ORIGINAL ARTICLE

Association between Dietary Inflammatory Index and Metabolic Syndrome: A Hospital-Based Study

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Abstract:

Background: Elevated inflammatory biomarkers in Metabolic Syndrome (MetS) are associated with Dietary Inflammatory Index (DII), which helps discern the inflammatory impacts of diet and hence the risk of Cardiovascular Diseases (CVD) in MetS. *Aim and Objectives:* To assess the association between DII scores and different components of MetS. To discern the degree of association between the dietary inflammatory potential and different components of MetS using the DII score specific to this population. *Material and Methods:* DII scores were calculated in 100 MetS participants and the diet was graded from maximally anti-inflammatory to maximally proinflammatory. Data were represented as mean ± standard deviation and compared using correlation coefficient and chi-square test. *Results:* DII scores were partially correlated with triglycerides (TG; P = 0.279) in the first quartile, with systolic blood pressure (P = 0.145) in the second, with High Density Cholesterol (HDL) in the third (P = - 0.0001), and with Triglycerides (TG) (P = 0.139) and diastolic blood pressure (P = 0.203) in the fourth quartile. *Conclusion:* The results reflect the role of diet in regulation of inflammation and are imperative to transform to a low inflammatory, antioxidant-rich diet to lower CVD risk.

Keywords: Atherogenic diet, Immune system, Inflammation, Insulin resistance

Introduction:

Metabolic Syndrome (MetS) is a group of conditions characterized by abdominal obesity, hypertension, insulin resistance, and hyperglycemia [1]. About 20–30% of the adult population in most countries is afflicted with MetS, which makes it a notable public health concern [2]. The risk of developing Cardiovascular Disease (CVD) increases more than two-fold in men with MetS than in those without MetS [3]. The population-attributable fraction of MetS for CVD, diabetes, and all-cause mortality is 12–17%, 30–52%, and 6–7%, respectively. Deleterious effects of weight gain, sedentary lifestyle, and/or an atherogenic diet are known to culminate as MetS [4]. These factors lead to the release of biomarkers, such as the proinflammatory cytokines [Interleukin (IL) 6, IL-18, and Tumor Necrosis Factor (TNF)-alpha (α)], leptin, Prothrombic Factors (PAI-1), Oxidized Low Density Lipoprotein (LDL) (OxLDL), and uric acid. Further, the biomarkers cause modulation of the immune system leading to a low-grade chronic systemic inflammation, which is correlated with the severity [5] and the number of components of MetS [1].

The suggested interventions focus on improving the level of physical activity, weight reduction, reducing substance abuse, and alteration of diet in order to reduce effectiveness of specific food items along with regulation of genes and various inflammatory markers.

Ramallah (2017) suggested that a diet with a proinflammatory potential can lead to a significantly higher annual weight gain along with a higher risk of developing new-onset overweight or obesity status [6].

Diet and lifestyle modifications, such as increasing the level of physical activity, discouraging substance abuse, and weight reduction can blunt the insulin resistance and prevent the metabolic and cardiovascular abnormalities associated with MetS [7]. According to Mendelian randomization experiments, there exists a causal relationship direction from greater adiposity to elevated systemic inflammation [8]. Although, modification in diet and lifestyle is suggested as the first parameter to defy MetS, the evidence remains inconclusive whether the improvement is either in a specific component or overall MetS [9].

Therefore, the need for an appropriate tool to measure the proinflammatory/anti-inflammatory potential of an individual's diet is imperative. The Dietary Inflammatory Index (DII) works on the basis of the pathophysiological processes and is useful in discerning the inflammatory potential of the diet. The DII score can further be used to categorize the diet from maximally anti-inflammatory to maximally proinflammatory. It significantly predicts the interval changes in C-reactive Protein (CRP) – an inflammatory marker; therefore, is a more specific and promising scoring index [10]. The association between DII and other inflammatory biomarkers is also established by several studies [11, 12].

However, there is paucity of studies evaluating the association between inflammatory potential of diet and the individual components of MetS, particularly in the region of south India. Hence, this study was aimed to discern the degree of association between the dietary inflammatory potential and different components of MetS using the DII score specific to this population. This study hypothesized that the patients consuming excessive proinflammatory diet (i.e., higher DII scores) have elevated measures of components of MetS relative to those with lower DII scores (anti-inflammatory diet).

Material and Methods:

The present cross-sectional study was conducted over a period of three months (July–October 2017) after obtaining an ethical clearance (2017-01251) from the Institutional Ethics Clearance and Review Board.

Sampling criteria:

A total of 100 subjects with MetS attending the outpatient departments of BLD (Deemed-to-be University) Shri B M Patil Medical College, Hospital, and Research Center, Vijayapura, were screened and enrolled in the study. The above sample size was calculated with anticipated Proportion of MetS 20% [2]. The minimum sample size was 100 patients with 1% level of significance and 10% absolute error.

Formula used was

$$n = \frac{z^2\, p*q}{d^2}$$

Where Z= Z statistic at α level of significance

d^2= Absolute error

P= Proportion rate

q= 100-p

Subjects with a history of CVD, complications of diabetes, or systemic disorders, such as severe hepatic and renal diseases, and pregnant women were excluded from the study. Further, participants

with White Blood Cell (WBC) count > 10,000/ml and serum creatinine level > 1.4 mg/dl were also excluded from the study. All the subjects were explained the purpose of the study and a written informed consent was obtained before the commencement of the study.

Data Collection:

The criteria for MetS were defined by the National Cholesterol Education Programs (NCEP) guidelines with recent modifications from the American Heart Association and the National Heart, Lung, and Blood Institute [11]. The criteria for MetS included serum Triglycerides (TG) ⩾ 15 mg/dl, serum High-Density Lipoprotein (HDL)-cholesterol concentration < 40 mg/dl, Fasting Blood Glucose (FBG) levels ⩾ 110 mg/dl or taking antidiabetic medications, waist circumference (> 40 inches in males and > 35 inches in women), and Systolic Blood Pressure (SBP) > 130 mmHg and Diastolic Blood Pressure (DBP) > 85 mmHg or taking antihypertensive medication. Subjects exhibiting more than three of the five reported criteria were diagnosed with MetS. All the subjects underwent tests to evaluate the FBG, HDL and TG. Waist circumference (cm) was measured at the midpoint between the inferior margin of the last rib and the iliac crest in a horizontal plane. Blood pressure was measured with a Baumanometer mercury sphygmomanometer (W.A. Baum, Copiague, New York, USA). Three readings of SBP and DBP were recorded, and the average of the last two readings was used for data analysis. Medication history of all the participants was also recorded.

Dietary Inflammatory Index:

The food frequency questionnaire was framed for the Indian diet to capture dietary intakes adequately and to calculate the DII Score [13]. The questionnaire was validated on a group of 20 peers before administering to the subjects. Dietary data were collected by interviewing the participants through a 24-hour recall and using household measures to ascertain portion sizes. The above details were used to calculate the DII to assess the inflammatory potential of the diet [14]. Construct validation of DII are as described in previous studies [15, 16].

A z score for each of the food parameters was calculated using the 24 h dietary recall data for each participant. Individuals' intake of each dietary parameter was subtracted from a world global standard database and then divided by the world Standard Deviation (SD) for that particular dietary parameter to obtain a z score. The standard deviation and global means of the food and nutrient intake collected from the 11 nations were employed for z score calculation. These values were then converted into percentile score and each percentile score was doubled and was subtracted by 1 to achieve a symmetrical distribution (from -1 to +1 and centered on 0). The centered percentile value was multiplied by the respective inflammatory effect scores to obtain the food parameter-specific DII score. Finally, the sum of all the dietary parameter-specific DII scores was provided as an overall DII score for each participant of the study. The greater the DII score, the more proinflammatory the diet was considered; negative values indicated the anti-inflammatory nature of the diet.

The range of the DII score was between - 8.87 (maximally anti-inflammatory) and + 7.98 (maximally proinflammatory). DII scores were then converted to quartiles (Quartile 1: - 6.27–- 1.26; Quartile 2: - 1.25–0.74; Quartile 3: 0.74–2.63; and Quartile 4: 2.64–5.89) for the convenience of statistical application.

The data were available only for 26 of the total 45 DII food parameters, which were used for DII calculation. DII calculation used the following food parameters as proinflammatory: total calories as energy, carbohydrates, and total fat (saturated as well as cholesterol); whereas, protein, Mono-unsaturated Fatty Acids (MUFA), Polyunsaturated Fatty Acids (PUFA), omega-3-fatty acids, n-6 fatty acids, fiber, iron, vitamin A, β-carotene, thiamin, riboflavin, niacin, vitamin C, garlic, ginger, onion, tea, and pepper were valued as anti-inflammatory. Parameters that were not obtainable due to an incomplete food database or due to very low intake were omitted during the DII calculation.

Data Analysis:

The data obtained from the study were represented as mean ± SD, quartiles and percentages were applied and Variables were compared using correlation coefficient, and Chi-square test was applied.

Results:

Demographic details of the study subjects are shown in Table 1. The prevalence was higher (37%) in subjects in the age group of 50–59 years. Out of the total 100 subjects, (52%) were female and (48%) were male, indicating that increased risk of MetS in females as compared to males. The association observed between the DII score and the components of the metabolic syndrome depicted as in Table 2, DII score, when split into quartiles showed weak correlation with the TG component ($P = 0.279$) in the first quartile; with SBP ($P = 0.145$) in the second quartile; However, DII score and TG had a $P = 0.139$ and DII score with DBP had a $P = 0.203$ in the fourth quartile. Further, a strong negative correlation between HDL and DII score in the third quartile ($P = 0.0001$) was observed, which was statistically significant as given in Table 3. There was also a significant difference ($P = 0.0001$) between the biomarkers of first and fourth quartiles of the DII score. A strong correlation was observed between DII and the components of metabolic syndrome—FBG (mg/dl) and SBP (mmHg)—in both males and females, which was statistically significant (Table 4). The component biomarkers of metabolic syndrome in the first and fourth quartiles were characteristic. Further, the level of variance between the quartiles was statistically significant (Table 5).

Table 1: Demographic Characteristics of Study Subjects

Variable		N (%)
Gender	**Female**	52 (53.0)
	Male	48 (48.0)
Age (years)	**< 40**	14 (14.0)
	40–49	30 (30.0)
	50–59	37 (37.0)
	⩾ 60	19 (19.0)

Table 2: Association between Dietary Inflammatory Index Score and the Components of the Metabolic Syndrome

Variable	DII score		*P*
	-4.2 – 0.22; n (%)	**0.05 – 6.01; n (%)**	
TG (mg/dl)			
< 150	4 (11.4)	12 (18.5)	0.360
> 150	31 (88.6)	53 (81.5)	
HDL (mg/dl)			
< 40	12 (34.3)	32 (49.2)	0.205
> 40	23 (65.7)	33 (50.8)	
FBG (mg/dl)			
< 110	2 (5.7)	5 (7.7)	0.712
> 110	33 (94.3)	60 (92.3)	
SBP (mmHg)			
< 130	4 (11.4)	15 (23.1)	0.157
> 130	31 (88.6)	50 (76.9)	
DBP (mmHg)			
< 85	21 (60.0)	46 (70.8)	0.275
> 85	14 (40.0)	19 (29.2)	

DII: Dietary inflammatory index, TG: Triglycerides, HDL: High density lipoprotein, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, FBG: Fasting blood glucose

Table 3: Association of Various Components of Metabolic Syndrome with Quartiles of DII Score

Variable	Quartile							
	1st Quartile		2nd Quartile		3rd Quartile		4th Quartile	
	R	*P*	r	*P*	r	*P* value	R	*P*
TG(mg/dl)	0.225	0.279	0.185	0.376	0.242	0.243	0.305	0.139
HDL (mg/dl)	- 0.124	0.555	- 0.131	0.534	- 0.658	0.0001*	-0.031	0.885
SBP (mmHg)	0.117	0.577	0.300	0.145	0.060	0.777	-0.217	0.298
DBP (mmHg)	0.185	0.375	0.055	0.792	- 0.005	0.981	0.264	0.203
FBG (mg/dl)	- 0.119	0.571	0.096	0.648	- 0.312	0.128	0.04	0.763

DII: Dietary inflammatory index, TG: Triglycerides, HDL: High density lipoprotein, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, FBG: Fasting blood glucose

Table 4: Correlation between Dietary Inflammatory Index and Components of Metabolic Syndrome in Males and Females

Variables	Total		Males		Females	
	R	*P*	*r*	*P* value	*r*	*P*
DII–TG (mg/dl)	0.30	< 0.01	0.27	0.07	0.32	0.02
DII–HDL (mg/dl)	− 0.03	0.76	− 0.15	0.34	0.14	0.30
DII–FBG (mg/dl)	− 0.56	< 0.001	− 0.54	< 0.001	− 0.60	< 0.001
DII–SBP (mmHg)	− 0.47	< 0.001	− 0.49	0.01	− 0.46	< 0.001
DII–DBP (mmHg)	− 0.43	< 0.001	− 0.46	0.01	− 0.44	0.01

DII: Dietary inflammatory index, TG: Triglycerides, HDL: High density lipoprotein, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, FBG: Fasting blood glucose

Table 5: Significant Difference between First and Fourth Quartiles of Biomarkers

Variable	Mean ± SD	*P*
TG (mg/dl)	161.08 ± 25.937	0.0001
	50.08 ± 7.842	0.0001
TG (mg/dl)	55.72 ± 20.742	0.0001
	174.96 ± 28.713	0.0001
FBG (mg/dl)	125.64 ± 21.313	0.0001
	47.00 ± 21.453	0.0001
DII–SBP (mmHg)	141.92 ± 15.529	0.001
	122.28 ± 21.652	0.001
DII–SBP (mmHg)	84.56 ± 5.788	0.0001
	138.32 ± 15.370	0.0001

SD: Standard deviation; P value of t-test/Mann-Whitney U test

Discussion:

Worldwide, a significant shift in the dietary pattern owing to the globalization has contributed to MetS, which has reached an epidemic proportion [17]. Inflammatory potential of the diet has gained momentum as it is known to have a significant effect on the development of inflammation and the inflammatory cascade [18]. Lifestyle and dietary interventions that are suggested to be the first line of management should be targeted at an early stage to modify the inflammation and effectively manage MetS [19]. DII was formulated with an intention to measure the inflammatory potential of macro- and micronutrients, such as vitamins, minerals, and other bioactive compounds, including flavonoids [14].

The present study was conducted to evaluate the degree of association of various components of MetS, such as serum levels of TGs, HDL, FBG, and blood pressure levels with the inflammatory potential of the diet using DII. The results suggest a mild association between TG component of the MetS and higher DII scores. This can be possibly due to increase in the inflammatory potential of the diet with high carbohydrate and low fat and protein composition, which is reflected by higher DII score [20]. Further, carbohydrate-rich diets increase the absolute concentrations of circulating TGs and are strongly correlated with high TGs even after a single meal [21].

In the present study, a strong negative correlation between HDL and DII score was observed in the third quartile. A diet with a proinflammatory potential is correlated with chronic disease etiology and mortality, which leads to oxidative stress and cellular injury. This further affects the structure and function of the organ system through the pathways that modulate chronic inflammation [22].

The protective role HDL modulates inflammation through its heterogenous antioxidative capacity. Paraoxonase-1 (PON-1), Phospholipase-A2 (PLA-2), Lecithin: Cholesterol Acyl Transferase (LCAT), apolipoprotein-AI (apo-AI), apo-AII, apo-E, apo-M, and apo-J contribute to the potent antioxidant function of HDL with PON1, perhaps, being the most prominent [23].

Traditional Mediterranean Diet (TMD), known to include larger portions of whole grains, fish, and green leafy vegetables, is low in red meat and has lower DII scores [24]. A study conducted by Hernaez *et al*. supported the fact that adherence to a TMD, especially the one enriched with virgin olive oil, leads to simultaneous improvement in all four key HDL functional traits, including cholesterol efflux capacity, HDL-C metabolism, HDL antioxidant/anti-inflammatory properties, and vasoprotective effects. Furthermore, the benefits could be through improvements in the HDL oxidative status, composition, and size as well [25].

However, the present study did not observe correlation between the DII score and other components of MetS, such as hypertension and Fasting Blood Glucose (FBG) levels. Similarly, a study conducted by Alkerwi *et al*. reported no association between DII and FBG [26]. It is suggested that DII has a weak positive association only with 2 h post-load glucose (2h-PG) and not with Impaired Fasting Glucose (IFG), Impaired Glucose Tolerance (IGT), Type 2 Diabetes Mellitus (T2DM), and insulin resistance [27]. Subjects with higher DII scores are known to be associated with significantly higher odds of developing T2DM [28]. Hence, dietary modifications, such as increased intake of fruits, vegetables, whole grains, dairy and dairy components, calcium, vitamin D, and whey protein, including MUFA and omega-3 fatty acids on a daily basis can have a beneficial effect in reduction of the components of MetS due to the predominant anti-inflammatory nature of such a diet [29].

The thorough understanding of the effect of diet on major components of MetS, such as glucose intolerance, lipid profile, and hypertension will aid in laying dietary goals for an individual and to switch over from proinflammatory diet towards anti-inflammatory diet (such as TMD). This will prevent the adverse consequences of the proinflammatory diet. Further, DII could be a standard and novel tool in analyzing and framing the simple and adequate routine diet plans for financially challenged population.

Conclusion:

The study results suggested a mild association between DII score and levels of TGs and HDL component of the MetS, thus reflecting the role of diet in regulation of inflammation. Therefore, it is important to modulate an individual's dietary pattern from proinflammatory (higher DII scores) towards a Mediterranean type of diet (low DII scores), which has lower inflammatory potential and is rich in antioxidant properties. Anti-inflammatory diet lowers the adverse effects of

chronic inflammation and the associated cardiovascular risks. Hence, conducting similar studies on larger sample population to analyze the role of diet on systemic inflammation will aid in predicting the risk of chronic inflammation and the related chronic disorders, such as MetS and CVD.

Strengths:

The present study has its own strength that that it is one of the few studies wherein, the association of DII with individual components of the MetS was evaluated in the south Indians. Furthermore, household measures were used to ascertain portion sizes, and the dietary data was collected by interviewing the participants through 24-h recall. Gender balance among the participants is an added strength, which enabled data analysis stratification by gender.

Limitations:

The present study was conducted with a validated food frequency questionnaire and followed a standardized dietary data collection by interviewing the participants with MetS. However, this study was not without limitations, a small sample size being one. Incomplete extraction of the dietary details of the participants due to discrepancies in the 24-h dietary recall may have affected the DII score to a certain extent. We did not follow-up the study participants, which adds as the third limitation. Further, studies with larger sample size will be needed to discern the more accurate inflammatory impacts of diet on systemic inflammation based on DII score, which plays a vital role in the pathophysiology of MetS.

References

1. Samson SL, Garber AJ. Metabolic syndrome. *Endocrinol Metab Clin North Am* 2014; 43(1):1-23.
2. Grundy SM. Metabolic syndrome pandemic. *Arterioscler Thromb Vasc Biol* 2008; 28(4): 629-36.
3. Malik S, Wong ND, Franklin SS, Kamath TV, L'Italien GJ, Pio JR, *et al*. Impact of the metabolic syndrome on mortality from coronary heart disease, cardiovascular disease, and all causes in United States adults. *Circulation* 2004;110:1245-50.
4. Ford ES. Risks for all-cause mortality, cardiovascular disease, and diabetes associated with the metabolic syndrome: a summary of the evidence. *Diabetes Care* 2005; 28 (7): 1769-78.
5. Robberecht H, Hermans N. Biomarkers of Metabolic Syndrome: Biochemical Background and Clinical Significance. *Metab Syndr Relat Disord* 2016;14(2):47-93.
6. Ramallal R, Toledo E, Martínez JA, Shivappa N, Hébert JR, Martínez-González MA, *et al*. Inflammatory potential of diet, weight gain, and incidence of overweight/obesity: the SUN cohort. Obesity (Silver Spring) 2017; 25(6): 997-1005.
7. Yudkin JS, Stehouwer CD, Emeis JJ, Coppack SW. C-reactive protein in healthy subjects: associations with obesity, insulin resistance, and endothelial dysfunction: a potential role for cytokines originating from adipose tissue? *Arterioscler Thromb Vasc Biol* 1999; 19(4):972-8.
8. Riccardi G, Rivellese AA. Dietary treatment of the metabolic syndrome--the optimal diet. Br J Nutr 2000; 83(Suppl 1):S143-8.
9. Kataria I, Chadha R, Pathak R. Dietary and lifestyle modification in metabolic syndrome: a review of randomized control trials in different population groups. *Rev Health Care* 2013; 4(4): 209-30.
10. Shivappa N, Steck SE, Hurley TG, Hussey JR, Ma Y, Ockene IS, *et al*. A population-based dietary inflammatory index predicts levels of C-reactive protein in Seasonal Variation of Blood Cholesterol Study (SEASONS). *Public Health Nutr* 2014; 17(8): 1825-33.

11. Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, *et al*. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. *Circulation* 2005; 112(17):2735-52.
12. Appel LJ, Moore TJ, Obarzanek E, Vollmer WM, Svetkey LP, Sacks FM *et al*. A clinical trial of the effects of dietary patterns on blood pressure. *N Engl J Med* 1997; 336 (16):1117-24.
13. Bharathi AV, Kurpad AV, Thomas T, Yusuf S, Saraswathi G, Vaz M. Development of food frequency questionnaires and a nutrient database for the Prospective Urban and Rural Epidemiological (PURE) pilot study in South India: methodological issues. *Asia Pac J Clin Nutr* 2008; 17(1):178-85.
14. Shivappa N, Steck SE, Hurley TG, Hussey JR, Hebert JR. Designing and developing a literature-derived, population-based dietary inflammatory index. *Public Health Nutr* 2013; 17(8):1689-96.
15. Shivappa N, Steck SE, Hurley TG, Hussey JR, Hébert JR. A population-based dietary inflammatory index predicts levels of C-reactive protein in the Seasonal Variation of Blood Cholesterol Study (SEASONS). *Public Health Nutr* 2014; 17(8):1825-33.
16. Shivappa N, Hébert JR, Rietzschel ER, De Buyzere ML, Langlois M, Debruyne E, *et al*. Associations between dietary inflammatory index and inflammatory markers in the Asklepios Study. *Br J Nutr* 2015; 113(4):665-71.
17. Misra A, Singhal N, Sivakumar B, Bhagat N, Jaiswal A, Khurana L. Nutrition transition in India: Secular trends in dietary intake and their relationship to diet-related non-communicable diseases. *J Diabetes* 2011; 3(4):278-92.
18. Dawson DR 3rd, Branch-Mays G, Gonzalez OA, Ebersole JL. Dietary modulation of the inflammatory cascade. *Periodontol* 2000; 2014; 64(1):161–97.
19. Beavers KM, Nicklas BJ. Effects of lifestyle interventions on inflammatory markers in the metabolic syndrome. *Front Biosci (Schol Ed)* 2011; 3:168-77.
20. Shivappa N, Steck SE, Hussey JR, Ma Y, Hebert JR. Inflammatory potential of diet and all-cause, cardiovascular, and cancer mortality in National Health and Nutrition Examination Survey III Study. *Eur J Nutr* 2017; 56(2):683-692.
21. Parks EJ. Effect of dietary carbohydrate on triglyceride metabolism in humans. *J Nutr* 2001; 131(10):2772S-2774S.
22. Graffouillère L, Deschasaux M, Mariotti F, Neufcourt L, Shivappa N, Hébert JR, *et al*. Prospective association between the Dietary Inflammatory Index and mortality: modulation by antioxidant supplementation in the SU.VI.MAX randomized controlled trial. *Am J Clin Nutr* 2016; 103(3):878-85.
23. Karlsson H, Kontush A, James RW. Functionality of HDL: Antioxidation and detoxifying effects. *Handb Exp Pharmacol* 2015; 224:207-28.
24. Bawaked RA, Schröder H, Ribas-Barba L, Izquierdo-Pulido M, Pérez-Rodrigo C, Fíto M, *et al*. Association of diet quality with dietary inflammatory potential in youth. *Food Nutr Res* 2017; 61(1):1328961.
25. Hernaez A, Castaner O, Elosua R, Pintó X, Estruch R, Salas-Salvadó J, *et al*. Mediterranean diet improves high-density lipoprotein function in high-cardiovascular-risk individuals: a randomized controlled trial. Circulation 2017; 135(7):633-643.
26. Alkerwi A, Shivappa N, Crichton G, Hébert JR. No significant independent relationships with cardiometabolic biomarkers were detected in the observation of cardiovascular risk factors in Luxembourg study population. *Nutr Res* 2014;34(12): 1058-65.
27. Moslehi N, Ehsani B, Mirmiran P, Shivappa N, Tohidi M, Hébert JR *et al*. Inflammatory properties of diet and glucose-insulin homeostasis in a cohort of Iranian adults. *Nutrients* 2016; 8(11):E735.
28. Gutierrez ED, Aguirre PM, Shivappa N, Hébert JR, Tolentino-Mayo L, Batis C *et al*. Dietary inflammatory index and type 2 diabetes mellitus in adults: the diabetes mellitus survey of Mexico city. *Nutrients* 2018; 10(4):E385.
29. Calton EK, James AP, Pannu PK, Soares MJ. Certain dietary patterns are beneficial for the metabolic syndrome: reviewing the evidence. *Nutr Res* 2014; 34(7): 559-68.

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