FOOD
RESEARCH

Food classification system based on food processing and its relationship with nutritional status of adults in Terengganu, Malaysia

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Abstract

There is increased interest in the novel approach of classifying food based on the nature of its processing and its contribution towards diet-related diseases. Therefore, the main objective of this study is to determine the relationship between this novel food classification system and nutritional status of adults in Kuala Nerus, Terengganu. This cross-sectional study involved 200 respondents aged 18 years and above. A self- and researcher-administered questionnaire consisting of three different parts, namely a socio-demographic profile, nutritional status assessment, and food classification system (via two days 24 hours dietary recall) was used to collect data. SPSS version 20.0 was used for data analysis. Results showed that energy contributions of respondents were dominated by foods from group 1 and group 2 i.e. unprocessed food, minimally processed food and processed culinary ingredients. The energy contribution from ultra-processed food consumption was 24% of the average total daily energy consumption at 1818 kcal. The average nutritional status of respondents showed both BMI (M = 25.33, IQR = 6.79) and body fat percentage (M = 28.01, SD = 9.08) were overweight. Further data, including waist circumferences (M = 84.57 cm, SD = 11.7); fasting blood glucose level (M = 5.3 mmol/L, IQR = 0.80); total cholesterol (M = 4.60 mmol/L, IQR = 1.6); triglycerides (M = 1.00 mmol/L, IQR = 0.44); and LDL level (M = 2.74 mmol/L, IQR = 1.35) were normal. Systolic blood pressure (M = 112.50 mmHg, IQR = 20) and diastolic blood pressure (M = 78.84mmHg, SD = 11.73) were optimal, and the HDL levels of the respondents were borderline (M = 1.42mmol/L, IQR = 0.47). Pearson and Spearman correlations were performed to determine the relationship between ultra-processed food consumption and nutritional status and found no significant relationship between both variables. All in all, the findings can be used in the development of evidence-based interventions aimed at encouraging the consumption of minimally processed foods and reducing ultra-processed food consumption among the general public.

1. Introduction

Malaysia, as a developing country, is currently experiencing epidemiologic, demographic and nutrition transitions. The rapid nutrition transition towards developed economic status has remarkably changed the dietary habits and lifestyles of the Malaysian population (National Coordinating Committee on Food and Nutrition Ministry of Health, Malaysia, 2016). These changes have had a tremendous effect on the increasing prevalence of the diet-related diseases over the past two decades, as stated in the National Plan of Action for Nutrition of Malaysia III 2016 – 2025 (Nutrition Division, Ministry of Health Malaysia, 2016). It is believed that there is a link between the prevalence of diet-related non-communicable diseases (NCDs) and the increased consumption of ultra-processed foods, but few studies have been carried out. The Nutrition Research Priorities in Malaysia for 11th Malaysia Plan 2016-2020 has highlighted the priority to conduct studies on ultra-processed foods and its contribution towards NCDs development.

Generally, ultra-processed food consumption is incorporated with higher energy density, higher overall fat content, higher saturated, trans-fat and higher levels

of free sugar for their nutritional profile when compared with natural or minimally processed foods (Cediel *et al.*, 2018). However, the role and impact of food processing in population health have been poorly studied, and no well-defined processed foods classifications have been proposed. Therefore, a recent approach for classifying food based on the extent and purpose of processing was introduced by a Brazilian researcher, and is known as the NOVA food classification (Monteiro *et al.*, 2010). NOVA was officially recognized as a valid tool for nutrition and public health research, policy and action in 2016. NOVA classifies food into four groups: group 1 is unprocessed or minimally processed foods; group 2 is processed culinary ingredients; group 3 is processed foods; and group 4 is ultra-processed foods (Monteiro *et al.*, 2016).

Consequently, many studies have shown that consumption of ultra-processed food has a huge negative impact on the quality of diets, bodyweight, metabolic syndrome and blood lipid profiles (Monteiro *et al.*, 2016). However, less research has been done in Malaysia on ultra-processed food consumption. Therefore, this study is aimed to assess the relationship between ultra-processed food consumptions (via NOVA food classification) and nutritional status among adults in a selected east coast region in Malaysia, Terengganu. Terengganu was chosen due to its high prevalence of obesity at 46.5% (Institute for Public Health, 2015).

2. Materials and methods

2.1 Research design

This cross-sectional study was conducted in Kuala Nerus, a district in Terengganu. The sample size of this study was calculated using the Cochran formula at a 95% of confidence level, with an expected proportion of 46.5% based on the prevalence of abdominal obesity for adult ages 18 years old and above, and assuming 7% attrition. Thus, a total of 200 respondents aged 18 to 59 years old were recruited through convenient sampling. A verbal and written informed consent form was obtained from each respondent prior to their participation. Ethical approval of this study was obtained from the University's Human Ethics Review Board of Universiti Malaysia Terengganu (UMT) with reference number: UMT/JKEPM/2017/3.

2.2 Research instrument

A self- and researcher-administered questionnaire consisting of three main sections were disseminated among the respondents. The first section obtained socio-demographic background information including gender, age, races, religious, marital status, educational status, occupation and monthly household income. The second part was a nutritional status assessment, including body height (via stadiometer), body weight and body fat percentage (via Tanita bioelectrical impedance), body mass index, waist circumference (via Seca measuring tape), blood pressure (via an Omron blood pressure monitor), fasting blood glucose level (via Accu Chek glucose monitor) and blood lipid profile (via Cardio Chek PA Analyzer). The third part was the food classification based on NOVA approach via a two-day 24-hours dietary recall intake. Respondents were asked to recall their food and beverages consumption for one weekday and a one weekend day. Pictures of household measurement were provided with the form for a more accurate estimation of the quantity of the foods they had consumed. Data taken from the 24-hour dietary recall was classified into NOVA food classification system and the energy provided by each food item was obtained in kcal by using Nutritionist Pro™ software as well as few guidance books such as the Nutrient Composition of Malaysian Book and Malaysian Food atlas.

2.3 Classification of foods according to NOVA food classification system

NOVA classifies foods into four distinct groups. Group 1 includes unprocessed or minimally processed foods (unprocessed foods refer to edible parts of plants or animals while minimally processed foods are natural foods that undergo process such as drying, grinding, roasting, boiling, pasteurization and etc. to confiscate inedible parts). Group 2 includes processed culinary ingredients (food substances attained directly from group 1 foods for the purpose of seasoning and preparing foods from Group 1). Group 3 includes processed foods (goods somewhat simply made by placing in salt, sugar, oil, or other groups 2 elements to group 1 foods, and normally involves two or three ingredients accompanying numerous cooking methods or preservations, such as bread, cheese and non-alcoholic fermentation). Group 4 includes ultra-processed foods (referring to industrial formulations which usually made up of five or more ingredients such as salt, anti-oxidants, stabilizers, and preservatives) (Monteiro *et al.*, 2016). Particularly important in this NOVA classification is that the underlying ingredients for each dish are classified in their respective NOVA food groups. However, due to the lack of standardized recipe provided by the respondent, it is relatively challenging to disseminate cooked dishes involving culinary ingredients into Group 1 and Group 2. Thus, we have combined Group 1 and Group 2 together, as the focus is more on processed and ultra-processed food consumption.

The average food consumption derived from the 24-hour dietary recall of each NOVA group has been

calculated and expressed as a percentage of total consumption dietary energy. The total energy of the total group is summed up as well. The average energy consumed of each group e.g. Group 1 is used as the numerator, and the denominator is the total energy of all food groups. Hence, the percentage of food consumed of the respondents from each food group can be determined from the total food consumption using the formula as follows:

Average energy obtained from Group 1 = (Energy obtained from Group 1)/(Total energy obtained from all groups) × 100%.

2.4 Data analysis

All data were analyzed using Statistical Package for the Social Science (SPSS) version 20. The normality test was performed using Kolmogorov-Smirnov. Frequency, percentage, mean score (SD) or median score (IQR) were used to present descriptive data. Pearson and Spearman correlation's coefficient was applied to determine the relationship between the consumption of ultra-processed food and nutritional status of the adults in this study at p<0.05.

3. Results

3.1 Socio-demographic characteristics and nutritional status assessment of respondents

Most of the respondents were government staff, female, Malay, had a median age of 33 years old and were married, as shown in Table 1. Most were degree holders and had a monthly household income of less than RM3000. It is apparent from Table 2 that about 53.5% were overweight or obese, which is reflected by the median BMI of 25.33 (6.79), indicating overweight. For body fat percentage, about 44% of respondents were nutritionally at risk (i.e. overweight and obesity), which is similar to NHMS survey carried out previously in Terengganu, with 44.2% of adults having overweight or obesity (Institute for Public Health, 2015). Waist circumference is an important indicator of central obesity (NRP, 2016). Thus, from the result obtained, approximately 49% had increased or substantially increased risk of metabolic complications.

More than half of the respondents had an optimum or normal range of blood pressure level and a normal fasting blood glucose level. However, what stands out in this fasting blood glucose findings is the number of respondents being at risk of diabetes is 30.5%, which was considered relatively high compared with previous NHMS report, where the percentage of known diabetes in Terengganu was 18.6% (Institute for Public Health, 2015). As for blood lipid profile, most of the respondents

had either normal or optimal for their total cholesterol, low-density lipoprotein (LDL), and triglycerides levels. For high-density lipoproteins (HDL), a majority had low or borderline levels, indicating a higher risk of atherosclerosis.

Table 1. Socio-demographic characteristics of respondent (n=200)

Characteristics	Number of respondents	Percentage (%)
Gender		
Male	50	25
Female	150	75
Age (Median (IQR*))	33 (8.19) years old	
18-25	63	31.5
26-30	34	17
31-35	52	26
36-40	25	12.5
41-45	9	4.5
46-50	5	2.5
51-55	9	4.5
56-60	3	1.5
Ethnicity		
Malay	184	92
Chinese	14	7
India	1	0.5
Others	1	0.5
Religion		
Muslim	185	92.5
Buddha	13	6.5
Hindu	1	0.5
Others	1	0.5
Marital status		
Single	80	40
Married	114	57
Divorced	5	2.5
Widow	1	0.5
Education Background		
Secondary School	44	22
Diploma	48	24
Degree	85	42.5
Master	16	8
PHD	4	2
Others	3	1.5
Monthly Household Income		
Less than RM 3000	103	51.5
RM 3000 - RM 3999	41	20.5
RM 4000 - RM 4999	24	12
RM 5000 - RM 5999	16	8
RM 6000 and above	16	8
Occupation		
Government workers	101	50.5
Student	60	30
Business people	7	3.5
Private workers	32	16
Others	27	13.5

Note: * IQR = interquartile range

Table 2. Nutritional status of respondent (n=200)

Nutritional Status	Distribution n (%)	Mean ± SD/ Median (IQR)
Average BMI		25.33 (6.79) kgm^{-2}
Underweight (<18.5)	17 (8.5)	
Normal (18.5 – 24.9)	76 (38.0)	
Overweight (25.0 – 29.9)	68 (34.0)	
Obesity (>30)	39 (19.5)	
Body Fat Percentage‡		28.01±9.08 %
Under Fat	28 (14.0)	
Healthy	84 (42.0)	
Overweight	49 (24.5)	
Obesity	39 (19.5)	
Waist Circumference		84.57±11.70 cm
Normal (m = < 94cm, w = < 80cm)	102 (51.0)	
Increased (m = > 94cm, w = > 80cm)	51 (25.5)	
Substantially Increased (m = > 102cm, w = > 88cm)	47 (23.5)	
Systolic Blood Pressure		112.50 (20) mmHg
Optimal (< 120 mm/Hg)	135 (67.5)	
Normal (< 130 mm/Hg)	28 (14.0)	
High normal (130 - 139 mm/Hg)	22 (11.0)	
Hypertension Stage I (140 - 159 mm/Hg)	13 (6.5)	
Hypertension Stage II (160 – 179 mm/Hg)	2 (1.0)	
Diastolic Blood Pressure		78.84±11.73 mmHg
Optimal (< 80 mm/Hg)	109 (54.5)	
Normal (< 85 mm/Hg)	37 (18.5)	
High normal (85 - 89 mm/Hg)	18 (9.0)	
Hypertension Stage I (90 - 99 mm/Hg)	27 (13.5)	
Hypertension Stage II (100 – 109 mm/Hg)	7 (3.5)	
Hypertension Stage III (≥ 110 mm/Hg)	2 (1.0)	
Fasting Blood Glucose Level		5.3 (0.80) mmol/L
Normal (3.9 – 5.5 mmol/L)	139 (69.5)	
Pre-Diabetes (5.6 – 7.0 mmol/L)	54 (27.0)	
Diabetes (> 7.0 mmol/L)	7 (3.5)	
Total Cholesterol		4.60 (1.60) mmol/L
Normal (< 5.2 mmol/L)	141 (70.5)	
Borderline (5.2 – 6.2 mmol/L)	32 (16.0)	
High (> 6.2 mmol/L)	27 (13.5)	
HDL Level		1.42 (0.47) mmol/L
Optimal (> 1.6 mmol/L)	53 (26.5)	
Normal (m = > 1.3 mmol/L, w = > 1.5 mmol/L)	30 (15.0)	
Borderline (m = 1.0 – 1.3 mmol/L, w = 1.3 – 1.5 mmol/L)	58 (29.0)	
Low (m = <1.0 mmol/L, w = < 1.3 mmol/L)	59 (29.5)	
LDL Level		2.74 (1.35) mmol/L
Optimal (< 2.6 mmol/L)	87 (43.5)	
Normal (2.6 – 3.3 mmol/L)	65 (32.5)	
Borderline (3.4 – 4.1 mmol/L)	26 (13.0)	
High (4.1 – 4.9 mmol/L)	14 (7.0)	
Very High (> 4.9 mmol/L)	8 (4.0)	
Triglycerides Level		1.00 (0.44) mmol/L
Normal (< 1.7 mmol/L)	166 (83.0)	
Borderline (1.7 – 2.3 mmol/L)	19 (9.5)	
High (2.3 – 5.6 mmol/L)	12 (6.0)	

‡ Cut-off point is gender- and age- based. Source for nutritional status cut-off points: BMI (WHO, 2018), body fat (Gallagher *et al.*, 2000), waist circumference (WHO, 2008), blood pressure (Kee *et al.,* 2008), blood glucose (Alberti and Zimmet, 1998), total cholesterol (Jellinger *et al.,* 2012).

3.2 Classification of energy Intake based on NOVA food classification

Prior to underpinning energy intake into the four groups of NOVA, all under-reported and over-reported dietary intakes were eliminated via the Goldberg method, which compares energy intake (EI) against BMR. BMR was calculated based on the BMR formula by Ismail *et al.* (1998) in this study. Once EI:BMR was calculated, it was compared to Goldberg *et al.* (1991) cut-off points as follow; ≤ 0.995 (under-reporting), 0.996 - 2.57 (normal range) and > 2.58 (over-reporting). After eliminating the under-reported (n = 33) and over-reported (n = 0) dietary intake of respondents, the energy contribution of different NOVA food groups was displayed in Table 3. From Table 3, it is apparent that the median energy intake of adults in this study was 1818.76 (480.09) kcal per day. The average energy intake from group 1+2, group 3 and group 4 was 1393.81 kcal, 8.05 kcal and 371.77 kcal respectively.

With respect to the main aim of this study, the most compelling finding was that the total contribution of the ultra-processed group towards overall daily energy consumption was 24%. It is encouraging to compare these findings with a recent study done in Indonesia which reveals that the ultra-processed group contributed approximately 16% (Setyowati *et al.*, 2018). Meanwhile, a study in Brazil found that ultra-processed food consumption contributed 27.7% of overall energy intake (Moubarac *et al.*, 2013).

3.3 Relationship between ultra-processed food consumption and nutritional status

Both Pearson and Spearman correlations were performed according to the normality of the respective data. It is somewhat surprising that no significant associations were found between ultra-processed food consumption and nutritional status (i.e. BMI status, body fat percentage, waist circumference, systolic blood pressure, diastolic blood pressure, total cholesterol, high-density lipoprotein cholesterol (HDL-c), low-density lipoprotein cholesterol (LDL-c), and triglycerides) at $p < 0.05$ as shown in Table 4.

4. Discussion

Few were found in previous studies on the question of ultra-processed food consumption in Malaysia. Thus, this study set out with the aim of assessing the relationship between ultra-processed food consumption

Table 3. Energy Consumption from each group towards total daily energy intake (%) in two- days 24-hour Dietary Recall (n = 167)

Total Energy Intake by NOVA food classification (kcal)	24-HR Dietary Recall	
	Percentage of contribution from each group towards total daily energy intake (%)	Mean ± SD / Median (IQR)
Total energy intake (kcal)		1818.76 (480.09)
Total energy intake for:		
Group 1+ Group 2 (kcal)	-	1393.81±426.38
Group 3 (kcal)	-	8.05 (38.10)
Group 4 (kcal)	-	371.77 (409.59)
Group 1+ Group 2 (kcal)	75%	
Group 3 (kcal)	1%	
Group 4 (kcal)	24%	

Table 4. Relationship between Ultra-processed Food Consumption and Nutritional Status for two-days 24-hour Dietary Recall

Correlation	Ultra-processed Food Consumption (24hr Dietary Recall)	
	r-value	p-value
BMI	-0.04	0.954
Body Fat Percentage	-0.45	0.568
Waist Circumference	0.025	0.745
Systolic Blood Pressure	-0.139	0.073
Diastolic Blood Pressure	-0.046	0.558
Fasting Blood Glucose Level	0.038	0.628
Total Blood Cholesterol	0.063	0.42
HDL Cholesterol	0.12	0.121
Triglycerides	0.006	0.936
LDL Cholesterol	0.061	0.43

$p > 0.05$ indicates no significant difference by using the Pearson and Spearmen correlation test.

(via NOVA food classification) and nutritional status among adults in Kuala Nerus, Terengganu. The most obvious finding to emerge from the analysis is that ultra-processed food consumption (Group 4) contributed to about one-fifth of energy intake in the daily food consumption compared to Group 1 + 2 (unprocessed or minimally processed food and processed culinary ingredients) and Group 3 (processed food). Comparison of the findings with those of other studies done in higher-income countries has confirmed that the consumption of ultra-processed foods in this study is somehow still low. Higher-income countries such as US (Poti *et al.*, 2015), UK (Moubarac *et al.*, 2013), and Canada (Moubarac *et al.*, 2014) had contributions of 61%, 63.4%, and 61.7% towards total daily energy consumption, respectively. These values being greater than 60% reflects the dominance of ultra-processed foods in high-income countries' food supplies and consumption. As a middle-income country, the amount of ultra-processed food in Malaysia is considered relatively low (Juul and Hemmingsson, 2015). This study supports evidence from other middle-income countries i.e. Indonesia (Setyowati *et al.*, 2018) and Brazil (Moubarac *et al.*, 2013) that ultra-processed food consumption is considerably low, mostly less than 30%. This can be explained by the fact that the price of ultra-processed foods in the marketplace is higher in middle-income countries when compared to higher-income countries (Moubarac *et al.*, 2013). It is almost certain the respondents' food consumption in this study remains dominated by non-processed foods i.e. cooked foods either from home- or away-from-home-prepared, in a combination of Group 1 and Group 2. These are valuable findings, as they shed new light on the novel approach of classifying foods according to the nature of its processing, particularly in Malaysia.

Unfortunately, this study has been unable to demonstrate a significant relationship between ultra-processed food consumption and the nutritional status of the respondents. This finding is contrary to previous studies which have suggested that ultra-processed food consumption had a significant positive association with BMI status (Louzada *et al.*, 2015; Juul and Hemmingsson, 2015); body fat percentage (Louzada *et al.*, 2015; Mendonca *et al.*, 2017); waist circumference (Tavares *et al.*, 2012); blood pressure (Tavares *et al.*, 2012); blood glucose level (Juul and Hemmingsson, 2015; Tavares *et al.*, 2012) and total fat (Tavares *et al.*, 2012; Mendonça *et al.*, 2017). In the same vein, another study done in Kenya among 453 households found no significant relationship between ultra-processed consumption and obesity (Kimenju, 2018). This discrepancy may be attributed to the small share of calories from ultra-processed foods among respondents in this study. Due to the average BMI and body fat

percentage being overweight in this study, it could conceivably be hypothesized that such connections exist between both variables and the consumption of Group 1 and 2, and not because of the consumption of ultra-processed foods. Higher consumption of total daily energy intake more than the recommended amount could be a major factor, if not the only one, causing higher BMI and body fat percentage. This provides some explanation as to why no association occurs between ultra-processed food consumption and nutritional status. However, more research on this topic needs to be undertaken before the association between consumption of ultra-processed foods and nutritional status is more clearly understood. The most important limitation lies in the fact that there is a lack of standardized recipes for typical Malaysian cuisines, which limits the classification of food groups into four different groups. Thus, further work is required to establish mechanisms underlying the NOVA approach of classifying foods mainly in Malaysia.

5. Conclusion

This study has provided better insights into classifying foods according to the NOVA food classification. Noteworthy, the main energy contributors were from Group 1 and 2 (unprocessed/minimally processed and culinary ingredients), followed by Group 4 (ultra-processed foods) and Group 3 (processed foods). Remarkably, the ultra-processed food consumption made up about 24% of total daily intake of adults in Kuala Nerus, Terengganu. These findings surprisingly showed that both BMI and body fat percentages were in the overweight category. Meanwhile, waist circumference, blood pressure, fasting blood glucose, total cholesterol, LDL, and triglycerides were in a normal range. In general, therefore, it seems that the biochemical assessment of the nutritional status indicates a healthy level; but not for the anthropometry assessments which reflect the respondents were nutritionally at risk. Unfortunately, no significant relationship was found between ultra-processed food consumption and BMI status, body fat percentage, waist circumferences, blood pressure, fasting blood glucose level and blood lipid profile in this study. All in all, these findings have significant implications for the understanding of how ultra-processed food consumption contributes towards total energy intake among the respondents, as the evidence of ultra-processed food consumption has been purely anecdotal in Malaysia.

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgements

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