ORIGINAL ARTICLE

Association between Knowledge and Practice of Thermally Abused Cooking Oil, Serum Lipid Profile, Body Composition, and Waist Circumference of Hyperlipidemia Patients Running Title: Usage of Reused Cooking Oil on Health Parameters

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ABSTRACT

Introduction: Frequent use of thermally abused cooking oil (TACO) increases risk of obesity, hyperlipidemia, cancer, and hypertension due to the presence of hazardous compounds in TACO. These compounds are formed from the oxidation and hydrolysis processes with repeated heating of TACO. Public has less awareness of the detrimental effect of TACO. Thus, it is essential to investigate the levels of knowledge and practice related to TACO use and further determine its association with serum lipid profile, body composition, and waist circumference among hyperlipidemia patients. **Materials and methods:** : A cross-sectional study was conducted among 197 hyperlipidemia patients in Hospital Universiti Sains Malaysia. Parameters assessed were medical history, serum lipid profile, anthropometry, body composition, knowledge and practice of TACO. Serum lipid profiles were acquired from medical folder. **Results:** Out of 197 respondents, there were 84.3% of them had high level of knowledge but still 64.5% of them practising TACO moderately. There were significant association between total cholesterol and fat free mass as well as between HDL-cholesterol with fat mass, fat free mass and waist circumference. Significant association was also observed between the fat mass and waist circumference, as well as between fat free mass and waist circumference. However, there was no significant association between knowledge and practice of TACO, serum lipid profile, body composition, and waist circumference. **Conclusion:** Use of TACO was still high although respondents knew it was hazardous to health. Future studies investigating specific biomarkers among TACO users can be conducted to identify the long-term effect of TACO use on gene mutation.
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Keywords: Thermally abused cooking oil, Reused cooking oil, Hyperlipidemia, Abdominal obesity, Lipid profile, Body composition

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INTRODUCTION

Hyperlipidemia refers to the abnormal lipid profile in the blood, indicating the elevation of serum total cholesterol, serum triglyceride and LDL-cholesterol while lower HDL-cholesterol (1). It is a chronic disorder that is harmful to human health as it promotes atherosclerosis which is the deposition of cholesterol within blood vessels, and raise the risk of cardiovascular disease (CVD) (2). Unhealthy dietary intake is among the factors that could lead to secondary hyperlipidemia, especially using reused cooking oil in deep-frying. The reused cooking oil, or known as, thermally abused cooking oil (TACO), will undergo thermal oxidation process when exposed to high temperature (3). Various by-products, hydroperoxide, polar compounds, trans fatty acid and malondialdehyde (MDA) are produced via primary, secondary and tertiary oxidation reaction (4). These hazardous components may threaten our health with habitual consumption which causes abnormal serum lipid profile, cardiovascular diseases (CVD), obesity, allergies and cancers (4,5). Obesity which is characterised by higher body fat percentage especially visceral fat increases risk of atherosclerosis (6). The abdominal obesity, with the waist circumference larger or equal to 90 cm for men and larger or equal to 80 cm for women (7), is related with higher proportion of visceral adipose tissue (VAT), and is associated with various health conditions such as metabolic syndrome and CVD (8). The intention of the research is to assess the association among the knowledge and practice of TACO, serum lipid profile, body composition, and waist circumference among hyperlipidemia patients in

Hospital Universiti Sains Malaysia (Hospital USM).

MATERIALS AND METHODS

This research is a cross-sectional study conducted in Hospital Universiti Sains Malaysia (Hospital USM), Kelantan. Hundred ninety-seven hyperlipidemia patients were recruited as research participants via the convenience sampling method. This study had obtained ethical approval from Human Research Ethics Committee Universiti Sains Malaysia with the ethical approval number USM/JEPEM/22060430. The inclusion criteria of the study were adults aged 18 years old and above diagnosed with hyperlipidemia by medical doctor. Patients in the intensive care unit (ICU), bedridden patients and those with serious hearing problems were excluded from the study.

The sample size was calculated using the one proportion formula using the prevalence of abnormal serum lipid profile of obese population. Moor *et al.* (2022) had shown the prevalence of hyperlipidemia as 52.9% among overweight and obesity adult. The expected proportion (p_1) of abnormal serum lipid profile was 0.529. Shabana *et al.* (2020) had further reported 50.7% of abnormal serum lipid profile among the 750 obese patients. Thus, the anticipated population proportion (p_2) was 0.507. With significance level (α) and power (β) of 0.05 and 80% respectively, the Z_α and Z_β were 1.96 and 0.84.

$$n = \frac{0.529(1\text{-}0.529) + 0.507(1\text{-}0.507)}{(0.529\text{-}0.507)} (1.96+ 0.84)^2$$

$$= 177.86 \sim 178 \text{ subjects}$$

Considering a drop-out of 10%, a total of 197 subjects were selected for this study.

A data collection form with the assistance of Bioelectrical Impedance Analysis (BIA) machine, Omron HBF-214, and measuring tape were used to assess their sociodemographic characteristic, medical history, knowledge and practice of TACO, body composition, and anthropometric data. The sociodemographic data obtained were age, ethnicity (Malay or non-Malay), education years, and monthly household income. In Kelantan, poverty was defined as having household income below MYR 3030 (DOSM 2020). The medical problems assessed were hospitalization status (either inpatient or outpatient), serum lipid profile, duration of hyperlipidemia and treatment taken for hyperlipidemia (either diet control or on lipid lowering drugs). Inpatients were hyperlipidemia participants who were recruited from the medical wards. Some patients were recruited from medical wards to meet the sample size of the study. Serum lipid profile was recorded from blood result in the past three months while the duration of diagnosis was obtained from medical folder.

The anthropometric data were presented as numerical data as median (interquartile range). Among the data recorded were weight, height, body mass index, waist circumference, fat mass, and fat free mass. Body mass index was calculated by dividing weight with square of height. Body mass index was presented as numerical data in this study. Waist circumference was measured at the narrowest section of the waist between the lowest ribs and the iliac crest. All the anthropometric data were assessed by the researcher and recorded as numerical data.

The TACO questionnaire used was referred from Aziz *et al.* (9) which was adopted and modified from the validated questionnaire published in Azman *et al.* (10). The modified questionnaire had been pre-tested with a set of bilingual (English and Malay) questionnaire before applying in the studies of Aziz *et al.* (9). There were two parts in the questionnaire, which were knowledge of TACO and practice of TACO. The part of TACO knowledge consisted of 10 questions while the second part had eight questions about the practice of TACO (Aziz *et al.*, 2018). Subjects were asked to choose one answer, whether "Agree", "Disagree" or "Not sure", except for choosing the source of information regarding the peroxide presence in TACO, type of disease associated with prolonged consumption of TACO, and the impact of high peroxide level in TACO. For the second part about the practice of TACO, subjects answered the type of cooking oil used, whether they had use TACO, frequency of TACO used before discard, reason of not using TACO, type of food prepared by TACO, whether they had eaten outside food, their approach to maintain the quality of TACO, and their source of information about TACO usage (Aziz *et al.*, 2018).

In the first part, each subject could score one in every correctly answered question and score zero for incorrect or not sure answer. At the end of part one, the score were summed and classified into low (score 0-3), moderate (score 4-6), and high (score 7-9) (Aziz *et al.*, 2018). Meanwhile, in the second part, various information regarding TACO were obtained from the answer of subjects, for instance, type of cooking oil used, method attempted to maintain the quality of TACO, and food frequently prepared using TACO. Even though these information obtained were involved in the scoring of TACO practice, they do provide us a framework of the use of TACO in our daily lives (Aziz *et al.*, 2018). The classification of TACO practice depended on the number of sessions using TACO in cooking. Zero to one time of using TACO was considered good, two to four times of using TACO as moderate and five or more times of using it as bad practice.

Data analysis was completed using IBM SPSS Statistic, version 26.0. The association between knowledge and practice of TACO with sociodemographic characteristics was tested using Kruskal Wallis test and Pearson Chi

Square. The median difference of knowledge and practice of TACO with serum lipid profile, body composition and waist circumference among hyperlipidemia patients were tested using Kruskal Wallis test. The relationship between serum lipid profile with body composition and waist circumference, as well as between body composition and waist circumference were assessed using Pearson's Correlation or Spearman's Correlation. The significance level of the test was set at a p value of less than 0.05 with the confidence interval of 95%.

RESULTS

Sociodemographic characteristics, anthropometry, body composition, clinical data and Thermally Abused Cooking Oil (TACO) knowledge and practice among hyperlipidemia patients

As in Table I, out of 197 hyperlipidemia patients in Hospital USM, 107 (54.3%) were female participants and majority of them were of Malay (84.8%) ethnicity ranging from 23- to 88-year-old. Most of them were married (94.9%). The median serum lipid profiles of subjects were listed in Table I as well. Majority of participants (n=173, 87.8%) were on lipid lowering drugs. The median BMI, fat mass, fat free mass and mean waist circumference for both genders were shown in Table II. From Table III, 166 (84.3%) respondents had high knowledge level of thermally abused cooking oil (TACO). However, there were only 68 (34.5%) respondents demonstrated good practice of TACO. Most of the respondents practiced TACO moderately (n = 127, 64.5%).

Table I: Sociodemographic characteristics of subjects (N = 197)

Sociodemographic & Clinical characteristics	Gender		Total (N=197)
	Male (n = 90)	Female (n = 107)	
Age (years) (Median ± IQR[a])	62.0±12.0	59.0±12.0	61.0±11.0
Ethnicity			
Malay, n (%)	79 (87.8)	88 (82.2)	167 (84.8)
Non-Malay, n (%)	11 (12.2)	19 (17.8)	30 (15.2)
Marital Status			
Single, n (%)	3 (3.3)	5 (4.7)	8 (4.1)
Married, n (%)	87 (96.7)	100 (93.5)	187 (94.9)
Divorce, n (%)	0	1 (0.9)	1(0.5)
Widow, n (%)	0	1 (0.9)	1(0.5)
Education Years (Median ± IQR)	13.0 ± 5.0	11.0 ± 0.0	11.0 ± 5.0
Monthly Household Income (RM[b]) (Median ± IQR)	2800.0 ± 3000.0	1650 ± 1600.0	2000.0 ± 3000.0
Hospitalization			
Inpatient, n (%)	9 (10.0)	11 (10.3)	20 (10.2)
Outpatient, n (%)	81 (90.0)	96 (89.7)	177 (89.8)

CONTINUE

Table I: Sociodemographic characteristics of subjects (N = 197) (CONT.)

Sociodemographic & Clinical characteristics	Gender		Total (N=197)
	Male (n = 90)	Female (n = 107)	
Serum Lipid Profile (mmol/L) (Median ± IQR[a])			
Total Cholesterol (TC)	4.2 ± 2.2	4.9 ± 2.1	4.6 ± 1.7
Total Triglycerides (TG)	1.3 ± 1.3	1.2 ± 1.4	1.3 ± 0.7
HDL-cholesterols	1.1 ± 0.5	1.4 ± 0.7	1.2 ± 0.4
LDL-cholesterols	2.4 ± 1.9	2.8 ± 2.2	2.7 ± 1.3
Duration of hyperlipidemia (years) (Median ± IQR)	5.3 ± 8.0	5.0 ± 8.0	5.0 ± 8.0
Treatment			
Lipid lowering drug, n (%)	79 (87.8)	94 (87.9)	173 (87.8)
On diet control alone, n (%)	11 (12.2)	13 (12.1)	24 (12.2)

Notes: [a]IQR = interquartile range; [b]RM = Ringgit Malaysia

Table II: Anthropometric and body composition data of subjects (N = 197)

Anthropometry and Body Composition Characteristics (Median ± IQR[a])	Gender	
	Male (n = 90)	Female (n = 107)
Weight (kg)	74.7 ± 18.5	66.2 ± 13.0
Height (cm)	165 ± 10	155 ± 10
BMI (kg/m^2)	26.1 ± 6.1	27.4 ± 6.7
Fat Mass (%)	27.5 ± 6.0	38.3 ± 6.8
Fat Free Mass (%)	30.7 ± 4.7	23.7 ± 4.0
Waist Circumference (cm) (Mean ± SD[b])	97.4 ± 10.4	94.3 ± 11.8

Notes: [a]IQR = interquartile range; [b]SD = standard deviation

Table III: Thermally abused cooking oil (TACO) knowledge and practice of subjects (N=197)

Knowledge and Practice of TACO	Participants, n(%)
Knowledge on TACO	
High	166 (84.3)
Moderate	24 (12.2)
Low	7 (3.6)
Practice on TACO	
Bad	2 (1.0)
Moderate	127 (64.5)
Good	68 (34.5)

Association between knowledge and practice of thermally abused cooking oil (TACO), sociodemographic characteristics, serum lipid profile, body composition and waist circumference among hyperlipidemia patients

The association between age and knowledge of TACO (p value = 0.001) as well as between marital status and practice of TACO (x^2 = 14.812, p value = 0.022) were significant as listed in Table IV. While in Table V, there

was no significant association between knowledge and practice of TACO, serum lipid profile, body composition and waist circumference among hyperlipidemia patients in Hospital USM ($p > 0.05$, N = 197).

Table IV: Association between knowledge and practice of thermally abused cooking oil (TACO) and sociodemographic characteristics of subjects (N = 197)

Sociodemographic characteristics	TACO[a]					
	Knowledge			Practice		
	High	Moderate	Low	Good	Moderate	Bad
Age						
Median ± IQR[b]	60 ± 12	63.5 ± 15	74 ± 12	61 ± 10	60 ± 13	53 ± 0
p-value		0.001*			0.765	
Formal Education Years						
Median ± IQR	11 ± 5	11 ± 6	11 ± 10	11 ± 5	11 ± 5	11 ± 0
p-value		0.209			0.629	
Monthly Household Income						
Median ± IQR	2000 ± 2000	1100 ± 1000	2500 ± 12200	2400 ± 3050	2000 ± 2000	1750 ± 0
p-value		0.06			0.3	
Gender						
Male n(%)	72 (43.4)	12 (50)	6 (85.7)	35 (51.5)	53 (41.7)	2 (100)
Female n(%)	94 (56.6)	12 (50)	1 (14.3)	33 (48.5)	74 (58.3)	0 (0)
X^2 (df)[c]		5.058			4.095	
p-value		0.08			0.129	
Ethnicity						
Malay n(%)	142 (85.5)	18 (75)	7 (100)	56 (82.4)	110 (86.6)	1 (50)
Non-Malay n(%)	24 (14.5)	6 (25)	0 (0)	12 (17.6)	17 (13.4)	1 (50)
X^2 (df)		3.109			2.515	
p-value		0.211			0.284	
Marital Status						
Single n(%)	8 (4.8)	0 (0)	0 (0)	4 (5.9)	3 (2.4)	1 (50)
Married n(%)	156 (94)	24 (100)	7 (100)	63 (92.6)	123 (96.9)	1 (50)
Divorced n(%)	1 (0.6)	0 (0)	0 (0)	0 (0)	1 (0.8)	0 (0)
Widow n(%)	1 (0.6)	0 (0)	0 (0)	1 (1.5)	0 (0)	0 (0)
X^2 (df)		1.967			14.812	
p-value		0.923			0.022*	

Tested using Kruskal Wallis Test and Pearson Chi Square
*p<0.05
Notes: [a]TACO = thermally abused cooking oil; [b]IQR = interquartile range; [c]X^2: Chi-square result

Table V: Association between knowledge and practice of thermally abused cooking oil (TACO), serum lipid profile, body composition and waist circumference of subjects (N = 197)

TACO[a]	Serum lipid profile (mmol/L) (Median ± IQR[b])								Body Composition (Median ± IQR[b])				Waist Circumference (cm) (Mean ± SD[c])	
	Total Cholesterol (TC)		Total Triglycerides (TG)		HDL-cholesterols		LDL-cholesterols		Fat Mass Percentage (%)		Fat Free Mass Percentage (%)			
	Median ± IQR	p-value	Median ± IQR	p-value	Median ± IQR	p-value	Median ± IQR	p-value	Median ± IQR	p-value	Median ± IQR	p-value	Mean ± SD	p-value
Knowledge of TACO														
High	4.62 ± 1.65	0.607	1.28 ± 0.72	0.942	1.22 ± 0.4	0.108	2.73 ± 1.25	0.694	34.1 ± 11.7	0.666	26.75 ± 7.6	0.109	94.15 ± 13.5	0.134
Moderate	4.45 ± 1.69		1.28 ± 0.62		1.39 ± 0.4		2.57 ± 1.35		32.1 ± 11.35		27 ± 7.75		95.5 ± 13.5	
Low	4.58 ± 1.96		1.3 ± 1.08		1.14 ± 0.55		2.56 ± 1.94		30.44 ± 12.1		33.3 ± 41.39		104.5 ± 11.5	

CONTINUE

Table V: Association between knowledge and practice of thermally abused cooking oil (TACO), serum lipid profile, body composition and waist circumference of subjects (N = 197)

TACO[a]	Serum lipid profile (mmol/L) (Median ± IQR[b])								Body Composition (Median ± IQR[b])				Waist Circumference (cm) (Mean ± SD[c])	
	Total Cholesterol (TC)		Total Triglycerides (TG)		HDL-cholesterols		LDL-cholesterols		Fat Mass Percentage (%)		Fat Free Mass Percentage (%)			
	Median ± IQR	p-value	Median ± IQR	p-value	Median ± IQR	p-value	Median ± IQR	p-value	Median ± IQR	p-value	Median ± IQR	p-value	Mean ± SD	p-value
							Practice of TACO							
Bad	5.93 ± NA[d]	0.514	0.83 ± NA	0.36	1.41 ± NA	0.702	4.14 ± NA	0.336	24.2 ± NA	0.06	32.85 ± NA	0.145	93.75 ± NA	0.826
Moderate	4.58 ± 1.44		1.31 ± 0.69		1.25 ± 0.37		2.64 ± 1.09		34.3 ± 12.6		26.7 ± 8.2		94.3 ± 14.5	
Good	4.6 ± 1.87		1.22 ± 0.77		1.22 ± 0.47		2.68 ± 1.70		32.55 ± 11.2		27 ± 8.55		95.5 ± 12	

Tested using Kruskal Wallis Test
Notes: [a]TACO = thermally abused cooking oil; [b]IQR = interquartile range; [c]SD = standard deviation; [d]NA = not available

Relationship between serum lipid profile with body composition and waist circumference among hyperlipidemia patients

In Table VI, the relationship between total cholesterol and fat free mass was found significant, weak and in positive direction (p =0.012, r-value 0.127). The significant association between HDL-cholesterol and fat mass was positively weak (p =0.017, r-value 0.188). Both the relationships between HDL-cholesterol and fat free mass (p=0.01, r-value -0.202), as well as HDL-cholesterol and waist circumference (p =0.01, r-value -0.202) were found to be significant and weak in inverse direction.

Table VI: Association between serum lipid profile, body composition and waist circumference of subjects (N = 197)

Serum Lipid Profile	Body Composition				Waist Circumference	
	Fat Mass Percentage		Fat Free Mass Percentage			
	r-value	p-value	r-value	p-value	r-value	p-value
Total Cholesterol (TC)	+0.127	0.106	-0.197	0.012*	-0.126	0.11
Total Triglycerides (TG)	+0.034	0.664	+0.017	0.828	+0.083	0.294
HDL-cholesterols	+0.188	0.017*	-0.202	0.01*	-0.202	0.01*
LDL-cholesterols	+0.063	0.426	-0.121	0.127	-0.065	0.41

r-value: correlation coefficient, tested using Spearman's Correlation
*p<0.05

Relationship between body composition and waist circumference among hyperlipidemia patients

Last but not least, the relationship between fat mass and waist circumference was significant but weakly positive (p 0.000<0.05, r-value 0.266); while the relationship between fat free mass and waist circumference was significant but weakly negative (p 0.004<0.05, r-value -0.202) as shown in Table VII.

Table VII: Association between body composition and waist circumference of subjects (N = 197)

Body Composition	Waist Circumference	
	r-value	p-value
Fat Mass Percentage	+0.266	0.000*
Fat Free Mass Percentage	-0.202	0.004*

r-value: correlation coefficient, tested using Spearman's Correlation
*p<0.05

DISCUSSION

Sociodemographic and Clinical Characteristics

From the total respondents (N = 197), 84.8% of them were from Malay ethnicity, which is in line with the statistics of Kelantanese population where 98% of the citizens are Malay (11). The median age of respondents was 61 years old, while more female adults (54.3%) involved in this research. These characteristics are similar to the 2021 dyslipidaemia prevalence study in Kelantan that aging is associated with hyperlipidemia status and more females (56.7%) are enrolled as compared to males (43.3%) (12). As for marital status of respondents, 94.9% of them are married and claimed that the wife will be responsible for preparing food at home which include the use of thermally abused cooking oil (TACO). Study by Wolfson (13) showed that women cooks more frequently than men in global. The current research indicates the median education years of 11 years which is in secondary level and household income of RM2000. Participants with higher education level and/or higher household income tend to have better health awareness and may afford more expensive oils such as olive oil, canola oil, sunflower oil instead of TACO (14).

In current research, the respondents are predominantly from the outpatient setting due to the higher daily flow of patients. Majority of the respondents seems having good lipid profile which shows median total cholesterol (4.6mmol/L), triglycerides (1.7mmol/L) and HDL-cholesterol (1.2mmol/L) within the normal range. The

LDL-cholesterol is targeted based on own cardiovascular risk (15). Almost 87.2% of the respondents in the current study was on lipid-lowering drugs for controlling their serum lipid profile. Baharudin et al (2022) reported that respondent with cardiovascular diseases in their study were not on lipid lowering drugs. A total of 89.5% of those without CVD but having high risk based on the Framingham Risk Score (FRS) were not on lipid lowering drug as well. Lipid lowering drug use was related to higher income (16).

Anthropometric and Body Composition Characteristics

In the present research, the median BMI value indicates overweight category for both male (26.1kg/m2) and female (27.4kg/m2) respondents. The activation of adipokines leptin in obese person will promote systemic chronic inflammation, abnormal lipid metabolism, insulin resistance, endothelial dysfunction and hypercoagulability which gradually leads to atherosclerosis and increased cardiovascular risk (17). Among the male respondents aged 31 to 88 years old, their median fat mass is 27.5% and median fat free mass is 30.7%; while among female respondents who aged 23 to 87 years old, their median fat mass is 38.3% and median fat free mass is 23.7%. Since the respondent's age varied widely, their median fat mass and fat free mass can be hardly classified as either optimum or abnormal. (18). Nevertheless, males had higher fat free mass while females had greater fat mass (19). In addition, aging is associated with increased fat mass and changes in body fat distribution contributing to raise in visceral adipose tissue. The mean waist circumference in the current research represents abdominal obesity for both male and female participants (>80cm for female and >90cm for male). The excessive visceral adipose tissue in abdominal obesity encourages the entry of high dose of adipokines into portal vein and brings hazardous health impacts such as diabetes mellitus, hypertensions, cardiovascular diseases, non-alcoholic fatty liver diseases, kidney disease and cancer (20).

Knowledge and Practice on Thermally Abused Cooking Oil (TACO)

The current result indicates that majority (84.3%) of the respondents had high level of knowledge (seven to nine scores) about TACO. Surprisingly, there were still 64.5% of respondents practised moderate use (two to four times) of TACO. The results are slightly different with previous research where 53.2% of participants reported moderate knowledge level and 50.0% of them practise TACO moderately (9). Studies by Azman (10) and Shukor and Rostam (21) had reported moderate level of knowledge and practice of TACO among night market food handlers in Kuala Lumpur and Pahang districts in Malaysia. The high level of TACO knowledge among hyperlipidemia patients in the current study is believed to be related to the widespread of its information on social medias such as internet (39.1%), television (29.9%), newspaper (23.9%), and magazine (18.3%), as well as via information from family members and friends (30.5%). There are information regarding the harmful health impacts of TACO on social medias such as causing cancer, inflammation, and atherosclerosis (22–24). TACO is commonly used to avoid wasting especially with the higher price of cooking oil.

Association of Knowledge and Practice on Thermally Abused Cooking Oil (TACO) with Sociodemographic Characteristics, Serum Lipid Profile, Body Composition, and Waist Circumference

Findings from the recent study found that the median age of participants having high level of thermally abused cooking oil (TACO) knowledge was 60 years old while that of good TACO practice level was 61 years old. This was different with the previous study that reported almost 60% of the participants were below 45 years old and had moderate awareness (53.2%) and practice level (50.0%) of TACO (9). The association between age and TACO knowledge was significant in the current research (p value<0.001). Older participants (74-year-old) had poor TACO knowledge due to the limited exposure to information from the Internet, magazines and newspapers. The median formal education years of participants with high TACO knowledge and good TACO practice were both 11 years, which was in line with the study in Malaysia that majority of the respondents had completed secondary school (47.2%) (25). The median monthly household income of participants with high TACO knowledge level was RM 2000. The price of cooking oil in Malaysia especially palm oil has increased which increases financial burden, thus promotes the use of TACO (26). The majority of respondents were married with high TACO knowledge level (n=156, 94%) but moderate TACO practice (n=123, 96.9%). The association between marital status and practice of TACO was significant. A 21-year longitudinal study conducted among older women found that married women had better dietary habits as compared to those who were single. Women cooking for their spouse and children tend to prepare healthier diets due to their parental role (27).

From the present research, the relationship between knowledge and practice of thermally abused cooking oil (TACO) with serum lipid profile, body composition and waist circumference were not significant. However, these relationships must not be disregarded. Frequent use of TACO contributes to the formation of aldehydes in TACO which significantly raise serum LDL-cholesterol and triglycerides, while reducing serum HDL-cholesterol and were associated with higher accumulation of triglycerides and active aldehydes in hepatic tissue (28). Besides, repeated cycle of heating TACO promotes the intake of free fatty acids and thermally oxidized products such as free radicals, hydroperoxides, aldehydes, ketones and alcohols which are produced through primary and secondary thermal oxidation (29,30). Excessive dietary free fatty acids will be stored in form

of triglyceride inside the adipose tissue via hypertrophy and hyperplasia, and thus it gradually leads to excessive body fat mass as well as overweight and obesity (31). The excessive free fatty acids in blood plasma which were not transformed into lipid droplet within adipose tissue will also contribute to lipotoxicity (32). Lipotoxicity is known as the detrimental impacts of lipid accumulation in non-adipose tissues, for instance liver, which could induce chronic inflammation and metabolic disorders such as insulin resistance and non-alcoholic fatty liver disease (32,33). In addition, regular intake of TACO is also associated with larger waist circumference (34). It is probably due to the high production of trans fatty acids in TACO which is capable of increasing both BMI and waist circumference via common obesity-associated gene (FTO) polymorphism (35). Abdominal obesity will gradually lead to or worsening of atherogenic hyperlipidemia (36).

Relationship of Serum Lipid Profile with Body Composition and Waist Circumference

The findings of the current study showed significant relationship between total cholesterol and fat free mass, as well as the relationship between HDL-cholesterol with fat mass, fat free mass and waist circumference. Hyperlipidemia is closely associated with the obesity epidemic, especially the abdominal obesity, which both are the key features of metabolic syndrome (37). This is supported by another study showing that individuals with normal BMI with abdominal obesity poses higher risk of developing high triglycerides level, low HDL-cholesterol level, high systolic blood pressure and high fasting blood glucose as compared to those with normal BMI without abdominal obesity (38). A cross-sectional study among 10482 adults from five states in Malaysia participating in the REDISCOVER study found that higher total cholesterol and LDL-cholesterol were common among individuals with hypertension, obese and having abdominal obesity, while higher triglyceride were common among men, those with diabetes, hypertension, obese and centrally obese (12).

Association of Body Composition with Waist Circumference

The current study revealed that the association between body composition, both fat mass and fat free mass, with waist circumference are significant. Both the body composition and waist circumference are measures of the adipose tissue, which are subcutaneous adipose tissue (SCAT) located beneath the skin and visceral adipose tissue (VAT) present in the intra-abdominal cavity in close proximity to major organs such as intestines and liver respectively (39). In recent study, VAT is said to be positively related to the risk of cardiovascular diseases as compared to SAT (40). The presence of VAT alone is associated with insulin resistance, hyperlipidemia, hypertension, cardiovascular disease, colorectal disease and cognitive impairment. VAT reduction among overweight people could significantly lower the risk of developing metabolic disorders (41). High visceral-to-subcutaneous ratio increases risk of non-alcoholic fatty liver disease (NAFLD) and the presence of advanced fibrosis among NAFLD patients (42). On the other hand, postmenopausal women and men tend to accumulate more VAT due to ageing and hormonal function. Decline of testosterone and estrogen levels in older men and women increased abdominal VAT deposition (38, 39). Thus, consumption of TACO among older adults tend to increase the risk of abdominal obesity and cardiovascular diseases.

Strength and Limitation

The current study highlights the knowledge and practice of TACO among hyperlipidemia patients and how these can be associated with several health parameters such as serum lipid profile, body composition and waist circumference. Besides, this research findings could be applied for future fundamental and interventions studies.

Alongside the research, there were also limitations that should be mentioned. Firstly, the research design is cross-sectional study where the causal inference between knowledge and practice of TACO, serum lipid profile, body composition and waist circumference cannot be concluded. Besides, the participants were mostly Malay, thus the findings of the study were unable to represent the Malaysian population. Furthermore, since majority of the hyperlipidemia patients involved in this research were taking lipid-lowering drugs, their serum lipid profiles were most probably within normal range.

CONCLUSION

In summary, the current findings illustrated that majority of the hyperlipidemia patients (84.3%) had high level of knowledge (seven to nine scores) on thermally abused cooking oil (TACO) but still 64.5% of them are practising it moderately (two to four times). The present study concludes that the association between knowledge and practice of TACO, serum lipid profile, body composition, and waist circumference of hyperlipidemia patients were not significant. Nevertheless, the relationship between total cholesterol and fat free mass as well as between HDL-cholesterol with fat mass and fat free mass were significant. Besides that, relationship between waist circumference with HDL-cholesterol, fat mass and fat free mass were significant. Future studies related to TACO should focus on the toxic compounds formed during the degradation of TACO when exposed to high temperature, their absorption rates, distribution within the body, and mechanism of toxicity. It is crucial to assess the environmental impact of disposing the TACO which may contribute to soil and water contamination.

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