EXPOSURE TO *TRANS* FATTY ACIDS FOODS OF RURAL AND URBAN POPULATIONS IN SELECTED WARDS OF MOROGORO REGION

LAISON GILBERT NZUNDA

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN HUMAN NUTRITION OF SOKOINE UNIVERSITY OF AGRICULTURE MOROGORO, TANZANIA

2021

EXTENDED ABSTRACT

Trans-fatty acids are unsaturated fats, their consumption poses adverse health risks. The current study was conducted to determine the levels of *trans* fatty acids (TFAs) in commonly consumed processed foods;"*Chapati*", wheat buns, rice buns, potato chips and partially hydrogenated oils (PHOs) in retail markets (street food vendors and restaurants) in Morogoro region. A total of 60 samples were collected from two districts and analysed for total TFAs by Gas Chromatography Mass Spectrometry (GC-MS). Data were analysed by IBM SPSS Software for ANOVA version 20.0 and Means were separated by Tukey's honest at P≤ 0.05. Results indicated that, with the exception of "*Chapati*",all samples contained TFAs levels that were above the maximum recommended level by WHO (less than or equal to 2g/100g of fat per day). The highest amount of TFAs was observed in PHOs (5.69±0.042g/100g fat). The mean TFAs concentration differed significantly among food types at P≤ 0.05. There was no significant effect of locations on mean TFAs concentration. The study indicated that the observed high amount of TFAs in PHOs, the most used ingredient in food preparations could pose a nutritional health hazard to most consumers. Other snacks and fast food in this study, when consumed on regular basis could potentially add up more TFAs in our bodies thereby increasing the risks for non-communicable diseases (NCDs) especially cardiovascular diseases (CVDs) which have become more prominent in Tanzania. In addition, a cross-sectional study conducted to determine the consumption pattern of foods containing TFAs. A total of 340 households were involved, whereby 176 were from Morogoro urban district (MjiMkuu ward and Mazimbu ward) and 164 from Morogoro rural district (Kiroka ward). Food frequency questionnaires (FFQ) were used to collect data. Results showed that, close to 70% of urban households in the study wards consumed processed foodstuffs and 66% of the rural households consumed more of minimally/non-processed foodstuffs. Most of processed

foods/snacks were found to have been prepared by frying with PHOs. Further results showed that there was a high consumption of cooking oil brand "*Korie*" (PHOs) by 87% and 70% in rural and urban areas, respectively. In a separate study, an assessment was conducted to determine the level of awareness among consumers and food/oil processors on TFAs. Study sample included the previous 340 households, but also 32 food/oil processors (22 = small scale; 10 = large scale). Structured questionnaires were used to collect the data. Descriptive statistics were used to determine the level of awareness on TFAs. About 98% of all consumers had neither knowledge nor awareness about TFAs and their associated health effects. Nevertheless, awareness level was observed to improve with location and level of education. The level of awareness of TFAs at MjiMkuu ward (urban) was significantly different from Kiroka ward (rural) (OR: =18.111; P= 0.020). However, no significant difference was observed in the level of awareness between consumers in Kiroka (rural) and in Mazimbu ward (urban) (OR: = 5.397; p=0.126). Large scale food and oil processors were more aware about TFAs than small scale. General awareness on TFAs and the associated adverse health effects among consumers were very low compared to that of processors and were also influenced by location and level of education.

DECLARATION

I, Laison Gilbert Nzunda do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution for a degree award.

Laison Gilbert Nzunda	**Date**
(MSc. Human Nutrition)	

The above declaration is confirmed by;

Prof. J. Kinabo	**Date**
(Supervisor)	

Dr. L. Chove	**Date**
(Supervisor)	

COPYRIGHT

ACKNOWLEDGEMENTS

First and foremost, I would like to thanks the Almighty God for giving me strength, good health and courage which enabled me to accomplish this study.

I owe a huge profoundly gratitude to my supervisors Prof. Joyce Kinabo (Department of Human Nutrition and Consumer Sciences) and Dr. Lucy Mlipano Chove (Department of Food Science and Agro-processing), at SUA for their tireless effort, patient guidance and kindness from proposal development up to final report of this study. Their constructive criticisms and suggestions helped to shape and improve this dissertation. I further extend my gratitude to Dr. Fortunatus Sunghwa and his colleagues for their supervision during my Laboratory work at the University of Dares Salaam.

I wish to express my gratitude to my employer and the management of the Ministry of Agriculture - Department of Training, Research & Extension Servicesfor the research fund support.

Furthermore my appreciation also goes to my fellow staff (MATI-Tumbi) and colleagues for their valuable assistance and encouragement given to me throughout my study period.
My special appreciations go to my beloved wife Elizabeth Marco, my children; Genevieve, Gisella and Graciella. Thanks for their unconditional love, prayers, support and encouragement they shown to me throughout my studies.

Finally for all academic and non-academic members of staff from Department of Food Technology, Nutrition and Consumer Sciences at SUA; their kind cooperation is highly appreciated.

DEDICATION

This work is dedicated to my beloved late parents Ms. Frola Mbembela and Mr. Stephano Nzunda who laid down the foundation for my education. I also dedicate this work to my beloved wife Elizabeth Marco, my children; Genevieve, Gisella and Graciella for their love, prayers, perseverance and encouragement that enabled me to conduct and complete this study.

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURE

LIST OF APPENDIX

LIST OF MANUSCRIPTS

MANUSCRIPT 1: TITLE; ***Trans*** **Fatty Acids (TFAs) in selected Processed Foods in retail Markets of Morogoro, Tanzania Submitted to** *Tanzania Journal of Agricultural Sciences* **(TAJAS)**

MANUSCRIPT 2: TITLE; Consumption Pattern of Foods containing *Trans* Fatty Acids in Morogoro region, Tanzania**to be submitted to** ***Tanzania Journal of Science and Technology*** **(TJST)**

MANUSCRIPT 3: TITLE; *Trans* Fatty Acids in Tanzania: Are Consumers and Processors aware of the associated health hazards? A case of Morogoro, Tanzania **presented during the** *2nd SUA Scientific Conference on Research and Technological Innovations towards Transformation of Lower Middle Income Countries* **(Sokoine Day) at** Sokoine University of Agriculture (25th-26th May 2021)

LIST OF ABBREVIATION AND ACRONYMS

3ADI+	Accelerator for Agriculture and Agro industry Development and Innovation Plus
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
CVD	Cardiovascular disease
CHD	Coronary Heart Disease
EFSA	European Food Safety Authority
FAO	Food and Agriculture Organization of the United Nations
FAME	Fatty Acid Methyl Ester
FID	Flame Ionization Detector
FSAI	Food Safety Authority of Ireland
GC- MS	Gas Chromatography Mass Spectrometry
HDL-c	High Density Lipoprotein Cholesterol
IBM- SPSS	International Business Machines – Statistical Package for Social Sciences
iTFAs	industrial *Trans* fatty acids
LDL-c	Low Density Lipoprotein Cholesterol
LMICs	Low and Mid Income Countries
NCDs	Non communicable disease
PHO	Partially Hydrogenated Oil
PHVO	Partially Hydrogenated Vegetable Oil
rTFAs	ruminant *Trans* fatty acids
SUA	Sokoine University of Agriculture
TFAs	*Trans* fatty acids

URT	United Republic of Tanzania
WHO	World Health Organization of the United Nations

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Fats are essential for health and their consumption allows the human body to store energy, absorb fat-soluble vitamins and supply essential fatty acids. However, it is important to control the overall fat intake in the diet as well as the intake of specific fats that are less healthy than other forms for example *trans* fatty acids (EFSA, 2010; Kagiono *et al*., 2018).

Trans-fatty acids (TFAs) are unsaturated fatty acids containing at least one double bond in the *trans* configuration (Kamel, *et al.,* 2018). In the common *cis* configuration, the carbon chain extends from the same side of the double bond. This results in bends in the molecule. In the *trans* configuration, the carbon chain extends from opposite sides of the double bond. This results in a much straighter molecule (Ganguly & Pierce, 2012) (Figure1.1).

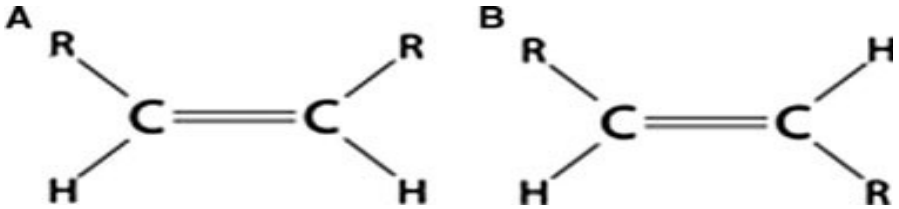

Figure 1.1: Differences between *cis* (structure A) and *trans* (structure B) fats. There are distinct differences in the configuration of *cis* and *trans* fatty acids, specifically, the orientation of the R groups around the double bond will promote distinct differences both in chemical configuration and biological effects

(Source: Ganguly & Pierce, 2012).

Trans-fatty acids (TFAs) can be classified as either industrial (iTFAs) or naturally occurring ruminant TFAs (rTFAs). iTFAs are formed during partial catalytic hydrogenation of liquid oils, mostly plant oils, which produces the partially hydrogenated vegetable oils (PHVO). The hydrogenation process turns oils into semi-solid and solid fats thus giving them qualities desired by the food processing industry such as increased tolerance against repeated heating, prolonged product shelf-life and sensory aspects (Mouratidou*et al.,* 2014).

Small amounts of *trans* fatty acids occur naturally in meat and dairy products, but the largest source of these lipids in the human diet comes from artificial sources, such as partially hydrogenated vegetable oils used in cooking and food preparation (Pfeuffer and Jahreis, 2018). The Major food sources of *trans* fatty acids are deep-fried potato chips, pastry and baked foods, packaged snack foods, margarines, and crackers. Naturally occurring *trans* fatty acids are consumed in smaller amounts (about 0.5% of total energy intake) in meats and dairy products from ruminants. These *trans* fatty acids are produced by the action of bacteria in the ruminant stomach (Mouratidou *et al.*, 2014). According to

the European Food Safety Authority (EFSA, 2010) the available evidence indicates that *trans* fatty acids from ruminant sources have adverse effects on blood lipids and lipoproteins similar to those from industrial sources when consumed in equal amounts (De Jong, 2016).

The adverse health effects of *trans* fatty acids in human are mediated by increase in plasma concentrations of low-density lipoprotein cholesterol (LDL-C) and reductions in high-density lipoprotein cholesterol (HDL-C) (Wu *et al*., 2017). Increased plasma concentrations of LDL-C leads to promotion of inflammation, endothelial dysfunction and possible effects on coagulation, insulin resistance and displacement of essential fatty acids from membranes, affecting prostanoid-related functions and possibly other key membrane-related functions (Mitrou and Lawrence, 2014). Furthermore, *trans* fatty acids intake has been linked to increased risk of chronic conditions such as coronary heart disease (CHD), cancer and type 2 diabetes (Mitrou and Lawrence, 2014).

Globally, in 2017, dietary risks were responsible for 11 million deaths (22% of all deaths among adults). Cardiovascular disease was the leading cause of diet related deaths (10 million deaths), followed by cancers (913,090 deaths) and type 2-diabetes (338,714 deaths). More than 5 million diet-related deaths (45% of total diet related deaths) occurred among adults aged younger than 70 years (Afshin *et al*., 2019).

Regionally, in 2017, the highest age-standardized proportions of diet-related deaths were reported. About 60% of deaths from cardiovascular disease were observed in Oceania and 64% in East Asia, 15% from cancer in East Asia and 41% of deaths from type 2-diabetes

were from high-income earners in North America (Afshin *et al*., 2019). The lowest age-standardized proportions of deaths from cardiovascular disease were reported in Western sub-Saharan Africa (5% of deaths), and Southeast Asia (29% of deaths). Among most populated countries, China had highest rates of diet-related cancer deaths (42 deaths per 100 000 population), and Mexico had the highest rates of diet-related type 2 diabetes deaths (35 deaths per 100 000 population). Japan had the lowest rate of diet-related cardiovascular disease deaths (69 deaths per 100 000 population) and diabetes deaths (one death per 100 000 population) (Afshin *et al*., 2019).

In Tanzania like many other developing countries, the burden of non-communicable diseases (NCDs) has been increasing steadily (Mayige *et al.*, 2011). WHO country estimates of 2010 showed that NCDs accounted for 27% of all annual deaths in Tanzania (URT, 2016). The WHO (2018) data on NCDs showed an account of 33% for all annual deaths in Tanzania.

1.2 Sources of *Trans* Fatty Acids

The presence of *trans* fatty acids (TFAs) in foodstuffs depends on whether the ingredients include industrially produced TFAs, as well as the origin of fat and whether the foodstuff is fried. The majority of TFAs in our diets are industrially produced and typically found in commercially produced as well as some homemade foodstuffs, such as baked and fried foods as reported by Mitrou and Lawrence (2014) (Table1.1).

Table 1.1: Common *trans* fatty acids (both ruminant and industrial forms)

Name	Class	Main source(s)	Predominant type
Conjugated Linoleic acid	18:2, *trans* -10, 11	Ruminant meat and dairy fat, supplements	Ruminant
Elaidic acid	18:1, *trans* -9	Hydrogenation of vegetable oils	Industrial
Linolelaidic acid	18:2, *trans* -9,12	Hydrogenation of vegetable oils	Industrial
Palmitelaidicacid[a]	16:1, *trans* -9	Ruminant dairy fat and Hydrogenation of vegetable oils	Ruminant and Industrial
Vaccenic acid	18:1, *trans* -11	Ruminant meat and dairy fats	Ruminant

[a]Palmitelaidic acid is the *trans* –isomer of the 16:1 fatty acid palmitoleic acid

(Source: Mitrou and Lawrence, 2014).

1.3 Health effects of *Trans* fatty acids

1.3.1 *Trans* fatty acids and Coronary Heart Diseases (CHD)

Coronary heart disease is the partial or complete blockage of the arteries supplying the heart by atherosclerotic plaques. Heart attacks, or myocardial infarctions, are considered CHD events and are caused by a complete blockage, cutting off blood flow to a portion of the heart muscle (Mitrou and Lawrence, 2014). There are a number of specific mechanisms through which TFAs increase the risk of cardiovascular disease. The most

important mechanistic effect identified is their effect on the plasma lipoprotein profile. TFAs make the plasma lipoprotein profile more harmful, by increasing the levels of harmful low-density-lipid cholesterol in the blood serum, while simultaneously decreasing levels of protective high-density-lipid cholesterol (Wang *et al*., 2016).

1.3.2 Global effect of *Trans* fatty acids on Coronary Heart Diseases (CHD)

Globally, increased TFAs intake is estimated to be responsible for more than 500,000 deaths per year. TFAs increase levels of LDL (unhealthy) cholesterol and decreases levels of HDL (healthy) cholesterol (Brouwer, 2016; Li *et al.,* 2019). Replacement of TFAs with unsaturated fatty acids decreases the risk of CHD, in part, by reducing the negative effects of TFA on blood lipids (Brouwer, 2016).

1.3.3 Global Surveillance of *Trans* fatty acids

TFAs intake is a health threat in high-income countries; however, it is also a threat in low- and middle-income countries (LMICs) (Figure 1.2). Data on TFA intake are scarce in many LMICs and an urgent need exists to monitor TFAs globally (Li *et al.*, 2019). Daily intake of total TFAs varies worldwide; the estimated contribution to total energy intake ranges from 0.2% in Barbados, 5.7 in Pakistani to 6.5% in Egypt (Li *et al.*,2019; WHO, 2019). Every year, more than a half-million deaths from CHD worldwide are attributable to high intake of TFAs (Ghebreyesus and Frieden, 2018). Information on the level of iTFAs in foods or on TFA intake is critical to motivate stakeholders and to evaluate the progress of eliminating partially hydrogenated oils in the food supply. To date, however, little is known about TFAs intake in most LMICs as reported by Li *et al*, (2019).

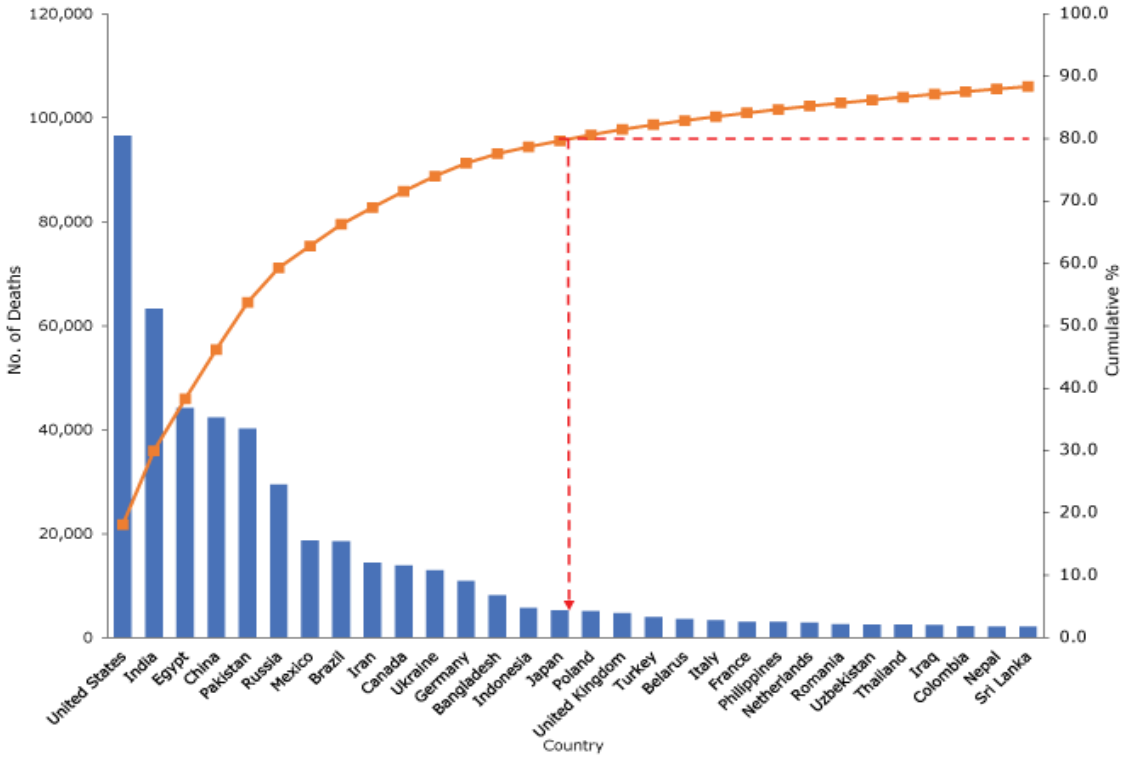

Figure 1.2: Bars indicate the estimated number of CHD deaths attributable to high TFA intake, the curved line indicates cumulative percentages, and the dashed line indicates the 15 countries that account for 80% of total CHD deaths attributable to high TFAs intake worldwide.

(Source: Li *et al.*, 2019)

1.4 *Trans* fatty acids and Diabetes

Diabetes is a chronic disease caused by insufficient insulin production or secretion, which impedes the ability of cells to digest glucose from the blood (Ruhembe *et al.*, 2014). Millions of people develop diabetes annually and the World Health Organization (WHO) has forecasted a 50% increase in the number of diabetes-related deaths over the next

decade (Canals *et al.*, 2017). Preliminary evidence suggests a relationship between consumption of TFAs and risk of type 2 diabetes mellitus (Mozaffarian *et al*., 2013).

1.5 *Trans* fatty acids and Cancer

Dhaka et al., (2011) reported that, there were positive associations of adipose stores of TFAs with postmenopausal breast cancer among the Europeans. However other scientific review reports that there is no scientific consensus that consumption of *trans* fatty acids significantly increases cancer risk (Ginter and Simko, 2016).

1.6 WHO Policy towards *Trans* fatty acids

The elimination of TFAs from the global food supply is a priority target of the World Health Organization's (WHO) current strategic plan (GPW13 2019 – 2023) and is identified as an effective and cost-effective policy measure to save lives. The elimination of TFAs is part of programmes being scaled up following global political commitment at the United Nations High-Level Meeting on NCDs held in September 2018 (WHO, 2018). Policies to eliminate TFAs can substantially contribute to achieving the global goal of reducing premature deaths from NCDs by one-third by 2030 and WHO's strategic priority to deliver better health and well-being to one billion people (WHO, 2018).

1.7 Problem Statement

There are consistent evidences of industrial trans fatty acids' adverse health effects, particularly on blood lipoprotein profiles, coronary heart disease, cancer, diabetes, promotion of inflammation and endothelial dysfunction, while no reports are available on any of their beneficial health impact (Mozaffarian *et al*., 2010; Schwab *et al*., 2014; Thornton, 2018).

WHO estimates that, *trans* fatty acids are believed to contribute to more than 500 000 deaths every year globally from cardiovascular disease, (Ghebreyesus and Frieden, 2018). Diets high in *trans* fatty acids increases heart disease risk by 21% and coronary heart disease deaths by 28% (Thornton, 2018).

Every extra gram of TFAs consumed per day increases the risk of heart attack or heart disease by about 5% (Nichols *et al*., 2016). Countries such as Denmark, US, Canada, Ireland, Ecuador, Iceland, Norway, Singapore, South Africa have already set the policy to limit on *trans* fatty acids to 1% in all foods (Thornton, 2018).

In May 2018, WHO announced strategic initiatives to make the world *trans* fatty free by 2023 (Ghebreyesus and Frieden, 2018). The package of initiatives included to review dietary sources of industrially produced *trans* fats (iTFAs) and the landscape for required policy change, to promote the replacement of industrially produced *trans* fat with healthier fats and oils, to legislate or enact regulatory actions to eliminate iTFAs, to assess and monitor *trans* fat content in the food supply and changes in *trans* fat consumption in the population, to create awareness of the adverse health impacts of *trans* fat among policy makers, producers, suppliers and the public, but furthermore to enforce compliance with policies and regulations (WHO, 2O18). Implementing these initiatives could potentially

eliminate iTFAs from the production and supply chain, therefore mitigating their adverse health effects (Ghebreyesus and Frieden, 2018).

Based on those adverse health effects of *trans* fatty acids, several countries have implemented policies to reduce iTFAs consumption, including nutrition guidelines, awareness programmes, voluntary or mandatory labelling of the TFAs content of foods and health warning labels. Voluntary or legislated programmes to encourage industries to reformulate food products without TFAs and support the production of healthy alternatives have led to improvements in some countries (Mozaffarian *et al*., 2010; Hendry *et al*., 2015).

According to WHO (2018) global report on non-communicable diseases (NCDs) Tanzania estimated to account for 33% of all deaths in 2016 with CVD ranking the top (13%) compared to other three east African countries in the region; the estimates in Uganda was 33% of all deaths, with CVD incidence of 10% while Kenya accounted lowest (27%) with CVD incidence of 8%. The recorded estimates of deaths from NCDs observed was an increase from 31% of deaths in 2012 (with CVD estimate of 9%) as reported by Mayige *et al*. (2016).

Tanzania imports of palm oil (PHOs) in 2016 was as high as over 500,000 MT (3ADI+,2019), since scientific evidences have linked the possibility of PHOs to contain

high proportion of iTFAs up to 60%, hence the annual consumption of such volumes of dietary source of fat could be posing health threat to consumers especially CVDs as reported by Mouratidou *et al.* (2014), Ginter and Simko, (2016) and Kagiono *et al*. (2018).

There have been efforts to respond to the burden of non-communicable diseases through the Ministry of Health, Community Development, Gender, Elderly and Children, with the establishment of a specific department to coordinate NCDs activities. However, the interventions put forward so far have been focused on strengthening provision of treatment to those with established disease (Mayige, 2016). Mayige and Kagaruki (2013) reported that Morogoro was among of the three sites (others being Dar es Salaam and Kilimanjaro) which demonstrated the considerably high risk of dying from non-communicable diseases during adulthood in Tanzania compared to developed countries.

1.8 Study Justification

In light of recognized evidence and scientific agreement, Global nutritional authorities consider all *trans* fatty acids equally harmful for health and recommend that their consumption be reduced to trace amounts (Thornton, 2018). The World Health Organization recommended that *trans* fatty acids make up no more than 1% of a person's diet. In 2018, it introduced a 6-step guide to eliminate industrially-produced *trans*-fatty acids from the global food supply (WHO, 2019).

Furthermore, according to the report from the joint FAO/WHO meeting (2017) on claim for “free” of *trans* fatty acids, Tanzania was among the countries that supported the claim. However, there is still very limited information regarding the knowledge of *trans* fatty

acids and their underlying health effects to the Tanzanian community (Codex Alimentarius Commission, 2017).

Therefore, it was important to undertake this study to help assess and generate information on *trans* fatty acids presence and concentrations in commonly consumed foods in Morogoro region. Furthermore, an assessment on the average population intake of *trans* fatty acid foods was conducted to ascertain the population at risk. This study is envisaged to contribute to examine the extent and effects of *trans* fatty acids with regard to the emerging rise in non-communicable diseases (NCDs) and guide policy formulation by the Government and interventions by nutritional stakeholders.

1.9 Study Objectives

1.9.1 Overall objective

To assess human exposure to *trans* fatty acids in Morogoro.

1.9.2 Specific objectives

i. To identify processed foods that contain *trans* fatty acids

ii. To determine *trans* fatty acids in selected food stuffs.

iii. To determine the consumption pattern of foods containing *trans* fatty acids

iv. To assess consumers, edible oil producers and food processors awareness pertaining to *trans* fatty acids.

The findings of this research work are reported in three manuscripts presented as chapters two, three and four.

References

Accelerator for Agriculture and Agro industry Development and Innovation Plus 3ADI+ (2019). The palm oil value chain Tanzania - UNIDO. 121pp.

[https://www.unido.org/sites/default/files/files/2019-04/3ADI%2] site visited on 15/05/2020

Afshin, A., Sur, P. J., Fay, K. A., Cornaby, L., Ferrara, G., Salama, J. S. and Afarideh, M. (2019). Health effects of dietary risks in 195 countries, 1990–2017: A systematic analysis for the Global Burden of Disease Study 2017. *The Lancet* 393(10184): 1958 – 1972.

Brouwer, I. A. (2016). Effect of trans-fatty acid intake on blood lipids and lipoproteins: A systematic review and meta-regression analysis. World Health Organization, Geneva. 94pp [http://www.who.int] site vited on 28/6/2019

Canals, A., Bandodkar, A., Vidal, L., Morallón, E., Wang, J., Abellán-Llobregat, A., and

Jeerapan, I. (2017).A stretchable and screen-printed electrochemical sensor for glucose determination in human perspiration. *Biosensors and Bioelectronics* 91: 885–891.

Codex Alimentarius Commission (2017). Joint FAO/WHO food standards programme. codex committee on nutrition and foods for special dietary uses, 39th session. Discussion paper on claim for “free” of *trans* fatty acids. [https:// www.ccnfsdu. de/previous-sessions/39th-session-summary] site visited on 11/02/2019.

De Jong, B. T. (2016). Analysis of the *trans* fatty acid content of beef from major retailers in Gauteng province. Thesis for Award of PhD Degree at University of Pretoria, South Africa, 83pp

Dhaka, V., Gulia, N., Ahlawat, K. S. and Khatkar, B. S. (2011).*Trans* fats-sources, health risks and alternative approach-A review. *Journal of Food Science and Technology* 48(5): 534 – 541.

European Food Safety Authority (2010). Scientific opinion on dietary reference values for fats, including saturated fatty acids, polyunsaturated fatty acids, monounsaturated fatty acids, *trans* fatty acids, and cholesterol. *Journal of*

European Food Safety Authority 8(3): 1461-1568.

Ganguly, R., & Pierce, G. N. (2012). *Trans* fat involvement in cardiovascular disease. *Molecular nutrition & food research*, *56*(7), 1090-1096.

Ghebreyesus, T. A. and Frieden, T. R. (2018). REPLACE: a roadmap to make the world *trans* fat free by 2023. The *Lancet* 391(10134): 1978 – 1980.

Ginter, E. and Simko, V. (2016). New data on harmful effects of *trans*-fatty acids. *BratislavskeLekarskeListy* 117(5): 251 – 253.

Hendry, V. L., Almíron-Roig, E., Monsivais, P., Jebb, S. A., Benjamin Neelon, S. E., Griffin, S. J. and Ogilvie, D. B. (2015). Impact of regulatory interventions to reduce intake of artificial trans–fatty acids: a systematic review. *American Journal of Public Health* 105(3): e32-e42.

Kagiono, S., Nagao, K., Yoshida, A., Mizobe, H., Nagai, T., Beppu, F. and Yoshinaga, K. (2018). Study of *trans* fatty acid formation in oil by heating using model compounds. *Journal of Oleo Science* 67(3): 273–281.

Kamel, S. and Al Otaibi, H. (2018). Trans-fats declaration, awareness and consumption in Saudi Arabia. *Current Research in Nutrition and Food Science Journal* 6(3): 748 – 756.

Li, C., Cobb, L. K., Vesper, H. W. and Asma, S. (2019). Global surveillance of *trans*-fatty acids. *Preventing Chronic Disease* Vol147 (16): 190 – 121.

[https://doi.org/10.5888/pcd16.190121] site visited 17/03/2020

Mayige, M., Kagaruki, G., Ramaiya, K. and Swai, A. (2011). Non communicable diseases in Tanzania: a call for urgent action. *Tanzania Journal of Health Research* 13(5): 1 – 2.

Mayige, M., and Kagaruki, G. (2013). Tanzania STEPS survey report. *Dar es Salaam: National Institute of Medical Research*.154pp.

[https://www.who.int/chp/steps/UR_Tanzania_2012_STEPS_Report.pdf?ua=1] Site visited on 15/07/2020

Mayige, Mary. (2016). Prevention of non-communicable disease in Tanzania using an inter-sectoral approach.[https://doi.org/10.13140/rg.2.1.3976.1047] site visited on10/02/2019.

Mitrou, F. and Lawrence, D. (2014).Narrative Review: The Relationship Between Dietary Trans-Fatty Acids And Adverse Health Outcomes. Food Standards, Australia New Zealand. 30pp.

Mouratidou, T., Livaniou, A., Saborido, C. M., Wollgast, J. and Caldeira, S. (2014).*Trans* fatty acids in Europe: where do we stand? A synthesis of the evidence: 2003-2013. [https://doi.org/10.2788/1070] site visited on 01/04/2019.

Mozaffarian, D. and Stampfer, M. J. (2010). Removing industrial *trans* fat from foods. *British Medical Journal* Vol.340:c1826; 1094-1095

Mozaffarian, D., de Oliveira Otto, M. C., Lemaitre, R. N., Fretts, A. M., Hotamisligil, G., Tsai, M. Y. and Nettleton, J. A. (2013).trans-Palmitoleic acid, other dairy fat biomarkers, and incident diabetes: the Multi-Ethnic Study of Atherosclerosis. *The American Journal of Clinical Nutrition* 97(4): 854–861.

Nichols, M., Townsend, N., Luengo-Fernandez, R., Leal, J., Gray, A., Scarborough, P. and Rayner, M. (2016). European Cardiovascular Disease Statistics 2012. *European Heart Network, Brussels*. European Society of Cardiology, Sophia Antipolis. 129pp. *[www.escardio.org] ;Site visited on 20/8/2019*

Pfeuffer, M. and Jahreis, G. (2018). *Trans* fatty acids. Origin, metabolism, health risks. Ernahrungs Umschau 65(12): 196–203.

Ruhembe, C. C. (2016). Prevalence, awareness and management of type 2 diabetes mellitus in Mwanza City, Tanzania (Doctoral dissertation, Sokoine University of Agriculture).

Schwab, U., Lauritzen, L., Tholstrup, T., Haldorsson, T. I., Riserus, U., Uusitupa, M. and Becker, W. (2014). Effect of the amount and type of dietary fat on cardiometabolic risk factors and risk of developing type 2 diabetes, cardiovascular diseases, and cancer: a systematic review. *Food and Nutrition Research* 58(1): 25 – 145.

Thornton, J. (2018). Eliminate" toxic" *trans* fats from food by 2023, WHO urges. *British Medical Journal;*Londonvol.361. [DOI:10.1136/bmj.k2154]

United Republic of Tanzania (2016). Strategic and Action Plan for the Prevention and Control of Non Communicable Diseases in Tanzania 2016-2020.Ministry of Health, Community Development, Gender, Elderly and Children, Dar es Salaam, Tanzania.pp.

Wang, Q., Afshin, A., Yakoob, M. Y., Singh, G. M., Rehm, C. D., Khatibzadeh, S. and Mozaffarian, D. (2016).Impact of non optimal intakes of saturated, polyunsaturated, and *trans* fat on global burdens of coronary heart disease. *Journal of the American Heart Association 5*(1): e002891.

World Health Organization (2018). Protocol for measuring *trans* fatty acids in foods.

[https://www.who.int/docs/default-source/replace/a-food-analysis-lab-protocol.pdf] site visited on 15/06/2019.

World Health Organization (2018). Non-communicable diseases country profiles. Geneva 124pp. [https://apps.who.int/iris/bitstream/handle] site visited on11/07/2019.

World Health Organization (2018). Thirteenth general programme of work 2019- 2023. [https://www.who.int/about/what-we-do/thirteenth-general-programme-ofwo

rk-201 9- 2023] site visited on 15/06/2019.

World Health Organization (2019). Replace action package: Module 3: Legislate or Regulate: How to guide for *trans* fat Policy Action (No. WHO/NMH/NHD/19.14). World Health Organization, Geneva. 27pp.

Wu, J., Zheng, M., Catterall, E., Downs, S., Thomas, B., Veerman, L. and Barendregt, J. (2017). Contribution of *trans*-fatty acid intake to coronary heart disease burden in Australia: A modelling study. *Nutrients* 9(1): 77-86.

CHAPTER TWO

2.0 TRANS FATTY ACIDS (TFAs) IN SELECTED PROCESSED FOODS IN RETAIL MARKETS OF MOROGORO, TANZANIA

L.G. Nzunda[1, 2], J. Kinabo[2], L.M. Chove[2*]

[1]Department of Training, Research & Extension Services, Ministry of Agriculture,

P.O. Box, 2182, Dodoma, Tanzania

[2]Department of Food Technology, Nutrition and Consumer Sciences, Sokoine University of Agriculture, P.O. Box 3006, Morogoro, Tanzania

* Email of the corresponding author; lucychove@sua.ac.tz

Abstract

There are reliable evidences of adverse health effects of industrial *trans* fatty acids (TFAs) on blood lipoprotein profiles, coronary heart disease, cancer, diabetes, promotion of inflammation and endothelial dysfunction. In Tanzania, there is a sharp increase in Diet-Related Non Communicable Diseases (DR-NCDs). Reduction of TFAs in foods is considered as the most appropriate measure for tackling DR-NCDs in low and middle income countries. The current study was conducted to determine the TFAs levels in "*Chapati*", wheat buns, rice buns, potato chips and partially hydrogenated oils (PHOs) from retail shops in Morogoro region. A total of 60 samples were collected from two

districts and analysed for total TFAs by Gas Chromatography Mass Spectrometry (GC-MS). Data was analysed by SPSS (version 20.0) and Means were separated by Tukey‘s honest at P≤ 0.05. Results indicated that all samples contained TFAs levels that were above the maximum recommended level by WHO of less than or equal to 2g/100g of fat, with the exception of “*Chapati*”. The highest amount (5.69±0.042g/100g fat) of TFAs was observed in PHOs. The mean TFAs concentration differed significantly among food types at P≤ 0.05). There was no significant effect of locations from where samples were collected on mean TFAs concentration at the same level. Other snacks in this study, when consumed on regular basis could add up more TFAs in our bodies thereby increasing the risks for DR-NCDs, especially cardiovascular disease (CVD) which have become more prominent in the country. Tanzania should also join efforts to eliminate industrially produced TFAs by implementing legislative /regulatory actions to prohibit and/or limit their use in foods.

Keywords: *Trans* fatty acids, Partially hydrogenated oils, Cardiovascular disease, Morogoro

2.1 Introduction

TFAs are a type of unsaturated fatty acids classified as either naturally occurring or industrially produced (Kamel, *et al.,* 2018). Naturally occurring TFAs or ruminant *trans* fatty acids (rTFAs) are found in small proportions (3% - 6%) in food products such as meat and milk products from animals (Mouratidou *et al*., 2014). Industrially produced *trans* fatty acids (iTFAs) are formed by the process of partial hydrogenation in the

industrial production of PHOs (Afaneh *et al*., 2017), during the process oil is hardened, which improves its sensory and texture profiles, also increases its shelf life and tolerance to repeated heating (Mouratidou *et al*., 2014). Oils that initially had a low content of TFAs, repeated heating (e.g. in cooking, deep-frying) can form additional TFAs (Dhaka *et al*., 2011). TFAs are considered the worst type of fat to eat (Wang *et al*., 2016). They tend to raise the low density lipoprotein cholesterol ("bad" cholesterol) while lowering the high density lipoprotein cholesterol ("good" cholesterol) (Wu *et al*., 2017). Diets which are high in TFAs tend to increase risk of cardio-vascular diseases (CVD) by 21% and deaths by 28% (Ginter and Simko, 2016).

Given TFAs' adverse health effects, WHO recommends limiting mean population TFAs intake to less than 1% of total energy (%E) (Li *et al.*, 2019). TFAs have no known health benefits and can be replaced in foods without impacting their consistency or taste (WHO, 2018). PHOs are the major source of fats/oils in Tanzania by about 60% annually (3ADI+, 2019), hence the high consumption of such dietary source of fat could be posing health threat especially CVDs to consumers (Kagiono *et al*., 2018). However, there is still limited information regarding the levels of TFAs and their underlying health effects to the Tanzanian population (Codex Alimentarius Commission, 2017). The information generated through this study has shed light on presence of TFAs and its concentrations in some processed commonly consumed foods in Morogoro region.

2.2 Materials and Methods

2.2.1 Study Area

This study was conducted in Morogoro urban and rural districts (Morogoro region; 6°, 49'S, 37°, 40'E). Morogoro region was selected for the study because previous studies had reported that, it was among of the three sites (including Dar es Salaam and Hai-Kilimanjaro) which demonstrated a considerably high risk of dying from non-communicable diseases (NCDs) during adulthood in Tanzania (Mayige and Kagaruki., 2013).

2.2.2 Study design

Cross sectional design was used in this study. Food samples for TFAs analysis were drawn from the street food vendors and restaurants in each street/village. A total of four Streets were selected, two from each of the two wards of Morogoro urban and two villages from one ward of Morogoro rural district.

2.2.3 Sampling procedure and sample collection

Simple random sampling was employed in selecting two districts out of 8 in Morogoro region (urban and rural). Furthermore purposive sampling was employed in selecting 2 wards (Mji Mkuu and Mazimbu) out of 29 from Morogoro urban district (Mazimbu ward had the highest population according to 2012 census and Mji Mkuu ward is situated at the town centre), and 1 ward (Kiroka) out of 31wards from Morogoro rural district (Kiroka ward was the most populated among all wards in Morogoro rural district). Thereafter

simple random sampling was employed to get locations (streets/villages) whereby; 4 (Karume A, Uhuru, Mazimbu Darajani and Boma A) out of 14 streets were selected from 2 wards in Morogoro urban and 2 (Kiroka and Kiziwa) out 4 villages were selected from 1 ward in Morogoro rural district. After that two samples were purposively selected from 2 points (food vendors and restaurants) in each street. Food samples collected included potato chips, wheat buns, "*chapati"*, rice buns and partially hydrogenated vegetable (PHOs) cooking oil (that had been used for frying chips).

During sample collection, forks were used to pick chips, buns, "*chapati*" and rice cakes which were then wrapped independently into Aluminium foils while the used vegetable cooking oils were stored in clean amber coloured plastic bottles with their caps tightly closed. All samples were stored in an insulated cool box maintained at temperature of around 4^0C. They were transported to Food Science Laboratory at Sokoine University of Agriculture; samples that were not analysed in the same day were stored in freezer at -18^0C.

2.2.4 Materials

Materials used for this study were food samples (wheat buns, "*Chapati*", potato chips, rice buns and cooking oil (PHOs) from the street food vendors and restaurants. Chemicals (Sulphuric acid 98%, Petroleum ether, Aluminium Chloride hexadrate, Methanol 99.8%, hexane and dichloromethane), all purchased from LobaChemie Pvt. Ltd, Mumbai (India), the standard used was Supelco 37 component Fatty Acid Methyl Ester (FAME) mix from

Sigma-Aldrich (Germany). All solvents and reagents were of HPLC analytical grade, double distilled water was also used for rinsing.

Equipment used included Soxhlet (model Foss Soxtec2055 - made in Germany), GC- MS (model QP 2010Ultra –Shimadzu Japan), Oven (Wagtech - Britain), Restek-5MS column (30m x 0.25mm x 0.25µm), Analytical balance (model T5Boeco - Germany), digital food Thermometer (model LDT-3305- China), No 41 Whatman filter papers, Stainless steel fork, Aluminium foils, amber coloured plastic containers and glass vials, Volumetric flasks, Petri dishes, Separating funnels, Ice packs, Cool box were also used.

Table 2.1: Number of samples collected from each street/village

					Food Vendors					**Restaurants**	**Total**
Sampling sites	Chips	Chapati	Wheat buns	Rice buns	Used Veg. Oils(PHOs)	Chips	Chapati	Wheat buns	Rice buns	Used Veg. Oils(PHOs)	
Karume A	1	1	1	1	1	1	1	1	1	1	10
Uhuru	1	1	1	1	1	1	1	1	1	1	10
Mazimbu Darajani	1	1	1	1	1	1	1	1	1	1	10
Boma A	1	1	1	1	1	1	1	1	1	1	10
Kiroka	1	1	1	1	1	1	1	1	1	1	10
Kiziwa	1	1	1	1	1	1	1	1	1	1	10
Total	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**60**

2.2.4.1 Sample preparation/extraction

Prior to fatty acids analysis, fat extraction procedure and Fatty Acid Methyl Esters (FAME) preparations were carried out by Soxhlet method (Olubunmi *et al.,* 2015) at the Department of Food Technology, Nutrition and Consumer Sciences (Sokoine University of Agriculture). After FAME preparation, the extracts were packed in an insulated cool box (with ice packs maintained at 4^0C) then transported by car to the Department of Fisheries and Aquatic Sciences Laboratory (University of Dar es Salaam, Tanzania) for *trans* fatty acids analysis.

2.2.4.2 Analysis of Fatty Acids Methyl Ester (FAME) by GC-MS

Analysis of FAME was conducted by Gas Chromatography-Mass Spectrometry (GC-MS) in a GCMS-QP 2010Ultra (Shimadzu, Japan) working in Electron Ionization (EI) mode (MS) at 70ev, and detected by FID for GC. A Restek-5MS column (30m x 0.25mm x 0.25µm) was used. The oven temperature program set at 60ºC to 280ºC, and held at 60ºC for 2 minutes. The temperature was raised to 260ºC for 2 minutes (holding time) at the rate of 13ºC per minute. The injection temperature was 250ºC with split injection mode. The flow rate of carrier gas (Helium) was 1.21mL min^{-1}. The ion source temperature and interface temperature in MS were 230ºC and 300ºC, respectively. Identification of FAME and other compounds in the sample was done by using a scan method which involved the use of Mass Spectral Library and Search Software (NIST). Quantification of FAME in samples was done by using the peak integration method in which ion allowance was 20%, target ion and other 5 quantification ions were employed on quantitative analysis adopting an official method (AOAC 996.06). 1.0 µL of the sample in dichloromethane was injected in GC-MS. Results reported were derived from calibration curve of FAME 37 Mix standard (Supelco37 component, Germany) (Figure 2.1- 2.3) using peak integration

method prepared. To get the concentrations of TFAs, peak integration was done for individual *trans* fatty acids contents (Figure 2.1 & 2.2):-

X = (Y + Intercept) /Slope (Khan *et al.*, 2017).

Where by:

X = TFAs concentration (mg/mL) and Y= Peak Area

i. X= (Y- 875)/25366…….....Elaidic acid

ii. X= (Y- 58.33)/29714 ……Linolelaidic acid

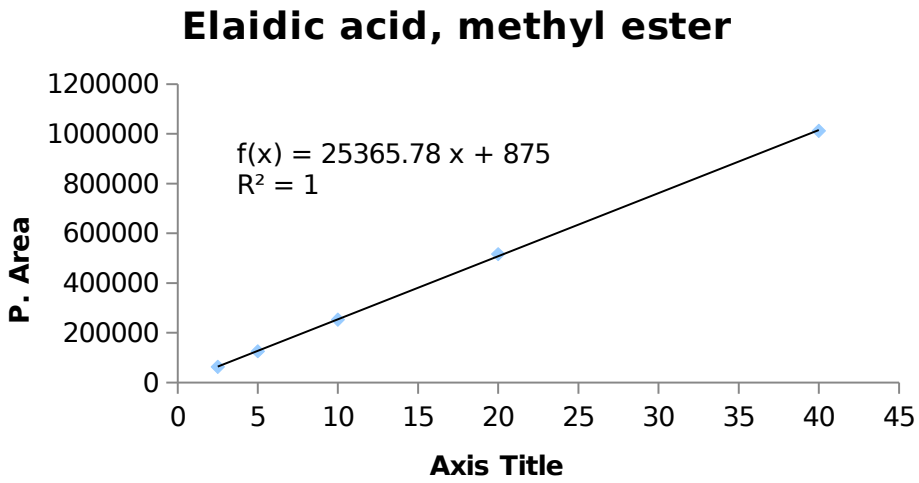

Figure 2.1: The Calibration curve for Elaidic acid, methyl ester

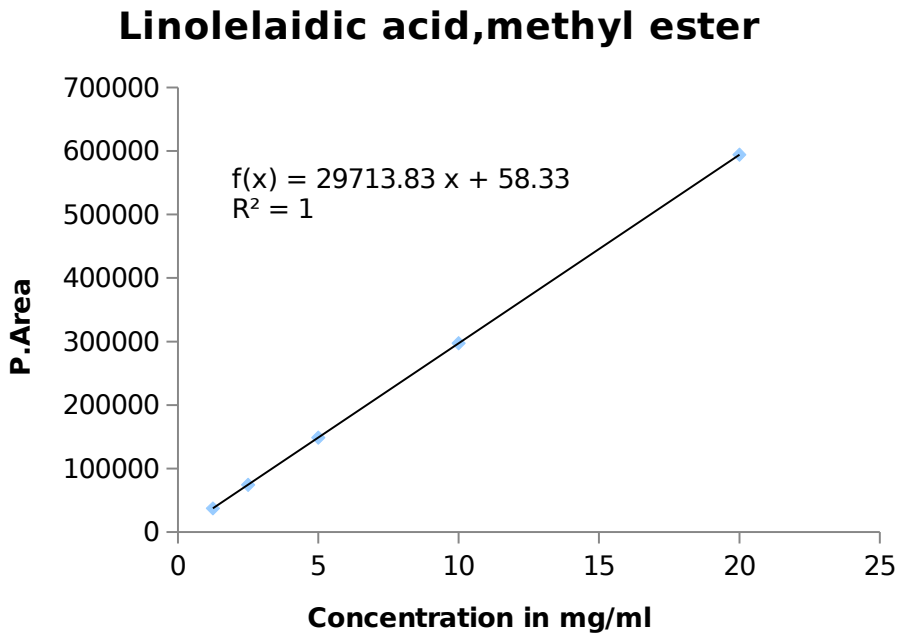

Figure 2.2: The Calibration curve for Linolelaidic acid, methyl ester

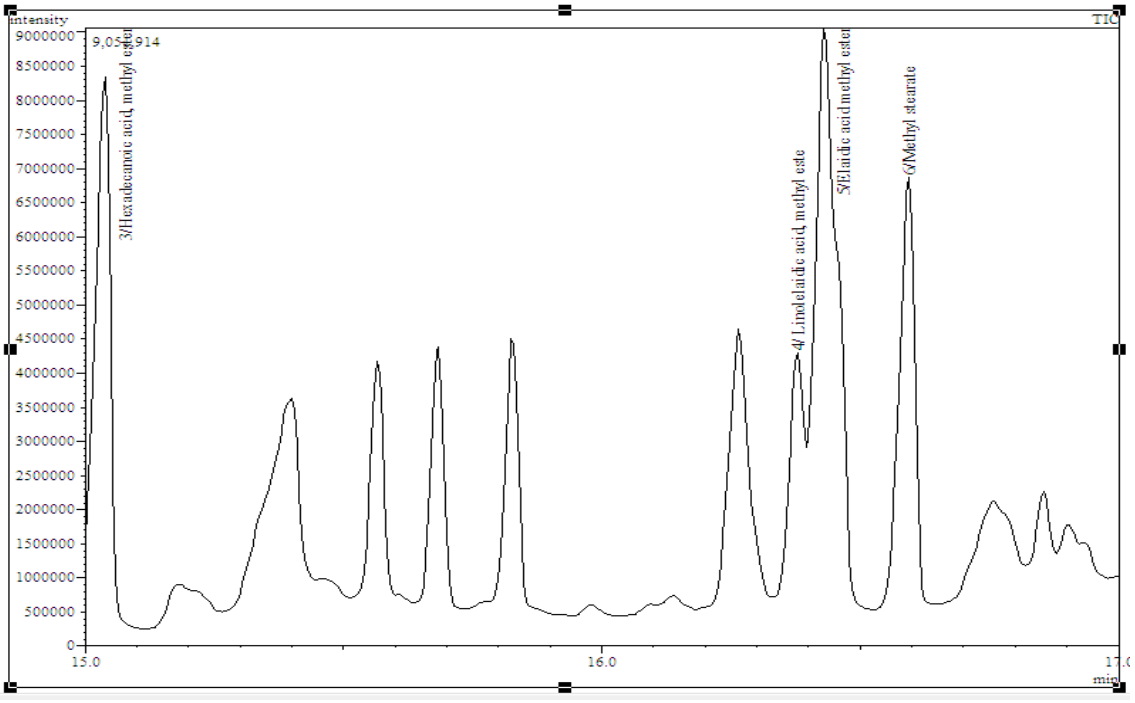

Figure 2.3: GC Chromatogram of TFAs standard (FAME 37 Mix standard /Supelco37 component)

2.2.5 Statistical analysis

IBM-SPSS statistics Windows software (IBM- SPSS Inc., Chicago, USA; version 20.0) was used for statistical analysis. Descriptive statistics were calculated for the TFAs concentration in g/100g fat. A two way ANOVA was used to compare variability in TFAs concentration among food type and location. To check further differences in means for the variables, the Tukey's HSD test ($P \leq 0.05$) was performed (Shah *et al.,* 2016) using the following model:-

$$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk}$$

Where by:

Y_{ijk} = Dependant variable (TFAs),

μ= Overall mean,

α_i= 1, 2, 3, 4, 5 (Food type effect),

β_j= 1, 2, 3,4,5,6 (location effect),

$(\alpha\beta)_{ij}$= Interaction effect,

ε_{ijk}= Random error term and k = Replication.

2.3 Results

2.3.1 Trans fatty acids in processed foods

Preliminary market survey conducted in the study area identified 5 types of foodstuffs ("*chapati*", wheat buns, potato chips, rice buns and used PHOs. All analysed food samples contained TFAs (more of Elaidic acid and Linolelaidic acid methyl esters) with an overall mean of 2.81±1.23g/100g fat, which ranged from 1.80±0.40 g/100g in chapati to 4.77±0.52 g/100g fat in fried potato chips among snacks (Table 2.2).

The mean TFAs concentration differed significantly ($P = 0.001$) between the food types. However post hoc analysis by Tukey's HSD at $P \leq 0.05$, revealed no significance difference

in TFAs concentration among wheat buns and rice buns. Furthermore the significant differences were observed between chapatti, potato chips, wheat buns and rice buns while wheat buns and rice buns showed no significant different.

With regards to the 6 locations, the mean TFAs concentration ranged from 2.54±1.3g/100g to 3.23±1.47g/100g fat (with an overall mean of 2.81±1.23 g/100g fat) among the six (6) locations (streets/villages). Furthermore, the overall mean TFAs concentration based on districts were 2.81±1.23. No significant differences were observed with respect to sample's location (either districts or streets) (Table 2.2). Also no significant differences were observed with respect to interaction effects between food samples and locations.

Table 2.2: *Trans* fatty acids in processed food (in g/100g Fat)

Category (Food Type)	**N**	**Mean± SD (g/100g)**	**F-ratio (P- value)**
"Chapati"	12	1.80±0.40[a]	125.108(0.001**)
Wheat buns	12	2.28±0.38[b]	
Rice buns	12	2.39±0.33[b]	
Chips	12	4.77±0.52[c]	
Overall	48	2.81±1.23	
(Streets/Villages)			
Uhuru	08	3.23±1.47[a]	0.273 (0.925)
Karume	08	2.67±0.93[a]	
Darajani	08	2.84±1.28[a]	
Boma A	08	2.54±1.30[a]	
Kiroka	08	2.87±1.51[a]	
Kiziwa	08	2.71±1.12[a]	
Overall	48	2.81±1.23	
(Districts)			
Urban	32	2.82±1.23[a]	0.007 (0.934)
Rural	16	2.79±1.29[a]	
Overall	48	2.81±1.23	
(Food Type* Location)			1.245 (0.306)

N.B: Given values are means of duplicate analysis along with standard deviation.
Means sharing the same superscripts letters along the same column are not significantly different at 5% level of significance.
**Significant results at 5% level of significance.
Food type* Location = Interaction effect of Food type & Location

2.3.2 *Trans* fatty acids in partially hydrogenated oils (PHOs)

Figure 2.1 presents the concentrations of TFAs analysed for PHOs samples from all locations which ranged between 4.94±0.34 g/100g to 5.98±0.01 g/100g), with an overall mean of 5.69±0.41g/100g fat, Fresh PHOs (reference oil) contained 4.71±0.04 g/100g fat of TFAs. Generally there was a significant difference in mean TFAs concentration between locations (F – ratio = 5.155; P = 0.035). TFAs concentrations in PHOs samples from Uhuru Street showed significant different from Karume 'A', Kiroka and Kiziwa but was not statistically significant different from Mazimbu Darajani and Boma 'A' (Figure 2.1).

TFAs concentration in PHOs were 5.56±0.45 g/100g and 5.95±0.04 g/100g fat in urban and rural districts respectively. Nevertheless, there was no significant difference observed (F– ratio = 2.75; P = 0.128) on mean concentration of TFAs in PHOs between urban and rural areas.

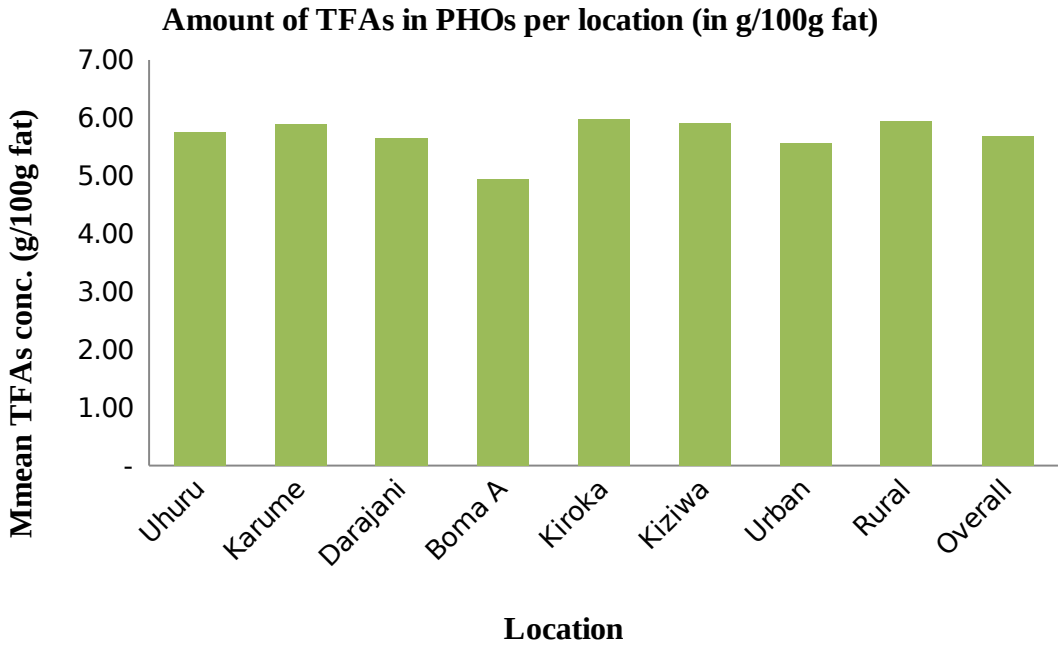

Figure 2.4: Amount of TFAs in partially hydrogenated oils (PHOs) based on locations

NB: The locations in bars not sharing a common letter are significantly different (P≤ 0.05).

2.4 Discussion

TFAs levels in the studied foods collected from various food outlets in Morogoro urban and rural districts were recorded. Results indicated that all samples from all locations contained TFAs, although in varying concentrations. This shows that regardless of locations, people living either in urban or rural districts were all exposed to TFAs. Previous studies have indicated that, TFAs cause lipid and other metabolic disturbances in epidemiological studies, and are consistently linked with a higher risk of cardiovascular disease (CVD) mortality (Kagiono *et al*., 2018). Data from some countries suggest that TFAs intake may also vary within populations (Wu *et al.,* 2017). The obtained results of the TFAs in the current study revealed that; the lowest amount (1.80±0.40g/100g fat) was found in "Chapati". The highest amount of TFAs (5.69±0.41 g/100g fat) was found in partially hydrogenated oils (PHOs) and the mean was found to be 4.71±0.04g/100g fat.

The observed high concentration of TFAs in used PHOs compared to fresh PHOs could be attributed by high heat treatment and repeated heating during potato chips frying. This argument was also found to be comparable with other studies conducted in Japan, Korea and Palestine (Tsuzuki *et al*., 2010; Song *et al.,* 2015; Afaneh *et al.,* 2017). Moreover the observed high amount of TFAs in rural areas could be attributed by low social economic status compared to those people living in urban areas hence there is higher possibility of re-using cooking oils for several times/days, which leads to further exacerbate the TFAs levels in foods.

A study done in India by Khan *et al*. (2017) found the amount of TFAs in PHO ranged from 3.31g/100g - 4.73g/100g of fat. Other contrasting findings of TFAs were observed from a study by Costa *et al*. (2016) from Portugal which found TFAs levels between 0.26g/100g to 2.16g/100g of fat in PHOs.

Results of the amount of TFAs reported for cereal products (Chapati, wheat buns and Rice buns) were far lower compared to those reported by Shah et al. (2016) in Pakistan, where it was found to range from 6.190±3.08g/100g fat to 38.691±0.133g/100g fat. The observed differences could be caused by the differences in the cooking temperature applied during frying. Furthermore the current results were comparable to those reported from the survey conducted in Ireland (FSAI, 2016), for the TFAs content in some processed foods (snacks and readymade pastry) which found to range from ≤0.5 to 4g TFAs per/100 g fat. Other similar results were previously reported by Costa et al. (2016) from the processed cereal foods in Portugal which found TFAs levels in fast foods ranging from 0.38g/100g to 3.07g/100g fat. Conversely, other results reported by Pérez-Farinós et al. (2016) in Spain; found most of food stuffs studied had a TFAs content less than 2g/100g of total fat. The lower amount of TFAs in Spain compared to the current study could be attributed by the strict measures by the Spanish government in reducing TFAs since the ill health effects became known to public.

The levels of *trans* fatty acids in Potato chips revealed by this study were higher (4.77±0.52g/100g) and statistically significantly different from other studied snacks (F-ratio= 125.108; P = 0.001). The obtained results in chips were in contrast with those reported from other countries; for instance in India where potato chips from retailers were found to have TFAs level of 2.61g/100g of total fats (Khan *et al*., 2017), also potato chips and French fries found to contain TFAs in a range from 0.17g/100g to1.26g/100g of total fat in Portugal (Costa *et al*., 2016; Bloks, 2019). The observed differences could be attributed by high temperature, long time and repeated heating applications during chips preparations in cooking oils (PHOs) especially in commercial food preparations both in rural and urban locations.

With the exception of "*Chapati*" with TFAs concentration of 1.80±0.40g/100g fat, the amount of TFAs found in all other foodstuffs were above the optimal recommended amount for iTFAs by WHO (≤ 2g/100g fat).It is worthy to note that the variations reported from previous studies, and those of the current study are probably due to the fact that in Tanzania, the policies have not yet been enforced to regulate the amount of TFAs in food products especially the iTFAs (Downs *et al.*, 2017; Li *et al*., 2019) which are regarded as major source of TFAs in foods (Mouratidou *et al*., 2014; De Jong, 2016). The most effective option to eliminate industrially produced TFAs from our food supply is by implementing regulatory actions to prohibit/ limit their use in foods.

2.5 Conclusion

All samples analysed exceeded the maximum recommended TFAs levels (≤ 2g/100g fat) as set by the WHO and European Food Safety Authority with exception of "chapati". Consumption of high levels of TFAs from PHOs is a risk factor for the development of cardiovascular disease (CVD). Tanzania needs to join other countries and impose serious measures to reduce the intake of TFAs in foods. The most effective and consistent way to eliminate industrially produced TFAs from our food supply is by implementing regulatory actions to limit their use in foods.

References

Accelerator for Agriculture and Agro industry Development and Innovation Plus 3ADI+ (2019). The palm oil value chain Tanzania- UNIDO121pp. [https://www.unido.org/sites/default/files/files/2019-04/3ADI%2] site visited on 15/05/2020 at 2200hrs.

Afaneh, I., Abbadi, J., Al-Rimawi, F., Al-Dabbas, G., & Sawalha, S. (2017). Effect of Frying Temperature and duration on the Formation of Trans Fatty Acids in Selected Fats and Oils. *American Journal of Food Science and Technology, Vol. 5, No. 6, 245-248*

Codex Alimentarius Commission (2017). Joint FAO/WHO food standards programme. codex committee on nutrition and foods for special dietary uses. 39th session discussion paper on claim for “free” of *trans* fatty acids. [https://www.ccnfsdu.de/previous-sessions/39th-session-summary] site visited on11/02/2019 at 1325hrs.

Costa, N., Cruz, R., Graça, P., Breda, J. and Casal, S. (2016). *Trans* fatty acids in the Portuguese food market. *Food control* 64: 128 – 134.

De Jong, B. T. (2016). Analysis of the *trans* fatty acid content of beef from major retailers in Gauteng province. Thesis for Award of PhD Degree at University of Pretoria, South Africa, 83pp

Dhaka, V., Gulia, N., Ahlawat, K. S. and Khatkar, B. S. (2011). Trans fats-sources, health risks and alternative approach-A review. *Journal of Food Science and Technology* 48(5): 534 – 541.

Downs, S. M., Bloem, M. Z., Zheng, M., Catterall, E., Thomas, B., Veerman, L. and Wu, J. H. (2017). The impact of policies to reduce *trans* fat consumption: a systematic review of the evidence. *Current Developments in Nutrition* 1(12): 117-127.

Food Safety Authority of Ireland (2016). Survey of the *trans* fatty acid content in processed food products in Ireland. 30pp, [https://www.fsai.ie/search-results.html?searchString=Trans%20Fatty%20Acid%20Survey]
site visited on 8/03/2020 at 1730hrs.

Ghebreyesus, T. A. and Frieden, T. R. (2018). REPLACE: a roadmap to make the world *trans* fat free by 2023. The *Lancet* 391(10134): 1978 – 1980.

Ginter, E. and Simko, V. (2016). New data on harmful effects of *Trans* fatty acids. *Bratislavske LekarskeListy* 117(5): 251 – 253.

Kagiono, S., Nagao, K., Yoshida, A., Mizobe, H., Nagai, T., Beppu, F. and Yoshinaga, K. (2018). Study of *Trans* fatty acid formation in oil by heating using model compounds. *Journal of Oleo Science* 67(3): 273–281.

Kamel, S. and Al Otaibi, H. (2018).*Trans* fats declaration, awareness and consumption in Saudi Arabia. *Current Research in Nutrition and Food Science Journal* 6(3): 748 – 756.

Khan, M. U., Hassan, M. F. and Rauf, A. (2017). Determination of *Trans* fat in selected fast food products and hydrogenated fats of India using attenuated total reflection Fourier transform infrared (ATR-FTIR) spectroscopy. *Journal of Oleo Science* 66(3): 251 – 257.

Li, C., Cobb, L. K., Vesper, H. W. and Asma, S. (2019). Global surveillance of *Trans* fatty acids. *Prevalence of Chronic Disease* 16: 190 – 121.

Mayige, M., and Kagaruki, G. (2013). Tanzania STEPS survey report. Dar es Salaam: National Institute of Medical Research.154pp[https://www.who.int/chp/steps/UR_Tanzania_2012_STEPS_Report.pdf?ua=1] Site visited on 15/07/2020 at 1325hrs

Mouratidou, T., Livaniou, A., Saborido, C. M., Wollgast, J. and Caldeira, S. (2014). *Trans* fatty acids in Europe: where do we stand? A synthesis of the evidence: 2003-2013. [https://doi.org/10.2788/1070] site visited on 01/04/2019 at 0915hrs.

Mozaffarian, D. and Stampfer, M. J. (2010). Removing industrial *trans* fat from foods. *British Medical Journal* Vol.340:c1826; 1094-1095

Olubunmi, A., Oluwaseeni, A., Oluwatimilehin, O., Kayode, C. and Adeosun, B. (2015). Direct preparation of fatty acid methyl esters and determination of *in vitro* antioxidant potential of lipid from fresh *Sebalcausarium* Seed. Journal of Applied Pharmaceutical Science 5(3): l24 – 128.

Pérez-Farinós, N., Saavedra, M. Á. D. R., Villalba, C. V. and de Dios, T. R. (2016). *Trans* fatty acid content of food products in Spain in 2015. *Gaceta Sanitaria* 30(5): 379 – 382.

Shah, F., Rasool, G., Sharif, M. K., Pasha, I., Ahmad, S. and Sharif, H. R. (2016). Determination of *trans* fat in traditional Pakistani breakfast and snack foods. *International Food Research Journal 23*(2): 849 - 853.

Song, J., Park, J., Jung, J., Lee, C., Gim, S. Y., Ka, H. and Lee, J. (2015). Analysis of *trans* fat in Edible oils with cooking process. *Toxicological research*, *31*(3), 307-312.

Tsuzuki, W., Matsuoka, A., and Ushida, K. (2010). Formation of *trans* fatty acids in edible oils during the frying and heating process. *Food Chemistry*, *123*(4), 976-982.

Wang, Q., Afshin, A., Yakoob, M. Y., Singh, G. M., Rehm, C. D., Khatibzadeh, S. and Mozaffarian, D. (2016).Impact of non-optimal intakes of saturated, polyunsaturated, and *trans* fat on global burdens of coronary heart disease. *Journal of the American Heart Association 5*(1): e002891.

World Health Organization (2018). Protocol for measuring *trans* fatty acids in foods. [https://www.who.int/docs/default-source/replace/a-food-analysis-lab-protocol.pdf]site visited on 15/06/2019 at 1610hrs.

Wu, J., Zheng, M., Catterall, E., Downs, S., Thomas, B., Veerman, L. and Barendregt, J. (2017). Contribution of *trans*-fatty acid intake to coronary heart disease burden in Australia: A modeling study. *Nutrients* 9(1): 77-86.

CHAPTER THREE

3.0 CONSUMPTION PATTERN OF FOODS CONTAINING *TRANS* FATTY ACIDS IN SELECTED WARDS OF MOROGORO REGION, TANZANIA

L.G. Nzunda[1, 2*], J. Kinabo[2], L.M. Chove[2]

[1]*Department of Training, Research & Extension Services, Ministry of Agriculture, P.O. Box, 2182, Dodoma, Tanzania*

[2]*Department of Food Technology, Nutrition and Consumer Sciences, Sokoine University of Agriculture, P.O. Box 3006, Morogoro, Tanzania*

* Email of the corresponding author nzundag@gmail.com

Abstract

Food consumption patterns is the system which include repetitive, consistent decision making and behaviour about food selection and use. The purpose of this study was to assess the consumption pattern of foods containing *trans* fatty acids (TFAs) in selected wards of Morogoro region. A cross-sectional study was conducted on 340 households whereby 176 samples were drawn from two wards in Morogoro urban district and 164 samples from one ward in Morogoro rural district. Food frequency questionnaires (FFQ) were used to collect data. Univariate tests were performed to determine the consumption pattern of the foods containing TFAs. Results showed that, generally 70% of urban households in the study wards consumed processed foodstuffs whereas 66% of the rural households in the study wards consumed more of minimally/non-processed foodstuffs. About 70% of processed foods/snacks were prepared by frying using partially hydrogenated oils (PHOs), which are known to contain high amounts of TFAs. Foodstuffs contained high TFAs were mostly consumed during breakfast by 89% and 65% in urban and rural households, respectively. Moreover, these foods were also mostly consumed

during dinner by 92% of urban households and 29% of the rural households. Furthermore, the consumption of cooking oil brand "*Korie"* (PHOs) was 87% and 70% in rural and urban areas, respectively. This clearly suggests that most of the households were exposed to TFAs, therefore at risk of developing non communicable diseases such as cardiovascular diseases (CVDs). The Ministry of Health and related government authorities should provide information regarding the negative health effects of high consumption of TFAs for all people in Morogoro region.

+**Keywords:** *Food Consumption Pattern, Trans fatty acids, Cardiovascular Diseases, PHOs*

3.1 Introduction

Food consumption pattern is a combination of foods which constitutes an individual's repetitive, consistent decision making and behaviour about food selection and use (Prabhat and Begum, 2012). Consumption patterns change over time, the major lead for such changes is the development in technology (Ruel *et al*., 2017). However, caution is also being exercised to control the bad effects of wrong dietary choices through monitoring awareness programs by public health authorities (Leyna *et al*., 2010). Food consumption habits are predictors of health and nutritional status (Zimmer *et al.*, 2012). Culture and socio- economic status of the population influence food choices and pattern of consumption, while consumption of some food items is likely to vary according to season and often based on availability and price; education and income are also important determinants of food intake (Cochrane and D'Souza, 2015). With respect to food consumption, urban people are reported to have better access to a variety of food items (Prabhat and Begum, 2012; Holmes *et al*., 2018).

Evidence indicates that non communicable disease such as cardiovascular diseases (CVD) are partly due to unhealthy eating pattern (Holmes *et al*., 2018). Increasingly the population's eating habit is shifting towards fast foods, which are often prepared by using unhealthy cooking oils/fats (PHOs) with significant amounts of *trans* fatty acids which exceeds the recommended amount of TFAs which is 2gm/100g fat (Dhaka *et al*., 2011). These oils/fats are preferred because of their good sensory attributes, cheap and readily available. Adverse health effects of *trans* fatty acids in human are mediated by increase in plasma concentrations of low-density lipoprotein cholesterol (LDL-C) (Wu *et al*., 2017), which leads to promotion of inflammation, endothelial dysfunction and possible effects on coagulation, insulin resistance and displacement of essential fatty acids from membranes (Mitrou & Lawrence, 2014). PHOs are the major source of fats/oils in Tanzania by about 60% annually (3ADI+, 2019), hence the high consumption of such dietary source of fat could be posing health threat especially CVDs to consumers (Kagiono *et al*., 2018).

Tanzania has recorded increased incidences of diet related non-communicable disease (DR-NCD), especially cardiovascular health problems and deaths from 27% in 2010 (Mayige *et al.*, 2011) to 33% in 2016 (Mayige, 2016; URT, 2016; WHO, 2018). However, there is still limited information regarding the consumption pattern of foods considered to contain TFAs and their underlying health effects to the Tanzanian population. The present study was conducted to assess the consumption pattern of foods containing TFAs in few selected wards of Morogoro region. The information generated through this study has shed light regarding the presence and concentration of TFAs in some commonly consumed processed foods in Morogoro and hence will help to inform Health and Nutritional authorities fight against the increased incidences of diet related non-communicable disease (DR-NCD) especially cardiovascular health problems.

3.2 Materials and Methods

3.2.1 Study Area

This study was conducted in Morogoro urban and rural districts (Morogoro region; 6°, 49'S, 37°, 40'E). Morogoro region was selected for the study because previous studies reported that, it was among of the three sites (including Dar es Salaam and Kilimanjaro) which demonstrated a considerably high risk of dying from non-communicable diseases (NCDs) during adulthood in Tanzania (Mayige and Kagaruki., 2013).

3.2.2 Sample size determination

The sample size was calculated using the Fisher's equation shown below:-

$$n = \frac{z^2 \times p(1-p)}{e^2}$$

Where by n = sample size, p = population proportion 33% (National prevalence of NCDs), e = Margin of error, set 5% for this study and Z = standard variance at a given confidence level, for this study 95%, confidence level = 1.96 (Kothari and Garg, 2014).

3.2.3 Study population

Urban and rural adult household members were involved in the study. This is because studies have demonstrated that there is a considerably high risk of dying from non-communicable diseases (NCDs) during adulthood. In addition, adults are responsible care givers for their families.

3.2.4 Sampling procedure

Simple random and purposive sampling approaches were used in the study. Morogoro region was randomly selected out of 3 sites (including Dar es Salaam and Hai-Kilimanjaro) reported with high risk of dying from non-communicable diseases during adulthood in Tanzania (Mayige and Kagaruki., 2013). Moreover, simple random sampling

was employed in selecting the two districts (Morogoro urban and rural) out of eight. Purposive sampling was employed in selecting two wards (MjiMkuu and Mazimbu) out of 29 in Morogoro urban, and one ward (Kiroka) out of 31wards from Morogoro rural. Mazimbu and Kiroka were the most populated wards in their respective districts, while MjiMkuu ward was selected because it was situated at the town centre. Simple random sampling was employed to get streets/villages whereby; four streets (Karume A, Uhuru, Mazimbu Darajani and Boma A) out of 14 and two villages (Kiroka and Kiziwa) out of four. Furthermore a total of 340 households were randomly allocated according to population size proportion by using lists of all names of household's heads from village/street leaders, whereby one adult individual (preferably a female) per household was eligible to participate in the study.

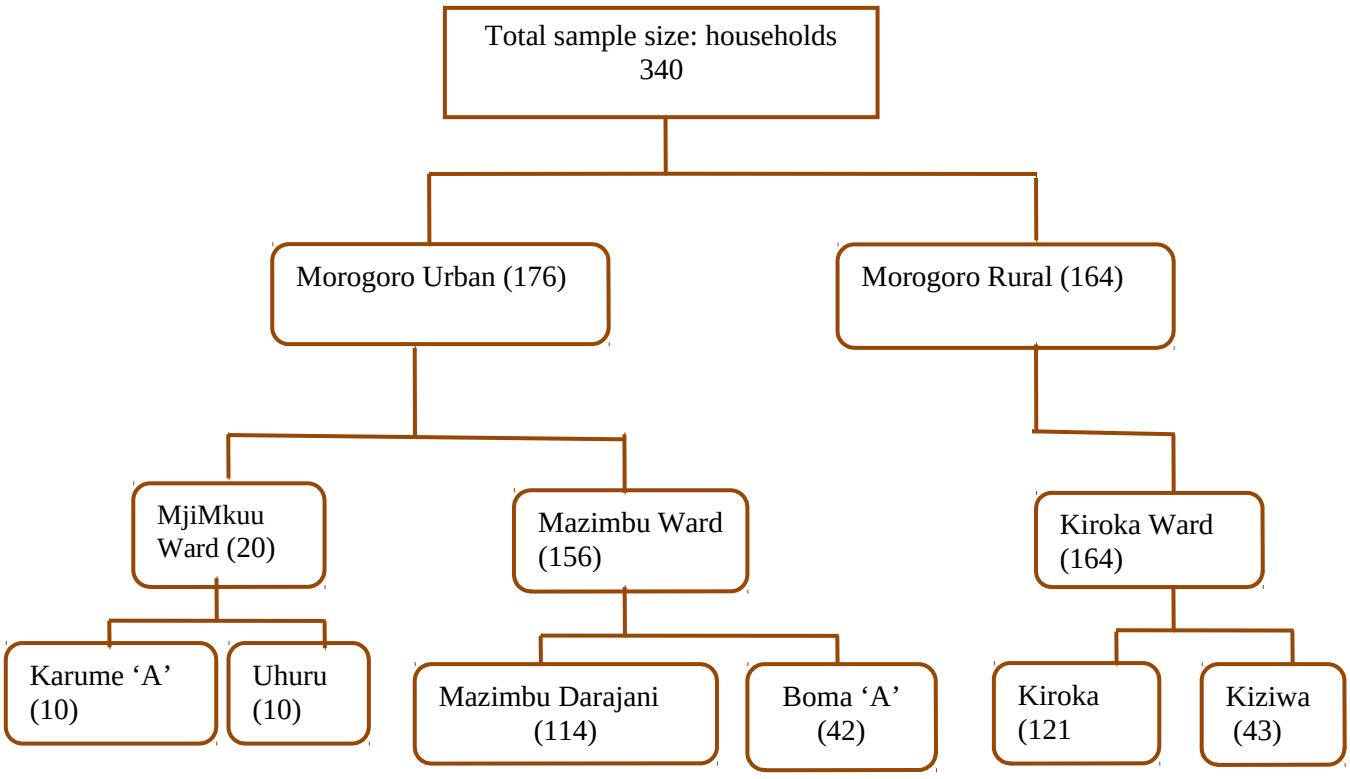

Figure 3.1: Distribution of repondents

3.2.5 Data collection

Consumption pattern was captured using food frequency questionnaires (FFQ). Food groups based on cereals, roots and tubers, meat/ poultry/fish and eggs, milk and its products and oils and fats) were developed together with their consumption frequencies. Respondents were asked to recall all the foods they had consumed during the period of 24 hours prior to the survey and also to indicate the frequency of consumption of all listed food items per day or per week for the past 12 months.

3.2.6 Data analysis

Consumption frequencies were captured quantitatively. Descriptive analysis (frequencies and percentage) were carried out to determine the consumption pattern of foods containing *trans* fatty acids within the identified locations. The Statistical procedure was carried out with the IBM-SPSS statistics Windows software package version 20.0 (IBM- SPSS Inc., Chicago, USA).

3.3 Results

3.3.1 Food Consumption pattern of households in Morogoro Urban and Rural areas

Results from the 340 surveyed households in Morogoro urban and rural districts indicate that majority (97%) consumed three meals per day (breakfast, lunch and dinner). About 3% of the respondents consumed two meals (lunch and dinner) per day (Table 3.1).

3.3.1.1 Foods consumed for breakfast, lunch and dinner

Breakfast: Foods regularly consumed for breakfast in the study areas included black tea, doughnut, bread, wheat buns, chapati, rice buns, fried and boiled cassava, fried and boiled

sweet potato, fruit juice, soft drinks, porridge, meat soup, cooked rice, and blue band (Table 3.1).

Lunch: The following foods were reported to be regularly consumed for lunch; stiff porridge, rice, beans, green vegetables, meat, fish, sardines, potato chips, fried eggs, fruits (Table 3.1). **Dinner:** stiff porridge, rice, beans, green vegetables, meat, fish, potato chips, fried eggs, fruits were reported to be regularly consumed for dinner (Table 3.1).

Overall, 59.4% of the surveyed households consumed tea with either chapati, wheat buns, doughnuts, rice buns or bread during breakfast (63% and 56% in Morogoro urban and rural respectively). Generally 84% of all households consumed stiff porridge, beans and/or green vegetables for lunch (72% in urban and 96% in rural areas). Dinner was composed of rice with beans or vegetables for 45% of all households. In urban households 65% consumed rice with beans or vegetables for dinner, and 71% of the households in Morogoro rural consumed stiff porridge with beans and/or green vegetables for dinner (Table 3.1).

Table 3.1: Food consumption pattern of households in Morogoro urban and rural districts

Meal type	Foods	Morogoro Urban		Morogoro Rural		Total	
		n	%	n	%	n	%
Breakfast	**No response**	**6**	**3.4**	**4**	**2.4**	**10**	**2.9**
	Black tea, milk, doughnut, bread, buns, rice cake, chapati	110	62.5	92	56.1	202	59.4
	Black tea, fried cassava, potato, rice cake	31	17.6	7	4.3	38	11.2
	Black tea, bread, Blue band, rice cakes	11	6.3	7	4.3	18	5.3
	Black tea, boiled cassava, potatoes	3	1.7	4	2.4	7	2.1
	Juice, soft drinks, bread	1	0.6	0	0.0	1	0.3
	Porridge	11	6.3	49	29.9	60	17.6
	Meat soup, chapati, buns	3	1.7	0	0.0	3	0.9
	Rice	0	0.0	1	0.6	1	0.3
	Total	**176**	**100**	**164**	**100**	**340**	**100**
Lunch	Stiff porridge beans, green vegetables, fruits	127	72.2	157	95.7	284	83.5
	Stiff porridge, meat, fish, sardines	46	26.1	7	4.3	53	15.6
	Rice, beans, vegetable, fruits	1	0.6	0	0.0	1	0.3
	Chips, Chips with eggs	2	1.1	0	0.0	2	0.6
	Total	**176**	**100**	**164**	**100**	**340**	**100**
Dinner	Stiff porridge, beans, green vegetables	14	7.95	116	70.7	130	38.2
	Stiff porridge, meat, fish, fruits	20	11.36	4	2.4	24	7.1
	Rice, beans, vegetable, fruits	114	64.77	40	24.4	154	45.3
	Chips, Chips with eggs	28	15.91	4	2.4	32	9.4
	Total	**176**	**100**	**164**	**100**	**340**	**100**

3.3.1.2 Proportions of processed foods and minimally/non-processed foods

Breakfast: During the study processed foodstuffs were consumed for breakfast by 89.2% and 65.2% of the households in urban and rural areas, respectively and minimally/non-processed foods were consumed by 7.4% and 32.3% in urban and rural households, respectively (Figure 3.2). During lunch (Figure 3.2) most of the households in rural (95.7%) consumed minimally/non processed foodstuffs compared to households in urban areas (72.2%). Processed foodstuffs were consumed more in urban households (92%) compared to rural households (29.3%) for dinner. Minimally/non processed foodstuffs

were consumed by 70.7% for dinner by households in rural areas and 8.0% in urban areas (Figure 3.2).

Generally, urban households consumed more (69.7%) of processed foods and rural households consumed more (66.2%) of minimally/un- processed foodstuffs (Figure 3.2).

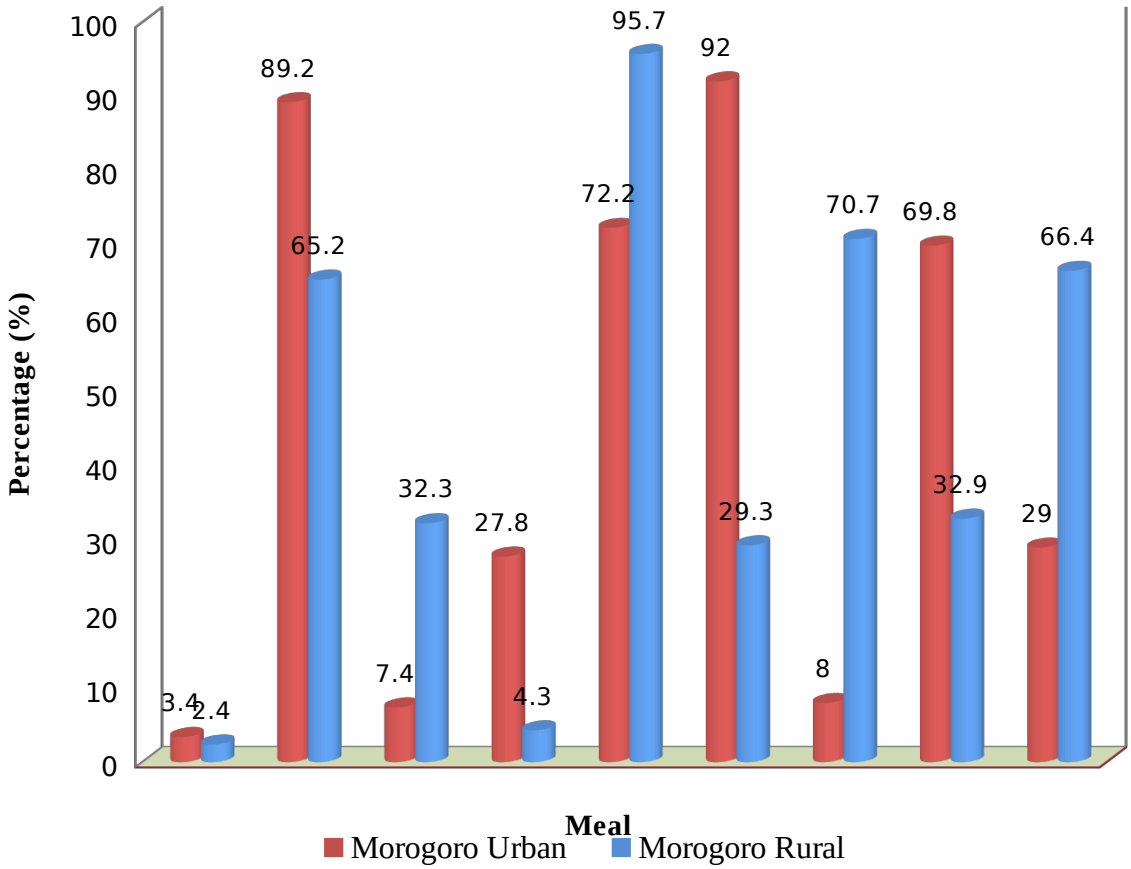

Figure 3.2: Proportions of processed foods and minimally/non-processed foods

3.3.2 Consumption pattern of foods containing *trans* fatty acids

Among the foodstuffs containing TFAs, "*Korie*" oil was highly consumed (6-7 days per week) by 87% and 70% in Morogoro rural and urban respectively. On other hands, sunflower oil reported to be less consumed (2-3 days per week), in rural and urban households respectively (Table 3.2). Furthermore, milk and milk products were consumed less (2-3 days per week) for urban and rural households by 68% and 58%, respectively (Table 3.2). From the group of Meat, poultry, fish and eggs, results shows; most

households consumed about2 -3 days per week. For example beef, fried eggs, fried fresh water fish, fried sea fish were less consumed in rural and urban households, respectively. Meanwhile fried sardines were moderately consumed (4-5 days per week) in both urban and rural households (Table 3.2).

Moreover for the group of cereals; processed wheat products were highly consumed, followed by cooked rice, which was moderately consumed by the households in Morogoro urban and rural areas, respectively. From the group of roots and tubers; fried round potato chips, fried cassava tubers were both moderately consumed by the households in urban and rural areas, respectively (Table 3.2).

Table 3.2: Consumption pattern of food containing *trans* fatty acids

	Less consumed				Moderate consumed				Highly consumed			
	Urban		Rural		Urban		Rural		Urban		Rural	
Foodstuff	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Wheat buns, bread, chapati, doughnuts	11	6.3	21	12.8	69	39.2	75	45.7	96	54.5	68	41.5
Fried cassava	25	14.2	28	17.1	85	48.3	86	52.4	66	37.5	50	30.5
Cooked/fried rice	11	6.3	65	39.6	126	71.6	83	50.6	38	21.6	8	4.9
Fried sweet potatoes	112	63.6	125	76.2	14	8	30	18.3	1	0.6	6	3.7
Fried round potato chips	38	21.6	52	31.7	95	54	104	63.4	43	24.4	8	4.9
Fried green banana	133	75.6	104	63.4	39	22.2	38	23.2	4	2.3	22	13.4
Beef	93	52.8	103	62.8	35	19.9	7	4.3	12	6.8	0	0
Goat meat	107	60.8	63	38.4	5	2.8	3	1.8	2	1.1	0	0
Fried Chicken	78	44.3	75	45.7	16	9.1	7	4.3	4	2.3	1	0.6
Fried eggs	110	62.5	112	68.3	17	9.7	7	4.3	10	5.7	0	0
Fried freshwater fish	137	77.8	126	76.8	13	7.4	7	4.3	8	4.5	1	0.6
Fried Sea fish	123	69.9	122	74.4	21	11.9	16	9.8	7	4	0	0
Cow milk & milk products	120	68.2	95	57.9	10	5.7	2	1.2	5	2.8	1	0.6
Blue band	68	38.6	51	31.1	26	14.8	3	1.8	8	4.5	0	0
Sunflower oil	61	34.7	69	42.1	1	0.6	2	1.2	49	27.8	12	7.3
Red palm oil	0	0	3	1.8	1	0.6	1	0.6	0	0	0	0
Korie oil (PHOs)	22	12.5	5	3	1	0.6	4	2.4	123	69.9	143	87.2

NB:-
Less consumed = Consumption for 2 to 3 days per week
Moderate consumed = Consumption for 4 to 5 days per week
High consumed = Consumption for 6 to 7 days per week

3.4 Discussion

3.4.1 Food Consumption pattern of households

The current study findings indicate that; most of the households were able to consume meals three times a day. Their meals comprised of mostly carbohydrates and fats with less vitamins and proteins. Furthermore, it was noted that; most of foods used for breakfast, lunch and dinner were prepared by frying especially in urban households compared to rural households where mostly they consumed on boiled foods. Further results in this study indicates that *"Korie"* brand of cooking oils was mostly used in both urban and rural households, the fact that "*Korie"* and related brands of cooking oils were readily available and cheap compared to other brands of unsaturated cooking oils in rural areas could be the reason why were mostly preferred.

"*Korie*" and the related oil brands such as *"Safi", "Maisha", "Masafi", "Kimbo"* are prepared through industrial process of partial hydrogenation of vegetable oils; hence termed as partially hydrogenated vegetable oils (PHOs). During the process oil is hardened, which improves its commercial appeal by enhancing its sensory and texture profiles. Previous studies have reported that PHOs are the major source of TFAs in foods especially when prepared with these fats/oils (Afaneh *et al*., 2017; Pfeuffer and Jahreis, 2018). With this consumption pattern it was clear that all households (urban and rural) were all at risk of exposure to TFAs although the practice of depending more on fried foods in urban households could exacerbate the incidence of exposure to TFAs which are regarded as the worst type of fat to eat (Wang *et al*., 2016; Thornton, 2018).

3.4.2 Proportions of processed foods and minimally/non-processed foods

Processed foods were mostly consumed by urban households than rural households. The reasons could be consumers living in urban areas have a wider range of food choices

because of several outlets of convenience foods (ready to eat/processed). In addition to higher purchasing power compared to those in rural areas who mostly rely on minimally processed foods like green vegetables. It was further noted that, most of the processed foods were consumed during breakfast and dinner, whereby on both occasions urban households observed to consume more compared to rural households.

As a result of the findings from above, households in urban areas were at a higher risk of exposure to *trans* fatty acids and hence further exposure on risks of non-communicable diseases (NCDs) such as cardiovascular, hypertension and diabetes. The current findings are in line with the study done by Cockx *et al.* (2017) which found that individuals who were living in urban areas relied more on conveniently consumed foods which in turn had a profound effect in increasing their risk of nutrition-related non-communicable diseases.

3.4.3 Consumption pattern of foods containing *trans* fatty acids (TFAs)

The overall consumption of foods with TFAs in this study was high (52%) out of all 340 surveyed households in the current study. From this study, it was observed that urban households consumed mostly on fried foods, which believed to have more content of TFAs more frequently per week compared to those in rural areas. Vegetable oils/fats *("Korie")* which are mostly prepared by industries through partially hydrogenation process (PHOs) were the most frequently used for frying/preparations of various foods in both (urban and rural) though it was found to be used more in rural households compared to urban ones. This might be attributed by the fact that, PHOs brands were readily available and affordable to the rural people compared to other cooking oil brands which are regarded as healthy but expensive such as sunflower, sesame and other unsaturated oil blends. In Morogoro region most of sunflower seeds oil processing mills are located in urban centres, which might contribute to difficultness for people in rural areas to access

healthy cooking oils. Nevertheless, urban and rural households were all exposed to risks of TFAs; people in urban were more exposed at risk of TFAs because of their increased frequency of consuming per week fried foodstuffs mostly using PHOs. From this study it was also found that; households were at higher exposure to industrial *trans* fatty acids (iTFAs) compared to those originating from natural/ruminants (rTFAs).

The overall results indicates that; the households were being exposed to *trans* fatty acids which eventually contributes to putting them at risk of Cardiovascular disease (CVD) and even other non-communicable diseases (NCDs) like Hypertension, Cancer, Inflammation and Diabetes, problems which requires immediate attention for action.

3.5 Conclusion

Households in urban had characteristic consumption on more of the processed foodstuffs while those in rural areas consumed mostly on minimally/non processed foodstuffs or traditional staples. Most households, both in urban and rural areas were largely using partially hydrogenated oils (PHOs) in preparing their foods; the consumption of these oils was significantly high. Most people in Morogoro region especially those in urban areas are at high risk of nutrition-related non-communicable diseases (NCDs) such as cardiovascular disease because of increasingly consumptions on PHOs and processed foods.

References

Accelerator for Agriculture and Agro industry Development and Innovation Plus 3ADI+ (2019). The palm oil value chain Tanzania - UNIDO. 121pp. [https://www.unido.org/sites/default/files/files/2019-04/3ADI%2]site visited on 5/05/2020 at 2200hrs.

Afaneh, I., Abbadi, J., Al-Rimawi, F., Al-Dabbas, G., and Sawalha, S. (2017). Effect of frying temperature and duration on the formation of *Trans* fatty acids in selected Fats and Oils. *American Journal of Food Science and Technology, 5(6): 245-248*

Cochrane, N., and D'Souza, A. (2015).Measuring Access to Food in Tanzania*:* A Food Basket Approach,EIB-135, U.S. Department of Agriculture, Economic Research Service, 34pp. [http://dx.doi.org/10.22004/ag. econ.198784] site visited on 8/06/2019 at 1420hrs

Cockx, L., Colen, L., and De Weerdt, J. (2017). From Corn to Popcorn, Urbanization and food consumption in Sub-Sahara Africa: Evidence from rural-urban migrants in Tanzania 44pp. [http://hdl.handle.net/10419/172042] site visited on 10/02/2020 at 2300hrs

Dhaka, V., Gulia, N., Ahlawat, K. S., and Khatkar, B. S. (2011).*Trans* fats sources, health risks and alternative approach-A review. *Journal of food science and Technology*, *48*(5), 534-541.

Holmes, M. D., Dalal, S., Sewram, V., Diamond, M. B., Adebamowo, S. N., Ajayi, I. O., and Volmink, J. (2018). Consumption of processed food dietary patterns in four African populations. *Public Health Nutrition*, *21*(8), 1529-1537.

Kagiono, S., Nagao, K., Yoshida, A., Mizobe, H., Nagai, T., Beppu, F. and Yoshinaga, K. (2018). Study of *trans* fatty acid formation in oil by heating using model compounds. *Journal of Oleo Science* 67(3): 273–281.

Kothari, C. R.and Garg (2014).Research Methodology: Methods and Techniques. New Age International, New Delhi India. 458pp

Leyna, G. H., Mmbaga, E. J., Mnyika, K. S., Hussain, A., and Klepp, K. I. (2010). Food insecurity is associated with food consumption patterns and anthropometric measures but not serum micronutrient levels in adults in rural Tanzania. *Public Health Nutrition*, *13*(9), 1438-1444.

Mayige, M., and Kagaruki, G. (2013). Tanzania STEPS survey report. Dar es Salaam: National Institute of Medical Research.154pp.[https://www.who.int/chp/steps/UR_Tanzania_2012_STEPS_Report.pdf?ua=1]Site visited on 15/07/2020

Mayige, Mary. (2016). Prevention of non-communicable disease in Tanzania using an inter-sectoral approach.[https://doi.org/10.13140/rg.2.1.3976.1047] site visited on10/02/2019 at 0245hrs.

Mitrou, F. and Lawrence, D. (2014).Narrative Review: The Relationship Between Dietary *Trans*-Fatty Acids And Adverse Health Outcomes. Food Standards, Australia New Zealand. 30pp.

Mozaffarian, D. and Stampfer, M. J. (2010). Removing industrial *trans* fat from foods. *British Medical Journal* Vol.340:c1826; 1094-1095

Pfeuffer, M., and Jahreis, G. (2018).Trans fatty acids. Origin, metabolism, health risks. Ernahrungs Umschau International 65(12): 196–203

Prabhat, A., and Begum, K. (2012). Food consumption pattern and nutritional status of women laborers from coastal areas of Karnataka. *National Journal of Community Medicine*, *3*(2), 321-325

Ruel, M. T., Garrett, J., Yosef, S., and Olivier, M. (2017). Urbanization, food security and nutrition. *Nutrition and Health in a Developing World* (pp. 705-735). Humana Press, Cham: [htttps://doi.org/10.1007/978-3-319-43739-2-32] Site visited on 18/09/2020 at 0515hrs.

Schwab, U., Lauritzen, L., Tholstrup, T., Haldorsson, T. I., Riserus, U., Uusitupa, M. and Becker, W. (2014). Effect of the amount and type of dietary fat on cardiometabolic risk factors and risk of developing type 2 diabetes, cardiovascular diseases, and cancer: a systematic review. *Food and Nutrition Research* 58(1): 25 – 145

Thornton, J. (2018). Eliminate" toxic" *trans* fats from food by 2023, WHO urges. *British Medical Journal.* [https://doi.org/10.1136/bmj.k2154] (Online), Vol. 361. Site visited 11/07/2019 at 1730hrs.

Wang, Q., Afshin, A., Yakoob, M. Y., Singh, G. M., Rehm, C. D., Khatibzadeh, S. and Mozaffarian, D. (2016). Impact of nonoptimal intakes of saturated, polyunsaturated, and trans fat on global burdens of coronary heart disease. *Journal of the American Heart Association*, *5*(1), e002891

Weaver, C. M., Dwyer, J., Fulgoni III, V. L., King, J. C., Leveille, G. A., MacDonald, R. S. and Schnakenberg, D. (2014). Processed foods: contributions to nutrition. *The American journal of clinical nutrition*, *99*(6), 1525-1542

Wu, J., Zheng, M., Catterall, E., Downs, S., Thomas, B., Veerman, L. and Barendregt, J. (2017). Contribution of *trans*-fatty acid intake to coronary heart disease burden in Australia: A modeling study. *Nutrients* 9(1): 77-86.

Zimmer, M. H., Hart, L. C., Manning-Courtney, P., Murray, D. S., Bing, N. M., and Summer, S. (2012). Food variety as a predictor of nutritional status among children with autism. *Journal of autism and developmental disorders*, *42*(4), 549-556

CHAPTER FOUR

4.0 *TRANS* FATTY ACIDS IN TANZANIA: ARE CONSUMERS AND PROCESSORS AWARE OF THE ASSOCIATED HEALTH HAZARDS? A CASE OF MOROGORO, TANZANIA

L.G. Nzunda[1, 2*], J. Kinabo[2], L.M. Chove[2]

[1]*Department of Training, Research & Extension Services, Ministry of Agriculture, P.O. Box, 2182, Dodoma, Tanzania*

[2]*Department of Food Technology, Nutrition and Consumer Sciences, Sokoine University of Agriculture, P.O. Box 3006, Morogoro, Tanzania*

* Email of the corresponding author nzundag@gmail.com

Abstract

This study was conducted to assess the awareness about TFAs among consumers and food/oil processors in Morogoro region using a cross-sectional study design. Study sample included 340 households, whereby 176 were from Morogoro urban and 164 from Morogoro rural districts, as well as 32 food/oil processors (22 = small scale; 10 = large scale). Structured questionnaires were used to collect data. Descriptive statistics were conducted to determine the awareness on TFAs and the health effects associated with the consumption of foods containing TFAs. About 98% of all consumers had neither knowledge nor awareness about TFAs and associated health effects. Nevertheless, awareness level was observed to improve with residence location and level of education (Those living in urban and those mostly educated showed high awareness). The level of awareness of TFAs between MjiMkuu ward (urban) compared to Kiroka ward in rural was significantly different (OR: =18.111; P= 0.020). No significant difference was observed in the level of awareness between consumers in Kiroka (rural) and in Mazimbu ward (urban)

(OR: = 5.397; p=0.126). Large scale food and oil processors were more aware about TFAs than small scale food and oil processors. General awareness on TFAs and the associated adverse health effects among consumers were very low compared to that of processors and were influenced by residential location and level of education. This study shows that consumers in the study area are at high risk of exposure to TFAs and developing conditions such as cardiovascular diseases (CVDs) and other non-communicable diseases (NCDs) due to lack of awareness.

+**Keywords**: TFAs, *Cardiovascular Diseases, Awareness, Consumers, Food/Oil Processors*

4.1 Introduction

Trans fatty acids (TFAs) are types of unsaturated fatty acids and can be classified as either naturally occurring or industrially produced (Kamel, *et al.,* 2018). Naturally occurring TFAs or ruminant *trans* fatty acids (rTFAs) are found in small amounts (3- 6%) in food products such as meat and milk products from animals (Mouratidou, *et al.* 2014). Industrially produced *trans*fatty acids (iTFAs) are formed by the process of partial hydrogenation in the industrial production of partially hydrogenated oils (PHOs) (Tsuzuki *et al*., 2010; Afaneh *et al*., 2017; Pfeuffer and Jahreis, 2018); during the process, oil is hardened, which improves its commercial appeal by enhancing its sensory and texture profiles, also increasing its shelf life; factors that often attract most food manufacturers to prefer PHOs (Dhaka *et al.,* 2011; Mouratidou*et al.*, 2014; Bloks, 2019). PHOs are the main source of TFAs (up to 60%) and are used as bakery shortening, frying oil and in household cooking (Taher*et al*., 2018). Although PHOs are edible their consumption is associated with increased risk of diet related non-communicable diseases (DR-NCDs) (Derbyshire, 2012; Musvosvi and Mhlanga, 2016). The adverse health effects of TFAs in humans are mediated by increased plasma concentrations of low-density lipoprotein

cholesterol (LDL-C) and reductions in high-density lipoprotein cholesterol (HDL-C) (Wu *et al*., 2017), which leads to promotion of inflammation, endothelial dysfunction, insulin resistance and displacement of essential fatty acids from membranes (Mitrou & Lawrence, 2014). DR-NCDs contribute to the global burden of disease especially in low and middle income countries (Derbyshire, 2012; Banseria *et al*., 2016; Taher *et al*., 2018; Li *et al.*, 2019). It is estimated that 2% increase in energy intake from TFAs is associated with a 23% increase in the risk of heart disease (Banseria *et al*., 2016). WHO recommends reducing TFAs intake to less than 1% of total daily dietary energy intake (Li *et al.*, 2019). PHOs are the major source of fats/oils in Tanzania by about 60% and its importation has reached about 500,000 MT (3ADI+, 2019). The annual consumption of such volumes of dietary source of fat could pose health threat especially DR-NCDs to consumers (Kagiono *et al*., 2018). However, there is still limited information and awareness regarding the levels of TFAs and their underlying health hazards to the Tanzanian population (Codex Alimentarius Commission, 2017). Tanzania has recorded increased incidences of DR-NCDs especially cardiovascular health problems and deaths from 27% in 2010 (Mayige *et al.*, 2011) to 33% in 2016 (Mayige, 2016; URT, 2016; WHO, 2018).

The aim of this study was to assess the level of awareness about *trans* fatty acids (TFAs) among consumers, edible oil producers and food processors. This study was envisaged to contribute to examining the knowledge of *trans* fatty acids with regards to emerging rise in DR-NCDs and guide policy formulation by the Government and interventions by nutrition stakeholders.

4.2.1 Materials and Methods

4.2.1.1 Study area

This study was conducted in Morogoro urban and rural districts (Morogoro region; 6°, 49'S, 37°, 40'E). Morogoro region was selected for the study because previous studies have reported that, it was among the three sites (including Dar es Salaam and Kilimanjaro) which demonstrated a considerably high risk of dying from non-communicable diseases (NCDs) during adulthood in Tanzania (Mayige and Kagaruki, 2013).

4.2.2 Sample size determination

The sample size was calculated using the Fisher's equation shown below:-

$$n = \frac{z^2 \times p(1-p)}{e^2}$$

Where by n = sample size, p = population proportion 33% (National prevalence of NCDs), e = Margin of error, set 5% for this study and Z = standard variance at a given confidence level, for this study 95%, confidence level = 1.96 (Kothari and Garg, 2014).

4.2.3 Study population

The study population included adult consumers residing in urban and rural households and edible oil producers and food processors.

4.2.4 Sampling procedure

Simple random and purposive sampling approach was used in the study. Morogoro region was randomly selected out of 3 sites (including Dar es Salaam and Hai-Kilimanjaro) reported with high risk of dying from non-communicable diseases during adulthood in Tanzania (Mayige and Kagaruki, 2013). Also, simple random sampling was employed in selecting the two districts (Morogoro urban and rural) out of eight. Furthermore, purposive sampling was employed in selecting two wards (MjiMkuu and Mazimbu) out of 29 wards

from Morogoro urban district, and one ward (Kiroka) out of 31wards from Morogoro rural district (Mazimbu and Kiroka wards were the most populated wards in their respective districts, while MjiMkuu ward was selected because it was situated at the town centre). Finally simple random sampling was employed to get streets/villages whereby; four streets (Karume A, Uhuru, Darajani and Boma A) out of 14 streets were selected from the two wards in Morogoro urban and two (Kiroka and Kiziwa) out of four villages were selected from one ward in Morogoro rural district. The random selection (districts and streets/villages) was done by using a computer program for random number generation. Furthermore a total of 340 households were randomly allocated according to population proportion by using lists of all names of household's heads from village/street leaders, whereby one adult individual per household was eligible to participate in the study.

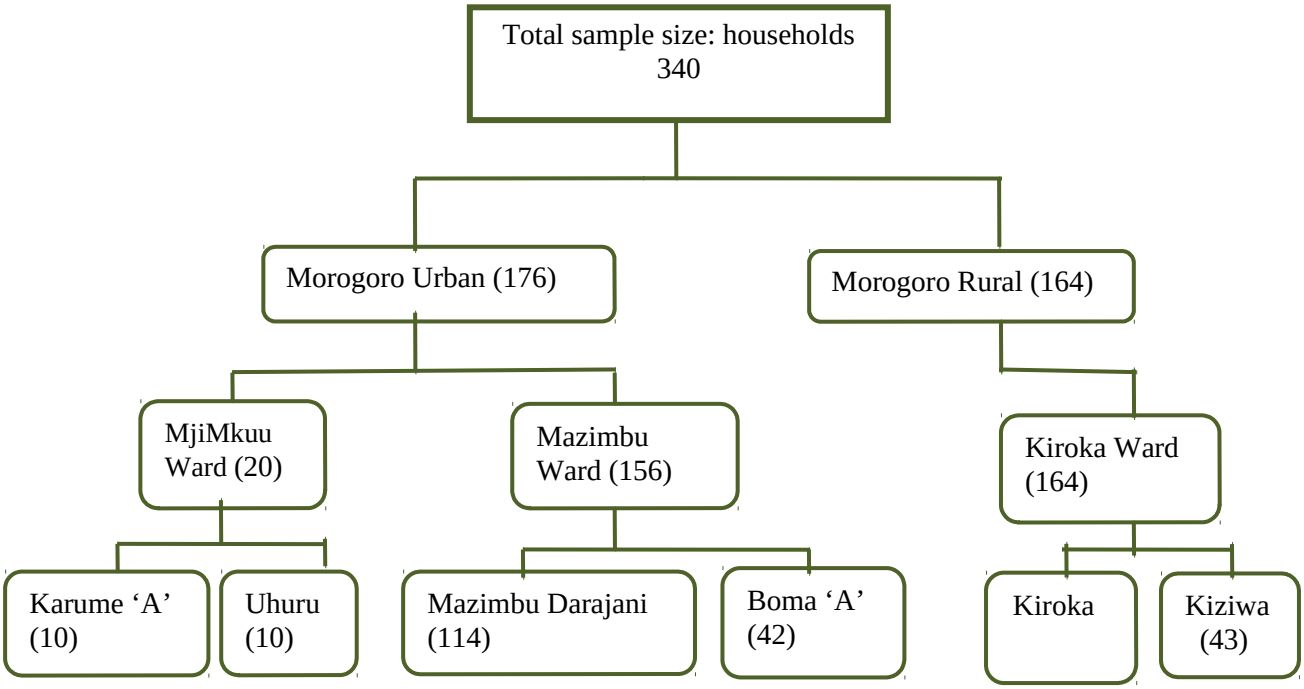

Figure 4.1: Distribution of consumers

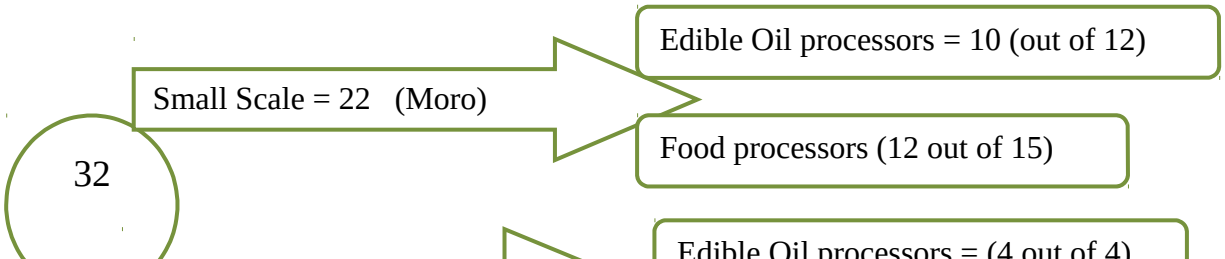

Figure 4.2: Distribution of Edible oil and Food processors

4.2.5 Data collection

Data on *trans* fatty acids awareness assessment were collected from 340 respondents representing the group of consumers, 14 participants involved in edible oil and 18 in food production. Structured questionnaires were administered to 176 consumers in Morogoro urban and 164 in Morogoro rural districts. Also there was an additional of some key people informants (Quality control/production personnel) currently working in edible oil and food processing factories (small and large scale) to make a total of 32 participants. Due to the fact that most of the branded industrial products (e.g. edible partially hydrogenated cooking oils/fats) were reported by the consumers and stakeholders (retailers and wholesalers) that were being manufactured in Dar es Salaam region, then it was decided to go and have the views from those large scale processors (edible PHOs and other products such as biscuits and breads), whereby their knowledge and awareness level regarding *trans* fatty acids was assessed.

(121)

Some of the key questions asked on knowledge about *Trans* fatty acids in general were as follows:-

"Heard of Trans fatty acids?", "Source of information on Trans fatty acids and associated health effects?", "Knowledge on how Trans fatty acids are formed?", "Knowledge on Foods rich in Trans fatty acids and associated health effects?", "Presence of any regulation(s) in Tanzania that prompt food processors to limit the amount of Trans fatty acids in processed foods?", "Existence of any policy/regulation that requires food processors to indicate the amount of Trans fatty acids content in processed foods"

4.2.6 Data analysis

Descriptive data were calculated as percentage and frequencies for the variables such as knowledge and awareness. The software for data analysis was SPSS version 20.0 (IBM - SPSS Inc., Chicago, USA) whereby the Fishers exact test was used to determine significance for the relationship between variables. Moreover binary logistic regression was used to test for associations between awareness as dependent and residence location, education level as independent variables.

For consumer's knowledge and awareness component, each item was given a score of "2" for a correct answer, "1" for "Not sure" and "0" for incorrect response. Hence, the total score for the 5 questions in this section was 10 (0-10) for each participant. Participants' overall knowledge was categorized using modified Bloom's cut-off point (Seid and Hussen, 2018). Consumers' overall knowledge and awareness was categorized as "Not aware" if the score was less than 50% (< 5 points), "Average awareness" if the score was between 51% and 79% (5 to 7 points) and "Aware" if the score was 80% and 100% (8 to 10 points). Similarly, for the processors' knowledge and awareness, each item was given a score of "2" for a correct answer, "1" for "Not sure" and "0" for incorrect or negative response. Hence, the total score for this section of 7 questions was 14 (0–14) for each participant. Processors' overall knowledge and awareness was categorized as "Below average awareness" if the score was less than 50% (< 7 points), "Average awareness" if the score was between 51% and 79% (7 to 10 points) and "Aware" if the score was between 80% and 100% (10 to 14 points).

4.3 Results

4.3.1 Demographic information

A total of 340 respondents were enrolled in the study, 176 from Morogoro urban and 164 from Morogoro rural district. About 94% of all respondents were female; 35% of the respondent's age ranged between 31 and 45 years old. About 61% of all respondents had attained primary education level; 62% from rural and 59% from urban areas. Generally, farming was the main source of income for 58% of all respondents. In Morogoro rural, 88% of the respondents depended on Agriculture and in Morogoro urban 47% of the respondents depended on small business as their main source of income (Table 4.1).

Table 4.1: Demographic information of respondents

Characteristic	Category	Morogoro Urban		Morogoro Rural		Total	
		n=176	%	n=164	%	N=340	%
Sex of respondents	Male	10	5.7	9	5.5	19	5.6
	Female	166	94.3	155	94.5	321	94.4
	Total	**176**	**100**	**164**	**100**	**340**	**100**
Age of respondents	21 -30	54	30.7	48	29.3	102	30.0
	31 - 45	56	31.8	64	39	120	35.3
	46 - 59	34	19.3	28	17.1	62	18.2
	60 and Above	32	18.2	24	14.6	56	16.5
	Total	**176**	**100**	**164**	**100**	**340**	**100**
Education level	Informal	19	10.8	40	24.4	59	17.4
	Primary	104	59.1	102	62.2	206	60.6
	Secondary	43	24.4	20	12.2	63	18.5
	Tertiary	10	5.7	2	1.2	12	3.6
	Total	**176**	**100**	**164**	**100**	**340**	**100**
Main source of income	Formal employment	23	13.0	5	3.0	28	8.3
	Casual Labour	18	10.2	0	0	18	5.3
	Farming	54	30.1	145	88.4	198	58.2
	Small business	82	46.6	14	8.5	96	28.2
	Total	**176**	**100**	**164**	**100**	**340**	**100**

4.3.2 Knowledge on *Trans* fatty acids (TFAs) among Consumers

Results in Table 4.2 show of all (340) surveyed consumers, 97.6% had no information or awareness on *trans* fatty acids before and 98.8% had no knowledge on how *trans* fatty acids are formed.

In addition, 98.5% of all consumers had no knowledge about the foods rich in *trans* fatty acids and their associated health effects. Furthermore, few consumers who had knowledge about *trans* fatty acids and associated health risks, 80% indicated that their source of information was through individual studies/readings, 20% obtained information from Health Officers. About 99% of consumers in Kiroka ward had never heard of *trans* fatty acids followed by consumers in Mazimbu ward (96.7%) and lastly MjiMkuu ward (90%). The knowledge on foods with *trans* fatty acids and associated health effects among consumers was very low. Only 5% of consumers in MjiMkuu ward, 3% in Mazimbu ward and 0.0% in Kiroka ward had knowledge on foods rich in *trans* fatty acids and associated health hazards.

Table 4.2: Consumer's knowledge on *Trans* fatty acids

Variables	Response	Total n=340	%	Wards: Mazimbu n=156	%	Mji Mkuu n=20	%	Kiroka n=164	%
Heard of trans fatty acids?	Yes	8	2.4	5	3.2	2	10	1	0.6
	No	332	97.6	151	96.8	18	90	163	99.4
Knowledge on how trans fatty acids are formed?	Yes	4	1.2	3	1.9	1	5	0	0
	No	336	98.8	153	98.1	19	95	164	100
Ways on how trans fatty acids are formed	Industrial process during preparation of Vegetable oils	4	1.2	3	1.9	1	5	0	0
	Formed naturally	1	0.3	0	0	0	0	1	0.6
	No idea	335	98.5	153	98.1	19	95	163	99.4
Knowledge on Foods rich in trans fatty acids and associated	Yes	5	1.5	4	2.6	1	5	0	0
	No	335	98.5	152	97.4	19	95	164	100
Who told you about foods rich in trans fatty acids and associated health effects?	Through studies/ readings	4	80	3	1.9	1	5	0	0
	Health officer	1	20	1	0.6	0	0	0	0

4.3.3 General Consumer's awareness on *Trans* fatty acids

Figure 4.3 shows 332 (98%) of all consumers had no knowledge and awareness with regards to TFAs. However, there were variations in the level awareness on TFAs between consumers from various wards. Low level of awareness was observed in 99% of consumers from Kiroka ward (Morogoro rural) followed by 96.8% of consumers in Mazimbu and 90% in MjiMkuu wards in Morogoro urban. There was no significant difference in awareness on TFAs between consumers in Kiroka and Mazimbu wards (OR: 5.397; p=0.126). There was a significant difference on the level of awareness on TFAs between consumers in Kiroka ward and MjiMkuu ward (OR: =18.111; P= 0.020). The odd of being aware was higher for consumers in MjiMkuu and Mazimbu wards than in Kiroka ward.

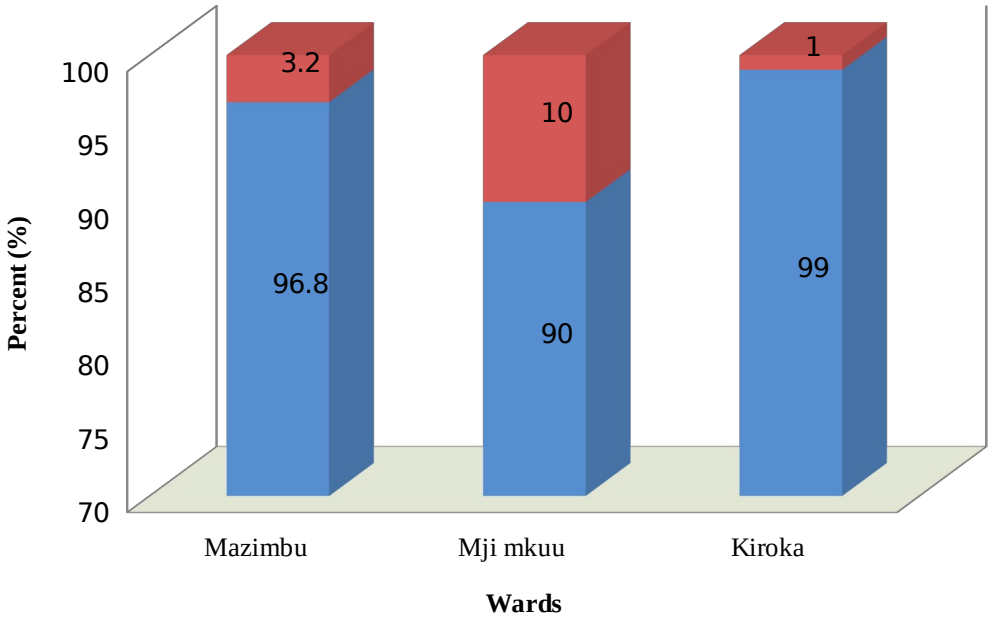

Figure 4.3: General Consumer's awareness on *Trans* fatty acids

4.3.4 Knowledge and awareness on *Trans* fatty acids among edible oil and food processors

Generally about 41% of the edible oil and food processors were aware of *trans* fatty acids (TFAs). All (100%) respondents from large scale edible oil and food processors, had prior knowledge about TFAs, followed by the group of small scale food processors who scored 17%, and lastly was the group of small scale oil processors (10%). Only 13% of all surveyed groups had knowledge on how TFAs are formed. About 50% of the group of large scale edible oil processors had higher knowledge on how TFAs are formed compared to other groups.

Only 16% of all respondents surveyed, had knowledge on foods rich in TFAs and associated health hazards. More (25%) of the large scale edible oil processors had knowledge about foods rich in TFAs compared to small (17%) and large scale food

processors (17%) and small scale edible oil processors (10%). The main source of information was through studies/readings for 60% of the respondents, and 40% obtained information from medical health facilities/institutions. Large scale food processors had the highest (83.3%) knowledge of the association between concentration of TFAs and the level of low density lipoprotein (LDL) - cholesterol in blood, followed by the large scale edible oil processors (75%), small scale food processors (17%) and small scale edible oil processors (0.0%).

4.3.5 General Awareness on TFAs among edible oil and food processors

Generally for the group of edible oil, results show that, awareness of all (100%) edible oil large scale processors on TFAs was above average, followed by 10% of the small scale edible oil processor's group (Figure 4.5). The Fishers test results showed a significant difference (P= 0.005) among the small and large scale edible oil processors in terms of general awareness on TFAs. For the food processors group, results show that; 100% of large scale processors were more aware on TFAs compared to 25% of small scale food processors who their awareness on TFAs were generally average. Fishers test for association results showed that; there was a significant difference (P= 0.009) in awareness among the small and large scale food processors in terms of general awareness on TFAs (Figure 4.5).

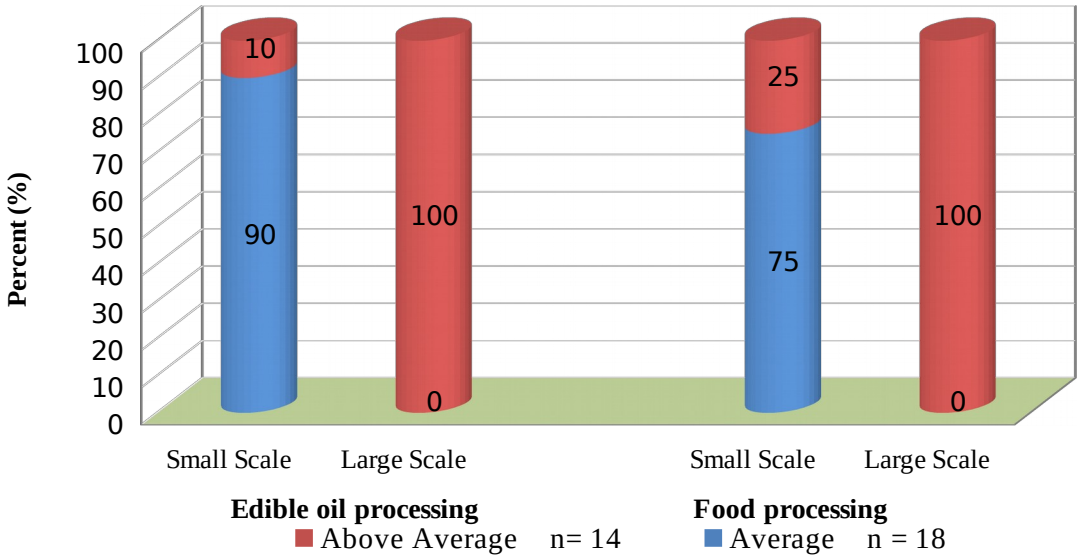

Figure 4.4: General Awareness on TFAs among edible oil and food processors

4.3.6 Awareness among edible oil and food processors on policies/regulations regarding *Trans* fatty acids (TFAs)

Edible oil and food processors had varied responses (Not sure = 72%, No = 22% and Yes = 6%) regarding presence of regulation (s) in Tanzania or WHO that prompt food processors to limit the amount of TFAs in processed foods. Nevertheless, 100% of small scale edible oil processors and 92% of small scale food processors were "Not sure" about the existence of policy/regulation governing TFAs.

Large scale edible oil (75%) and food processors (67%) were not aware of the existence of policy/regulations governing TFAs (Figure 4.5). About 59% of the surveyed processors were not sure while 41% had no information of the existence of policy/regulation that requires food processors to indicate the amount of TFAs content in processed foods (Figure 4.5). All large scale edible oil processors and about 83% of large scale food processors were 'Not sure' of the existence of policy/regulations on revealing content of TFAs in foods and oils. Similarly, 58% of the small scale food and edible oil processors (50%) had "No idea" about the policy/regulation (Figure 4.5).

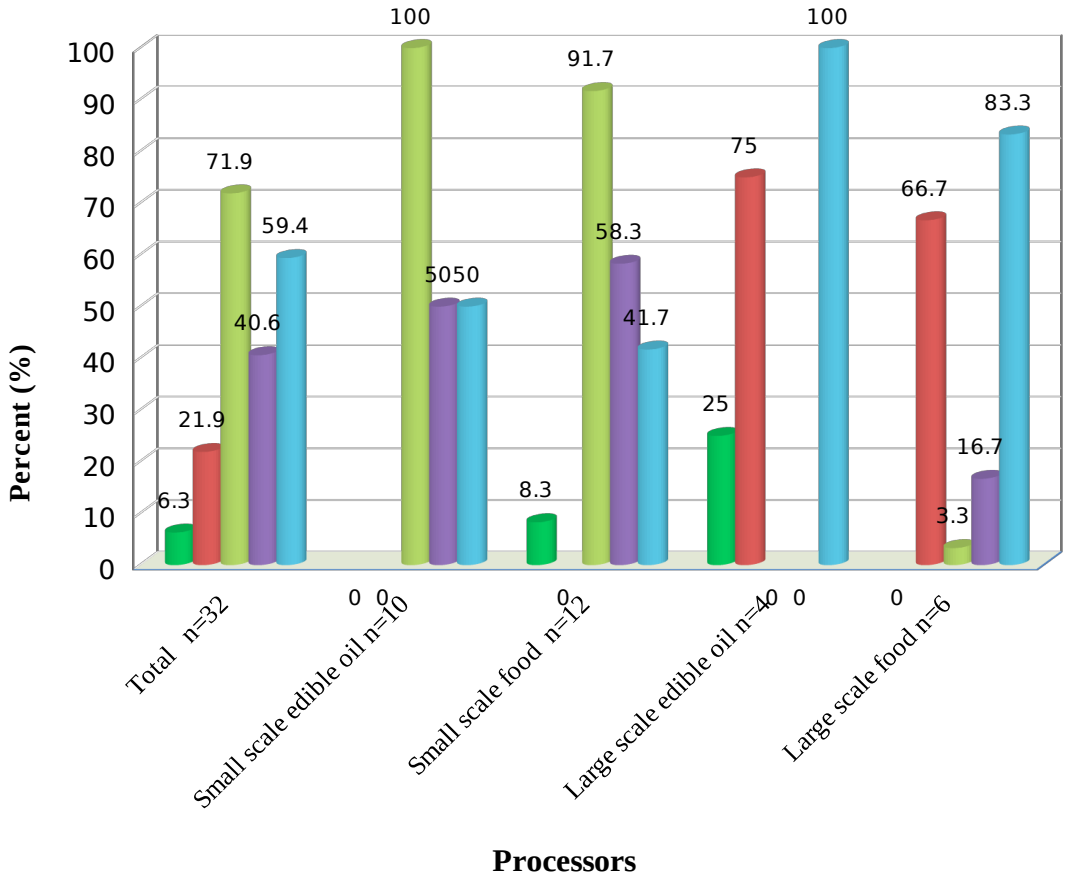

Figure 4.5: Awareness of edible oil and food processors on policies/regulations regarding *Trans* fatty acids

4.3.7 General awareness of edible oil and food processors on policies/regulations regarding *Trans* fatty acids (TFAs)

Generally 20 out of all (32) processors had an average awareness on policies and regulations regarding TFAs. About 83% of all large scale food processors and 58% of all small scale food processors had an average score on awareness. There was no significant difference (P= 0.600) between large and small scale food processors in terms of awareness about policies/regulations on TFAs (Figure 4.6). Similarly, 75% of large scale and 50% of small-scale edible oil processors had an average score on awareness. No significant difference (P= 0.580) was observed between small and large scale edible oil processors in terms of awareness regarding policies/regulations on TFAs (Figure 4.6).

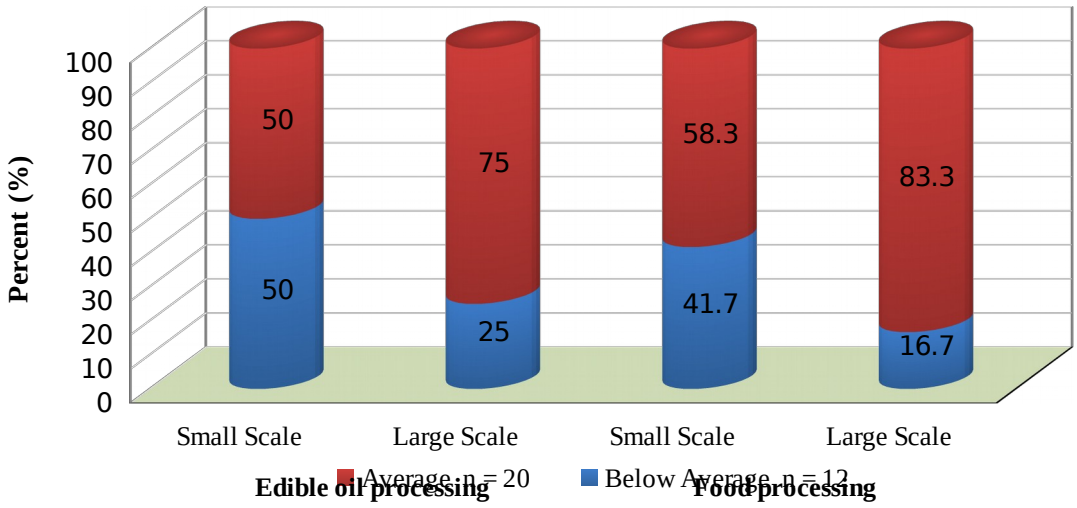

Figure 4.6: General awareness on policies and regulations regarding TFAs among processors

4.4 Discussion

4.4.1 Consumer's awareness on *Trans* fatty acids (TFAs)

The current study has revealed that most of the surveyed consumers had low level of knowledge and awareness on *trans* fatty acids (TFAs) and their associated adverse health effects. There were differences between rural districts and urban districts. Most of the respondents from Morogoro rural district had attained Primary school education whereas those in urban district had attained Secondary school education (and even Tertiary education levels).

In the present study, education level was probably one of the factors that contributed to increased level of consumer's awareness in the urban compared to their counterparts in rural districts. Similarly, households in urban were more exposed to many sources of information regarding healthy eating such as Television, Radios, Newspapers, Posters and Health centres compared to rural areas. Despite all those sources of information, still they consumed more on unhealthy foodstuffs such as processed and PHOs, less on vegetables and fruits. Meanwhile, despite low level of education for those consumers in rural

households, they consumed more on minimally processed foods like vegetables, beans but more on PHOs because it was cheap and readily available.

Furthermore the observed low level of awareness in the current study could be attributed by low nutrition education regarding overconsumption of edible oils, TFAs and their associated health effects in general, also the absence of government policy to limit TFAs in processed foods could be the major factor for lack of awareness and limited control of the amounts and presence in foods. This in turn exacerbates the high level of exposure to TFAs for both urban as well as rural households. Similar study done by Musvosvi and Mhlanga (2016) observed that the level of awareness of consumers on TFAs in Kitwe – Zambia increased with the level of education. Also Pletzke *et al*. (2010) observed that nutrition education was associated with more TFAs knowledge and awareness scores among consumers.

4.4.2 General awareness on TFAs among edible oil and food processors

Large scale edible oil processors were more aware on TFAs compared to small scale edible oil processors whose level of awareness on TFAs were average. The observed differences in their awareness might be contributed by the fact that; all small scale processors were dealing with Sunflower oil (seed oil) processing of which literature has reported that they are healthy, on other hand large scale oil processors were dealing with partially hydrogenated vegetable oil (PHOs) either in processing or repackaging, that's why their awareness level were higher, moreover; most previous studies had reported that PHOs from industrial sources contain higher proportional of TFAs due to the process of partial hydrogenation during their preparation (Mozaffarian *et al*., 2013; Pfeufferand & Jahreis, 2018; Thornton, 2018).

Furthermore in this study, results for food processors group show that; large scale food processors were more aware on TFAs compared to small scale food processors who their awareness level were average; this might be contributed by the fact that most of the personnel involved in large scale food processing attained tertiary education, while majority of the small scale food processors attained primary and only few secondary level of education, this is supported by other studies (Lin *et al*.,2010; Musvosvi and Mhlanga, 2016) where awareness on TFAs observed to improve with education. Also being in the large scale processing industry could be another factor that favoured large scale processors of increased awareness on TFAs than those small scale processors. This instance puts most consumers in Morogoro at risk of diet related non communicable disease especially cardiovascular disease (CVDs) in particular, since most of them consume on processed foodstuffs manufactured/prepared either by small or large scale processors.

4.4.3 General awareness of edible oil and food processors on policies/regulations regarding *Trans* fatty acids (TFAs)

The findings in this study found that; awareness among all groups of edible oil and food processors towards country's policies and regulations regarding TFAs were generally average. Moreover some variations were observed, whereby the score for large scale processors were slightly higher compared to small scale processors, besides both group having an average awareness. The observed moderate awareness of both large and small scale processors regarding policies and regulations on TFAs could be contributed by the fact that in Tanzania, the policies and regulations on TFAs are not yet set in place. This situation predisposes consumers at more risk of non-communicable diseases especially CVDs. The obtained findings are also supported by (Li *et al.,* 2019) from the study on evidence from global surveillance of TFAs which showed that Tanzania was one among countries in Africa which had not yet set the regulations and policies on TFAs. Results of

the current study positively correlate with a study by Juma *et al*. (2016) which found that; in sub-Saharan Africa, there is limited research on the application and success of multi-sectoral approach in the formulation and implementation of policies aimed at prevention of non-communicable diseases. Furthermore findings of this study agrees with the World Health Organization (WHO, 2019) which argue that, understanding TFAs sources, the supply chain, stakeholders, regulatory agencies and legal processes will help inform which policy intervention will be most effective and practical to reduce consumption of industrially produced TFAs.

4.5 Conclusion

Better nutrition knowledge, especially knowledge about diet-disease relationships, can help promote healthful dietary choices and enhance health literacy among consumers. Awareness and understanding of different fats to food consumers, edible oil and food processors may also help decrease the risks of diet related non communicable diseases (NCDs) as attributed by *trans* fatty acids.

A further research needs to be conducted by considering other factors that might be contributing to the low level of awareness towards *trans* fatty acids among households/consumers and also considering other consumer locations in Tanzania.

It is better for the government through the Ministry of Health in collaboration with other relevant authorities to provide guidance on policy options and steps to design, enact and implement legislative and regulatory actions suitable to the Tanzanian context in order to reduce industrially produced *trans* fatty acids in the food supply.

It is recommended that; there is a need to increase awareness regarding the danger of *trans* fatty acids among Morogoro households which will reduce or cut down their usage in their diet plans.

References

Accelerator for Agriculture and Agro industry Development and Innovation Plus 3ADI+ (2019). The palm oil value chain Tanzania - UNIDO. 121pp. [https://www.unido.org/sites/default/files/files/2019-04/3ADI%2] site visited on 15/05/2020 at 2200hrs.

Afaneh, I., Abbadi, J., Al-Rimawi, F., Al-Dabbas, G., and Sawalha, S. (2017). Effect of frying temperature and duration on the formation of *Trans* fatty acids in selected Fats and Oils. *American Journal of Food Science and Technology, Vol. 5(6): 245-248*

Banseria, R., Gothwal, S., Dixit, S., and Saroshe, S. (2016). A cross-sectional study to assess the awareness of the presence of *trans* fat in packaged food items and their harmful effects in a metropolitan city of central India. *International Journal of Medical Science and Public Health, 5*(12), 1-4

Bloks, S. A. (2019). The regulation of *trans* fats in food products in the US and the EU. Utrecht L. Review 15(3): 57 – 162.

Codex Alimentarius Commission (2017). Joint FAO/WHO food standards programme. Codex committee on nutrition and foods for special dietary uses. 39th session discussion paper on claim for “free” of *trans* fatty acids. [https://www.ccnfsdu.de/previous-sessions/39th-session-summary] site visited on11/02/2019 at 1325hrs

Derbyshire, E. (2012). *Trans* fats: Implications for health. *Nursing Standard, 27*(3), 51-56.

Dhaka, V., Gulia, N., Ahlawat, K. S., and Khatkar, B. S. (2011).*Trans* fats sources, health risks and alternative approach-A review. *Journal of food science and technology*, *48*(5), 534-541.

Juma, P. A., Mohamed, S. F., Wisdom, J., Kyobutungi, C., and Oti, S. (2016). Analysis of non-communicable disease prevention policies in five sub-Saharan African countries: Study protocol. *Archives of Public Health*, *74*(1), 25-32

Kagiono, S., Nagao, K., Yoshida, A., Mizobe, H., Nagai, T., Beppu, F. and Yoshinaga, K. (2018). Study of *trans* fatty acid formation in oil by heating using model compounds. *Journal of Oleo Science* 67(3): 273–281.

Kamel, S. and Al Otaibi, H. (2018). *Trans*-fats declaration, awareness and consumption in Saudi Arabia. *Current Research in Nutrition and Food Science Journal* 6(3): 748 – 756.

Kothari, C. R. (2014). *Research Methodology: Methods and Techniques*. New Age International, New Delhi India. 458pp

Li, C., Cobb, L. K., Vesper, H. W. and Asma, S. (2019). Global surveillance of *trans*-fatty acids.*Preventing Chronic Disease* Vol147 (16): 190 – 121. [https://doi.org/10.5888/pcd16.190121] site visited 17/03/2020 at 0530 hrs.

Lin, C. T. J., and Yen, S. T. (2010). Knowledge of dietary fats among US consumers. *Journal of the American Dietetic Association*, *110*(4), 613-618.

Mayige, M., Kagaruki, G., Ramaiya, K. and Swai, A. (2011). Non communicable diseases in Tanzania: a call for urgent action. *Tanzania Journal of Health Research* 13(5): 1 – 2.

Mayige, M., and Kagaruki, G. (2013). Tanzania STEPS survey report. *Dar es Salaam: National Institute of Medical Research*.154pp. [https://www.who.int/chp/steps/UR_Tanzania_2012_STEPS_Report. pdf?ua=1] Site visited on 15/07/2020 at 1625 hrs.

Mayige, Mary. (2016). Prevention of non-communicable disease in Tanzania using an inter-sectoral approach.[https://doi.org/10.13140/rg.2.1.3976.1047] site visited on10/02/2019 at 0150 hrs.

Mitrou, F. and Lawrence, D. (2014).Narrative Review: The Relationship Between Dietary Trans-Fatty Acids And Adverse Health Outcomes. Food Standards, Australia New Zealand. 30pp.

Mouratidou, T., Livaniou, A., Saborido, C. M., Wollgast, J., and Caldeira, S. (2014).*Trans* fatty acids in Europe: where do we stand? A synthesis of the evidence: 2003-2013. European Commission Joint Research Centre Science and Policy Report. [https://doi.org/10.2788/1070]. Site visited 01/04/2019- at 0240 hrs.

Mozaffarian, D., de Oliveira Otto, M. C., Lemaitre, R. N., Fretts, A. M., Hotamisligil, G., Tsai, M. Y., and Nettleton, J. A. (2013). *trans*-Palmitoleic acid, other dairy fat biomarkers, and incident diabetes: the Multi-Ethnic Study of Atherosclerosis (MESA). *The American Journal of Clinical Nutrition*, 97(4), 854–861.

Musvosvi, A., and Mhlanga, R. (2016). Awareness and consumption of *Trans* fats among Kitwe Urban residents. *Solusi University Research*, 22. Retrieved from: [https:// publication.babcock.edu.ng] site visited 04/08/2020 at 2115 hrs.

Pfeuffer, M., and Jahreis, G. (2018).Trans fatty acids. Origin, metabolism, health risks. Ernahrungs Umschau International 65(12): 196–203

Pletzke, V., Henry, B. W., Ozier, A. D., and Umoren, J. (2010). The effect of nutrition education on knowledge, attitude, and behaviour relating to *trans* fatty acids in foods. *Family and Consumer Sciences Research Journal*, *39*(2), 173-183.

Seid, M. A., & Hussen, M. S. (2018). Knowledge and attitude towards antimicrobial resistance among final year undergraduate paramedical students at University of Gondar, Ethiopia. *BMC infectious diseases*, *18*(1), 1-8.

Taher, E. M., El-Essawy, H. A., Saudi, A. M., and Aly, S. A (2018).Fatty Acid Profile of Some Fat Rich Foods with Special Reference to their Trans Fatty Acids Content. *International Journal of Pharmaceutical and Chemical Sciences Vol.7(2):32 -37*

Thornton, J. (2018). Eliminate" toxic" *trans* fats from food by 2023, WHO urges. *British Medical Journal.* [https://doi.org/10.1136/bmj.k2154](Online), Vol. 361. Site visited 11/07/2019 at 2240 hrs.

Tsuzuki, W., Matsuoka, A., and Ushida, K. (2010). Formation of trans fatty acids in edible oils during the frying and heating process. *Food Chemistry*, *123*(4), 976-982.

United Republic of Tanzania (2016). Strategic and Action Plan for the Prevention and Control of Non Communicable Diseases in Tanzania 2016-2020. Ministry of Health, Community Development, Gender, Elderly and Children, Dar es Salaam, Tanzania. 128pp.

World Health Organization (2018).Non-communicable Diseases Country Profiles. Geneva 124pp. [https://apps.who.int/iris/bitstream/handle] site visited on 11/07/2019 at 0920 hrs.

World Health Organization (2019). Replace action package: module 3: legislate or regulate: How-to guide for *trans* fat policy action (WHO/NMH/NHD/19.14).World Health Organization. [http://apps. who.int/iris.]Site visited on 07/01/2020 at 0418 hrs.

Wu, J., Zheng, M., Catterall, E., Downs, S., Thomas, B., Veerman, L. and Barendregt, J. (2017). Contribution of *trans*-fatty acid intake to coronary heart disease burden in Australia: A modeling study. *Nutrients* 9(1): 77-86.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMEDNATIONS

5.1 Conclusion

1. The results obtained from this study demonstrated that; with the exception of "chapati", all samples analysed exceeded the maximum recommended TFAs levels (≤ 2g/100g fat) as set by the WHO and EFSA. Consumption of high levels of TFAs from PHOs is a risk factor for the development of Coronary heart disease (CHD).

2. There is high possibility of increasing more TFAs when the same oils/fats are repeatedly heated or used in frying for several times. There were no significant differences in TFAs levels across locations. This suggest that people who were living either in urban or rural had equal chance of being at risk of non-communicable disease especially Cardiovascular disease (CVDs).

3. Most households, both in urban and rural areas were largely using PHOs in their various food preparations and the consumption of these oils was high. From previous studies, PHOs are the primary source of industrial *trans* fatty acids which are regarded as toxic, so most people in Morogoro region especially those in urban are at high risk of nutrition-related non-communicable diseases (NCDs) such as cardiovascular disease as fuelled by increasingly consumptions on processed or fast foods.

4. Awareness among all groups of edible oil and food processors towards country's policies and regulations regarding TFAs were generally moderate. The observed moderate awareness of both large and small scale processors regarding policies

and regulations on TFAs could be contributed by the fact that in Tanzania, the policies and regulations on TFAs are not yet set in place. This situation predisposes consumers at more risk of non-communicable diseases especially CVDs.

5.2 Recommendations

Based on the findings of this study, the following are the recommendations:-

1. It is better for the Government in collaboration with other relevant stakeholders to formulate policy and provide guidance on policy options and steps to design, enact and implement legislative and regulatory actions suitable to the Tanzanian context or to update the existing legal framework to reduce or if possible to eliminate industrially produced TFAs from our food supply.

2. To conduct another study involving a wide range of foodstuffs and samples from human biological tissues in order to capture the recent TFAs intake from foodstuffs in a wide range of Tanzanian population.

3. Human nutritional and health experts should provide nutrition education regarding the negative health effects of *trans* fats for all people in Morogoro region, if possible the whole country and also with the consideration of other aspects of healthy eating as when combined with physical exercises, tends to acts as the most effective and low cost intervention to reduce the cases resulting from diet related non-communicable diseases (NCDs especially in low resource country like Tanzania.

4. A further research to be conducted by considering other factors that might be contributing to the low level of awareness towards TFAs among households/consumers and also considering other consumer locations in Tanzania.

APPENDICES

Appendix 1: Questionnaire for assessing dietary pattern and awareness on *trans* fatty acids in foods

Questionnaire no;…….
Date of interview;……

Section A: Demographic information of respondent

1. Name of respondent …….....
2. Age of respondent…….....
3. District…….....
4. Ward.....
5. Village/street.....
6. Sex: 1) Male [ ] 2) Female [ ]
7. Educational level 1) Non formal education [ ] 2) Primary level [ ] 3) Secondary Education [ ] 4) College [ ] 5) University [ ] 6) No schooling [ ]
8. Marital status 1) Single [ ] 2) Married [ ] 3) Divorced [ ] 4) Widowed [ ]
9. Total number of house hold members 1) 3 -5 [ ] 2) 6 – 8 [ ] 3) More than 8 [ ] 4) Others specify [ ]

Section B: Socio economic information of respondent

10. Source of income 1) Formal employment [ ] 2) Casual labour [ ] 3) Farming [ ] 4) Small business [ ] 5).Sales of livestock [ ]
11. How much do you spend to buy food per month 1). Less than 20,000/- [ ] 2). 20,000/- [ ] 3). More than 20,000/- [ ]
12. Type of floor used for the house 1). Mud [ ] 2). Concrete [ ] 3) Wood [ ]
13. Type of roof used for the house 1). Grass [ ] 2). Corrugated iron sheets [ ]
14. Type of wall used 1) Mud [ ] 2). Cement [ ]

Section C: Awareness on fats and *trans* fatty acids in foods

15. Which kind of foods are most enjoyed by family members?
    1). Boiled [ ] 2). Fried [ ]
16. Which cooking method do you normally prefer to use when preparing food for your family?
    1). Boiling[ ] 2). Frying [ ]
17. If boiling, are there times that you fry foods?
    1). Yes [ ] 2). No [ ]
18. If yes in Qn. 17 above, which kind of oil do you usually use for frying? (Name or brand)
    …….…….
19. Why do you prefer the particular type of cooking oil you that have mentioned in Qn. 18 above?
    …….
20. What is their favourite meals?. For:-
    i). Breakfast ……
    ii). Lunch ……..…..
    iii). Dinner ……..
21. Do you know of any problems that are associated with overconsumption of cooking oils/fats?
    1). Yes [ ] 2). No [ ]
22. If you answered yes in Qn.21 above, Which problems?.
    ……
23. Have you heard about partially hydrogenated oils (PHOs)?
    1). Yes [ ] 2). No [ ]
24. If you answered Yes in Qn.23 above,
    Where?.....

Please mention examples of those oils.....

25. Do you think that partially hydrogenated oils are unhealthy to human?
    1). Yes [ ] 2). No [ ] 3). Not sure [ ]
26. Do you have the habit of reading a food label in packed food products before purchasing?
    1). Yes [ ] 2). No [ ]
27. Have you heard of *trans* fatty acids?
    1). Yes [ ] 2). No [ ]
28. Do you know how *trans* fatty acids are formed?
    1). Yes [ ] 2).No[ ]
29. If you answered Yes, in Qn. 28 above
    how?.....
30. Have you ever been told about foods that are rich in *trans* fatty acids and the associated health effects?
    1).Yes [ ] 2). No [ ]
31. If you answered Yes in Qn.30 above, where? ……and by who?.....
32. What will be your advice to the Government so as to create awareness regarding *trans* fatty acids?
    i). …….
    ii). ……..……
    iii). ……..

Section D: Dietary Assessment
Food Frequency Questionnaire

Ask for frequency of consumption of different foods available in the community. Take note of where does food come from (major source) and seasonal variations								
Food item	**Frequency of consumption**					**Major source**	**Seasonal variation**	
	Daily	Weekly	Monthly	Rare	Never	1= Own production, 2= Purchase	Rainy season	Dry season
Cereals								
Maize								
Sorghum								
Finger millet								
Wheat								
Rice								
Roots, tubers, plantain								
Cassava								
Sweet potato								
Round potato								
Green banana								
Legumes								
Beans								
Peas (Njegere)								
Cowpeas (kunde)								
Pigeon peas (Mbaazi)								
Green grams (Choroko)								
Chickpeas (Dengu)								
Soybeans								

(soya)								
Nuts and Seeds								
Groundnuts								
Coconut								
Cashew nut								
Other seeds								
Meat, poultry, fish, eggs								
Cow beef								
Liver								
Goat								
Pork								
Eggs								
Sea fish								
Sardines								
Fresh water fish								
Dried fish								
Poultry chicken								
Milk and Milk product								
Cow's milk (whole)								
Goat's milk (whole)								
Processed & packed milk								
Yoghurt								
Butter								
Cheese								
Ghee								
Oils and fats								
Sunflower oil								
Korie oil								
Ground nut oil								
Red palm oil								
Other oil or fat (mention)								
Vegetables								
Cabbage								
Amaranth leaves								
Sweet potato leaves								
Cassava leaves								
Pumpkin leaves								
Carrots								
Tomatoes								
Spinach								

Egg plant								
Cowpea leaves								
Other indigenous leaves								
Fruits								
Citrus e.g. Oranges								
Mangoes								
Passion fruits								
Water melons								
Bananas								
Pineapple								
Papayas								
Avocado								
Other indigenous fruits								
Beverages								
Coffe								
Tea								
Juice								
Milk								
Local brew								
Beer								
Soda								

SECTION E: General awareness about fats and *trans* fatty acids with their relationship to human health

(NB: To be filled by people involved in edible Oil production and Food processing)

A). Basic information of respondent

1. Name of respondent …….....

2. Age of respondent…….....

3. Region…….....

4. District.....

5. Village/street.....

6. Name of factory/Industry……..

7. Position of respondent in the factory/Industry…….

8. Major activities involved by the factory: 1). Edible oil production [ ] 2). Food processing and packaging [ ] 3). Others, specify …….

9. Sex: 1). Male [ ] 2). Female [ ]

10. Educational level 1). Non formal education [ ] 2). Primary level [ ] 3). Secondary Education [ ]

4). College [ ] 5). University [ ] 6). No schooling [ ]

B). Awareness about fats and *trans* fatty acids with their relationship to human health

11. Do you know of any problems that are associated with overconsumption of cooking oils/fats?

1). Yes [ ] 2). No [ ]

12. If you answered yes in Qn12 above, Which problems?. ……

13. Have you heard about partially hydrogenated oil?

1). Yes [ ] 2). No [ ]

14. If you answered Yes in Qn.14 above, Where?.....

Please mention examples of those oils.....

15. Do you think that partially hydrogenated oils are unhealthy to human?

1). Yes [ ] 2). No [ ] 3). Not sure [ ]

16. Do you think it is important for consumers to have the habit of reading a food label in packed food products before purchasing?

1). Yes [ ] 2). No [ ]

17. If your answer in Qn.17 above is Yes, Why?.....

18. Have you ever heard of *trans* fatty acids?

1). Yes [ ] 2). No [ ]

19. Do you know how *trans* fatty acids are formed?

1). Yes [ ] 2). No [ ]

20. If you answered Yes, in Qn 19 above how? .....

21. Have you ever been told about foods that are rich in *trans* fatty acids and the associated health effects?

1).Yes [ ] 2). No [ ]

22. If you answered Yes in Qn.21 above, where? ……and by who?.....

23. What kind of cooking oil do you usually process or use in the processing of various foods in your factory?

……

24. Why do you prefer to use the oils mentioned in Qn. 23 above?

.....

25.In Tanzania, most industries concerned with palm oil production, do import in its crude form and purify then pack it

1).Yes [ ] 2). No [ ] 3). Not sure [ ]

26. If you answered Yes in Qn.25 above, what major operations involved to prolong shelf life?

……

27. Is there any positive relationship between concentration of *trans* fatty acids and the level LDL-cholesterol in the blood?

1).Yes [ ] 2). No [ ] 3). Not sure [ ]

28. Margarine usually contains low proportions of *trans* fatty acids

1).Yes [ ] 2). No [ ] 3). Not sure [ ]

29. Are there any regulation(s) in Tanzania that prompt food manufactures/processors to limit the amount of *trans* fatty acids in processed foods?

1).Yes [ ] 2). No [ ] 3). Not sure [ ]

30. Have you ever heard in Tanzania, about regulations/policies that require food manufactures/ processors to indicate the amount of saturated fats and *trans* fatty acids content in processed foods?

1).Yes [ ] 2). No [ ] 3). Not sure [ ]

31. What will be your advice to the Government so as to create awareness regarding *trans* fatty acids?

i) ……..……..

ii) …….

iii) ……..

Thank You Very Much for Your Cooperation.