (n=9)	**1.8% (n=3)**	92.7% (n=152)
4. The average AGE consumption in our daily intake is around 15,000 AGE k/U day.	**2.4% (n=4)**	3.7% (n=6)	93.9% (n=154)

Note. The one in **BOLD** is the correct answer

Attitude towards AGE

For this section, the attitude of the respondents was measured by using the Likert scale accordingly. Table IV depicted that moderate group dominates the categories with the percentage of 51.8% (n=85), second is from good group with the percentage of 47.6% (n=78) and the poor group has the lowest percentage, 0.6% (n=1).

Table V Categories of attitude group among 164 students

Attitude group	Frequency	%	Mean ± SD
Good	78	47.6	1.53 ± 0.513
Moderate	85	51.8	
Poor	1	0.6	

Table VI Attitude statements towards AGE (n=164)

Statements	% (n)
1. I think there is no problem not knowing about AGE.	
Strongly disagree	7.3% (12)
Disagree	12.2% (20)
No opinion	22.6% (37)
Agree	44.5% (73)
Strongly agree	13.4% (22)
2. I believe fruits and vegetables are important to include in the diet as they contain low level of AGE.	
Strongly disagree	0.6% (1)
No opinion	24.4% (40)
Agree	46.3% (76)
Strongly agree	28.7% (47)
3. I believe that Western-style food is the major contributors to high AGE level.	
Strongly disagree	1.2% (2)
Disagree	8.5% (14)
No opinion	45.1% (74)
Agree	32.3% (53)
Strongly agree	12.8% (21)
4. I am confident that foods high in sugar content contains high level of AGE.	
Strongly disagree	0.6% (1)
Disagree	4.3% (7)
No opinion	44.5% (73)
Agree	39.0% (64)
Strongly agree	11.6% (19)
5. Dry heat cooking method such as grilling, roasting, broiling, baking and frying should be practiced moderately.	
Strongly disagree	1.2% (2)
Disagree	4.9% (8)
No opinion	27.4% (45)
Agree	54.3% (89)
Strongly agree	12.2% (20)
6. I will take initiative to learn the knowledge regarding AGE.	
Strongly disagree	1.2% (2)
No opinion	23.8% (39)
Agree	44.5% (73)
Strongly agree	30.5% (50)

Practice (consumption of AGE-containing foods among students)

The practice section of the respondents was based on the food frequency questionnaire which consists 26 high AGE foods. Since the average consumption of AGE is 15,000 AGE k/U per day, the respondents that consumed more than the average amount is classified as high AGE group and if the consumption is less than 15, 000 AGE k/U day, it is classified as low AGE group. About 10.4% of the students were classified as high AGE group while the remaining 89.6% were from low AGE group. Figure I portrayed the percentage of AGE-consumption among students for both groups.

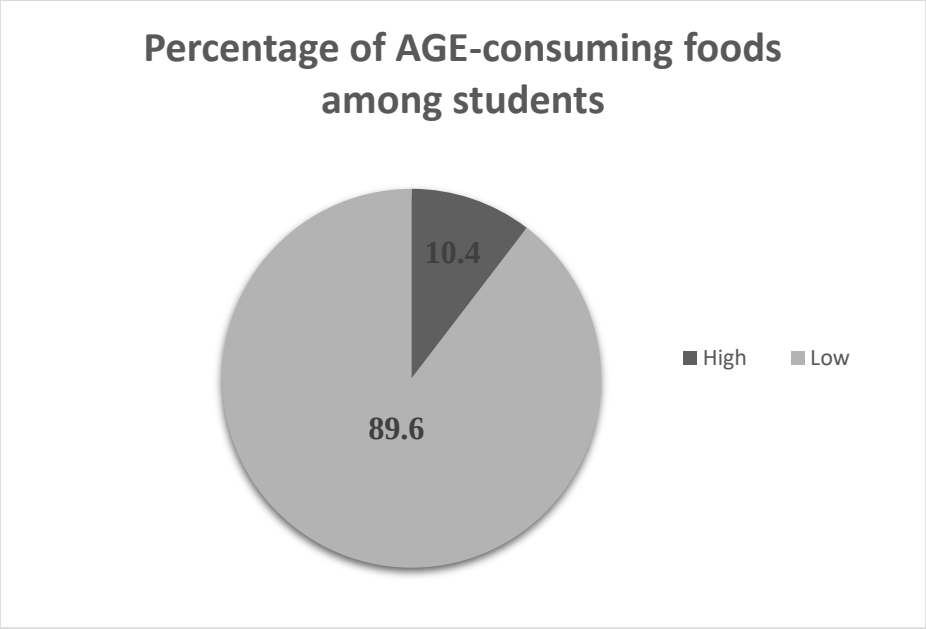

Figure I The percentage of AGE-foods consumption among students

The association between knowledge score and attitude score towards AGE among students

The correlation between the knowledge score and attitude score among showed that there was a moderate, positive correlation between knowledge score and attitude score among IIUM Kuantan undergraduate students.

Table VII Summary table for Pearson's correlation analysis

	Mean ± SD	***r***	***p***
Knowledge	6.77 ± 5.857	0.532	<0.001
Attitude	40.14 ± 4.955		

The association between knowledge score and AGE content per day among students

The correlation between knowledge score and AGE content per day among students showed that there was no correlation between knowledge score and the AGE content per day among students.

Table VIII Summary table for Pearson's correlation analysis

	Mean ± SD	***r***	***p***
Knowledge	6.77 ± 5.857	- 0.05	0.528
AGE consumption (unit)	8320.03 ± 6919.83		

DISCUSSION

It can be observed that 60% of the respondents had never heard about AGE all this time (Table II). This can be expected since the study on AGE is still gaining attention globally and not much research is done in Malaysia yet. Out of 19 students from Kulliyyah of Medicine, 18 of them stated that they have heard about AGE compared to their counterparts from other kulliyyah. They stated that they learned about AGE in one of the subtopics under Diabetes Mellitus. As for the assessment of knowledge, majority of the students are unsure whether AGE and Maillard reaction is the same process or not. According to Malene et. al (2016), AGE and Maillard reaction are distinguishable. Maillard reaction is the process that responsible for the flavouring, aroma and colouring of the foods for desirable effects while AGE are the products that are formed through this process. Considering that half of the respondents managed to answer correctly regarding the relation between diabetes and cardiovascular diseases (CVD) with AGE, this proves that students were aware about the deleterious effects of diabetes and CVD. The association between diabetes with AGE have been clearly described by Malene et al. (2013) that observed the positive correlation between serum concentration of AGE with Type 1 and Type 2 diabetes. Claudia & Karen (2010) reported in their studies that the in vivo accumulation of AGE may lead to changes in the function and structure of cardiovascular system for a prolonged period. Low knowledge percentage regarding the sources of AGE that have been studied widely and average consumption of AGE per day is in line with the percentage of awareness regarding AGE among students based on Table II. Since there is a lack of awareness among students, it does make sense that the knowledge is also low due to lack of exposure regarding AGE. Overall, most of the students have poor knowledge regarding AGE. The attitude of the students can be concluded as having moderate-positive attitudes. Only a few numbers of students strongly disagreed that not knowing about AGE is no problem. Among the reason could be due to students not having the idea regarding AGE and the importance of knowing it. Almost half of the students believed that fruits and vegetables are important to include in the diet. This indicates that they acknowledge the benefits of consuming fruits and vegetables in their daily intake. Most of the students stated that they have no opinion whether the Western-style diet is the major contributors to high level of AGE meaning that they have never heard or read about it. This result is similar with the statement 'I am confident that foods high in sugar content contains high level of AGE'. The statement 'Dry heat cooking method such as grilling, roasting,

broiling, baking and frying should be practiced moderately' recorded the highest percentage among all statements indicating that students are aware that this kind of cooking method are not classified as healthier options for cooking. Majority of the students agreed to take initiative to seek the knowledge regarding AGE upon completing this questionnaire. Meanwhile, the practice of the students on the consumption of AGE-containing foods showed that most of the students are from low group which indicates that their consumption is less than 15,000 AGE k/u per day. The average consumption of dietary AGE is found to be 14,700 ± 680 AGE kU/day from the cohort study that is conducted among heathy adults of New York city. Therefore, this data is used to define between a high and low-AGE diet in this study. Nevertheless, the foods listed in the questionnaire are also limited and the selection of foods are based on the database that is conducted by Jaime et al. (2010) in New York. Further studies to analyse AGE in common Malaysian foods is highly warranted.

The students' knowledge was significantly correlated with the attitude indicating that increased knowledge is associated to positive attitudes regarding AGE. However, based on the results of Pearson's correlation analysis, it showed a moderate correlation. The association between knowledge and attitude have historically been found reported a weak to moderate correlation (Lay & Anuthra, 2014). In order for someone to develop good attitude towards AGE, they must have relevant knowledge regarding it first. Therefore, it is necessary to conduct more interventions to improve the knowledge and develop an educational model to reinforce the attitude of the students towards AGE. In contrast, the students' knowledge showed no correlation with their practice meaning that increased knowledge does not influence their practice regarding the consumption of AGE-containing foods. As been discussed earlier, this is highly due to the limitation of foods listed in the food frequency questionnaire. Therefore, future research should focus on analyse more foods that commonly consumed among university students as well as reinforce positive practices towards the consumption of AGE-containing foods.

CONCLUSION

Based on the findings, we observed that most of the students have poor knowledge regarding AGE despite their positive attitudes. Students are more prone to consume Western-style diet since it is more accessible and readily available. Majority of them are also classified under the group with low consumption of AGE-containing foods indicating that their dietary habits are on a satisfactory level. An approach to spread the information regarding AGE and its consequences to health must be conducted to enable target populations to distinguish between low- and high-quality foods plus can prevent from pathogenic and carcinogenic properties of AGE.

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