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Energy contribution of NOVA food groups and socio-demographic determinants of ultra-processed groups among adults in Terengganu, Malaysia

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Abstract

The Malaysian Nutrition Research Priorities for Malaysia's 11th Plan noted the necessity to investigate in depth the consumption of ultra-processed food among the Malaysian population. No empirical research has focused on exploring the energy contribution of ultra-processed foods and the socio-demographic determinants of ultra-processed foods. Thus, this study was conducted to investigate the relationship between the increasing consumption of ultra-processed foods with socio-demographic factors particularly in Terengganu, Malaysia. This cross-sectional study provides a novel approach to quantifying energy contribution of 200 adults (living in Terengganu; aged 18 to 59 years) based on the ultra-processed food classification named as NOVA, via semi-quantitative Food Frequency Questionnaire, and to determine the association between energy contribution of ultra-processed foods and socio-demographic characteristics. The self-administered questionnaire consists of three sections: socio-demographic profile, frequency of ultra-processed food consumption and energy contribution of NOVA food groups. All data were analysed using SPSS version 21. The findings show that the contribution of ultra-processed foods among respondents was lower (40.38%) compared to unprocessed and minimally processed foods (55.73%). The most frequent consumed ultra-processed foods were noodles and fried chicken (fast food). Meanwhile, the least frequently consumed foods included frozen chicken pie and garlic spread. There were significant associations between the energy contribution of ultra-processed foods and marital status, educational level, monthly household income and occupational status meanwhile there was no significant association between age and gender at $p<0.05$. This study provides the first comprehensive assessment of ultra-processed foods consumption using NOVA classification via semi-quantitative FFQ in Malaysia.

1. Introduction

NOVA has received recognition from the Food and Agriculture Organization of the United Nations and the Pan American Health Organization as a valid tool for nutrition and public health research, policy and action (Monteiro *et al*., 2016). NOVA (a name, not an acronym) is a food classification that has been recently proposed as a new approach to classify all foods and beverages into four distinct groups according to the nature, extent and purpose of their processing, including unprocessed or minimally processed foods, processed culinary ingredients, and processed and ultra-processed foods, in order to study the role of industrial food processing in the nutritional transition (Monteiro *et al*., 2010). The rapid transition of eating habits from consuming freshly prepared meals from nutritious foods to ready to consume ultra-processed products that are nutritionally imbalanced clearly shows a remarkable increase in the consumption of ultra-processed products (Filippa and Erik, 2015). As estimated from the direct consumption of ultra-processed products, daily per capita energy intake in Sweden increased by 15%, from 2820 kcal in 1960 to 3250 kcal in 2010 (Filippa and Erik, 2015). In Canada, an average of 61.7% of daily energy was found to be contributed by ready-to-eat products; a total of 54.9% of energy came from the ultra-processed products (Moubarac *et al*., 2013). Meanwhile, in Mexico, 54.0% of the energy intake was contributed by unprocessed or minimally processed foods, and 29.8% of the energy contribution came from the ultra-processed products (Joaquín *et al*., 2018).

The consumption of ultra-processed food has been growing both in relative and absolute terms in high and middle-income countries, despite being higher in high-

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income countries (Moubarac *et al*., 2013). From 2002 until 2009, purchases of ultra-processed foods increased more among lower-income families than among higher-income families (Martins *et al.,* 2013). The decreasing price of ultra-processed food could be the main factor for increasing consumption among the poorer classes. The purchase of ultra-processed food, which previously used to be higher among upper-income classes during the last two periods, has increased in all income groups mainly among those of lower income (Martins *et al.,* 2013). Increased consumption of food such as fried foods, sugar and fat has been associated with those with low economic position meanwhile increased consumption of whole grains, lean meats, fish, low-fat dairy products and fresh fruits and vegetables has been associated with those with high socioeconomic position of those in the developed countries (Galobardes, 2001). In contrast to developing countries, aside from higher income people, individuals living in urban areas who are younger also tend to have a higher consumption of ultra-processed foods (Gustavo *et al.,* 2017). Furthermore, women have the highest proportion of ultra-processed food intake compared to men, although the contribution of ultra-processed foods to the overall diet was very similar between men and women (Thibault *et al.,* 2018). Women living without a partner, with higher education, stable income and normal BMI consume ultra-processed foods more frequently (Marrón-Ponce *et al.,* 2018). People with educational background advantages tend to purchase more fresh fruit and vegetables more regularly than the least educated (Garvin Turrell *et al.,* 2002). In Mexico, 41.6% of participants that had consumed ultra-processed products lived in households in which the head of the family had lower educational background status (Joaquín *et al.,* 2018). Head of family's educational level was closely related to unprocessed or minimally processed food consumption since it related to the availability of healthier foods at home (Fernanda *et al.,* 2016). All in all, socio-demographic may influence the energy contribution of each of the NOVA food groups.

Furthermore, studying consumption of ultra-processed foods is crucial, as emphasized in the Nutrition Research Priorities for 11th Malaysia Plan (2016-2025). There is strong evidence that increasing rates of obesity are due to the consumption of high-energy foods, such as processed foods which are higher in fats and sugars compared to the low-energy foods. According to the National Health and Morbidity Survey (NHMS), the rate of obesity in Terengganu has increased from 14.0% in 2011 to 18.6% in 2015. A study by Malaysian Adult National Survey (MANS) showed that socio-economic developments such as urbanization and economic growth in the country are attributed largely towards the changes in the lifestyle and dietary habits of Malaysians population over the last decade (Norimah *et al*., 2008). These developments have been important drivers for changes in lifestyle, such as less frequent meals at home and increased snacking (Filippa and Erik, 2015). Traditional dietary patterns based on unprocessed or minimally processed foods have been replaced with the rapidly growing products, and there has been no verification of the consistency of the associations between socioeconomic position and consumption of ultra-processed foods (Simões *et al.,* 2018).

The association of ultra-processed food with different socio-demographic position indicators needs to be explored in order to verify the consistency of the associations between socio-demographic position and consumption of ultra-processed foods. This study is important in order to determine whether there is a relationship between the increasing consumption of ultra -processed foods and socio-demographic factors. Furthermore, Malaysia lacks national-level data of the consumption of ultra-processed foods and its relation to social and economic status. Research is much needed on various aspects, including the classification of the foods and several factors affecting the increasing consumption among the Malaysian population, especially in Terengganu.

2. Materials and methods

2.1 Sampling plan

This study was conducted in Kuala Nerus, a district in Terengganu. Kuala Nerus was purposely selected for its fast development, higher education institutes, as well as various industrial and housing areas. This study used convenience sampling in which adults with from 18 years old and above in Kuala Nerus was selected as the respondents. The minimum sample size derived from Cochran formula for this study was 162 respondents ($Z_{1-\alpha/2}$ = 1.96, prevalence proportion of obese in Terengganu (NHMS, 2015) = 28.9%, and absolute error or precision = 0.07). The study was carried out between June and August 2018. A subject information sheet and informed consent were given to respondents prior to the data collection. Ethical approval for this study was attained from the Human Ethics Board of Committees of Universiti Malaysia Terengganu with reference number: UMT/JKEPM/2017/3.

2.2 Food frequency questionnaire

A total of 165 food items in the Food Frequency Questionnaire (FFQ) are listed in the Malaysian Adult Nutrition Survey (MANS). Food items consumed in the FFQ for the last month were assigned to four groups according to the NOVA food classification, which is based on the nature, extent, and purpose of industrial

food processing: unprocessed or minimally processed foods and processed culinary ingredients; processed foods; and ultra-processed foods. Each food item listed was given a standard serving size based on the food album, *Album Saiz Sajian Malaysia*. The response format of the FFQ was per day, per week, and per month. Frequency of intake of the items in FFQ was estimated using the formula from Norimah *et al*. (2008). The conversion factor used to estimate food intake was based on the frequency of intake of each food.

2.3 Energy contribution of NOVA food groups

The energy contribution of the foods in the FFQ was estimated using the formula by the Wessex Institute of Public Health, 1995 and Norimah *et al.* (2008) as the following:

Energy value estimate = Conversion factor x Serving size x Total number of serving x Weight of food in one serving

This equation contains the number of servings consumed per occasion times weight/serving size times daily intake frequency times nutritional composition of the food serving. The nutritional composition of each food serving was determined based on the Malaysian Food Composition table. The conversion factors are as shown in Table 1. The mean energy contribution for each NOVA food groups was calculated from the energy contribution obtained.

Table 1. Example of FFQ score

Frequency of intake	Frequency	Conversion factor
Per day	Once	1
	Twice	2
	3 times	3
Per week	Once	1/7
	Twice	2/7
	3 times	3/7
	4 times	4/7
Per months	Once	1/30
	Twice	2/30
	3 times	3/30

Serving size of each food listed in the food frequency questionnaire was determined by using the formula shown below:

$$Serving\ size = \frac{Amount\ of\ food\ consume\ per\ day}{weight\ of\ serving\ size}$$

Based on the summation of NOVA groups, total energy contribution was obtained. The average energy contribution of each NOVA groups can be achieved to make comparisons concerning which groups contribute more energy in daily consumption.

$$Average\ energy\ contribution\ (\%) = \frac{Total\ energy\ contribution\ of\ a\ group\ in\ NOVA}{Total\ energy\ in\ a\ day} \times 100$$

2.4 Procedures to classify foods according to NOVA classification

The frequency of consumption of ultra-processed foods was evaluated according to the different classification based on the degree of processing underlying each group. Group 1 is unprocessed or minimally processed foods such as fresh, dry or frozen fruits and vegetables, packaged grains and pulses, flakes or flours made from corn and water. Group 2 is processed culinary ingredients that include sugar, oils, fats, salt and other ingredients used in the kitchens for seasoning or cooking the unprocessed or minimally processed foods. Group 3 includes processed food, which is similar to ready-to-eat products manufactured with the addition of unprocessed or minimally processed foods and salt, sugar and other substances of culinary use. Group 4 includes ultra-processed foods such as sweet, fatty or salty packaged snack products, ice-cream, chocolates, candies, mass-produced packaged bread, cookies, pastries, cakes and many ready-to-heat products. However, instead of having four stand-alone NOVA food groups, this study combined Group 1 and Group 2, leaving three main NOVA food groups; Group 1 and 2, Group 3 and Group 4.

All the listed food items were sorted according to each respective NOVA food groups in Microsoft Excel. From the FFQ data collection, the information needed to calculate the energy contribution was obtained. The calculation of energy calculation was done using Microsoft Excel. The energy contributions were needed in order to obtain the average for each group and compare the data between groups. The average for each group was calculated by dividing the energy contribution of each group with the total energy contribution for all groups.

2.5 Data analysis

All analyses were performed with the statistical software package IBM SPSS Statistics version 22. Estimated mean energy contributions of the three NOVA food groups were calculated in the Microsoft Excel. $p<0.05$ is considered significant. Kolmogorov-Smirnov test was used in order to test the normality of data since it is suitable for the samples higher than 50. To determine the association between energy contribution and socio-demographic characteristics, the data were analysed using cross tabulation and Chi-Square. For normal distributed data, mean (SD) was used; meanwhile, for non-normal data, using the interquartile range (IQR), the mean values of the energy contributions for each food group were calculated. To find the differences between the average consumption in each group, the Kruskal-Wallis test was used.

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3. Results

3.1 Socio-demographic characteristics of respondents

Table 2. Socio-demographic profiles of the respondents (*n*=200)

Socio-demographic profile	Frequency	Percentage (%)
Age		
18-25	61	30.5
26-30	34	17
31-35	54	27
36-40	24	12
41-45	9	4.5
46-50	6	3
51-55	9	4.4
56-60	3	1.5
Gender		
Male	50	25
Female	150	75
Race		
Malay	184	92
Chinese	14	7
Indian	1	0.5
Others	1	0.5
Religion		
Muslim	185	92.5
Buddha	12	6
Hindu	1	0.5
Others	2	1
Marital status		
Single	79	39.5
Married	114	57
Divorce	6	3
Widow	1	0.5
Educational status		
Never attended school	0	0
Primary school	0	0
Secondary school	43	21.5
Diploma	48	24
Bachelor's degree	86	43
Others	23	11.5
Monthly household income		
Less than RM3000	99	49.5
RM3000 – RM3999	44	22
RM4000 – RM4999	26	13
RM5000 – RM5999	14	7
RM6000 and above	17	8.5
Occupational status		
Clerk	36	18
Student	59	29.5
Businessman/woman	7	3.5
Science Officer	9	4.5
Security Guard	8	4
Lecturer	3	1.5
Staff	47	23.5
Technician	3	1.5
Others	28	14
Daily cooking frequency		
Yes	78	39
No	122	61

Table 2 shows the socio-demographic characteristics of the respondents. This study involved 200 respondents from 18 to 59 years old in Kuala Nerus, Terengganu. Almost 87% of the respondents were aged from 18 to 40 years old. Most of the respondents were female, married, Malay, and Muslim. Most of them had a high educational level since 43% of respondents had a bachelor's degree. Approximately 49.5% reported a monthly income of less than RM3000, considering that about one-third of the respondents were 18 to 25 years old. Most respondents were working, while 29.5% were students. This may be why 61% reported not cooking daily.

3.2 Energy contribution of NOVA food groups via food frequency questionnaire (FFQ)

The energy from each NOVA food groups was determined using the FFQ together with the frequency and amount of serving size that they consumed. It can be seen from Table 3 that the highest percentage of 55.73% came from Group 1 and 2, which are unprocessed and minimally processed food and processed culinary ingredients. 40.38% came from ultra-processed foods and other 3.89% came from processed foods.

Table 3 shows that the mean energy intake of adults in Kuala Nerus was 2238.00 kcal ±1236 where the average energy intake from Group 1 and 2, Group 3 and Group 4 were 1247.38 kcal, 87.11 kcal and 904.74 kcal, respectively. According to the Recommended Nutrient Intake (2005), the energy requirements for male adults age 19-59 years old who are moderately active range between 2190 kcal and 2240 kcal. For female adults, energy requirements range between 1840 kcal and 1900 kcal. The results of total mean energy intake are higher for females according to the recommendation of RNI. Conversely, it was still within the acceptable range for males.

3.3 Frequency of consumption of ultra-processed foods among adults in Kuala Nerus

From Table 4, it can be seen that the most consumed ultra-processed foods by adults in Kuala Nerus included noodles, frozen fried chicken, cream crackers, oyster sauce, white bread, commercial milk and keropok lekor. Of 200 respondents, only 20 respondents (10.0%) did not eat noodles at all for the whole month. Additionally, only 29 respondents (14.5%) did not consume fried chicken in a month. Only 31 respondents (15.5%) did not eat white bread for the whole month and 10 respondents (5.0%) ate white bread every day. However, 74 respondents (37.0%) did not consume commercial milk at all in a month and 6 respondents (3.0%) consumed it every day. Interestingly, 43 respondents (21.5%) ate keropok lekor

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Table 3. Mean energy contribution of Group 1+2, Group 3 and Group 4 and their percentage

Total energy intake by NOVA food	Percentage of contribution from each group	Mean±SD
Total energy intake (kcal)		2238.00±1236
Total energy intake for :		
Group 1 + 2 (kcal)	55.73	1247.38±684
Group 3 (kcal)	3.89	87.11±130
Group 4 (kcal)	40.38	903.74±716

Table 4. Most- and least- frequent ultra-processed foods consumed by adults in Kuala Nerus

Frequency	Ultra-processed foods consumption in a month				
	Not consumed	1-2 times	3-4 times	5-6 times	Every day
	n (%)	n (%)	n (%)	n (%)	n (%)
Most frequent ultra-processed foods					
Noodle	20 (10.0)	36 (18.0)	36 (18.0)	64 (32.0)	44 (22.0)
Fried chicken (fast food)	29 (14.5)	44 (22.0)	31 (15.5)	58 (29.0)	38 (19.0)
Cream crackers	84 (42.0)	31 (15.5)	24 (12.0)	33 (16.5)	28 (14.0)
Oyster sauce	73 (36.5)	9 (4.5)	24 (12.0)	72 (36.0)	22 (11.0)
White bread	31 (15.5)	58 (29.0)	54 (27.0)	47 (23.5)	10 (5.0)
Commercial milk	74 (37.0)	35 (17.5)	32 (16.0)	53 (26.5)	6 (3.0)
Keropok lekor	66 (33.0)	52 (26.0)	36 (18.0)	43 (21.5)	3 (1.5)
Least frequent ultra-processed foods					
Frozen chicken pie	184 (92.0)	8 (4.0)	6 (3.0)	2 (1.0)	0 (0.0)
Garlic spread	183 (91.5)	13 (6.5)	2 (1.0)	2 (1.0)	0 (0.0)
Frozen mixed vegetables	183 (91.5)	10 (5.0)	1 (0.5)	5 (2.5)	1 (0.5)
Frozen sweet corn	179 (89.5)	8 (4.0)	8 (4.0)	4 (2.0)	1 (0.5)
Frozen meatballs	174 (87.0)	10 (5.0)	5 (2.5)	10 (5.0)	1 (0.5)
Frozen potato wedges	173 (86.5)	19 (9.5)	1 (0.5)	7 (3.5)	0 (0.0)
Hash brown	173 (86.5)	12 (6.0)	10 (5.0)	5 (2.5)	0 (0.0)
Cream cheese	168 (84.0)	15 (7.5)	6 (3.0)	11 (5.5)	0 (0.0)

Table 5. Association between ultra-processed foods and socio-demographic characteristics

Socio-demographic characteristics	Classification	Ultra-processed foods consumption				p-value
		<30% energy intake		>30% energy intake		
		N	%	n	%	
Age	Below 40	76	43.7	98	56.3	(X^2=4.284)
	40 and above	17	65.4	9	34.6	0.056
Gender	Male	19	38	31	62	(X^2=1.936)
	Female	74	49.3	76	50.7	0.192
Race	Malay	89	48.4	95	51.6	(X^2=3.231)
	Others	4	25	12	75	0.115
Religion	Muslim	89	48.1	96	51.9	(X^2=2.564)
	Others	4	26.7	11	73.3	0.177
Marital status	Married	63	55.3	51	44.7	(X^2=8.184)
	Not married	30	34.9	56	65.1	0.006*
Educational background	Lower than bachelor's degree	53	57.6	39	42.4	(X^2=8.451)
	Bachelor's degree and above	40	37	68	63	0.004*
Monthly household income	Lower than RM3000	39	37.9	64	62.1	(X^2=6.367)
	RM3000 and above	54	55.7	43	44.3	0.016*
Occupational status	Working	76	54.3	64	45.7	(X^2=11.371)
	Unemployed	17	28.3	43	71.7	0.001*

*Significant at $p<0.05$

5-6 times per month.

Table 4 illustrates the least frequent ultra-processed foods consumed by adults in Kuala Nerus. The least consumed ultra-processed foods were frozen chicken pie, garlic spread, frozen mixed vegetables, frozen sweet corn, frozen meatballs, frozen potato wedges, hash brown and cream cheese. From the results, a majority of the respondents (92.0%) did not consume frozen chicken pie in a month. 183 respondents (91.5%) also did not consume garlic spread at all in a month. Meanwhile, for hash browns and cream cheese, both had similar results, as no respondents consumed these every day.

3.4 Association between energy contribution of ultra-processed foods and socio-demographic characteristics

The association between energy contribution of ultra -processed foods and socio-demographic characteristics was analysed using Chi-square test since the data is not normal. Ultra-processed foods consumption was classified into less than 30% of energy intake and more than 30% energy intake in order to determine the level of consumption. According to Monteiro *et al*. (2010), an average daily energy intake <30% is an indicator of low consumption of ultra-processed foods meanwhile >30% indicates high consumption of ultra-processed foods.

Based on Table 5, marital status, educational background, monthly household income and occupational status had significant associations with ultra -processed foods consumption ($p<0.05$), while age, gender, race and religion had no significant association ($p>0.05$). Contrary to expectations, the findings slightly differ compared to previous studies. Studies have proven that age and gender had a significant association with the consumption of ultra-processed foods.

4. Discussion

4.1 Energy contribution of NOVA food groups via food frequency questionnaire (FFQ)

It was apparent that most of the energy intake in a month by the adult came from Group 1 and 2 (about 56%), which include foods that are mostly unprocessed or involve minimal processing, such as meat, poultry, fresh, dry or frozen fruits and vegetables, packed grains and flours made from corn and water. Food in Group 2 are usually inedible by themselves, high in energy density and lower in nutrients compared to the whole foods that they were extracted from and are typically used in the preparation of the dishes making up Group 1 (Monteiro *et al*., 2010). The least energy contribution came from Group 3 (about 4%), which includes food manufactured by adding culinary ingredients and includes process such as canning, bottling and fermentation (Fardet *et al*., 2015). Group 4, which contributes 904 kcal, includes ultra-processed foods including snack products, ice cream, chocolates, candies and many ready-to-heat products.

Ultra-processed foods were formulated to replace freshly prepared foods based on unprocessed and minimally processed groups (Fardet *et al*., 2015). The results show that the energy that came from ultra-processed groups were slightly lower compared to the unprocessed and minimally processed group which can be assumed that the respondents preferred to prepare foods from scratch using raw materials instead of consuming processed foods. However, almost 41% of the consumption of ultra-processed and processed foods could be caused by time constraints. People tend to consume processed foods in order to save time and when there is no source of raw foods to be cooked.

In certain countries, particularly developed countries such as the United Kingdom, the consumption of ultra-processed foods is higher compared to unprocessed or minimally processed foods because there has been a rapid development of ultra-processed foods with lower prices (Marrón-Ponce *et al*., 2018). While the development of ultra-processed foods is still lower in Kuala Nerus compared to unprocessed or minimally processed foods, average energy of 904 kcal in a day is still considered high. A study by Setyowati *et al*. (2018), in Jakarta, found similar results, as energy consumption of ultra-processed foods among the Indonesian population was lower compared to unprocessed or minimally processed foods. Despite being less consumed, an increasing trend of ultra-processed foods consumption is apparent in both Malaysia and Indonesia. The characteristics of ultra-processed foods which are high in fat, salt and glycaemic loads will lead to increased cases of obesity and diet-related non-communicable diseases (NCD) globally (Swinburn *et al*., 2007).

4.2 Frequency of consumption of ultra-processed foods among adults in Kuala Nerus

The most consumed ultra-processed foods by adults in Kuala Nerus were noodles, frozen fried chicken, cream crackers, oyster sauce, white bread, commercial milk and *keropok lekor*. The main fast food restaurants in Malaysia are very competitive in terms of pricing. They continuously lower their prices to make it affordable to all people (Mohamed and Daud, 2012). According to Habib *et al*. (2011), 84% of Malaysian students consume fast food, thereby explaining the higher consumption at almost 41% of energy intake from ultra-processed foods, since most of the respondents in this study were students.

Bread is surprisingly commonly consumed by adults in Kuala Nerus since it can be easily consumed especially during breakfast, during which working people do not have enough time. Among ultra-processed foods, bread contributes a higher amount of energy which is 9.2% of energy intakes compared to pizza, hamburgers, and cakes (Louzada *et al*., 2015). According to Norimah *et al.* (2008), bread and noodles have been listed as the top 10 weekly consumed foods by Malaysian with mean frequencies ranging from 1.79 to 2.73.

Full cream milk was the second most daily consumed by Malay women, compared to men who preferred consuming sweetened condensed milk frequently (Norimah *et al*., 2008). This indicates that women are more aware of the health benefits of milk. According to Chee *et al*. (2003), milk drinking significantly lowers the risk of osteoporosis, thus explaining the high consumption among women. *Keropok lekor* is a traditional food in Terengganu. It is associated with localities and certain areas, thus explaining the high frequency of consumption in Kuala Nerus.

The least consumed ultra-processed foods were frozen chicken pie, garlic spread, frozen mixed vegetables, frozen sweet corn, frozen meatballs, frozen potato wedges, hash browns and cream cheese. The trend of eating away from home had become habitual to the young generation where they do not have to spend time on cooking due to time restrictions (Rahman *et al*., 2018). According to Marry *et al*. (2014), eating out is defined as consuming foods outside the house which require no cooking at all. Even though frozen foods are convenient and require less time cooking, especially frozen chicken pies that only need to be heated for a few minutes before being consumed, eating out is much easier.

4.3 Association between energy contribution of ultra-processed foods and socio-demographic characteristics

Marital status, educational level, monthly household income and occupational status showed strong evidence for an association related to the consumption of ultra-processed foods. A high educational status involuntarily leads to having high occupational status and monthly household income. According to Cediel *et al*. (2018), the consumption of ultra-processed food tends to increase with the increasing monthly household income since the price of ultra-processed foods became affordable to the high monthly income groups. In high-income countries such as the United States, the production of ultra-processed foods is highly concentrated, thus changing the food consumption patterns based on affordability (Rayner *et al*., 2006). However, food consumption patterns in Asian middle-income countries including Malaysia, China and Thailand have already shown increasing consumption of ultra-processed foods, since the rapid development of ultra-processed foods and beverages manufacturing is on-going (Baker and Friel, 2016).

According to Adams and White, (2015), the consumption of ultra-processed foods shows significant correlation with age. The consumption of ultra-processed foods tends to decrease with age since older people tend to cook and eat healthy foods rather than consuming ultra-processed foods that are high in energy density and low in nutrient density. Gender had no significant association with the consumption of ultra-processed foods since several studies have shown differing results for gender and the association with ultra-processed foods. According to Djupegot *et al*. (2017), men more commonly consume ultra-processed foods compared to women; however, a study by Simões *et al*. (2018) shows the opposite finding, proving that gender has no association with the consumption of ultra-processed foods.

Even though the energy contribution that came from ultra-processed foods in Kuala Nerus is still less than unprocessed or minimally processed foods, the frequent consumption will relatively lead to the diet-related non-communicable disease (NCD). This identification will be beneficial in order to promote healthy eating among groups that consume lower energy foods from the unprocessed or minimally processed groups. It is also important in order to keep track of the trend towards the consumption of ultra-processed foods that has developed rapidly in Malaysia. Dietary patterns have shifted from the intake of homemade meals towards ready-to-eat, packaged and convenience foods (Moubarac *et al*., 2017).

5. Conclusion

This study set out to classify foods according to NOVA food classification and explore the influence of socio-demographic factors towards ultra-processed food consumption. One of the more significant findings to emerge from this study is that ultra-processed foods, with a percentage contribution of around 40%, were slightly less consumed compared by unprocessed or minimally processed foods, which contribute about 55% of energy. The association of energy contribution from ultra-processed foods shows no significance with age and gender. However, the results show significant associations between socio-demographic characteristics including marital status, educational level, occupational

status and monthly household income. Therefore, it can be concluded that it is important to determine the factors that influence the energy contribution from ultra-processed foods in the prevention of higher consumption towards it in the future. This study provides the first comprehensive assessment of ultra-processed foods consumption using NOVA classification via semi-quantitative FFQ in Malaysia. This NOVA approach will prove useful in expanding our understanding of ultra-processed food consumption in Malaysia and specifically in Terengganu. This particular study will also help the Ministry of Health Malaysia gather data on the consumption of ultra-processed foods since this has been a major contributor to the non-communicable disease (NCD) development. Even though NCDs were not part of the 2000 Millennium Development Goals, in 2011 they became a focus, with the United Nations and the World Health Organization calling for a 25% reduction in NCD-related mortality by 2025.

The study is limited by the lack of information on NOVA approach in Malaysia. A limitation of using this FFQ is that it only affords the capture of the listed items of ultra-processed foods in the questionnaire. Thus, the actual consumption of ultra-processed foods could not be meticulously studied. Furthermore, the listed items on the FFQ were slightly confusing for a few of the respondents since it involved too many foods. Finally, the generalisability of these findings is limited to adults in Kuala Nerus. Even though NOVA food classification was introduced to classify foods based on the extent and purpose of their processing, it could be better used in the future if the development of it is well-upgraded. In terms of directions for future research, further work could include more items especially from ultra-processed groups for the data to be more significant since nowadays various ultra-processed foods that are newly produced can be found in the market. Moreover, to make it clear for the respondents and avoid any errors during data collection, adding a description or picture to describe each food item could be used to improve future studies. Improvements can be made by conducting the study in larger areas and involving larger populations. Therefore, a number of possible future studies using the same NOVA approach are apparent.

Conflict of interest

The authors declare there is no conflict of interest.

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