

Patterns of biochemical markers, metabolic syndrome and their predictors among adult population in *Moringa stenopetala* consuming and non-consuming areas in Southern Ethiopia: A comparative cross-sectional study

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Abstract

Background: *Moringa stenopetala* has widely been used as food for humans, feed for livestock and medicine in Southern Ethiopia. This study aimed to assess the effect of moringa in biochemical markers and risk for metabolic syndrome, in *M. stenopetala* consuming and non-consuming areas in Southern Ethiopia.

Methods: A comparative cross-sectional study was conducted in selected *M. stenopetala* consuming and non-consuming woredas, Southern Ethiopia from August to September, 2016. WHO NCD Steps and locally constructed structured questionnaires were used for data collection. Physical measurements and clinical parameters were also determined. Data were analyzed using SPSS version 22. Multivariate logistic regression analyses were performed to determine the associated factors and p-value less than 0.05 considered a significant association.

Results: The normal BMI, total cholesterol, LDL and triglycerides level for moringa consuming and non-consuming participants were 84.8% versus 84.3%, 95.5% versus 92.7%, 99.3% versus 95.4% and 75% versus 81.3%, respectively. No significant change was observed in total cholesterol, HDL, LDL, triglyceride, BUN, creatinine, ALP, ALT and AST levels. On the other hand, fasting blood sugar and physical measurements *i.e.*, BP, BMI and waist circumference also showed no significant changes in both study areas.

Conclusion: From these findings, it may be concluded that consuming *M. stenopetala* may not have an advantage over non-consumption in avoiding the risks of metabolic syndrome. The results of the study, however, needs to be substantiated with prospective longitudinal follow up to ascertain the effects of the frequent use of *M. stenopetala*.

Keywords: *Moringa stenopetala*, multipurpose application, biochemical parameters, community-based study

Introduction

M. stenopetala is indigenous in the South and South west of Ethiopia. The leaves are widely used as human food. The different parts are also employed as medicine for various ailments by the indigenous community. *M. stenopetala* leaves infusion are traditionally claimed to be useful for the treatment of diabetes, hypertension, asthma, common cold, anemia and many others (Mekonnen and Gessesse 1998; Demeulenaere 2001; Yang et al. 2006; Padayachee and Bajinath 2012; Abrar and Azmaxh 2017). Various Investigations conducted on *M. stenopetala* for its medicinal and nutritional value have been cited in scientific literature. The leaves of *M. stenopetala* contain fats, carbohydrates, proteins, crude fiber, vitamins namely vitamin C and β -carotene, minerals such as K, Fe, Ca, P and Zn that are comparable to some leafy vegetables. It is also reported that it can serve as an input to fight malnutrition in Ethiopia through appropriate processing and blending with locally available foods (Abuye et al. 2003; Makkar and Becker 1997; Belay et al. 2013). The aqueous and

hydro-alcoholic crude extract of the leaves and solvent partitions from these extracts showed hypoglycemic and anti-hyperglycemic activities as well as anti-hypertriglyceridemia and cholesterol lowering effects in alloxan and streptozocin induced diabetic mice, rats and rabbits (Makonnen et al. 1997; Mussa 2008; Nardos, 2011; Ghebreselassie 2011; Toma 2016., Seleshi 2014). The extract decreased systolic and diastolic blood pressure, and had vasodilator and diuretic (saluretic) activities (Mengistu et al. 2012; Geleta et al. 2015; 2016A and 2016B). The extracts, however, produced neither toxicity nor adverse effects (Berger et al. 1984). Tests for clinical parameters such as hematology, and liver and kidney functions are within accepted value ranges (Ghebreselassie 2011; Seleshi 2014; Musa 2014; Musa et al. 2015).

There are no community-based studies on the effect of *M. stenopetala*. This study, therefore, aimed to investigate alterations in biochemical markers and metabolic syndrome among study participants in selected woredas of moringa consuming and non-consuming areas in Southern Ethiopia.

Materials and Methods

Study design and study population: A comparative cross-sectional design was employed for this study. This study was conducted in selected rural and urban areas of Konso and Derashe woredas where *M. stenopetala* is a common staple food and growing abundantly, and Chenchu and Bonkey woredas, where moringa is not consumed. The study areas have relatively similar culture, agroecology and disease burden.

Sample size determination and sampling technique:

The sample size was calculated using double population proportion formula considering 95% confidence level, 5% margin of error and 50% prevalence to get sufficient sample size. Then the final sample size was 732 including non-response rate, of which 366 was for *M. stenopetala* consuming group and 366 for non- *M. stenopetala* consuming group. Rural and urban study areas were selected randomly from each district, then sampling frame was prepared from the list of households and WHO, KISH methods was applied to select one adult and under five from each targeted household.

Data collection techniques: WHO NCD Steps and locally constructed structured questionnaires that were modified following the pretest was employed for data collection from 732 households for this study. Data were collected using personal digital assistants (PDAs) and transferred to central server using internet file streaming system (IFSS). The collected data were on socio-demographic characteristics, nutrition and diet factors, health status, physical and biochemical parameters measurements, and moringa use as food and/or medicine from the study participants.

Blood sample collection: Blood samples (5-8 ml) were collected from antecubital vein of the arm of overnight fasted participants using evacuated yellow tip tubes (gel and clot activated) designated for clinical parameters. The serum was then separated from the blood after centrifugation, collected in a Nancy serum collection tube and stored in a mobile deep freezer at -20°C and transported to EPHI. The serum specimen was then transferred and stored at -80°C until analysis.

Blood chemistry analysis: Serum was used to analyze biochemical parameters namely fasting blood sugar, total cholesterol, HDL cholesterol, LDL cholesterol, Triglycerides, blood urea nitrogen, creatinine, Alkaline phosphatase (ALP), Alanine amino transferase (ALT) and Aspartate amino transferase (AST). The analysis was performed using COBAS 6000 (c501) and COBAS e41 analyzer (Roche Diagnostics GmbH, Mannheim, Germany) at clinical chemistry laboratory, EPHI.

Physical measurements: Blood pressure, heart rate, body weight, height, waist circumference, and hip circumference of all study participants were measured. Blood pressure and heart rate measurements were taken three times on the right arm in a sitting position, using a Boso-Medicus Uno instrument with a universal cuff and automatic blood pressure and heart rate monitor. The mean of three measurements was taken for analysis. Body weight and height were measured with electronic Growth Management Scale, which measures body weight and height, and calculates body mass index (BMI) = (Body weight (kg)/Body height (m²)). Waist circumference was measured by placing a tape measure around the bare abdomen at the midpoint between the lower margin of the last palpable rib and the top of iliac crest of the hip bone.

Operational definitions

- **Moringa stenopetala consuming:** Study participants consuming *M. stenopetala* as cooked vegetable, soup, tea infusion or the staple local meals *kurkufa*, *fosese* and *dama* that are prepared by cooking *M. stenopetala* leaves and rolled maize or sorghum flour together.
- **Moringa stenopetala non-consuming:** Study participants who do not consume on *M. stenopetala* as cooked vegetable, soup, tea infusion or the staple local meals made from it.

Data management and analysis: Data were collected using tablets, Cispro-software was used to design and program the data collection tools and analyzed using IBM SPSS Statistics version 22 (Armonk, NY: IBM Corp., 2013). Descriptive analysis was used to describe the mean, frequency and percentages for relevant variables in the study. Logistic regression was used to fit the data to identify factors associated with outcome variables. Chi-square test was used to show presence of association of independent with dependent variables.

All factors with a p-value ≤0.05 in the bivariate analysis were further entered into the multivariate logistic regression model to control confounding effects. Odds ratios (OR) with 95% confidence intervals (CI) were calculated. Statistical significance was accepted at the 5% level (p≤0.05).

Ethical Considerations: Scientific and ethical approval was obtained from Institutional Review Board of Ethiopian Public Health Institute (approval letter reference number EPHI 6.13/796). Data were collected anonymously without any personal identifiers, and confidentiality was protected. Letter of support was obtained from SNNPRS health bureau to facilitate the study. Informed consent was obtained

from each participant before administering the questionnaire and collecting blood specimen. Assent was obtained from the children between 16 and 18 years to collect information about the children and blood specimen besides the proxy consent obtained from guardians. Adequate explanation was given to the study participants on the survey procedure, risk, benefit, confidentiality, and the right to withdraw from the study. Individuals with high blood pressure, hyperglycemia and hypercholesterolemia were advised on prevention strategies by the study team and also to visit the nearby health institution for further management.

Results

Socio-demographic characteristics: A total of 732 adult participants were included in this survey. The rural (49% and 51% for moringa and non-moringa area, respectively) and urban (51% and 49%) participants were almost equivalent. The mean age of the study participants was 30.7 ± 3.9 years. The majority of the study subjects were the indigenous ethnic groups mainly Gamo (49.6%), Dherashe (22.5%) and Konso (22.4%) while the rest (5.5%) constituted other ethnic groups. Female study participants accounted for 41%, while 59% of the study participants were male. The majority (85%) of the study subjects were married. Half of the study participants did not read and write and more than 40% of the participants made their livelihood using farming. The majority of study participants (31%) in moringa consuming area fell under first quintile. Similarly, 28% of the participants in non-moringa consuming area were in the middle quintiles. Small proportion of the study participants (9%) in non-moringa consuming area was in the first quintile, while 28% and 19% of the respondents were classified under middle and highest quintiles, respectively (Table 1).

Biochemical parameters: The mean values for biochemical parameters for moringa consuming and non-consuming participants were FBS 85.6 mg/dl (SD 17.5) *versus* 74.2 mg/dl (SD 18.3), T-cholesterol 162.5

mg/dl (SD 39.7) *versus* 146.8 mg/dl (SD 38.7), HDL-Cholesterol 45.7 mg/dl (SD 16.9) *versus* 35.6 mg/dl (std dev 10.1), LDL-Cholesterol 85.7 mg/dl (SD 32.0) *versus* 80.5 mg/dl (std dev 30.5) *versus* Triglycerides 128.6 mg/dl (SD 68.1) *versus* 115.5 mg/dl (SD 50), respectively (Table 2). The difference in mean values FBS, triglycerides, Total, HDL and LDL cholesterol values showed significantly (2 tailed t-test, $P=0.05$ and 0.01), respectively) increased values for moringa consuming compared to non-consuming participants. There was no significant variation in the values of triglycerides, LDL and HDL cholesterol in the study areas, and they were within the reference normal range interval of the test kits and 95% confidence interval range (Table 2 and Tables 3).

The mean value of liver and renal function test in both moringa consuming and non-consuming participants were in the normal reference range interval of the test kits and within 95% confidence interval range. However, the mean value of ALT and AST in moringa consuming participants were significantly elevated as (2 tailed t-test, $p=0.01$). The mean values of vitamin A, urine sodium, potassium and chlorine were significantly higher in non-moringa consuming than moringa consuming participants (2 tailed t-test, $p=0.001$) (Tables 2 and 3). Categorical analysis for the values of BP, BMI, FBS, total cholesterol, LDL and triglycerides which may be predisposing factors for metabolic syndrome were within the normal values for the majority of participants (>85%) with the exception of HDL in moringa consuming and non-consuming settings. Similarly, the kidney function and liver function tests values were within the normal values in the majority of the study participants (>85%) of moringa consuming and non-consuming settings (Table 4).

The result showed that the mean values of waist circumference, systolic BP, diastolic BP and body mass index in moringa consuming and non-consuming areas were 85.5 and 81.6 cm, 124.9 and 120.1 mmHg, 83.8 and 79.6 mmHg and 22.9 and 22.3 Kg/m², respectively.

Table 1: Socio-demographic and economic characteristics of the comparative study population in *M. stenopetala* consuming and non-consuming areas (N=732)

Variable characteristics	Comparative study participants		Total No (%)
	<i>M. stenopetala</i> consuming area n (%)	<i>M. stenopetala</i> non- consuming area n (%)	
Age			
16-30	181 (24.4%)	181 (25.2%)	362 (24.8%)
31-45	155 (20.9%)	87 (12.1%)	242 (16.6%)
46 and above	36 (4.9%)	92 (12.8%)	128 (8.8%)
Sex			
Male	244 (68.3%)	259 (2.5%)	503 (68.7%)
Female	113 (31.7%)	116 (32.5%)	229 (31.3%)
Area of residence			
Urban	191 (51.3%)	178 (49.4%)	369 (50.4%)
Rural	181 (48.7%)	182 (50.6%)	363 (49.6%)
Religion			
Orthodox	205 (55.1%)	73 (20.3%)	278 (38%)
Protestant	149 (40.1%)	280 (77.8%)	429 (58.6%)
Others	18 (4.8%)	7 (1.9%)	25 (3.4%)
Ethnicity			
Derashe	165 (44.4%)	0 (0%)	165 (22.5%)
Konso	164 (44.1%)	0 (0%)	164 (22.4%)
Gamo	8 (2.2)	355 (98.6%)	363 (49.6%)
Others	35 (9.4%)	5 (1.4%)	40 (5.5%)
Marital status			
Married	341 (91.7%)	312 (89.7%)	653 (89.2%)
Others	31 (8.3%)	48 (13.3%)	79 (10.8%)
Level of Education			
Do not read and write	229 (61.6%)	191 (80.8%)	420 (57.4%)
Can read or write	30 (8.1%)	91 (25.3%)	121 (16.5%)
Complete elementary school	84 (22.6%)	63 (17.5%)	147 (20.1%)
Secondary and above	29 (7.8%)	15 (4.2%)	44 (6%)
Work status			
Farming (crop or livestock)	184 (49.5%)	147 (40.8%)	331 (45.2%)
Housewife	60 (16.1%)	97 (26.9%)	157 (21.4%)
Trader	69 (18.5%)	47 (13.1%)	116 (15.8%)
others	59 (15.9%)	69 (19.2 %)	128 (17.5%)
Family size			
Less than 5	122 (32.8)	120 (33.3%)	242 (33.1%)
5 to 14	250 (67.2%)	240 (66.7%)	490 (66.9%)
Woreda			
Konso	179 (49.4%)	0 (0%)	179 (24.5%)
Derashe	183 (50.6%)	0 (0%)	193 (26.4%)
Bonke	0 (0%)	180 (50%)	180 (24.6%)
Chencha	0 (0%)	180(50%)	180 (24.6%)
Wealth Index			
Lowest quintiles	115 (30.9%)	33 (9.2%)	148 (20.2%)
Second quintiles	83 (22.3%)	63 (17.5%)	146 (19.9%)
Middle quintiles	47 (12.6%)	99 (27.5%)	146 (19.9%)
Fourth quintiles	51 (13.7%)	95 (26.4%)	146 (19.9%)
Highest quintiles	76 (20.4%)	70 (19.4%)	146 (19.9%)

Predictors of metabolic abnormalities: Biochemical parameters and physical measurements were evaluated to determine the risks or potential predictors for metabolic abnormalities using unadjusted odds ratio (OR) and 95% confidence interval (CI). The crude OR for total cholesterol was significantly high ($p=0.01$). There were no, however, significant differences in the values of triglycerides, LDL and HDL cholesterol in the study area. The finding of the present study revealed that no significant difference was observed in physical measurement in both groups (Tables 3 and 4), and values of the biochemical parameters and physical measurement were within the reference range. There were no differences in the un-conditional prevalence of raised blood pressure and raised fasting blood sugar

values among moringa consuming and non-consuming areas for (Chi square and p-test 3.275, 0.27; 2.415, 0.120 and 3.896, 0.11, respectively). Furthermore, the majority of the study participants in both study areas were not at risk of metabolic syndrome for CVD (Chi square and p-test 3.514, 0.12) (Table 5). However, study participants in moringa consuming area had increased biochemical parameters value compared to those in non-consuming area although the values are within normal test kits reference (Table 2). The results of both bivariate and multivariate logistic regression analyses for the overall biochemical and physical measurement values of study participants did not show significant differences.

Table 2: Physical and biochemical parameters among comparative study population in study sites (N=732)

Variable	Physical and biochemical parameters measurements values							
	<i>M. stenopetala</i> using participant				<i>M. stenopetala</i> non using participant			
	N	Mean	SD	95% CI	N	Mean	SD	95% CI
Fasting Blood Sugar	310	85.6	17.5	83.6, 87.5	259	74.2	18.3	71.9, 76.4
Total cholesterol	311	162.5	39.7	158.0, 166.9	259	146.8	38.7	142.0, 151.5
HDL cholesterol)	309	45.7	16.9	43.8, 47.6	243	35.6	10.1	34.4, 36.9
LDL cholesterol)	310	85.7	32.0	82.1, 89.3	259	80.5	30.5	76.7, 84.3
Triglycerides	310	128.6	68.1	120.9, 136.2	259	115.5	50.0	109.4, 121.6
Blood urea nitrogen	310	19.3	15.1	17.6, 21.0	259	18.4	23.7	15.5, 21.3
Creatinine	309	0.54	0.127	0.52, 0.55	259	0.55	0.11	0.54, 0.57
ALP	312	82.3	48.9	2, 389	260	75.9	43.3	8, 346
ALT	312	11.9	8.19	10, 37.5	260	7.89	4.28	5, 34.4
AST	312	13.2	12.3	11.8, 14.5	260	19.2	6.71	18.3, 20.0
Serum Vitamin A	314	1.61	0.77	1.52, 1.70	252	1.24	0.65	1.16, 1.32
Urine Sodium	254	99.3	57.4	92.1, 106.4	123	162.8	84.8	147.7, 178.0
Urine Potassium	254	86.9	40.5	81.9, 91.9	123	130.6	71.5	117.9, 143.4
Urine chlorine	234	140.9	74.5	131.7, 150.1	123	218.1	110.9	198.3, 237.9
Average systolic BP	389	124.9	15	123.5, 126.5	343	120.1	13.1	118.7, 121.5
Average diastolic BP	389	83.8	9.8	82.8, 84.7	343	79.6	8.83	78.7, 80.6
Average heart rate	389	80.6	10.4	44.7, 125	343	77.4	11.1	44, 117.3
Body mass index	389	22.9	3.59	22.6, 23.4	343	22.3	2.71	22.0, 22.6
Waist circumference in Cm	389	85.5	15.6	43, 89	343	81.6	12.2	44, 34

Test kit Normal values for adults: FBS: 75-106 mg/dl; Total cholesterol: $m < 200$ mg/dl; HDL cholesterol: > 55 mg/dl male, female > 65 mg/dl; LDL cholesterol < 100 mg/dl; Triglycerides: > 200 mg/dl; BUN: 16.6-48.5 mg/dl; 75-106 mg/dl; Creatinine: 0.7-1.2 mg/dl male, female 0.5-0.9 mg/dl; ALP: male 40-129 U/L, female 35-104 U/L; ALT: male up to 41U/L, female up to 33 U/L; AST: up to 40mkt/dl male, female up to 32 mkt/dl; 4.20 mIU/ml; Serum vitamin A: $< 0.7 \mu \text{mol/l}$; Urine sodium: 20-250 mmol/L; Urine potassium: 3-250mmol/l; Urine chlorine: 20-250mmol/L.

International Diabetic Federation consensus worldwide definition on physical measurements value: Average systolic BP < 100 -139 mm/Hg; Average diastolic BP: 60-89mmHg; Average heart rate: 60-80 rate/min; Body mass index: 22-25 Kg/m², Waist circumference: < 94 cm for male, female < 80 cm.

Table 3: Independent sample test for Physical and biochemical parameters among comparative study population in study areas (N=732)

Variable/Characteristics	T-test for equality of means			
	t	2-tailed Sig (P value)	Mean diff	95% CI
FBS	t (567, 539) = 7.62	0.05	11.47	8.51, 14.42
Total cholesterol	t (568, 554) = 4.75	0.05	15.7	9.22, 22.19
HDL cholesterol	t (550, 514) = 8.24	0.07	10.08	7.68, 12.49
LDL cholesterol	t (567, 557) = 0.453	0.05	5.21	0.02, 10.39
Triglycerides	t (567, 558) = 2.58	0.01	13.1	3.12, 23.2
Blood urea nitrogen	t (567, 423) = 0.52	0.61	0.847	-2.37, 4.07
Creatinine	t (566, 563) = 1.62	0.11	-0.017	-0.037, 0.035
ALP	t (570, 568) = 1.63	0.10	-6.35	3.90, 14.01
ALT	t (570, 485) = 7.10	0.01	4.00	2.89, 5.11
AST	t (570, 497) = 7.10	0.01	-6.04	-7.72, -4.37
Serum vitamin A	t (564, 563) = 5.97	0.001	0.366	0.246, 0.489
Urine sodium	t (375, 177) = 8.56	0.001	-63.6	-78.2, -48.96
Urine potassium	t (375, 160) = 7.57	0.001	-43.79	-55.2, -32.4
Urine chlorine	t (375, 177) = 7.97	0.001	-77.2	-96.2, -58.1
Weight in Kg	t (730, 717) = 4.16	0.05	2.73	1.44, 4.01
Waist circumference (Cm)	t (730, 718) = 3.73	0.05	3.91	1.86, 5.97
BMI	t (730, 712) = 2.73	0.06	0.65	0.18, 1.12
Average systolic BP	t (730, 729) = -1.63	0.112	31.2	15.38, 117.6
Average diastolic BP	t (730, 729) = 4.67	0.06	4.90	2.84, 6.96
Average heart rate	t (730, 704) = 4.02	0.01	3.21	1.64, 4.77

Table 4: *M. stenopetala* consumption as food or medicine by Physical and biochemical parameters among comparative study population in study areas (N=732)

Variable characteristics	Consumption of moringa in family as food source Number in agreement (%)		COR (95%CI)	p Value	AOR (95%CI)	p Value
	<i>M. stenopetala</i> non-using N (%)	<i>M. stenopetala</i> using N (%)				
Level of Blood pressure						
Normal	295 (86%)	352 (90.5%)	1		1	
Raised	48 (14%)	37 (9.5%)	1.770 (1.6815-1.8585)	0.18	2.087 (0.947-4.599)	0.68
BMI level						
Normal	279 (84.3%)	306 (84.8%)	1		1	
Underweight	22 (5.6%)	23 (9.7%)	1.057(0.576-1.941)	0.86	2.016 (0.564-7.206)	0.28
Overweight	26 (7.9%)	29 (13.5%)	1.205 (1.151-3.153)	0.11	2.429 (0.980 -6.020)	0.15
Obese	4 (1.2%)	3 (3.5%)	1.285 (1.058-10.200)	0.34	3.805 (0.515 -28.090)	0.19
Fasting blood sugar level						
Normal	253 (97.7%)	301 (97.4%)	1		1	
Raised	6 (2.3%)	8 (2.6%)	1.408 (1.020-3.672)	0.06	1.348 (0.358-5.074)	0.66
Total cholesterol level						
Normal	240 (92.7%)	257 (95.9%)	1		1	
Raised	19 (7.3%)	44 (14.1%)	2.082 (1.082-3.665)	0.01	1.164 (0.485 -2.798)	0.734
HDL level						
Normal	0 (0%)	33 (10.7%)	1			
Raised	243 (100%)	276 (99.3%)	0.000 (0.000)	0.99		
LDL level						
Normal	247 (95.4%)	288 (99.3%)	1			
Raised	12 (4.5%)	20 (6.5%)	0.429 (0.685-2.983)	0.34		

Table 4: *M. stenopetala* consumption as food or medicine by Physical and biochemical parameters among comparative study population in study areas (N=732) continued (Continuous)

Variable characteristics	Consumption of moringa in family as food source Number in agreement (%)		COR (95%CI)	p Value	AOR (95%CI)	p Value
	<i>M. stenopetala</i> non-using N (%)	<i>M. stenopetala</i> using N (%)				
Triglyceride level						
Normal	209 (81.3%)	231 (75%)	1			
Raised	48 (18.7%)	77 (25%)	1.451 (0.967-2.178)	0.07		
BUN level						
Normal	255 (98.8%)	306 (98.7%)	1		1	
Raised	3 (1.2%)	4 (1.3%)	1.115 (0.247-5.030)	0.89	0.518 (0.142-1.891)	
Creatinine level						
Normal	259 (100%)	300 (100%)	1	0.75	1	
Raised	0 (0%)	0 (0%)	1.052 (0.773-1.433)		0.275 (0.017 -4.345)	
ALP level						
Normal	224 (86.2%)	269 (86.2%)	1		1	
Raised	36 (13.8%)	43 (13.9%)	0.995 (0.617-1.602)	0.98	4.277 (0.814 -22.463)	
ALT level						
Normal	260 (100%)	307 (98.4%)	1		1	
Raised	0 (0%)	5 (1%)	13681 (0.000)	0.99	4.277 (0.814 -22.463)	
AST level						
Normal	256 (98.5%)	303 (97.1%)	1		1	
Raised	4 (1.5%)	9 (2.9%)	1.901 (0.579-6.245)	0.29	4.277 (0.814 -22.463)	

Table 5: Prevalence of metabolic syndrome in comparative study adult population in selected rural and urban kebeles of the study areas (N=732)

Variable characteristics	Study sites			Moringa use as food source or medicine of participants		χ^2 Test, p-value
	<i>M. stenopetala</i> growing area	Non moringa growing area	χ^2 Test, p-value	Moringa using (no, %)	Moringa non-using (no, %)	
Unconditional prevalence of raised BP			6.597, 0.19			3.275, 0.27
No	312 (83.9%)	304 (84.4%)		359 (92.1%)	290 (84.5%)	
Yes	60 (16.1%)	56 (15.6%)		31 (7.9%)	53 (15.5%)	
Unconditional prevalence of raised blood sugar			5.071, 0.14			2.415, 0.120
No	290 (97.3%)	262 (97%)		299 (96.8%)	251 (96.9%)	
Yes	8 (2.8%)	8 (3%)		10 (3.2%)	8 (3.1%)	
Prevalence of fasting blood sugar			5.228, 0.13			3.896, 0.11
Normal (<100 mg/dl)	288 (96%)	258 (95.6%)		303 (97.7%)	247 (95.4%)	
Impaired fasting glucose (100-125 mg/dl)	8 (3%)	9 (3.3%)		5 (1.6%)	9 (3.5%)	
Raised blood sugar (≥ 126 mg/dl)	3 (1%)	3 (1.1%)		2 (0.6%)	3 (1.1%)	
Prevalence of metabolic syndrome			10.732, 0.11			3.514, 0.12
Normal	337 (91.1%)	328 (89.9%)		354 (86.6%)	298 (86.9%)	
At risk of CVD	35 (9.9%)	37 (10.1%)		55 (8.6%)	45 (13.1%)	

Discussion

Biochemical markers are valuable tools for disease screening and diagnosis besides monitoring the progress of treatment efficacy (Katayey et al. 2010). Our finding did not show significant difference in the majority of biochemical parameters between moringa consuming and non-consuming study participants, the mean values being within 95% confidence interval range and the reference range interval of the clinical guide (Wu AHB 2006; Lohr et al. 2009; Katayey et al. 2010).

The present study showed no association between *M. stenopetala* consumption and plasma concentrations of total cholesterol, HDL, LDL and triglyceride values indicating that consumption of *M. stenopetala* does not alter lipid profile. The community in *M. stenopetala* growing study area eats cooked leaves of *M. stenopetala* as vegetable or the widely known local meals “*Kurkufa*, *Fosose* and *Dama*”. The frequencies of consuming *M. stenopetala* based food by study participants from moringa growing area were once (>46%), twice (>31%) and more than three times (>20%) per day. The majority consumes daily a handful or more parcel of the leaves branches which is about 1Kg and above. The tea infusion or soup of *M. stenopetala* leaves are also used by the community for treatment of diabetes, hypertension, and other diseases (Yang et al. 2006; Padayachee. and Baijnath 2012; Abrar and Azmaxh 2017). Experimental animals based studies on single and repeated doses administration of *M. stenopetala* leaves extracts reports indicated that it possessed antihypertensive, hypotensive, hypoglycemic, anti-hyper-lipidemic and cholesterol lowering effects (Makonnen et al. 1997; Mussa et al. 2008; Nardos et al. 2011; Toma et al. 2016. Seleshi et al. 2014; Mengistu et al. 2012; Fikadu et al. 2017), which are not in agreement with the findings of the present community-based comparative study. The discrepancy might be attributed to the decomposition of the active component/s responsible for cholesterol lowering effect upon cooking of the leaves while preparing the traditional meal by the community. Moreover, the cross-sectional nature of the study that allows only one time data collection may not be appropriate to give information over a period of time. Prospective longitudinal follow up study may provide better findings to explain the effects of frequent use of *M. stenopetala* on biochemical parameters and physical measurement values.

Non communicable diseases (NCDs) are becoming the major causes of morbidity and mortality that receive global attention. The major contributing risk factor for the development of NCDs could be insufficient physical activity, and low fruit and vegetable, high saturated trans fatty acid, and high salt intake as well

as behavioral factors such as smoking, alcohol consumption, etc (Lozano et al. 2010; Cocchini et al. 2010). Globally blood pressure is the leading metabolic risk factor in terms of attributable deaths accounting for 18%, followed by overweight and obesity and raised blood glucose (Alwan et al. 2010).

Various studies in Ethiopia indicated the prevalence of hypertension 19.6% (23.5% in urban population and 14.7% in rural/urban population), prevalence of in males and females was 20.6% and 19.2% respectively (Smeeth et al. 2007). The findings showed that the percentage of study participants with unconditional prevalence's of blood pressure (SBP $\geq$ 140 and or DBP $\geq$ 90 mmHg) were 7.9% and 15.5% for moringa consuming and non-consuming participants, respectively. Similarly, the percentage with raised fasting blood glucose ($\geq$ 126mg/dl) and prevalence of metabolic syndrome at risk of CVD were 0.6% and 1.1%, 8.6% and 13.1% in moringa consuming and non-consuming participants, respectively (Table 5). The normal BMI, total cholesterol, LDL and triglycerides levels for moringa consuming and non-consuming participants were 84.8% versus 84.3%, 95.5% versus 92.7%, 99.3% versus 95.4% and 75% versus 81.3%, respectively. The biochemical and physical measurement values were within normal reference range interval of the International Diabetic Federation consensus worldwide definition on physical measurements values (Ichihara 2014; Alberti et al. 2009).

Metabolic derangements may be an early indicator of increased CVD risk even in normal weight or subjectively healthy individuals. According to the 2009 harmonized definition, metabolic syndrome could be possibly diagnosed in the presence of any three of the following conditions increased waist circumference (WC) (men $\geq$ 94 cm, women: $\geq$ 80 cm), low HDL-Cholesterol (men $<$ 40 mg/dl (1 mmol/l), women: $<$ 50 mg/dl (1.3 mmol/l)), hypertriglyceridemia $\geq$ 150 mg/dl (1.7 mmol/l), elevated BP (systolic BP $\geq$ 140 mmHg and/ or diastolic $\geq$ 90 mmHg) and elevated blood sugar (FPG $\geq$ 100 mg/dl (5.6 mmol/l))(Alberti et al. 2009). A BMI $\geq$ 25 indicates overweight conditions, while a BMI $\geq$ 30 indicates that a person is obese. Abdominal obesity is considered when the waist circumference is $\geq$ 94 cm for men and $\geq$ 80 cm women (Alberti et al. 2007). Increasing levels of waist circumference (WC) and BMI have been associated with increased CVD risk. Both BMI and WC do not differentiate between visceral adipose tissue (VAT) and subcutaneous adipose tissue (SAT). VAT plays a significant role in the pathogenesis of CVD, and increased levels of VAT has been associated with increased cardio-metabolic

risk and coronary artery calcification regardless of BMI (Shah et al. 2014).

In addition, monitoring biochemical parameters such as HDL and total cholesterol in serum are of clinical importance since an inverse correlation exists between serum HDL and total cholesterol concentrations for the risk of atherosclerotic disease (Nauk et al. 2014).

Low Density Lipoproteins (LDL) play a key role in causing and influencing the progression of atherosclerosis and, in particular, coronary sclerosis (Rifai et al. 1992). The LDL-cholesterol value is the most powerful clinical predictor among all single parameters with respect to coronary atherosclerosis. The findings from the present study demonstrate that *M. stenopetala* consuming or non-consuming may not infer to have unique advantage on biochemical parameters and risks of metabolic syndrome as there was no significant variation in the comparative cross-sectional study participants. The findings of this study, therefore, needs to be substantiated with prospective longitudinal follow up and/or clinical studies to ascertain the effects of frequent use and medicinal values of *M. stenopetala*.

Strength and Limitation of the study: As the current community-based study is the first in its kinds for assessment of the effect of *M. stenopetala* consumption on the biochemical parameters besides determining behavioral factors and physical measurements, it may serve as a baseline for other studies. One of the limitations of this study is its cross-sectional nature that may not be used to establish temporal relationship between the exposures and outcome variables elevated blood glucose, lipid profile, etc. Conflict of interests

The authors declare that they have no conflicts of interest related to this article.

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