Food Fraud in Nigeria: Challenges, Risks and Solutions

Joy Ewomazino Opia

Technological University Dublin

Follow this and additional works at: https://arrow.tudublin.ie/sfehthes

Part of the Computer Sciences Commons

Recommended Citation


This work is licensed under a Creative Commons Attribution-Noncommercial-Share Alike 4.0 License
Food Fraud in Nigeria: Challenges, Risks and Solutions

Joy Ewomazino Opia

Msc. Food Safety Management

Submitted to Technological University Dublin, Cathal Brugha Street, in partial fulfilment of the requirements of the Degree of Science (Food Safety Management, DT9437)

Supervisor: Christine O’Connor

School of Food Science and Environmental Health

College of Sciences and health

Technological University Dublin

January 2020
ABSTRACT

Food fraud is one of the most urgent and active food research and regulatory areas. It is an evolving problem in Nigeria that has led to the deaths of many people especially the vulnerable groups that includes mostly children, the elderly and immunocomprised persons. Therefore the aim of this study is to investigate the current challenges of food fraud in Nigeria, identify the risks it poses on the health and wellbeing of Nigerians and propose measures to tackle food fraud at local and international levels by regulatory and government agencies. This study explored the relationship between food fraud, food security and the UN Sustainable Development Goals. This study is relatively new as it has never been carried out before so it relied on information from previous research articles, journals and publications. A total of 68 participants from the general public took part in this study and some key officers from the National Agency for Food and Drug Administration and Control (NAFDAC) were interviewed to obtain their opinions on the current state of food fraud in Nigeria. The findings revealed common foods being adulterated in Nigeria are mostly fats and oils, alcoholic and non-alcoholic drinks and honey. Poverty, corruption and poor food safety and control systems were identified throughout this study. The study concluded by reviewing several policy framework and actions taken by the Nigerian government to proffer solutions that can actualise the goals of the Sustainable Development Goals by 2030.
DECLARATION

I hereby certify that this material, which I now submit in part fulfilment of the requirement for the award of MSc in Food safety Management, is entirely my own work and has not been taken from the work of others save and to the extent such work has been cited and acknowledged within the text of my work.

The thesis was prepared according to the guidelines for dissertation production in the MSc. Food Safety Management and has not been submitted in whole or in part for an award in any other Institute or University.

The Institute has permission to keep, to lend or to copy this thesis in whole or in part, on condition that any use of the material of the thesis be duly acknowledged.

Signed

Date
ACKNOWLEDGEMENTS

My sincere appreciation goes to God Almighty for the wisdom and idea in making this research study a reality. May his name be praised.

I also like to thank my family for their prayers, encouragement and relentless efforts with my survey questionnaire and interviews with regulatory officers from NAFDAC. Thank you so much for all your assistance in making this research a success.

My profound gratitude to the Director General of NAFDAC for her timely intervention and permission to collect data from her agency and to the staffs for their insights and wisdom in the course of this research study. Your assistance has proved to be a milestone in the accomplishment of my end goal.

I am deeply grateful to all the participants who took part in my survey questionnaire. I acknowledge and appreciate your help and support with my research work.

I wish to express my special thanks to my supervisor, Christine O’Connor for her contributions and support towards this study. It is whole-heartedly expressed that your advices for my research proved to be a landmark effort towards the success of my thesis.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AESAN</td>
<td>Agencia Española de Seguridad Alimentaria y Nutrición</td>
</tr>
<tr>
<td>AFBE</td>
<td>Association of Food, Beverage and Tobacco Employers</td>
</tr>
<tr>
<td>AFFCON</td>
<td>Association of Fast Foods and Confectionaries Operators of Nigeria</td>
</tr>
<tr>
<td>APP</td>
<td>Agriculture Promotion Policy</td>
</tr>
<tr>
<td>APHIS</td>
<td>Animal and Plant Health Inspection Services</td>
</tr>
<tr>
<td>ATA</td>
<td>Agricultural Transformation Agenda</td>
</tr>
<tr>
<td>ATWAP</td>
<td>Association of Table Water Producers</td>
</tr>
<tr>
<td>BHA</td>
<td>Butylated hydroxyanisole</td>
</tr>
<tr>
<td>CAC</td>
<td>Codex Alimentarius Commission</td>
</tr>
<tr>
<td>CBN</td>
<td>Central Bank of Nigeria</td>
</tr>
<tr>
<td>CFSAN</td>
<td>Center for Food Safety and Applied Nutrition</td>
</tr>
<tr>
<td>CQP</td>
<td>Coffee Quality-Improvement Program</td>
</tr>
<tr>
<td>DG SANCO</td>
<td>Directorate General for Health and Consumers</td>
</tr>
<tr>
<td>DSS</td>
<td>Department of State Services</td>
</tr>
<tr>
<td>EMA</td>
<td>Economically Motivated Adulteration</td>
</tr>
<tr>
<td>EP</td>
<td>European Parliament</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
</tr>
<tr>
<td>EVOO</td>
<td>Extra Virgin Olive Oil</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization</td>
</tr>
<tr>
<td>FCCPC</td>
<td>Federal Competition and Consumer Protection Commission</td>
</tr>
<tr>
<td>FEC</td>
<td>Federal Executive Council</td>
</tr>
<tr>
<td>FDA</td>
<td>Food and Drug Administration</td>
</tr>
<tr>
<td>FIRS</td>
<td>Federal Inland Revenue Service</td>
</tr>
<tr>
<td>FMARD</td>
<td>Federal Ministry of Agriculture and Rural Development</td>
</tr>
</tbody>
</table>
FMH  Federal Ministry of Health
FSAN  Food Safety and Applied Nutrition
FSIS  Food Safety and Inspection Services
FT    Fourier Transform
FTIR  Fourier Transform Infrared
GAPs  Good Agricultural Practices
GC    Gas Chromatography
GC-MS Gas Chromatography-Mass Spectrometry
GDP   Gross Domestic Product
GFSI  Global Food Safety Initiative
GLC   Gas-Liquid Chromatography
GHPs  Good Hygiene Practices
GMPs  Good Manufacturing Practices
GSC   Gas-Solid Chromatography
HACCP Hazard Analysis and Critical Control Point
HICs  High-Income Countries
HPLC  High-Performance Liquid Chromatography
IAEA  International Atomic Energy Agency
IEA   International Energy Agency
IECT  Information, Education, Communication and Training
IR    Infrared
IR-MS Infrared-Mass Spectrometry
KFDA  Korea Food and Drug Administration
LC    Liquid Chromatography
LDA   Linear Discriminant Analysis
LFN   Law of the Federation of Nigeria
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>LMICs</td>
<td>Low and Middle-Income Countries</td>
</tr>
<tr>
<td>LOD</td>
<td>Limits of Detection</td>
</tr>
<tr>
<td>MDGs</td>
<td>Millenium Development Goals</td>
</tr>
<tr>
<td>MIR</td>
<td>Mid-Infrared</td>
</tr>
<tr>
<td>MLR</td>
<td>Multiple Linear Regression</td>
</tr>
<tr>
<td>MRM</td>
<td>Mechanically Recovered Meat</td>
</tr>
<tr>
<td>MS</td>
<td>Mass Spectroscopy</td>
</tr>
<tr>
<td>NAFDAC</td>
<td>National Agency for Food and Drug Administration and Control</td>
</tr>
<tr>
<td>NAQS</td>
<td>Nigerian Agricultural Quarantine Service</td>
</tr>
<tr>
<td>NASSI</td>
<td>National Association of Small Scale Industrialists</td>
</tr>
<tr>
<td>NCSC</td>
<td>NAFDAC Consumer Safety Club</td>
</tr>
<tr>
<td>NCDs</td>
<td>Non-Communicable Diseases</td>
</tr>
<tr>
<td>NEPC</td>
<td>Nigerian Export Promotion Council</td>
</tr>
<tr>
<td>NIR</td>
<td>Near-Infrared</td>
</tr>
<tr>
<td>NIS</td>
<td>Nigeria Immigration Service</td>
</tr>
<tr>
<td>NIPC</td>
<td>Nigerian Investment Promotion Commission</td>
</tr>
<tr>
<td>NMR</td>
<td>Nuclear Magnetic Resonance</td>
</tr>
<tr>
<td>OSIC</td>
<td>One Shop Investment Centre</td>
</tr>
<tr>
<td>OMC</td>
<td>O-Methylcafestol</td>
</tr>
<tr>
<td>OPEC</td>
<td>Organization of Petroleum Exporting Countries</td>
</tr>
<tr>
<td>PARAFAC</td>
<td>Parallel Factor Analysis</td>
</tr>
<tr>
<td>PCA</td>
<td>Principal Component Analysis</td>
</tr>
<tr>
<td>PCR</td>
<td>Polymerase Chain Reaction</td>
</tr>
<tr>
<td>PDO</td>
<td>Protected Designation of Origin</td>
</tr>
<tr>
<td>PGI</td>
<td>Protected Geographical Indication</td>
</tr>
<tr>
<td>PLS</td>
<td>Partial Least Squares</td>
</tr>
</tbody>
</table>
PMS  Post Market Surveillance
POO  Pomace Olive Oil
PV   Pharmacovigilance
QUID Quantitative Ingredient Declaration
RASFF Rapid Alert System for Food and Feed
RMSEC Root Mean Squares Error of Calibration
RMSEV Root Mean Squares Error of Validation
SD   Sustainable Development
SDGs Sustainable Development Goals
SFVs Street Food Vendors
SMEs Small and Medium-sized Enterprises
SON Standard Organization of Nigeria
SORTS Spatially Offset Raman Spectroscopy
SPS  Sanitary and Phytosanitary
TLC  Thin-Layer Chromatography
TSG  Traditional Speciality Guaranteed
US   United States
USA  United State of America
USDA United States Department of Agriculture
USFNA United States Food and Drug Administration
UV   Ultraviolet
UV-Vis Ultraviolet Visible
WHO  World Health Organization
WTO  World Trade Organization
Table of Contents

ABSTRACT

DECLARATION

Acknowledgements

Abbreviations

List of Figures

List of Tables

1. LITERATURE REVIEW

1.1 Introduction

1.2. History of Food fraud

1.3. Food Authenticity and Authenticity factors

1.3.1. Production method

1.3.2. Variety and species

1.3.3. Geographical origin

1.3.4. Genuiness

1.3.5. Shelf life

1.3.6. Labelling

1.4. Legal Framework

1.5. Analytical methods for the detection of food fraud

1.5.1. Chromatographic techniques

1.5.1.1. Gas Chromatography

1.5.1.2. High-performance liquid chromatography

1.5.2. Spectroscopy techniques

1.5.2.1. UV-Vis spectroscopy

1.5.2.2. Fluorescence spectroscopy

1.5.2.3. Infrared spectroscopy
1.5.2.4. Nuclear magnetic resonance spectroscopy

1.5.3. Stable isotope analysis

1.5.4. DNA-based methods

1.5.5. Examples of spectral data for various food products

1.6. Sustainable Development Goals (SDGs): An overview

1.7. Nigeria: An overview

1.8. Aims and objectives

2. METHODOLOGY

2.1. Data collection

2.2. Interview questions

2.3. Survey questionnaire design

2.4. Data analysis

3. FOOD FRAUD – CURRENT STATUS IN NIGERIA

3.1. Food smuggling and trafficking

3.2. Street food practices

3.2.1. Sources and quality of raw foods and ingredients

3.2.2. Food preparation, handling and vending

3.2.3. Vending environments

3.2.4. Hygiene practices

3.2.5. Agricultural practices

3.3. Nigerian food fraud incidents/fradulent commodities

3.4. Food control systems

4. FOOD SAFETY LEGISLATION IN NIGERIA

4.1. Regulatory and legislative framework

4.2. Key actors in regulating and monitoring of food safety standards and practices

4.2.1. The Federal Ministry of Health (FMH)
4.2.2. The National Agency for Food and Drug Administration and Control (NAFDAC)

4.2.3. Standards Organization of Nigeria (SON)

4.2.4. The Federal Ministry of Agriculture and Rural Development (FMARD)

4.2.5. Nigerian Agricultural Quarantine Service (NAQS)

4.2.6. Federal Competition and Consumer Protection Commission (FCCPC)

4.2.7. The Federal Ministry of Environment

4.2.8. Local Governments (LGs)

4.3. National food control systems

4.4. National Agency for Food and Drug Administration and Control (NAFDAC)

4.4.1. Functions of NAFDAC

4.4.2. Regulatory strategies of NAFDAC

5. RESULTS

5.1. Interviews with regulatory officers at NAFDAC

5.2. Consumer Survey Questionnaire

6. DISCUSSION, RECOMMENDATIONS AND LIMITATIONS

6.1. Recommendations

6.2. Limitations

7. CONCLUSION

8. REFERENCES

9. JOURNAL ARTICLE

Abstract

Keywords

1. Introduction

2. Methodology

3. Food fraud – current status in Nigeria

4. Food safety legislation in Nigeria
5. Results

6. Discussion, Recommendations and Limitations

7. Conclusion

8. References

10. APPENDIX

10.1. Guide for Authors for Food Control Journal

10.2. Survey questionnaire
List of figures

Figure 1.: Structure of Tetrodotoxin

Figure 2.: Flow diagram of food fraud and food authenticity factors

Figure 3.: Structure of Ochratoxin A

Figure 4.: Picture showing a GC-MS instrument

Figure 5.: Picture showing a HPLC instrument

Figure 6.: Picture showing an NMR spectrometer

Figure 7.: $^1$H NMR spectra in the region of the 16-OMC signal in experimental Arabica/Robusta mixtures with 0–7% of Robusta content

Figure 8.: $^1$H NMR spectrum of typical Robusta and Arabica coffees (roasted coffee, lipophilic extracts). The following signals are marked: 16-OMC (a), caffeine (b), triglycerides (c), kahweol (d)

Figure 9.: The region of the 16-OMC signal for selected coffee samples

Figure 10.: Overall $^1$H-NMR 95% confidence spectral envelope of the set of spectra from 26 BIPEA Quality Control honey analyses performed over more than one month. In blue: 2.5% quantile, in red: 97.5% quantile, in green: median. The zooms are focused on spectral regions with smaller signals and more discriminant information

Figure 11.: FT-Raman spectra of: (a) skimmed and (b) whole spreadable cheese

Figure 12.: FT-Raman spectra of: (a) standard spreadable cheese, (b) 2% (w/w) starch, (c) 6% (w/w) starch, (d) 10% (w/w) starch and (e) pure starch

Figure 13.: The 17 UN Sustainable Development Goals (SDGs)

Figure 14.: Map of Nigeria showing the six geopolitical zones

Figure 15.: Street food retailing on major street

Figure 5.1.: Bar graph showing the overall ratio of commonly adulterated food commodities in percentage

Figure 5.2.: Bar graph showing the percentage of participants that agree/disagree on poor implementation of food laws in Nigeria

Figure 5.3.: Pie chart showing the percentage of participants that agree/disagree on the efforts of NAFDAC in tackling food fraud

Figure 5.4.: Bar graph showing the percentage of participants that are aware/unaware of the UN Sustainable Goals (SDGs)
Figure 5.5: Bar graph showing percentage of participants that agree/disagree on the problem of food smuggling in Nigeria

Figure 5.6: Bar graph showing the percentage of participants that agree/disagree that consumers are partly responsible for food adulteration in Nigeria.

List of Tables

Table 1: Elements of food integrity

Table 2: Participants’ profile (n = 68)

Table 3: Food commodities commonly adulterated in Nigeria
1. LITERATURE REVIEW

1.1. INTRODUCTION

Fraud can be defined as an intentional misrepresentation of fact by one person alone or acting on behalf of an organization in order to deceive another person to part with something of intrinsic value. Food fraud is a collective term used to include intentional and deliberate substitution, diversion, exploitation or misrepresentation of food, food ingredients or food packaging, or a misleading or false assertion about an economic benefit commodity (Spink and Moyer, 2011a). Food fraud forms include adulteration, bribery, overrun, stealing, diversion, simulation, and falsification (Spink and Moyer, 2011b). Food supply chain fraud may result from (1) product integrity (authenticity) misrepresentation—the inherent quality attribute of totality or completeness (Manning and Soon, 2014) which is intrinsic; (2) process integrity – the practices undertaken to manufacture food items that include the design, evaluation, monitoring and inspection of processes within the product life cycle to ensure they remain genuine and intact i.e. extrinsic; (3) people integrity may be defined as the honesty and morality shown by individuals and/or (4) data integrity of information accompanying food items throughout the supply chain, consistent and accurate data through the life cycle of food products (Table 1).

<table>
<thead>
<tr>
<th>Elements of food integrity</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product integrity</td>
<td>Adulteration and economically motivated adulteration (EMA), counterfeit product, expiration date, simulation and tampering.</td>
</tr>
<tr>
<td>Process integrity</td>
<td>Diversion of products outside of intended markets, illegal importation, over-run, theft.</td>
</tr>
<tr>
<td>People integrity</td>
<td>Characterizations such as cyber criminals and hacktivist, disgruntled individual, extortionist, extremist, irrational individual, opportunist, professional criminal.</td>
</tr>
<tr>
<td>Data integrity</td>
<td>Illegal importation, improper, fraudulent, missing or absent health certificates, expired, fraudulent or missing common entry documents or import declarations, mislabelling.</td>
</tr>
</tbody>
</table>

Table 1: Elements of food integrity (Adapted from Bouzembrak and Marvin (2016); PAS 96 (2014); Spink and Moyer (2011)).

Fraud in connection with food is not recent. For economic gain, most early food laws and codes concentrated on adulterants. Philosophers have raised doubts since the 4th century B.C and the penalty of Roman law for food adulteration included servitude or exile (Fortin, 2009). Some of the earliest reported cases of food fraud involving olive oil, wine, spices and tea dating back thousands of years (Foster, 2011; Norton et al., 2011; Wilson, 2008). The same products, along with a number of other products, continued
to be associated with fraud. Food and food additives typically associated with food fraud usually include olive oil, fish, honey, milk and dairy products, highly processed foods, meat products, grain-based foods, fruit juices, wine and alcoholic beverages, organic foods, spices, tea and coffee. How widespread food fraud is in the U.S. or internationally is not known conclusively. This is partially because those who commit fraud do not intend to cause physical harm and do not want to be found. Many accidents go undetected because they typically do not result in a risk to food safety and customers are often unaware of a quality problem. However, since the motive to commit food fraud is unlawful monetary gain, a secondary concern is the type of food that could be or become adulterated is a secondary consideration (i.e. any kind of food or food ingredient); rather, it is the probability or likelihood of fraud that usually causes fraud (CRS, 2013). Although the vast majority of incidents involving food fraud do not pose a risk to public health, there have been incidents involving fraud that do not pose a risk to public health, and cases of fraud have resulted in actual or potential threats to public health. Food theft, whatever the definition of crime, is a type of criminal behaviour. Food fraud's effects are catastrophic. Food companies and their image are harmed, reports go viral, entire supply chains are painted with the same brush, erodes consumer confidence, failure of markets and management and/or staff are fired, charged and locked up. The overall effects are comparable to other corporate fraud (Kuang and Lee, 2017). Losses for individual businesses may include social losses and sanctions, losses from third parties (e.g. additional tests), losses of confidence, losses of sales and overpayment, as well as losses from recall (Bindt, 2016). There is some popular belief that food theft is primarily an external threat from organized crime groups who aim to permeate the food supply chain. While politically convenient, in fact, actors in the food supply chain who make the most of the criminal opportunities that emerge are more often a problem (Lord et al., 2017). Fraud is the product of the relationship between motivated criminals and the opportunities offered by victims and those responsible for controlling risks according to Levi (2012). While food fraud is not really a new phenomenon, food authentication and the truthfulness of food labels are currently a major concern for many different groups of people, including the food industry, regulators, customers, etc. (Charlebois et al., 2016).

The American Chemical Society (ACS) SciFinder database explicitly shows that there is a significant increase in the number of publications concerned with “food fraud” and “food fraud research”. Food fraud originally began in the Greek and Roman Empires, but only recently, due to the advent of distinct analytical techniques, it has become possible to detect deficiencies in the distribution of food. To be “authentic”, a food product must comply with labelling requirements, the composition of ingredients, manufacturing procedures, other methods and technologies, and genetic identity. Because of the 2013 European horsemeat scandal and the 2008 Chinese milk scandal, it became clear that mislabelling has become a real big issue in modern society, and violations could occur on a huge scale. Another reason for the catalytic growth of food counterfeiting could be attributed to the increase in world trade and emerging new markets as well as the fact that food prices are increasingly growing globally (Holbrook, 2013).
Increasingly, manufacturers and retailers are forced to substitute specific ingredients or even whole products in order to set a competitive price for an intended market. Supply bottlenecks, the opportunity to make more profit, insufficient regulation in different countries have facilitated inaccurate labelling, also leading to consumer fraud. Fish and seafood products are the most known and documented cases (Jacquet and Pauly, 2008). Fake products sold in southern Europe are stated to have been mislabelled by 30 percent as confirmed by DNA analysis (Garcia-Vazquez et al., 2011). A meat study conducted in 2015 found a substitution rate of 57 percent and, subsequently, major discord with the label details (Di Pinto et al., 2015). In addition, chicken sausages are often mislabelled, posing significant issues of food safety and market prediction (Bottaro et al., 2014). In Europe, the European authorities discovered an operation that allegedly made goods from decomposed apples, tainted with mycotoxins and other toxic chemicals, unsuitable for human consumption and detrimental to public health. Italian and Serbian authorities have confirmed that they cracked the fraud ring involved in the production and trade of supposedly organic food and beverages from rotten apples. Nine members of an alleged organized crime group were charged in a joint action, coordinated by Eurojust. Illegal properties valued at €6 million ($6.7 million) and 1,411 tons of adulterated items were seized at an estimated value of approximately €5 million ($5.6 million). In Italy and Serbia, the assets of six firms suspected to be involved have been identified. Pisa's Public Prosecutor in Italy launched the international group investigation, which officials say had branches in several countries. Investigations uncovered an illegal trade in adulterated fruit, preserves, and other canned foods. Foods had been processed with water and sugars and falsely branded as organic products of European origin and marketed.

Eight arrest warrants had been issued in Italy and one in Serbia. People charged are accused of fraud and involvement in a criminal organization. The Guardia Civil confiscated 300 tons and 39,000 litres of falsified food and beverages in Spain. Three people were detained in Grenada after reportedly selling about 500 tons of vegetables including zucchini, peppers and cucumbers as organic, while their suppliers were not certified as organic. Two consignments of eggs were sold as organic in Madrid but were of a lower category and, according to officials, did not meet the requirements laid down by legislation. Police confiscated a total of 45,360 eggs and prosecuted six individuals (Food Safety News, 2019). An analysis of 50 coffee and 50 juice samples by Danish officials found that in four cases, the manufacturer had unlawfully added either water or sugar to the drink. In nine cases, lower-priced Robusta beans were found in Arabica coffee in Germany, Portugal, and Switzerland. The quality of Robusta ranged from 7% to 100%. Spain's authorities have arrested a group in Malaga province reportedly transporting young fish without sanitary controls. Officials said the group were fishing in the Port of Malaga between sunset and sunrise, and monthly earnings were projected to be as high as € 50,000 ($56,000). In an operation called “Diximus”, which started more than a year ago, the Guardia Civil detained 16 people and prosecuted another seven. Also involved was the Spanish Food Safety and Nutrition Agency (AESAN), as the group reportedly used formaldehyde to protect the fish they caught. According to official reports from the
Guardia Civil, they cautioned that purchasing and eating immature fish could present a health hazard because it is caught, treated and transported under poor hygienic and sanitary conditions, it is not known to be traceable and formaldehyde is an illegal additive (Food Safety News, 2019). With the increasingly poor food safety and security practices in Nigeria, there is a tendency to suffer severe health consequences and to report massive death rates from pollutants every day. Sadly, there are poor food safety practices and standards in Nigeria which, according to the National Agency for Food and Drug Administration and Control (NAFDAC), has resulted in enormous economic losses, as can be seen in the myriad of rejections of some Nigerian food exports at international borders as a result of contamination, inadequate storage methods and adulteration of food products. A 2015 internal memo issued to Sahara Reporters from the National Agency for Food and Drug Administration and Control (NAFDAC) Nigeria's Food Safety and Applied Nutrition (FSAN) office disclosed that tomato paste imported from China and sold in Nigeria fell well below national food safety standards. This was discovered by the FSAN after conducting a study in which 314 tomato paste packets purchased in Lagos were tested in a laboratory to determine if they had a tomato content of at least 28 percent, the minimum requirement stated by Codex Alimentarius Standards and Nigerian Industrial Standards. The study results showed that 286 samples, or 91.1% of the samples analysed, had tomato content below the minimum of 28%. In the internal FSAN report obtained by Sahara Reporters, the FSAN considered the consequences of the test results to be very alarming and concluded that tomato paste product companies were working with Chinese tomato paste manufacturers to sell to unsuspecting Nigerian consumers because Nigeria consumes approximately 300,000 tons of tomato paste imported from China annually. As a result, the FSAN recommended that retailers refrain from selling imported tomato paste from China until further notice and released a national recall of imported tomato paste brands from China (Sahara Reporters 2016). A dietary study conducted at Lagos and Kano revealed at the point of consumption, an alarming amount of contaminated food. The food was allegedly contaminated with chemicals, metals and traces of pesticides (Premium Times, 2019). In 2018, a warning was issued by the Ghanaian Health Authority against the consumption of puffer fish which resulted in the death of two family members while four others were hospitalized after eating the fish for dinner. They revealed that the puffer fish contains tetrodotoxin, a neurotoxin that makes the fish lethal and is stated to be 1000 times more toxic than cyanide, and that it does not have an antidote and kills by suffocating the diaphragm (NAFDAC, 2018).
1.2. HISTORY OF FOOD FRAUD

Human beings have modified the condition of food since prehistoric times to prolong their longevity or enhance their taste. Early humans had harnessed fire to cook and preserve meat at least as ancient as 300,000 years ago, and later determined that salt could be used to preserve meat and that salt could be used to preserve meat without cooking. Wine was often blended with honey, herbs, spices and even saltwater, chalk or lead in ancient Rome and Greece, serving both as a sweetener and as a preservative. The act of adulterating food for economic gain started to emerge overtime. Imported spices were pretty valuable during the Middle Ages. Merchants often mixed spices with multiple cheap substitutes such as groundnut shells, ashes, seeds, juniper berries, stones or dust because of their high prices and limited supply. In response, trade guilds were established to control product quality and prevent food adulteration, and legislation was drawn up throughout Europe to regulate the quality of bread, wine, milk, butter and meat. Nevertheless, after the reformation, the guilds’ influence waned and their rules along with them. The loss of food for profit was widespread during the 18th and 19th centuries, as the United States moved from an agricultural to an industrial economy and urbanization separated people from food production. Milk has often been treated and coloured with chalk or cement substances that have also been applied to the flour volume. Wine and beer were added to lead, and coffee, tea, and spices were combined with water, sand, or other leaves on a regular basis. Although a number of laws prevented the introduction of harmful substances to food, they were difficult to enforce as there were no reliable testing to prove the existence of contaminants. In 1820, when his book “A treatise on adulteration of food and culinary poisons” was published, a chemist called Fredrick Accum drew attention to numerous cases of food poisoning. Microscopes have been able to detect variations between ingredients and chemical reactions to recognise the presence of toxic substances by this time (Schumm, 2014).

Nevertheless, the growing number of urban dwellers relied on others for food—frequently transported long distances with inadequate cooling and poor sanitation—and the custom of applying harmful additives to prolong the shelf life of a product persisted. By the end of the 19th century, the increase of analytical chemistry made it possible for manufacturers to conceal the degradation of food in ways that were difficult
to detect. Simultaneously, herbal elixirs, tinctures, and “medicines” containing morphine, cocaine, heroin, and other narcotics were marketed without limits, warnings, or labelling of ingredients. In 1906, the chief chemist in what is now the Department of Agriculture, Dr. Harvey W. Wiley, assembled a group of volunteers to test the effects of ingesting some of the most common food preservatives in use at the time, such as borax, copper sulphates, sulphuric acid and formaldehyde. This group of men, known as the poison squad, decided to eat increasing amounts of each chemicals while tracking their effect on their bodies carefully. The alarming findings received widespread attention and both the Meat Inspection Act and the Original Food and Drugs Act were passed by Congress in 1906 banning the manufacture and interstate sale of adulterated and misbranded products and drugs. Nevertheless, it was not until 1958 that manufacturers had to carry out the checks necessary to prove the safety of a drug before it was introduced to the public. Although the security of our food supply has greatly improved over the last century, food fraud involving cases of dilution, duplication and mislabelling in the global food industry continues to persist. Since processed foods with different ingredients come from many countries and the supply chain has become more complicated, tracking contamination origins – whether deliberate or not – has become a major challenge (Schumm, 2014).

1.3. FOOD AUTHENTICITY AND FOOD AUTHENTICITY FACTORS

Food fraud and adulteration problems include a study of the definition and nature of the food-related authenticity concept. Food authenticity is a major concern for customers, food authorities, food producers and processors, as inaccurate food labelling and other forms of fraudulent practices have been shown to have a negative impact on the consumer's trust and health (Barnett et al., 2016). Regulation (EU) No 1169/2011 (EU, 2011) of the European Union allows consumers to be properly informed about the food they eat. This is crucial for maintaining a high level of health security and upholding their right to information, as well as protecting companies from unfair competition from scrupulous suppliers. Health, economic, environmental, social and ethical factors can influence the choices of consumers. Nevertheless, the general dictionary definition of 'authenticity' is 'the quality of being true, trustworthy, or genuine,' and the related dictionary definition of 'authentic' includes 'not fake or copied; genuine; actual' and 'having an unquestionable evidence-based origin; authenticated; checked.' More specifically with regard to food authenticity, a CEN standard recently produced describes food authenticity in the sense of food and feed as the connection between the features of the food product and the corresponding representations of the food product (CEN WS/86). Such criteria for labelling, which are legally defined and vary depending on the product, may include the scientific name or breed and method of processing (e.g. organic, free-range, wild-caught, etc.). Nevertheless, certain product features may also be included by manufacturers to inform consumers, including (i) ethical issues (halal, vegetarian, etc.), (ii) nutritional composition (vitamins, omega 3, etc.) (iii) areas where the product has been captured or farmed (for purposes of sustainability or with particular regard to EU legislation on safe designation of origin (PDO), protected geographical indication (PGI), assured traditional specialities (TSG), etc., (iv) product status (e.g. whether the product
was previously frozen or defrosted) and (v) the inclusion of undeclared products that may also pose a health risk to consumers (e.g., gluten, nuts, etc). Consumers are increasingly interested in knowing the geographical origin along with the perceived quality of the products they eat and drink because of the globalization of food markets and the resulting rise in variety and availability of food items from other countries. Quality assurance and food authentication approaches are of great interest from both commercial and legal viewpoints (Drivelos and Georgiou, 2012). Consumers, suppliers, and regulators have been concerned about authenticity since ancient times (Posudin et al., 2015). Modern equipment, developments in basic sciences and information and communication technology provide the means to accurately measure and elucidate the origin of foods (Georgiou and Danezis, 2015). Food validity depends on the following factors to be addressed in more detail.

![Flow Diagram of Food Fraud and Food Authenticity factors.](image)

**Figure 2:** Flow Diagram of Food Fraud and Food Authenticity factors.

### 1.3.1. PRODUCTION METHOD

The manner in which certain food items are produced or processed can be viewed as a measure of authenticity for a particular food product. Oils and, in particular, olive oil are among the most frequently adulterated food items. *Olea europaea*, commonly referred to as the olive tree, is native to the Mediterranean region and is one of the oldest tree species whose fruits and by-products, such as olive oil, have traditionally served as a food source for indigenous populations residing in the area. Roughly 70% of olive oil production is currently undertaken in Mediterranean countries, including Spain, Turkey, Greece, Italy, Morocco and Tunisia (EP 2017). Nevertheless, in other parts of the world, including Australia and the USA, olive oil is also made. Due to the identification of distinct polyphenol profiles even between different types of olive oil developed within a single country (Vossen, 2007), different olive oil varieties with different qualities exist. Unlike olives, olive oils have different characteristics and qualities. The legislation specifies olive oil characteristics and marketing criteria for both regulatory and producer
and consumer-friendly purposes. Overall, eight separate categories are classified within the EU, of which only four are available to consumers, including the following:

- Extra virgin olive oil
- Virgin olive oil
- Olive-pomace oil
- Blended olive oil

The following categories within the EU are not retailed:

- Refined olive oil
- Lampante olive oil
- Refined olive-pomace oil
- Crude olive-pomace oil (Ebeler et al., 2007)

Thanks to its perceived health benefits, olive oil's popularity has increased worldwide in recent decades. This is particularly true for extra virgin olive oil (EVOO). According to the legal definition by EC 1019/2002 of extra virgin olive oil, it is a superior form of olive oil obtained directly from the fruit of the olive tree by mechanical or other means only and according to the Fats and Oil Regulation of Sections 5 and 30 of the NAFDAC Act Cap N1 LFN 2004 and Section 12 of the Food, Drugs and Related Products Act Cap F33 LFN 2004, it contains no processed olive oil, it has superior sensory characteristics and consistency based on chemical composition of free acidity, expressed as oleic acid, of not more than 0.8 g per 100 g and whose other characteristics correspond to those applicable international standards for this category (NAFDAC, 2019). The easiness to adulterate EVOO, identification complexity, disparity between supply and demand, economic factors, as well as cultural and behavioural risk factor, and lack of control measures lead to EVOO's vulnerability to fraud. Three standard olive oil frauds have been reported: (a) mixing with other vegetable oils is the most common way (Jabeur et al., 2014), (b) replacing vegetable oil with added chemical compounds to mask adulteration (Roca et al., 2010), and (c) replacing EVOO with lower grades of olive oil. Refined olive oil (ROO) (Karbasian et al., 2015) and pomace olive oil (POO) (Škevin et al., 2011), as well as soft deodorized oils (Aparicio-Ruiz et al., 2017) may be included. Calvano et al., (2012) stated that the most important source of agricultural fraud in the EU is adulteration of EVOO. In some cases, particularly the processing and manufacturing method can be registered as a traditional specialty guaranteed (TSG).

1.3.2. VARIETY AND SPECIES

Food authenticity and traceability are important issues in our modern society as it can be deduced, for example, from past events involving the adulteration of meat products with non-declared species such as horse meat (Premanandh, 2013). It reflects the global demand of customers around the world to have accurate and reliable information about the food they eat. This is particularly true for processed meat
products where a simple visual inspection would not make it as easy to differentiate between the various components as in the case of intact fresh meat (Flores-Munguia et al., 2000). Of course, there are essential underlying reasons for this argument. Today, price and lifestyle will influence the individual's choice of food products depending on their composition, along with different religions or health concerns. An example is the Muslim community's growing interest in certifying the Halal status of the meat they consume in an evolving global meat market, and a number of reports on this topic have been published (Ali et al., 2012; Farouk, 2013; Nakyinsige et al., 2012). One example is the growing demand for conventional and/or regional meat products that customers view as high-quality, value-added foods (Montowska and Pospiech, 2012). To ensure food safety and preference for customers, honest and accurate food labelling is important. There is a provision in meat products to signify the quantity of each ingredient present in them, what is known as the QUID. The declaration sets out a new definition of meat for the proper marking of the drug. The definition limits the word “meat” to the skeletal muscle along with the connective tissue and fat content limitations. Excess fat and/or connective tissue cannot be treated as meat and must therefore be listed separately on the bottle. This also ensures that each animal species found in the commodity is stated and quantified separately. Moreover, mechanically recovered meat (MRM) and other parts of the carcass such as the liver, lung, heart, or tongue, for example, cannot be classified as meat and must also be defined separately (Zukal and Kormendy, 2007). The main areas vulnerable to fraud in the meat industry include: (a) the origin of meat and the animal feeding scheme (for example, in the case of approved regional products), (b) the substitution of meat ingredients with other animal species, tissues, fat or proteins, (c) the modification of meat product processing methods and (d) the addition of non-meat components such as water or additives (Ballin, 2010). Honey is the natural sweet substance from the nectar of plants or secretions of living parts of plants produced by honey bees. It could also be derived from excretions of plant-sucking insects on the living parts of plants that the bees collect, turn by combining with their own different substances, deposit, dehydrate, store, and leave to grow and develop in the honeycomb (CAC, 2001). Honey has long been a subject of adulteration as a natural product with a relatively high price (Bogdanov and Martin, 2002). Honey's credibility is of great importance both in terms of trade and wellbeing. It is difficult to detect adulteration in honey due to the large natural variability in honey due to differences in plant species, maturity, climate, processing and storage techniques (Sivakesava and Irudayaraj, 2002). Honey can be adulterated by adding foreign substances such as molasses, starch solution, glucose, sucrose, water and inverted sugar, or by modifying the physiochemical parameters (El-Bialee and Sorour, 2011). Of honey adulteration, the following sweeteners were used: acid-inverted syrups, maize syrups, naturally occurring syrups such as maple, cane sugar, beet sugar and molasses. On the other hand, the use of excess heat for pasteurization and liquefaction may adversely affect the quality of the honey, e.g. loss of volatile compounds and reduction of enzyme activity (Nasir et al., 2010). Honey harvesting with high humidity or subsequent addition of honey water can result in fermentation and spoilage of honey (Bogdanov and Martin, 2002).
Dairy products have high nutritional value and are widely consumed food groups for public nutrition, and ingredients for everyday use are also widely used in the food industry. Because of their great economic value, they are therefore one of the most frequently adulterated goods (Cattaneo and Holroyd, 2013; De La Fuente and Juarez, 2005). Buffalo, goat and ewe milk are used worldwide in conventional fermented dairy products such as Roquefort, Feta and Manchego cheeses, some mixed varieties in Austria, and Erzincan Tulum and Mihalik cheeses in Turkey (Mayer, 2005). Bovine milk is the most prevalent in the world for human consumption. However, particularly among children, cow milk allergy is very common (Ceballos et al., 2009). The composition of goat milk is similar to cow milk, but it lacks beta-carotene and agglutinin, has smaller fat globules and different types of casein, making it easier to digest (Ceballos et al., 2009). Furthermore, during heat treatments, goat's milk stability is lower than that of cow's milk (Montilla and Calvo, 1997; Karoui and Blecker, 2011). Goat milk production in many countries, especially in the Mediterranean region and the Middle East, is an important part of the national economy. It is particularly important in France, Italy, Spain and Greece, where goat milk and dairy products are traditional practices of great social, cultural and environmental significance (García et al., 2014; Zachar et al., 2011). Pure goat cheeses are considered to be specialties with very unique flavours and aromas that are well received on the Italian market. Goat milk and dairy products command much higher prices than cow's and sheep's milk in relation to the seasonality of production and naturally small milk production per animal (Golinelli et al., 2014). The fraudulent use of cheaper bovine milk during cheese production is common practice due to its excellent nutritional properties and higher commercial value. Goat by-product mislabelling, related mainly to the undeclared complete or partial substitution of goat's milk with cow's or sheep's milk, has been widely reported worldwide and is a major safety concern due to significant consumer protection consequences (Mašková and Pauličková, 2006). In addition, for reasons of intolerance or allergy, political, ethical or cultural objections, and legal requirements, it can become an issue (Agrimonti et al., 2015; López-Calleja et al., 2007; Van Hengel, 2007, Wal, 2004). Adulteration of roasted coffee that include the quality of beans, i.e. species, geographic origin, and defective beans, as well as the addition of other substances, i.e. coffee husks and stems, corn, barley, chicory, wheat middling, brown sugar, soybean, rye, triticale, and açai, to coffee blends to make them less expensive (Toci et al., 2016). Two varieties are economically and commercially important among the several species of the genus Coffea known so far: Coffea arabica (Arabica coffee) and Coffea canephora (Robusta coffee). Because of their superior flavour, Arabica beans are more popular than Robusta beans (Barbin et al., 2014). Although fresh coffee beans can be separated macroscopically or organoleptically, chemical analysis is required after roasting and grinding to detect the adulteration of Arabica beans with Robusta beans. The International Coffee Council (ICC) has released a document outlining a plan of action needed to implement a Coffee Quality-Improvement Program (CQP) for the control of coffee adulteration. CQP sets minimum requirements for exportable coffee, specifying that for Arabica, more than 86 defects per sample of 300 g and for Robusta, more than 150 defects per 300 g are not to be exported. The main concern about the
presence of ochratoxin A is likely. To this end, the Food and Agriculture Organization (FAO) has been named to audit a project aimed at eliminating or minimizing mould formation (Toci et al., 2016).

![Structure of Ochratoxin A](image)

**Figure 3: Structure of Ochratoxin A**

1.3.3. GEOGRAPHICAL ORIGIN

Consumer behaviour is geared towards a greater preference for goods whose geographical origin is stated as this knowledge clearly increases their trust when buying food. Due to its unique organoleptic properties, monosaturated fatty acid content and antioxidant properties, olive oil is a highly desirable food product on the international market (Bendini et al. 2007; Frankel, 2011). It is of utmost importance to maintain the consistency of these olive oils. The value of geographical declaration on the label is largely due to the fact that extra virgin olive oil (EVOO) is viewed by customers as an additional guarantee of their consistency and authenticity. For that purpose, a standard scheme of geographical indications such as Protected Designation of Origin (PDO) (EU, 2012) was adopted by the European Union (EU). In addition to the PDO information on the bottle, in the case of non-PDO oils, the user can also request information on the origin. The specific PDO and labelling regulations, however, do not prescribe an empirical method for checking the details recorded on the mark. This reality has given rise to the interest of analysts and researchers in developing a reliable authentication process. Following extensive research on the chemical characterization of olive oils from different locations, often even from the same cultivar, there are now enough chemical and mathematical histories to indicate that oils’ chemical compositions are partially correlated with their sources. A recent review summarizes the most interesting and innovative approaches (e.g., using optical techniques, measuring electrical characteristics, instruments equipped with electronic chemical sensors) with a potential and practical application to develop simple, easy-to-use, environmentally friendly instruments to track the geographical origin of virgin olive oil (Valli et al., 2016).

The ingredient that is of great interest to the commodity's provenance is honey. Honey is commonly pursued throughout the world. Nevertheless, it is necessary to ensure its innocuousness and validity in order to commercialize it. In this regard, the law of the European Union specifies that honey exported must be traceable over time (EU Directive 178/2002). This legislation is intended to prevent false claims of geographical and botanical origin that have occurred in the past due to a significant variance in the price of honey by origin (Camina et al., 2012; Dong et al., 2016). In general, traceability is stated in documents of the product life cycle that are obviously susceptible to fraud (Olsen and Borit, 2013). For this reason, it is important to back up traceability reports with more reliable information, such as analytical tests or product chemical data (Zhao et al., 2016; Soares et al., 2017). Because knowledge on the geographical
and botanical origin of honey is a guarantee of product quality, the ability to prove its origin is crucial for the acquisition and preservation of consumer niches (Mohammed et al., 2018). Historically, microscopic pollen inspection has been carried out to verify the botanical origin of honey (Louveaux et al., 1977; Jaafar et al., 2017), but this melissopalynological approach involves knowledge that can be expensive. Therefore, efforts have been made to define other honey criteria that can be implemented systematically in procedures for certification of origin. Chemometric knowledge has been one of the most effective methods (Soares et al., 2017). Such variables include physiochemical properties, mineral content (including trace elements), concentration of phenolic, flavonoid and volatile compounds, as well as details on the strength of honey absorption or reflection at different wavelengths, from visible to near infrared spectrum, among others (Camina et al., 2012; Cosonni and Cagliani, 2015; Bontempo et al., 2017; Laza et al., 2017). For example, Kropft et al., (2010) and Bontempo et al., (2017) used 13C and 15N in addition to other variables of chemical composition to differentiate between different honey floral sources. Therefore, to assess the honey authenticity for sugar adulteration, stable isotopes were used (Dong et al., 2018). Such information is then analysed to classify related honey groups using multivariate statistical methods such as discriminant analysis, logistic regression (LR) or neural network models (Camina et al., 2012). The model developed will later be used to assign a new sample of honey to one of these groups of origin.

1.3.4. GENUINNESS

The most obvious factor of authenticity is that it must be genuine (i.e. authentic) food product. Nevertheless, adulteration in the form of a mixture of a cheaper product is perhaps one of the most frequently encountered problems of food authenticity. In 2007, more than 60,000 false food cases were reported by the Xinhua News Agency; more than 15,500 tons of under-standard food were seized, and 180 food producers were listed as processing under-standard food or using inedible ingredients in food production (Veeck et al., 2010). Nevertheless, Lord et al., (2017) and Van Ruth et al., (2017) claim that food fraud is not only perpetrated by highly organized crime syndicates infiltrating food systems (Elliott, 2014; Europol, 2015), but can also be perpetrated by legitimate food chain actors who have access to a location where food fraud can be perpetrated and where criminal opportunities arise to participate in fraudulent activity. Coffee is one of the beverages with higher consumption worldwide, mainly due to its sensory and calming properties, along with enhanced awareness of potential health effects (Ludwig et al., 2014). However, it has been the subject of adulteration for decades due to the high commercial value of coffee, particularly Arabica coffee. In Brazil, the world's largest coffee manufacturer, with a high percentage of adulterated roasted coffee samples sold in the internal market, this is of particular concern (Domingues et al., 2014; Souto et al., 2015). Coffee adulteration can also impair the sensory properties and chemical composition of the beverage, in addition to being against regulations and consumer rights, thereby minimizing its beneficial health effects. The most popular coffee frauds include the introduction of lower commercial value roasted and ground vegetable items such as maize, barley, rye, wheat, and so on (Jham et al., 2007; Toci et al., 2016). Such products are distinct from coffee, making it possible to
differentiate them by physical and chemical characteristics, but the new frauds using coffee by-products, such as coffee husks and stems, pose an increased challenge for analytical chemists (Reis et al., 2013a; Toci et al., 2016). Milk is a rich source of nutrients including proteins, carbohydrates, vitamins and minerals, and the increased nutritional value of milk has led to higher worldwide consumption and production of milk and milk products (Nascimento et al., 2017). Nonetheless, due in part to this demand, milk powder is an adulteration product, ranking second to olive oil on food fraud and economic adulteration according to the USP database (Moore et al., 2012). Milk powder can be diluted and/or mixed with inexpensive, readily available, fairly odourless, colourless and tasteless substances to mask inferior quality, increase quantity, or substitute cheaper adulterants for economic gain for natural constituents (MacMahon et al., 2012; Nascimento et al., 2017). Sadly, milk powder is sometimes adversely affected by economically motivated adulteration (EMA). For starters, in two cases of milk and wheat gluten adulteration with nitrogen-rich melamine, EMA of food ingredients received worldwide attention. In 2007, co-contamination of a wheat gluten product with melamine and cyanuric acid induced renal failure associated with pet food in a number of cats and dogs in the US (Brown et al., 2007; Qin et al., 2013). In 2008, infant formula melamine adulteration in China resulted in thousands of cases of kidney infection, at least six confirmed deaths, and multi-country precipitation of mass product recalls (MacMahon et al., 2012; Qin et al., 2013; Xin and Stone, 2008). Widespread global attention to the melamine controversy, increased government agency controls, and the development of various analytical methods have reduced the risk of melamine events occurring (Draher et al., 2014; MacMahon et al., 2012; Turnipseed et al., 2008; FDA, 2017a, b, c). EMA of milk powder, however, remains a serious concern with many other nitrogen-rich adulterants.

The Food Safety Division of the Canadian Food Inspection Agency has compiled a list of potential economic adulterants based on the criteria for a potential milk powder adulterant (MacMahon et al., 2012). Combined with other information on intelligence, this list led the FDA to establish a targeted LC-MS system for six potential economic adulterants: dicyandiamide, urea, biuret, triuret, cyromazine and amidinourea (MacMahon et al., 2012). In addition, cyanuric acid (Draher et al., 2014), ammonium sulfate and aminotriazole are possible nitrogen-rich adulterants (DeVries et al., 2017; Finete et al., 2013). There are signs of falsified MP content due to the addition of plant proteins, according to studies from the European Union (Luykx et al., 2007; Maraboli et al., 2002; Scholl et al., 2014). Low prices and protein abundance, such as soybeans and peas, make them attractive in milk powder as possible adulterants. To change the physical characteristics of milk powder such as viscosity, taste, and nutrition, these plant protein isolates can be added. Overall, for commercial gain, EMA of these foreign proteins is not expected to occur at concentrations below 1% in milk powder (Haasnoot et al., 2001; Luykx et al., 2007). Ironically, melamine controversies have overshadowed the production of accurate analytical test methods for detecting EMA from milk powder products with plant proteins (Scholl et al., 2014). In addition, possible milk powder adulterants are polysaccharides / disaccharides such as starch, sucrose, and maltodextrin
To change the density and freezing point of the adulterated drug, these adulterants could be applied (de Almeida et al., 2012). EMA from these food additives is generally expected to range from 20% to 25% of total weight; however, rates suspected to be as high as 60% were suggested (Borin et al., 2016). Finally, certain inorganic salts, such as carbonates and bicarbonates, may be used as neutralizers to change the pH of poorly preserved milk to freshly transmit the processed milk (Handford et al., 2016).

1.3.5. SHELF LIFE

Under Regulation EC 1169/2011 (EU, 2011), the label of any product must signify the “use by date” or the “best before date”; this regulation also very clearly describes the distinction between these two phrases: the “best before date” is used in the case of foods which may undergo chemical, physical or sensory modifications without prejudice to the health of consumers, while the “use by date” is used in the case of foods which may undergo chemical, physical or sensory modifications that poses a health risk to consumers. From a scientific and technological viewpoint, these dates are considered “shelf life” (McGinn, 1982), which is a very important aspect for business management (Stone and Sidel, 2004). Under Regulation 11 of Sections 5 and 30 of the National Agency for Food and Drug Administration and Control Act Cap N1 Laws of the Federation of Nigeria (LFN) 2004 of the Governing Council of NAFDAC on the 2019 date labelling of pre-packaged food, water and ice labelling, all pre-packaged foods shall indicate and display on the label the day, month and year of manufacture. To ensure the safety and quality of a food to be consumed before a certain date, the “use by date” or “expiration date” must be declared and “the best before date” or “best quality before date” must be declared when such phrases are not needed (NAFDAC, 2019). Those requirements ensure that the product is safe for use over a period of time and that the product typically meets reasonable sensory standards including freshness, texture, and taste.

1.3.6. LABELLING

While food fraud is hardly a new phenomenon (Shears, 2010), food authenticity and food label veracity are currently major concerns for many, including academics, consumers, regulators, and the food industry at all levels of the food spectrum. Food theft dates back as far as the Greek and Roman Empires, but in recent years, exposure to better technology has made it possible for people to recognize flaws in food distribution (Charlebois and Haratifar, 2015). An authentic finished food product must comply with labelling regulations, particularly with regard to composition of ingredients, manufacturing processes and procedures, technology and genetic identification. In view of the European horsemeat crisis, mislabelling has now become a much larger issue in modern society, and violations can occur on a very large scale (Falkheimer and Heide, 2015; Le Vallée and Charlebois, 2015). The growing number of cases of food fraud can be due in part to the increase in world trade and new emerging markets as well as the steady rise in food prices around the world (DeKeiffer, 2006; Holbrook, 2013). Both producers and distributors are often tempted to substitute ingredients or products in order to reach the appropriate price level for an
intended market (Charlebois and Haratifar, 2015). The scarcity of resources, the opportunity for higher profits, and insufficient regulation have all facilitated inaccurate labelling, which often leads to consumer fraud. Many food groups were more affected than others. Fish and seafood products are the most documented cases in the food industry (Jacquet and Pauly, 2008; Leal et al., 2015). For example, on the basis of species substitution, DNA analysis of hake products marketed in southern Europe has shown more than 30% mislabelling (Garcia-Vasquez et al., 2011). However, other groups have also been identified in previous years. In meat, a previous study reported a high 57 percent substitution rate and, subsequently, significant discord with label details (Di Pinto et al., 2015). A study involving chicken sausages found similar results (Bottaro et al., 2014). Obviously, this poses important issues of food safety and consumer protection. Mislabelling can also impact marketability and brand equity. Food fraud has been argued to affect the security of an area or country's intellectual property and may hamper innovation by displacing legitimate sales (Qian, 2014). Mislabelling can potentially affect a region's or even a country's brand image. With regard to the assessment of knowledge on food labels, several past studies have already examined the interaction between customers, industry and regulators. Nocella et al. (2014) concluded that trust in food knowledge disseminated by public regulators is greater than that commonly found in industry. Researchers also say that conduct directly affects the ability of public and private providers to pay for reliable food information. Nonetheless, a few studies have investigated how information would be interpreted in an atmosphere in which customers could determine the validity of information given to them. Kjærnes (2012) notes that continuing changes in food systems are that the powerlessness of consumers, and consumers may not feel in control of their own purchases. It's hard, if not difficult, for customers to know where their food comes from with high accuracy. Food labels are a primary communication tool for industry, regulators, and customers (Charlebois and Summan, 2015).

It can be argued that falsified or counterfeited food products will reduce the symbolic value of authentic goods and dilute a region's brand and country of origin. Counterfeits are reproductions or replacements that are closely similar or identical to authentic food products. These provide packaging, marking, and trademarks that are passed as the original product. This act may or may not be deliberate as it is always difficult to understand the extent of adulteration in the supply chain. Many customers will purchase counterfeit food products unknowingly and unwittingly because they are closely similar to the genuine product. It has been recognized that mislabelling can be present in various forms as well as at any point of the supply chain (Meloni et al., 2015). The list of ingredients may stay the same on labels as unreported substitutes are made during the production process or the country of origin may have been modified to promote local goods or a region, despite having a different origin. Ingredients such as allergens may also be considered mislabelling. Industry at various levels of the food supply chain exercises stringent protocols to ensure that the information given to customers about the sources, make and conditions of production is in line with the standards and regulations of consumers. Considering how complex food systems are, breaches of confidence between organizations are possible and require higher levels of scrutiny. It is also
known that food authorities play a role in controlling the quality of food labels. While some countries routinely proactively analyse labels, others respond to complaints from customers. When consumers are expected to learn more about food and how food is produced and distributed, regulators are trying to monitor and implement existing legislation (Barker et al., 2011). Consumers often agree that it is the industry's duty to market food products with clear labelling. Both food systems, policies and market dimensions have a profound impact on consumer confidence (Ringsberg, 2015). Of course, what's hanging in the balance is consumer confidence. Although there is broad consensus on the interrelationship between consumer confidence and food purchasing, there is little or no general agreement within the social sciences on how to conceptualize faith in food buying space (Chen, 2013). Research shows that consumers are particularly concerned about food safety and label accuracy (Drescher et al., 2012; Zhou and Hui, 2003). Consumers need to be convinced that food label knowledge truly defines the items they want to purchase in grocery stores. Understandable concerns regarding deception, fraud, and uncertainty have resulted in mistrust and increased government traceability regulation (Gutman, 1999). Consumers’ trust could potentially erode overtime by accumulating explosive cases of food fraud (Charlebois et al., 2014). Since allegations of food fraud have proliferated, whether organic, kosher, halal or other product types are mislabeled, many customers have expressed doubts about the authenticity of food labels (Conrad, 2009). Nevertheless, research on where buyers have become more cynical about brands in the world is not definitive.

1.4. Legal Framework

The National Agency for Food and Drug Administration and Control (NAFDAC) is the regulatory agency in Nigeria with the mandate to regulate and control the manufacture, importation, exportation, distribution, advertisement, sale and use of food, drugs, cosmetics, medical devices, packaged water, chemicals and detergents which is collectively known as regulated products and it is the lead agency for food safety and quality. In relation to food authenticity, According to sections 5 and 30 of the NAFDAC Act Cap NI Laws of the Federation of Nigeria (LFN) 2004 on pre-packaged food, water and ice labelling regulations 2019, Regulation 5 of this act specifically prohibits any labelling, presentation and advertisement of pre-packaged food to be “false, misleading, deceptive or likely to create an erroneous impression regarding its identity, character, quality, quantity, composition or origin” (NAFDAC Act Cap NI LFN 2004 Regulation 5, Section 1a). This act also prescribes the minimum required information needed to be included in food labelling:

- The name of the food (Regulation 3, Section 1 - 6).
- The brand or trade name (Regulation 4, Section 1 - 2).
- List of ingredients (Regulation 6, Section 1 - 12).
- The net content of pre-packaged food (Regulation 8, Section 1 - 4).
The main purpose of this act is to ensure that information on labelling and advertisements of food products in Nigeria is accurate, clear and designed to promote credibility and trust by the general public and to protect consumers from misrepresentation of food products either directly, indirectly or by implication which can influence the consumer behaviour towards the purchase of a food product (NAFDAC, 2019).

1.5. ANALYTICAL METHODS FOR THE DETECTION OF FOOD FRAUD

There has been a range of different detection methods developed and used in the determination of the authenticity of food. In a review by Reid et al., (2006), many methods of detection were scrutinised including spectroscopy (UV, NIR, MIR, Raman), isotopic analysis, chromatography, electronic nose, polymerase chain reaction, enzyme-linked immunosorbent assay and thermal analysis – all of which are techniques that have been applied to food authentication since 2001 and will be discussed below.

1.5.1. CHROMATOGRAPHIC TECHNIQUES

Chromatographic techniques in their various forms are amongst the important methods used in food analysis. The term “chromatography” encompasses techniques based on adsorption and/or partition of analytes between a mobile and a stationary phase. They are usually classified according to the character of the stationary and mobile phases, the form of the stationary phase and the driving forces of separation (Forgács and Cserháti, 2003). Chromatographic techniques provide rapid and reliable separation of chemically similar compounds in complex food matrices (Cserháti et al., 2005). Thus, gas chromatography (GC), either performed as gas-liquid chromatography (GLC) or gas-solid chromatography (GSC), represents a method where the mobile phase is gaseous. In liquid chromatography (LC), usually referred to as high-performance liquid chromatography (HPLC), the solid stationary phase is applied in a column and the mobile phase is pumped through the column. Thin-layer chromatography (TLC) systems consist of a planar solid phase and a liquid mobile phase. Owning to the superior capability of GC and HPLC, the latter technique has only rarely been used for authentication purposes for example, in differentiating...
between authentic and adulterated Noni (Morinda citrifolia L.) juices (Lachenmier et al., 2006) and fingerprinting of flavonoids and saponins from Passiflora species (Birk et al., 2005).

1.5.1.1. GAS CHROMATOGRAPHY (GC)

Gas chromatography (GC) is a common type of chromatography used in analytical chemistry for separating and analysing compounds that can be vaporised without decomposition. In gas chromatography, the mobile phase (or moving phase) is a carrier gas, usually an inert gas which moves through a column which is packed with the stationary phase. The mobile phase flows through the column at a set rate. Depending on the affinity of the component to the stationary phase, the sample components will travel through the column at different rates and are separated. For analytes to be determined by gas chromatography, they need to be easily vaporized without being decomposed. Therefore, volatile food constituents such as aromatic compounds are particularly suitable candidates for GC analysis, mostly in combination with mass spectrometric detection. According to a review published by Cordella et al., (2002), GC-MS coupling is the most widely used technique (>50%), followed by GC coupled to other types of detectors. GC has found wide application in food authentication studies in dairy products such as milk (Li et al., 2009; Molkentin and Giesemann, 2007), herb and spice (Ma et al., 2015; Bononi et al., 2010; Wielogorska et al., 2018), and as quality markers of cocoa beans (Caligiani et al., 2007) and beer (Erbe and Bruckner, 2000; Junge et al., 2007).

![Figure 4: Picture showing a GC-MS instrument](image)

1.5.1.2. HIGH-PERFORMANCE LIQUID CHROMATOGRAPHY (HPLC)

High-performance liquid chromatography (HPLC) is one of the most versatile analytical techniques and is extremely widely used in food authentication, as both polar and non-polar compounds can be analysed. In normal phase, HPLC polar stationary phases are used and the analytes separated using non-polar mobile phases, whereas reversed-phase (RP) HPLC is characterized by hydrophobic stationary phases e.g. C18 or C8, and polar eluents. The application of HPLC has been successfully used in detecting triacylglycerols and fatty acids in vegetable oils (Lee et al., 2001; Marikkar et al., 2005; Kamm et al., 2001). It is also a
good tool for analysis of triacylglycerols and tocopherol (Gonzáles et al., 2001; Segall et al., 2005b) or phenolic acids (Andrade et al., 1997), which are present in coffee. HPLC has also been reported to be effective in dairy products authenticity (Simpkins and Harrison, 1995; De la Fuente and Juárez, 2005; Karoui and Baerdemaeker, 2007) and in the analysis of several fractions of milk proteins, such as casein (Veloso et al., 2002, 2004; Mayer et al., 1997; Mayer, 2005) and/or β-lactoglobulins (Ferreira and Caçote, 2003; Enne et al., 2005) or furosine, which comes from the fructolysine complex at the beginning of the Maillard reaction during heat treatment of milk.

![HPLC instrument](image)

**Figure 5:** Picture showing a HPLC instrument

### 1.5.2. SPECTROSCOPIC TECHNIQUES

Most spectroscopic techniques used in food authentication and fraud detection are based on near infrared (NIR), mid infrared (MIR), Fourier transform infrared (FTIR), Raman or nuclear magnetic resonance (NMR) spectroscopy as well as ultra-violet visible (UV-Vis) and fluorescence spectroscopies. They are frequently combined with chemometrics, which is a chemical discipline that uses mathematical and statistical methods to provide maximum chemical information by analysing chemical data (Leardi, 2003). The choice of methods depends mainly on the chemical nature and the physical state of the sample, prior knowledge and the timescale required for results (Belton, 2000). Other issues that need to be considered are the costs of obtaining and running the analytical equipment and the specificity of the measurement.
1.5.2.1. **ULTRA-VIOLET VISIBLE (UV-Vis) SPECTROSCOPY**

UV-Vis spectroscopy is one of the most widely used techniques for measuring amounts of absorbing species in food analysis. The main advantages of this technique include ease of operation, the ability to determine a wide range of compounds in a non-destructive manner, good sensitivity and accuracy, and moderate selectivity. The principle of quantitative analysis with this technique is Beer’s law, based on which the concentration of an analyte dissolved in a solvent will be proportional to the amount of light it absorbs. A large number of spectrophotometric and fluorometric methods have been developed to characterize a variety of food products such as cheese, milk and honey for substances such as peptides, amino acids, fatty acids, sugars, vitamins or mineral elements (Cordella et al., 2002). UV-Vis spectroscopy has found useful application in authentication studies. In a study by Mignani et al., (2010) to discriminate high-quality extra virgin olive oils from adulterated samples containing lower-grade olive oils commonly used in commercial counterfeits, the oil samples were analysed with a set-up based on optical fibre technology and diffuse-light absorption spectroscopy over the wavelength range of 400-1700 nm. Spectroscopic data were subjected to PLS regression in order to quantify adulterant concentrations, and PCA and LDA were subsequent used to identify the type of adulterant used.

Mignani et al., (2010) also used a fibre-optic setup for diffuse-light absorption spectroscopy over the range of 400-1700 nm in order to detect and quantify adulteration of extra virgin olive oil with lower-grade olive oil. Absorption measurements provided spectral fingerprints of authentic and adulterated oils that were successfully analysed with multivariate methods to identify the type of adulterant used and predict its proportion in the adulterated oil. Alamprese et al., 2013 investigated the potential of UV-Vis, NIR and MIR spectroscopies in combination with multivariate data analysis methods for detecting minced beef adulteration with turkey meat. The spectral data for minced meat samples from pure bovine, pure turkey and mixtures of minced beef adulterated with turkey meat in proportions of 5 to 50% (w/w) were analysed by PCA, LDA and PLS regression. A variable selection method was used before classification and regression, and the NIR, MIR and UV-Vis spectroscopy results were compared. Using a combination of UV-Vis, NIR and MIR data was found to improve model performance for both qualitative analyses.

Dankowska et al., (2017) evaluated the potential of fluorescence and UV-Vis spectroscopies for quantifying roasted Coffea arabica and Coffea canephora var. robusta in coffee blends. They assessed the classifying ability of LDA as applied to fluorescence and UV spectral data for samples of the two types of coffee and their mixtures. PCA-LDA analysis performed best when applied to a combination of UV and fluorescence data. LDA exhibited an average sensitivity of 96% for the test set and 100% for the training set. The results showed that fluorescence and UV-Vis spectroscopy had a complementary effect on the quantification of roasted Coffea arabica and Coffea canephora var. robusta in blends.
1.5.2.2. FLUORESCENCE SPECTROSCOPY

Fluorescence spectroscopy provides a fast, sensitive, selective analytical tool for extracting nutritional, functional and compositional information that can be used as a fingerprint for foodstuffs such as dairy products, fish, edible oils and wines. The use of this technique for food characterisation and authentication has grown steadily over the past decade, probably as a result of its potential being enhanced by chemometrics (Sádecká and Tóthová, 2007). Characterisation and classification of different food products such as dairy products, meat, egg, fish, wine, honey and edible oils based on different chemometric methods such as principal component analysis (PCA), hierarchical cluster analysis, k-nearest neighbours, partial least squares (PLS), linear discriminant analysis (LDA) and parallel factor analysis (PARAFAC) have been reported. Dankowska et al., (2015) investigated the potential of fluorescence spectroscopy for the detection and quantification of butter adulteration with palm and coconut oils. Fluorescence spectral data over the range of 240-700 nm were obtained at 10, 30, 60 and 80 nm intervals of which 60 nm provided the lowest limits of detection of adulteration (LOD, 5.5%). MLR models allowed adulteration to be detected with RMSEC and RMSEV of 3.8 and 3.9% respectively. Ruoff et al., (2005) applied front-face fluorescence spectroscopy to honey samples for the authentication of unifloral and multifloral honey types that were previously classified by using traditional methods such as chemical, pollen and sensory analysis. Spectral data were subjected to PCA and LDA. Based on the results, front-face fluorescence spectroscopy was effective for authenticating the botanical origin of honey and identifying geographical origin within the same unifloral honey type.

1.5.2.3. INFRARED SPECTROSCOPY (IR)

Infrared spectroscopic methods operate in various electromagnetic wavelength regions including near-infrared (NIR, 14,000-4000 cm⁻¹), mid-infrared (MIR, 4000-400 cm⁻¹) and far infrared (400-50 cm⁻¹). Only the MIR and NIR regions are typically used for food authentication, however. IR spectroscopy has become an attractive, flexible research tool on account of its ease of operation and little sample preparation required (Abbas et al., 2012; Rodriguez-Saona and Allendorf, 2011). Also, the high sensitivity and specificity of IR spectroscopy has enabled its use as a fingerprint generator in food analysis. NIR spectroscopy is based on the absorption of electromagnetic radiation at wavelengths over the range of 780-2500 nm. NIR bands arise from molecular overtones and combinations of vibrational modes (Stuart, 2004). Mid-infrared (MIR) spectroscopy (4000-400 cm⁻¹) is based on real-time monitoring of the vibrations of functional groups and associated rotational-vibrational effects. Infrared spectroscopic methods provide simple, expeditious, inexpensive tools for preliminary sample screening in routine authentication analyses. NIR spectroscopy is particularly promising in this respect by virtue of its expeditiousness, accuracy and ability to provide spectra for solid and liquid samples with no need for prior manipulation (Blanco and Villarroya, 2002). Raman spectroscopy is a non-destructive measurement technique based on Raman scattering of light from molecules, which results in shifted energy frequencies.
Raman signals result from inelastic scattering of light samples, the resulting frequency shift containing information about the vibrational modes involved (Craig et al., 2013; Larkin and Larkin, 2011). Raman spectroscopy encompasses Fourier transform (FT) Raman spectroscopy, dispersive Raman spectroscopy, spatially offset Raman spectroscopy (SORS) and surface-enhanced Raman spectroscopy (SERS). The ensuing spectra can provide a fingerprint of a particular substance that is useful for analysing compounds present in different samples; also, they provide the basis for structural and qualitative analyses (Yang and Ying, 2011).

NIR, Raman and, mainly, MIR spectroscopy have been used to develop simple, fast methods for authentication, quality control and adulteration detection in a variety of food products. Zhao et al., (2015) used dispersive Raman spectroscopy in combination with multivariate data analysis to detect adulteration of comminuted meat products with beef offal (kidney, liver, heart and lung). Georgouli et al., (2017) proposed a method based on FTIR and Raman fingerprinting coupled with a novel dimension reduction method for identifying adulterants such as hazelnut oil in extra virgin olive oil. Hussain et al., (2014) examined the feasibility of discriminating pure canola oil from samples adulterated with palm oil by using NIR spectroscopy coupled with multivariate analysis. Using LDA allowed adulterated samples to be detected with an overall accuracy of 100% at a lowest detection level of 3.23%.

1.5.2.4. NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY (NMR)

NMR-based metabolomics has proved to be an efficient method for authenticating food from raw materials to end-product for quality control and the tracing of fraudulent labelling. Also, as shown by extensive research, NMR spectroscopy has proved advantageous for the analysis of olive oil and a useful tool for assessing its quality and authenticity. The two methodological approaches to metabolomics (viz., metabolic profiling and metabolic fingerprinting), and multivariate analysis methods for food authentication, have proved effective in this field (Dais and Hatzakis, 2013). In the past decade, NMR spectroscopy has been successfully used to analyse various types of edible oils for quality and authenticity. Thus, Kim et al., (2015) confirmed the authenticity of sesame oils by using a combination of 1H-NMR spectra and fatty acid profiles for the oils. Based on the results, the proposed method allowed the authenticity of the samples to be accurately verified. The NMR spectrum can provide an informative “fingerprint” for various agricultural products; in fact, it contains useful information about variety and origin for classification purposes for example, Rezzi et al., (2005) used 1H-NMR fingerprinting of olive oil from various Mediterranean areas to specify their geographical origin and year of production. Hohmann et al., (2014) used 1H-NMR to authenticate organically produced tomatoes (Solanum lycopersicum). They analysed tomato samples of two different cultivars from four different producers over a seven-month period. PCA afforded differentiation between organically and conventionally produced tomatoes. Also, LDA revealed significant differences between growing regimes and external validation confirmed 100% accuracy in the classification of tomato samples.
1.5.3. STABLE ISOTOPE ANALYSIS

Of the many techniques available to aid in authenticity and traceability testing, the most widely used method is isotope ratio mass spectrometry (IRMS). The reasons for this are the high accuracy method, the small amount of sample required for analysis and the fact that the same technique can be used for almost any type of food or beverage and the results are generally not altered by the production technique. Stable isotope analysis has been used in food control, since around 1975, to detect adulteration of products like wine, honey, fruit juice, or maple syrup with cheaper extenders, such as sugar syrup made from maize or cane carbohydrates, industrially produced acids, or simply water (Rossmann, 2001). These “traditional” applications of stable isotope analysis in food control rely on the measurement of the isotopic ratio of only one or two elements (13C/12C and 18O/16O, 13C/12C and D/H). This can confirm if a certain component of a food material was a non-natural (exogenous) additive from other plants or industrial production. More recently, other applications based on multi-isotope ratio analysis (2H/1H or D/H, 13C/12C, 18O/16O, 15N/14N, 34S/32S, 87Sr/86Sr) have included geographical origin verification studies of olive oil (Camin et al., 2010), orange fruit (Rummel et al., 2010), honey (Schellenberg et al., 2010), cereals (Goitom Asfaha et al., 2011; Luo et al., 2015), tomato (Bontempo et al., 2011; Trinchieri et al., 2014), Chinese cabbages (Bong et al., 2012), animal products (Rees et al., 2016; Vinci et al., 2013) and feeds (Nietner et al., 2014), seafood (Kim et al., 2015), and coffee (Santato et al., 2012).

1.5.4. DNA-BASED METHODS

DNA-based techniques have been highlighted for the authentication of processed foods, owing to their sensitivity and accuracy regardless of growing condition, harvesting period, and manufacturing process. Real-time PCR, a more recently developed technique, can detect multiple species from a mixture and quantify the amount of PCR products formed during the amplification process (Arya et al., 2005).
Moreover, its reliability, sensitivity, specificity and rapidity are suitable for the development of advanced detection methods to regulate EMA foods and food allergens. Real-time PCR systems have been previously used for the authentication of various foods including meat products, seafood products, dairy products, spices and dietary supplements (Amaral et al., 2017; Di Pinto et al., 2000; Kang, 2018a, 2018b; Kang and Tanaka, 2018; Kim et al., 2017; Kim et al., 2018; Taboada et al., 2017; Velasco et al., 2013), as well as for the detection and quantification of allergenic foods including soybean, lupines, nuts, crustaceans, and fish (Costa et al., 2017; Eischeid and Stadig, 2018; Fernandes et al., 2018; Garino et al., 2016; Herrero et al., 2014; Villa et al., 2018).

1.5.5. EXAMPLES OF SPECTRAL DATA FOR VARIOUS FOOD PRODUCTS

Coffee: NMR spectroscopy was used to verify the presence of Arabica and Robusta species in coffee. Lipophilic extracts of authentic roasted and green coffees showed the presence of established markers for Robusta (16-O-methylcafestol (16-OMC)) and for Arabica (kahweol). The integration of the 16-OMC signal (δ 3.165 ppm) was used to estimate the amount of Robusta in coffee blends with an approximate limit of detection of 1–3% (Monakhova et al., 2015).

![Figure 7: $^1$H NMR spectra in the region of the 16-OMC signal in experimental Arabica/Robusta mixtures with 0–7% of Robusta content](image)

![Figure 8: $^1$H NMR spectrum of typical Robusta and Arabica coffees (roasted coffee, lipophilic extracts). The following signals are marked: 16-OMC (a), caffeine (b), triglycerides (c), kahweol (d).](image)
Honey: The detection of the most common adulterations and quality deviations in honey were reported by Spiteri et al., (2015). Also using 1H NMR profiling coupled with chemometric procedures, labelling verification of monofloral and multifloral honey types was possible. With spiking experiments (i.e. addition of pure compound into authentic food matrices), the authors showed that sugar addition down to 10% levels is detectable. In combination with chemometric procedures, quantification of regulated parameters such as glucose, fructose, sucrose and hydroxymethylfurfural is possible within the same NMR-experiment.

Cheese: FT-Raman spectroscopy was explored to evaluate spreadable cheese samples. A partial least squares discriminant analysis was employed to identify the spreadable cheese samples containing starch. To build the models, two types of samples were used: commercial samples and samples manufactured in local industries. The method of supervised classification PLS-DA was employed to classify the samples as adulterated or without starch. Multivariate regression was performed using the partial least squares method to quantify the starch in the spreadable cheese. The limit of detection obtained for the model was 0.34% (w/w) and the limit of quantification was 1.14% (w/w). The reliability of the models was evaluated.
by determining the confidence interval, which was calculated using the bootstrap re-sampling technique (de Sá Oliveira et al., 2016).

![FT-Raman spectra of: (a) skimmed and (b) whole spreadable cheese](image)

**Figure 11:** FT-Raman spectra of: (a) skimmed and (b) whole spreadable cheese

![FT-Raman spectra of: (a) standard spreadable cheese, (b) 2% (w/w) starch, (c) 6% (w/w) starch, (d) 10% (w/w) starch and (e) pure starch.](image)

**Figure 12:** FT-Raman spectra of: (a) standard spreadable cheese, (b) 2% (w/w) starch, (c) 6% (w/w) starch, (d) 10% (w/w) starch and (e) pure starch.

### 1.6. SUSTAINABLE DEVELOPMENT GOALS (SDGS): AN OVERVIEW

Historically, the idea of sustainable development (SD) was introduced in a paper called “Our Common Future” by the UN Commission on Environment and Development (Brundtland Commission) report. This definition promotes the need for growth to meet the needs of the present generation without undermining the capacity of the future generation to meet their own needs (Brundtland et al., 1987). Nevertheless, one of the key sustainability issues, according to Govindan et al., (2013) is to operationalize the Brundtland Commission recommendations to guide organizational decisions. Sustainable Development's new principles are becoming more and more relevant than they were two decades ago because it goes beyond purely environmental, economic and social development issues and affects the very life of people (Kumi et al., 2014). There is a need for science to support politics in this sense, as well as coping with demands from the government and various shareholders when they are faced with the task of achieving sustainable development (Aricò, 2014). The idea of creating the SDGs originated at the 2012 Rio+20 United Nations Summit in which Member States decided to adopt a set of guidelines for global development with a view to growing the benchmark for developing countries and disadvantaged
communities (Gupta and Vegelin, 2016), as well as building a stronger commitment to human-centred growth, human rights and environmental sustainability. The Sustainable Development Goals were set through a series of measurable goals and required a great deal of global cooperation and commitment at several levels when it came to monitoring, which is sadly seldom even feasible (Giupponi and Gain, 2016). The Rio+20 Conference endorsed a mechanism in its final document, “The Future We Want”, while rejecting several others, in order to negotiate a consensus on the Sustainable Development Goals (UN, 2012). Consequently, the outcome of Rio+20 was structured in many respects to be qualitatively different from the Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs) aimed at being more responsive to a variety of stakeholders at multiple levels of governance (Gellers, 2016). Following “The Future We Want”, the UN document “Transforming Our World: The Sustainable Development Agenda 2030” contains a declaration of the 17 SDGs and 169 targets, as well as monitoring and assessment mechanisms (Gupta and Vegelin, 2016). The Sustainable Development Goals were developed through a comprehensive participatory mechanism and progressed through high-level committees such as “Open Working Groups” (OWG) along with various inquiries until the Heads of State finally approved a negotiated agreement. Five key areas have been identified by the Heads of State or the Five Ps of the 2030 SDG Agenda, which are people, planet, prosperity, peace, and partnerships (Jayasooria, 2016). As Aitsi-Selmi et al., (2016) reports, 193 countries agreed on the Sustainable Development Goals, predecessors of the Millennium Development Goals, in September 2015 in New York, USA, focusing on an extremely comprehensive set of development goals. The Sustainable Development Goals outlined sensitivities to weaknesses created by gender, age, and disabilities when it comes to losses and disasters. Nevertheless, like the MDGs, the SDGs do not include, in an ecological sense, a particular and consistent goal relevant to world population growth and the new targets for 2030 (Bergaglio, 2016). Subsequently, the SDGs have the ability to mobilize academic groups and social movements around them to seek structural reform and responsibility for those who carry out the objectives. Therefore, they may be reinforced by the commitment to equitable standards of growth towards all stakeholders concerned (Gupta and Vegelin, 2016). To this end, it is the primary responsibility of each government, state or country to mobilize and collect financial resources, which in turn would promote new partnerships between the private sector and civil society (Jayasooria, 2016). According to Stafford-Smith et al., (2016), the SDGs’ objectives established an agenda for the sustainable development of all nations that adhered to economic growth, social inclusion and protection of the environment and includes:

- Goal 1: No poverty
- Goal 2: Zero hunger
- Goal 3: Good health and well being
- Goal 4: Quality education
- Goal 5: Gender equality
- Goal 6: Clean water and sanitation
• Goal 7: Affordable and clean energy
• Goal 8: Decent work and economic growth
• Goal 9: Industry, innovation and infrastructure
• Goal 10: Reduced inequalities
• Goal 11: Sustainable cities and communities
• Goal 12: Responsible consumption and production
• Goal 13: Climate action
• Goal 14: Life below water
• Goal 15: Life on land
• Goal 16: Peace, justice and strong institutions
• Goal 17: Partnerships for the goals

1.7. NIGERIA: AN OVERVIEW

Nigeria, officially the Federal Republic of Nigeria, is a country in West Africa, bordering Niger in the north, Chad in the northeast, Cameroon in the east and Benin in the west. Its coast in the south is located on the Gulf of Guinea in the Atlantic Ocean. It comprises of 36 states and 1 Federal Capital Territory, where the capital Abuja, is located and 774 local government areas. The states are grouped into six distinct geopolitical zones – North Central, North East, North West, South East, South South and South West (Figure 1). Nigeria is often referred to as the ‘Giant of Africa’, owing to its large population and economy. The current population of Nigeria is 202 million based on the latest United Nations data (Worldometers, 2019), ranking Nigeria as the most populous country in Africa and the seventh most populous country in the World. Nigeria has a total area of 923,768 km2 (356,669 sq. mi), making it the world’s 32nd largest country. It is comparable in size to Venezuela, and is about twice the size of the US state of California. Its borders span 4,047 kilometres (2,515 mi), and it shares borders with Benin (773 km or 480 mi), Niger (1,
497 km or 930 mi), Chad (87 km or 54 mi) and Cameroon (1,690 km or 1,050 mi). Its coastline is least 853 km (530 mi).

**Figure 14:** Map of Nigeria showing the six geopolitical zones

Nigeria has been a developing economy with her economic growth being unstable, unpredictable and unsatisfactorily low in recent years especially when compared with some other nations of the world (Machi, 2011). As the largest exporter of oil in Africa and an oil dependent economy, the country has witnessed many oil prices shocks and disturbances over the years due to oil price volatility in the international market. The oil price has been fluctuating since the 1980s and the 1990s due to activities of the world powers in the global market. Apart from the incessant drop in the price of oil in the past, the recent notable one was the drastic fall of the oil price from $112 per barrel in 2014 to almost $38 per barrel as at the end of 2015 due to the incessant and massive supply of Shale oil by the United States to the global market (British Petroleum Statistical Review of World Energy, 2017). In 2014, according to International Energy Agency (IEA, 2015), Nigeria earned $77 billion from oil export. However, with the fall in oil price in 2015, Nigeria’s oil revenue fell to $41.33 billion (OPEC Annual Statistical Bulletin, 2016). By implication, the fall in oil price in the global market implies fall in the revenue accruing to the Nigerian economy and difficulties in achieving a sustainable level of growth. The reason being that over 80 percent of the government revenue comes from oil export. In addition, the monolithic nature of the Nigerian economy since the start of oil exploration in the 1970s has been persistently threatened by the fluctuation in oil prices. This has made the government to come to terms with the growing need for economic diversification from oil to non-oil economy. In the 1960s, prior to the discovery of oil, more than 70% of the rural population of Nigeria engaged in one type of agricultural activity or the other and between 1963 and 1964, the non-oil sector contributed as much as 65% to the Nation’s Gross Domestic Product (GDP) (Yesufu, 1996). However, the oil boom of 1973/74 changed the economic environment drastically as the windfall from oil boom around this time had a pervasive effect on the Nigerian economy even till the early
1980s. The shocks nevertheless, slowed-down the economic activity and as a result caused severe fiscal imbalances for Nigeria and oil revenues decreased drastically (Audu, 2012). The over reliance on the exogenous and volatile nature of oil revenue led the Nigeria government to make structural changes in order to look into alternative means of financing the economy by reconsidering the non-oil sector that had been neglected in the past due to oil exploration (Edame and Efejiom, 2013). After decades of neglect, the Federal Government of Nigeria began to reform the agricultural sector in 2011 following strategic direction laid out in the Agricultural Transformation Agenda (ATA) of the Federal Ministry of Agriculture and Rural Development (FMARD) (FMARD, 2016). The ATA’s core purpose was to help Nigeria to refocus federal government policymaker attention to agriculture, and the strategy’s main goal was to rebuild the agricultural sector (FMARD, 2016). The current development strategy of the agricultural sector – denoted the Agriculture Promotion Policy (APP) – builds on and refines the strategic direction of the ATA. The APP was launched in 2016 and applies for the five-year period lasting until 2020. It aims at addressing two key challenges of Nigeria’s agriculture: (1) to meet the food needs of a rapidly growing population with domestically produced food; and (2) to transform the agricultural sector so that Nigeria becomes a successful exporter of agricultural products complying with international quality standards (FMARD, 2016). Thus, agricultural transformation has been at the centre of Nigeria’s agricultural development policy plan since the beginning of the 2010s. Yet, despite its vast agricultural potential, Nigeria imports food – mostly staple foods – worth billions of dollars annually. Many Nigerians and even a large proportion among the farming population lack adequate food for a healthy diet and suffer from malnutrition.

1.8. AIMS AND OBJECTIVES

The aims and objectives of this research project is to carry out an investigative study on the challenges of food fraud in Nigeria, identifying the risks and proposing solutions. At the end, this research project will seek to determine the following key areas:

- To address the level of food fraud and its impact in attaining sustainable economic growth in Nigeria.
- To identify lack of food policies and national control systems that will enforce regulations in tackling food fraud in Nigeria.
- To identify how regulatory and government agencies can promote food safety that will enhance good health and wellbeing among consumers in Nigeria.
- To propose measures that regulatory and government agencies in Nigeria can adopt in preventing food fraud.
2. METHODOLOGY

2.1. Data Collection

An internet search was conducted using food fraud and Nigeria as key words. Data sources including online newspapers, ScienceDirect, Google Scholar, Google Books as well as other scholarly articles and journals were used to gather data from scientific studies. However, there was very limited quantity of data available on food fraud cases in Nigeria though cases of food fraud has been reported on various Nigerian online newspapers and from the recall and alert notifications of the National Agency for Food and Drug Administration and Control (NAFDAC) which is the leading agency in food safety and regulation in Nigeria. After an initial comprehensive review of publicly available data, gaps of data were identified. From the identification of the data gaps, non-formal interviews were undertaken with key regulatory officials in an attempt to fill these gaps. Therefore, this project relies on data that is publicly available and interview accounts to provide a detailed overview of food fraud in Nigeria. Given the commercial sensitivity issues surrounding data collection, interviewee identities were kept anonymous throughout this report.

2.2. Interview Questions

- What are the food commodities that are commonly adulterated in Nigeria?
- Why are food laws in Nigeria poorly implemented and why are food commodities still adulterated in the Nigerian markets?
- Are there publications, published research articles or a food database where cases of food fraud have been documented in Nigeria for the last 10 years?
- What are the processes for recalling adulterated food commodities and issuing food safety alerts?
- How does the regulatory processes in NAFDAC work and who develops the regulations?
- What are the roles of the risk assessors and risk managers in food safety management?
- What has NAFDAC done in tackling cases of food fraud in Nigeria?
- What is the relevance of NAFDAC and other agencies, both locally and internationally in tackling food fraud?
- What has NAFDAC done in promoting food safety in Nigeria and its relevance with the UN Sustainable Development Goals (SDGs)?

2.3. Survey Questionnaire Design

An online survey questionnaire was designed using SurveyMonkey containing 13 questions, some of which were multiple choice and the remaining being open-ended questions. The survey was distributed via social media such as Facebook, WhatsApp and LinkedIn. Subsequently, a paper-based survey questionnaire alongside an informed consent form and information sheet, was sent to participants via email.
2.4. Data Analysis

The results from the survey was analysed on SurveyMonkey by creating custom charts and data tables, filtering and comparing results and exporting results in various formats. The results from the interviews were analysed in order to identify common themes among the responses of the interviewees and consumers.
3. FOOD FRAUD – CURRENT STATUS IN NIGERIA

3.1. Food Smuggling and Trafficking

Smuggling is the illicit cross-border trade of goods (Joosen and Raw, 2012); the importation of contraband goods (Ferrier, 2009) or the movement of goods into or out of a country or trading area often to avoid tariffs or legal obligations. Smuggling is an ancient practice and is one part of a wider set of informal, illicit or illegal economic activities that are not effectively controlled by government (Hartnett and Dawdy, 2013). Illicit trade is “any statute prohibited action or conduct relating to production, shipping, acquisition, storage, delivery, sale or purchase, including any practice or conduct intended to encourage such activity” (WHO, 2003). Illicit trading is defined by the quality of the goods (Bevan et al., 1988), for example, “black goods” are illegal, whereas “black parallel markets” describe legal goods that are exchanged illegally at the supply chain level rather than individual actors operating in a supply chain that is otherwise legitimate. Terms used to describe illegal goods include black, dark, second, parallel, secret, shadow, underground, unreported, unrecorded, covert or illegal goods (Feige, 1990). Consequently, illicitness is not an intrinsic property of commodities or of particular economic actors, but rather a temporary quality attribute that is often related to the distribution or circulation mechanisms of a food item (Gregson and Crang, 2016). The Global Food Safety Initiative Position Paper on Food Fraud (GFSI, 2014) states that “food fraud, including economically motivated adulteration subcategory, is of increasing concern. Consumers are misled by the use of food products, ingredients and labelling for economic gain and include substitution, unapproved modifications, misbranding, counterfeiting, stolen or other goods”. The definition does not include trafficking and smuggling of food directly. Spink et al., (2016) however, found smuggling to be a form of food trafficking. Translating concepts of human smuggling and trafficking, food smuggling can be defined as when all parties involved, except regulatory and enforcement agencies, completely agree to illegal behaviour, while food trafficking requires violence against one or more parties, but sometimes the fine line between smuggling and trafficking is ambiguous (Butterly, 2014). Díaz (2015) distinguishes between small, petty smuggling (for personal use) and skilled smuggling or profit trafficking where a large volume of goods is transported via international shipping channels (Ferrier, 2009). Many food products are subject to additional import tariffs to protect national farmers (Lotta and Bogue, 2015). It illustrates the economic driver to participate in such activity for individuals and organizations. Joossens and Raw (2012) distinguished between tax avoidance, legal and legitimate activity, as well as tax evasion, illegal activity, conducted to pay less or no tax. Smuggling to achieve economic advantage is global. The cross-border smuggling of food and other goods is troublesome and has a direct impact on the economic growth of affected countries (Chen-Charpentier et al., 2015). The economic incentive for smuggling is the size of the difference between the price of a food in the country of origin and the price in the country of destination (Ferrier, 2009), citing examples of sugar, wheat and rice (Golub and Mbaye, 2007). Factors that may result in “black” economic activity include high taxes or complex tax structures, low tax morale, low Gross Domestic Product, poor institutions and corruption
(Snowdon, 2012). Differences in recorded prevalence rates of smuggling between countries are due to the types of goods affected by any trade prohibitions, the degree of non-transparency of smuggled goods, the ease of putting improperly classified materials on manifest papers, and the targeting of any enforcement resources including purposive sampling (Ferrier, 2009).

For example, rice (Oryza sativa L) is a major dietary component in most countries, providing around 20% of the world's dietary energy supply (Deepak and Prem, 2017; FAO, 2006; Vlachos and Arvanitoyannis, 2008). Rice is consumed when boiled or fried in Nigeria, and previous reports suggest that an average Nigerian consumes about 21 kg of rice per year (Odenigbo et al., 2014). While rice is primarily used as a staple food due to its high carbohydrate content, it also contains significant amounts of proteins, lipids, minerals, and water-soluble vitamins such as thiamine, riboflavin, and niacin (Fresco, 2005; Mohammad et al., 2012). Despite Nigeria's rise in rice production, consumer demand for it far exceeds supply. Therefore, Nigeria's increase in rice import exceeds over the past decade. Recently, developing countries' declining economies have forced the Nigerian government to implement policies such as massive rice production programs that promote increased local rice production. Despite these measures, some businesses are still engaging in rice imports, possibly due to some individuals and others' preference for foreign rice. The preferences of consumers between local rice, imported rice and other staple foods are not influenced by relative price changes alone. The recent history of rice growth in West Africa indicates that there is a peaceful coexistence between local rice production and rice imports, following radical changes in trade policy and changes in the macroeconomic environment at the local and international level. This Western African business structure was not significantly affected by changes in tariff policy or the rise in international prices. Due to the different quality attributes of local and imported rices, this led to segmentation of the West African market. Meanwhile, importers in charge of logistical functions (treatment, storage, conditioning) and supply networks of retailers are driving the value chain for imported rice, primarily in urban areas but increasingly also in rural areas. Imported rice is often sold in near-market grocery stores in combination with other basic goods (e.g. oil, sugar, flour). Such retailer categories sell local rice very rarely, although they do so in countries where local rice production is sufficiently large and can be regularly supplied. On the other hand, local rice retailers add imported rice to their list of staple foods.

Paradoxically, the rice trade liberalization proponents and their critics supporting higher tariff regulation and control of rice imports follow the same concept of how the rice market works. Both assume that West Africa rice markets are efficient and capable of delivering price opportunities that will cause a shift in the actions of rice market players. Such two trade policy choices are expected to be optimal replacements for local and imported rice, but this theory is not routinely confirmed. Consumers in Guinea, for example, have a strong preference for local rice, which is usually sold at a higher price than imported rice, whereas consumers in Nigeria and Ghana, who do not have the same rice eating culture, prefer imported parboiled rice, even when the tariff makes its price much higher than the local one. A survey of the preferences of
West African consumers found that even when they value the organoleptic properties of local rice, they give greater consideration to quality attributes related to marketing and processing (Chohin-Kuper et al., 1999; Demont et al., 2013; Demont and Ndour, 2015). Therefore, a large proportion of urban customers put more value on the market quality attributes than the organoleptic ones. Many consumers buy imported rice rather than local rice because their quality is more homogeneous, they are cleaner and packaged better, and they are available throughout the year.

In addition, imported rice retailers that profit from credit provided by their wholesaler are able to provide credit to their customers, while local rice retailers are not; this strengthens the market position of imported rice over local rice. Nigerian borders are notoriously porous and several reports have established how numerous goods including rice, find their way into the country through the borders, especially the ones adjoining Benin Republic (Premium Times, 2019). According to a news report by the Comptroller-General of the Nigerian Customs Service, 99 percent of rice smuggled through the land borders are unfit for consumption. He further revealed that rice is mixed with other grain bags or stuffed inside any available crevice and compartments of vehicles, including the engine area to deceive custom service officials. The concealed rice is thereafter re-bagged half cooked and presented in the markets for sale as imported rice. Often times, importers in the borders re-bagged expired rice to prolong their shelf life and as a result, rice being a perishable product, loses valuable shelf life in non-conducive storage conditions (Premium Times, 2016). In late August 2019, Nigerian President Muhammadu Buhari ordered the partial closure of its boundary with Benin to curb rice smuggling. His administration further banned trading across all land borders to force neighbours Benin and Niger to halt food smuggling into the country (Bloomberg, 2019).

3.2. Street Food Practices

Safe food supply is a fundamental human right, leading to sound health, prosperity, and a platform for sustainable development and poverty alleviation. Street foods are enjoying increasing patronage due to industrialization, which causes many urban residents to eat their daily meals out of their homes (Alimi et al., 2014). Street food vending is a common feature of most cities and towns in developing countries (Ekanem, 1998). Street food is ready-to-eat food and beverage prepared and sold for immediate consumption by vendors and hawkers, especially in the streets and other public places (WHO, 1996; WHO / FAO, 2015). Street food safety depends on the quality of raw materials, food preparation, handling and storage practices. Therefore, any person who handles food, irrespective of whether they prepare or serve it, is a food vendor (Isara and Isah, 2009). Street food vendors (SFVs) are divided into two groups: mobile vendors; moving from place to place with prepared and packaged food intended for sale on their heads, carts, bicycles, motorcycles or tricycles (Abdalla et al., 2009) and stationery vendors; having developed stalls where food is prepared, processed and served to consumers (Almeida et al., 1996). Mobile and stationery food vendors work day and night in parking lots, warehouses, markets and schools to name a few, where multiple customers are present. Due to increased tourism, the street food vending of the
economy has extended to low and middle-income countries and provided access to a range of affordable food to a variety of consumers (Chukuezi, 2010). Apart from delivering ready-made meals at relatively low prices, teeming urban dwellers are addicted to street foods due to their gustatory attributes. Such qualities are associated with the vendors’ culinary prowess (Choudhury et al., 2011; Alimi et al., 2016). Akinyele (1998) reported that millions of practitioners along the chain have made a significant contribution of street foods to nutrition and food security. They were also described by Draper (1996) as possible vehicles for fortification of micronutrients. Street food vendors have been an integral part of the supply chain in many developing countries, including Nigeria, particularly after the advent of urbanization (Akintaro, 2012). The street food industry has made a significant contribution to human and economic development, as studies in some African countries such as Nigeria, Morocco and Kenya have shown that major street food vendors usually earn more than the minimum wage of these countries (Omemu and Aderoju, 2008; Ifenkwe, 2012; Mwangi, 2002). It has been reported that the street food sector has a socio-economic role in terms of its job creation potential, yielding income especially for women, and providing food at affordable cost to lower city income groups (Tavonga, 2014). Across Nigeria, inhabitants of urban cities spend as much as half of their street food budget (Cohen and Garnet, 2002). In most developing countries, street food vending are largely outside of government regulation and security. Due to the informal nature of the organization and the lack of official data on the volume of trade involved, the economic value of the operations is not well understood (Alimi and Workneh, 2016). The sector, however, is full of unhealthy activities that have been reported to raise serious concerns about the safety of practitioners, especially consumer health (Muyanja et al., 2011). Such unhealthy practices spanned the entire street food business chain from agricultural raw materials to the final street food retail and were fingered in the outbreaks of illnesses and diseases (Akinbode et al., 2011). It has been stated that the prevention, conservation and treatment of diseases from street food borne illnesses has resulted in the heavy drain on individuals and governments’ purses in developing countries due to huge expenditure (Ekanem, 1998). The street food market in Nigeria, as in other developing countries, is facing challenges. The risk factors, also known as danger points, permeate the entire street food business chain and are listed below:

3.2.1. Sources and quality of raw foods and ingredients

The vendors’ desire for profit maximization or the need to make street foods accessible to customers make certain vendors patronize cheap and unhealthy ingredients that can threaten consumers’ health. Results of survey conducted by Omemu and Aderoju (2008) showed that vendors of street foods in Nigeria considered the volume (94%) and the price (93%) than the freshness and cleanliness when buying raw foods to be cooked or vended. In a study conducted in India, Choudhury et al., (2011) observed that procurement habits of food items by street vendors differ according to the size of the establishments and was significantly (p < 0.05) influenced by the type of vendors, ownership and average monthly income. The study reported that from grocery stores, both mobile vendors and small restaurant owners procure
unlabeled and unpacked food grains and semi-processed ingredients. While the majority (87%) of small restaurant owners procure branded and packaged condiments, dry fruits and spices from grocery stores, most (44%) of mobile food vendors buy condiments and spices, nuts and dry fruits from traditional weekly or daily markets with 37% of them being cooked, dried and powdered at home. Nearly 56 percent of mobile vendors used spices and condiments unlabeled and unpacked. Studies have shown that home-made cereal flour and condiments used in street food preparations are contaminated with Bacillus cereus (Umoh and Odoba, 1999; Obuekwe and Ogbimi, 1989; Yusuf et al., 1992)) which was allegedly responsible for food-borne disease outbreaks (Gilbert, 1979). The highest frequency of Bacillus cereus recorded by Umoh and Odoba (1999) observed for “kunu”, a fermented cereal product in West Africa was the result of local spices and raw materials used as condiments in their survey of microbial quality of street foods sold in the streets of Zaria, Nigeria.

3.2.2. Food preparation, handling and vending

The temperatures used in cooking and frying during street food preparations are high enough to destroy the vegetative cells, but microorganisms’ resistant spores can survive (Bryan et al., 1988). Nevertheless, street foods are being cooked, treated and marketed in ways and habits that predispose them to recontamination, cross contamination and transmission of pathogens and food-borne diseases. Some street foods are usually prepared in bulk ahead of sale at different times (Umoh and Odoba, 1999). The long holding period of more than 6 h, sometimes at ambient temperature (Muyanja et al., 2011), was reported to be a common factor contributing to food-borne disease through multiplication of microorganisms favored by holding temperatures between 5 and 60 °C (described as a danger zone). Mosupye and von Holy (2000) proposed that the high load of Bacillus spp. may be responsible for holding conditions that favored the survival and germination of Bacillus spores isolated in ready-to-eat food on the street. The mode of transportation plays a significant role in street food contamination. Transportation and display of meat has been reported to play an important role in accelerating their spoilage and zoonotic disease transmission (Okoli et al., 2005). The manner in which animal carcasses are transported from slaughter points to distribution points in crude structures such as wooden carts, open plastic or aluminum trays on heads or “off-road” vehicles has increased the likelihood of cross contamination. Okoli et al., (2005) stated that vehicles not equipped for meat transport such as taxis and buses without cooling facilities and even motorcycles carrying meat products from slaughter points to retail outlets are a common site in Nigeria. Okoli et al., (2005) maintained that it is not unusual to see butchers and retailers turning carcass meat for human consumption into sitting or resting platforms in the vehicles during the cause of transportation. Meats are retailed in open wooden trays in the markets and streets of Africa, which are typically difficult to wash thoroughly, thereby harboring niches for meat contamination by microorganisms and deposition of airborne pollutants. In the streets of Johannesburg, South Africa, Mosupye and von Holy (2000) recorded high aerobic plate and spore counts of 7.6 and 2.2 log cfu/g in raw beef/chicken for retail. Some
studies reported high loads of microorganisms, despite high processing temperatures, exceeding acceptable tolerable amounts from some processed meats for street vending.

In processed beef and chicken sold in the streets of Zambia and Nigeria, Bryan et al., (1997) and Ekanem (1998) recorded high levels of coliforms greater than 105 cfu/g. Lues et al., (2006) attributed high levels of microorganisms extracted from processed meats to re-contamination by vendors’ hands, utensils, and vending environment. Non-regulation of time and holding temperature are recognized as major risk factors in street foods that lead to the outbreak of diseases (Muyanja et al., 2011). The majority of vendors in Abeokuta, Nigeria (90%) and Ozamiz, Philippines (55%) prepared their goods on the morning of sale (Omemo and Aderoju, 2008; Canini et al., 2013), while the majority of vendors in Kampala, Uganda cooked on-site food (75%) and well ahead of consumption (77%) (Muyanja et al., 2011). Certain risk factors found in the preparation and handling of street foods include: widespread use of stove charcoal for food storage and heating over a long period of time, which may not provide adequate temperature to prevent the spread of pathogenic microorganisms (Lues et al., 2006; Bryan et al., 1996)) as heating of food at temperatures below 40°C could increase Salmonella contamination (Cardinale et al., 2005), overheating at higher temperatures may lead to the loss of essential nutrients and flavours in the food; the retention of food at ground level and the incessant uncovering of foods for dispensing of exposed street foods to dust contamination and flies associated with food-borne diseases such as cholera and diarrhoeal (Sukontason et al., 2000). Mosupye and von Holy (2000) found that when vendors were serving customers, ready-to-eat food could be left uncovered for up to 10 minutes. Umoh and Odoba (1999) confirmed that more than 13 percent of street foods surveyed in Zaria, Nigeria were contaminated with Salmonella aureus of which 43.8% were haemolytic strains and 18% enterotoxigenic. The study described post-processing handling as the major cause of contamination as the high processing temperature and low water activity of most foods surveyed were enough to prevent the proliferation of microorganisms and the production of toxins that are harmful to human health.

3.2.3. Vending environments

Reports also raised serious concerns about the vulnerability and exposure of street foods in the vending environments. Street food vendors tend to target high-traffic areas for showcasing their goods to boost sales. Street food vending are common in areas such as major street corners, industrial/building sites, bus/train terminals, public places and school compounds (Akinbode et al., 2011). The vending units are either mobile or stationary with open or covered crude structures such as push carts, wooden tables, aluminum trays, bowls or chop bars (Canini et al., 2013). Retailing of a street food along a major street in a developing country is shown in Fig. 15.
The conditions in which street foods are cooked, sold and eaten have predisposed them to recontamination and cross-contamination from contaminants of the environment, such as airborne chemicals in dust, exhaust discharges from moving vehicles and industrial engines, burning fumes and offensive smell from accumulated waste and industrial discharges, insects and rodents (Proietti et al., 2014; Mensah, 2002). Airborne pathogens and microbes that can be pathogenic if allowed to settle on the prepared food surfaces abound in dust (Muyanja et al., 2011). Bryan et al., (1997) observed large heaps of garbage accumulated around street food vending sites in Zambia that harboured insects and rodents (known as disease vectors). It has also been stated that littering is common practice at Uganda’s vending sites (Muyanja et al., 2011). Since consumer proximity is the primary goal of street food suppliers, vending sites usually lack basic facilities such as toilets, hand washing facilities, drinking water, adequate drainage and waste disposal system (Idowu and Roland, 2006). Where some of these facilities are established, large concentrations of vendors in congested human areas tend to place severe strain on them, resulting in conflict with city plans and adverse effects on daily life (Muyanja et al., 2011). All of these factors increase the incidence of food borne illnesses and disease transmission among vast street food consumers (Ekanem, 1998).

### 3.2.4. Hygiene practices

Several studies of street food hygienic practices verified by WHO (1984) suggest that most street food vendors have knowledge of hygienic practices, but concluded that most of them do not put the knowledge into practice (Muyanja et al., 2011; Lues et al., 2006; Omemo and Aderoju, 2008). While street vendors were stated to have good personal cares, they were lax at the preparation and vending sites to comply with correct hygienic practices. This was mostly due to non-compliance with basic hygiene standards, insufficiency or near absence of basic facilities at the vending sites. Benny-Oliviera and Badrie (2007) analysis of hygienic practices by street food vendors inTrinidad, West Indies recorded that most of the sites surveyed did not have pipe-borne water, 97.5 percent did not have drain to channel waste water and toilet facilities. Regarding street food vending sites in Kingston, Jamaica (Powell et al., 1990), Lima, Peru
(Bhat and Waghray, 2000), Philippines (Azanza et al., 2000) and Uganda (Muyanja et al., 2011), the result was no different. The shortage of toilet and washing facilities at the vending sites forced most street food hawkers to check for secluded areas in the vicinity such as bushes and abandoned buildings for excretion. Idowu and Rowland (2006) reported that most street food vendors in Abeokuta, Nigeria used dung hills and nearby bushes instead of toilets and cleaned up with paper sheets. Open bins have been commonly used to collect garbage. Muyanja et al., (2011), however, reported that 92.8 percent of vendors in Kampala, Uganda used gunny bags for waste collection. Several studies have documented that the overflowing of garbage bins was a common site at most vending points, whereas the final disposal of garbage is normally far from vending sites. Heaps of garbage around the vending sites may serve as breeding grounds for rats, insects, and flies that encourage microorganism proliferation and increase the risk of food contamination and disease transmission (Umoh and Odoba, 1999; Mensah et al., 2002).

3.2.5. Agricultural practices

The growing world population is placing enormous pressure on the production of food. The corresponding effect is the increasing need to optimize available resources to feed the growing population for improved farm yield. Farmers use inorganic agrochemicals and organic manure to increase farm yields, avoid weed competition and maintain quality by preventing insect infestation and microorganism spoilage on the field and during storage. In developed countries, the use of these chemicals is well regulated by the enactment and implementation of acts and laws that govern and restrict their use for agricultural practices. Such laws are intended to avoid the residual effect on users of these chemicals (Harris, 2002). Among developing countries, however, where farmers use excessive pesticides to produce bumper yields, the opposite is the case. Farmers also patronize easily synthesized, inexpensive and expired chemicals in developing countries (Carvalho, 2006). Residues from excessive chemical applications to improve farming operations have been identified at high levels in soil, livestock and aquatic animals (Carvalho, 2006; Taylor et al., 2003). A significant relationship between residual chemical accumulation in soil and absorption by crops, livestock and aquatic animals has been identified (Carvalho, 2006; Wang et al., 2006). Scientific research has shown that residual agrochemicals in foods are harmful to human health. In the human system, the accumulation of foreign chemicals such as lead (Pb), arsenic (As), cadmium (Cd), copper (Cu) and mercury (Hg) was linked to immune suppression, hypersensitivity to chemical agents, breast cancer, decreased sperm count and infertility (Uri, 1997; Sharpe, 1999).

3.3. Nigerian Food Fraud Incidents/fraudulent commodities

Food fraud is a prevalent problem in Nigeria. On the 28th of November 2019, the management of the National Agency for Food and Drug Administration and Control (NAFDAC) issued an alert on the unscrupulous activities of business men and traders who revalidate expired rice and also repackage local rice as foreign rice. The Ogun State office of the agency received the report from the Department of State Services (DSS) in the state, of ongoing food fraud at Oke-Aje market in Ijebu Ode. On the 14th of
November 2019, Officers of the state office in company of officers of the Nigerian Police Force proceeded to the scene of the illegal activity. On arrival, the suspected perpetrators of the food fraud instigated unnamed persons to unleash mayhem on the team of investigators. However, enforcement officers of the agency and its federal task force team stormed the market in company of Department of State Service officials. They sited the perpetrators at the market who took to their heels and discovered expired rice, caked rice, bags of local rice, bags of popular foreign rice and sealing machines at the shops. The NAFDAC enforcement team gained access into the shops and sealed three shops during the operation. The management of the agency noted that expired and caked rice are unwholesome as they contain moulds and microorganisms that cause diseases which are of immense public health concern (NAFDAC, 2019a). Similarly, on the 11th of November 2019, the agency issued an alert to the public on frozen raspberries contaminated with norovirus from China. The contamination of the frozen raspberries with norovirus was detected in Germany with some of the contaminated products being exported to Nigeria from Germany. The agency warned members of the public not to consume the contaminated frozen raspberries as norovirus is a highly infectious virus that causes vomiting and diarrhoea, and implored importers to desist from importing the contaminated product to Nigeria (NAFDAC, 2019b). Major convictions of Nigerian importers and business traders took place between 2017-2019. For example, Mrs Esther Akinsanya, a business woman and her company in a popular market in Lagos, was convicted on the 30th of November, 2018 by the Federal High Court in Lagos for rebagging smuggled, adulterated and misbranded sugar. She was fined the sum of N1,300,000.00 ($3,611.00) and ordered by the court to bear the cost of destruction. On the 5th of December, 2018, operatives of the agency in Katsina State arrested three suspects for the sale and distribution of banned and rebagged sugar. The suspects were convicted by the Federal High Court in Katsina and fined the sum of N100,050.00 ($277,91.00) each. The court ordered the forfeiture of the products to NAFDAC for destruction and the cost to be borne by the convicts. Okey Joseph Okeke, a business man was arraigned at the Federal High Court, Akwa, Anambra State on 29th April, 2018 for the sale of unwholesome processed foods including vegetable cooking oil, extra virgin cooking oil, alcoholic whiskey and vodka. Also, Mrs Nkiru Okoro of Ezedams Enterprises Nigeria Ltd. was investigated for illegal production of counterfeit alcoholic beverages and obstruction of NAFDAC officers in the course of their operation. She was arraigned at the Federal High Court, Lagos on 27th June, 2019 (NAFDAC, 2019c).

3.4. Food control systems

Food control systems were identified by the Food and Agricultural Organization (FAO)/World Health Organization (WHO) and subsequently by numerous researchers (Anyanwu and Jukes, 1990; Neeliah and Goburdhun, 2007, Nguz, 2007, Whitehead, 1995) many of whom also reported food control systems in their countries or other countries. Nonetheless, a reasonable description of food control systems must be given before the goals and components of such a system are defined. In accordance with the FAO/WHO authority on food control systems, the term that defines such systems as “the mandatory regulatory activity
by national or local authorities to implement food laws and regulations” (FAO/WHO, 2003) is recognized and used here. According to this definition, the food control system depends on food-related legislation and proper implementation of these regulations, the former of which is enacted as a result of pressure from the system’s specific objectives. Such objectives have been described as the need to protect consumers by ensuring that food produced during the stages of handling, storage, processing and distribution is safe for consumption (FAO/WHO, 2003). The aim is to facilitate trade in foodstuffs for economic development (FAO/WHO, 2003), a goal that was later emphasized due to the global increase in food trade. The goals of a food control system are accomplished through the roles of different components of the food control system that operate together. Food law enforcement (inspection and analytical services); information, education, communication and training (IECT) as well as food management and administration (FAO/WHO, 2003) are included in the FAO/WHO (2003) documents. Food laws provide the government’s mandate to carry out food control activities while inspection and analytical services are necessary to assess compliance with published laws by manufacturers, producers or importers. IECT refers to the training of system personnel, communication of government decisions and contact between various system agencies/components and system stakeholders (FAO/WHO, 2003). IECT also refers to the duty of the government to adequately educate consumers and other stakeholders (including manufacturers) on the functions of the food control system and the need for food safety and quality within the country.

Food control systems may vary in structure and the FAO/WHO (2003) has identified three types of these systems where the first category is distinguished by the structure and functions of the food control system being divided, typically into different government departments or levels of government (FAO/WHO, 2003). This is referred to as multiple agency food control system and division can be horizontal as well as vertical where food law drafting, inspection and analytical services and IECT are physically and functionally separated into different departments of the same government. An example of this type of food control system is the United States of America (USA) where the Department of Health and Human Services, the U.S. Department of Agriculture (USDA) and the Department of the Treasury’s Customs Services are all involved in aspects of food control. Through the Food and Drug Administration (FDA), and especially via the Center for Food Safety and Applied Nutrition (CFSAN), the Department of Health and Human Services performs food safety activities. Consequently, CFSAN is the competent authority to enforce legislation that protects against unhealthy and impure food as well as fraudulently branded food (FDA/USDA, 2000). The USDA includes the Food Safety and Inspection Services (FSIS) and the Animal and Plant Health Inspection Services (APHIS) and the Environmental Protection Agency (EPA) (FDA/USDA, 2000), the first two of which are responsible for ensuring safety and proper labelling of meat, poultry and egg products, while the EPA is responsible for protecting the public from pesticide-related hazards and for advising on adequate pest management systems (FDA/USDA, 2000). Additionally, the Treasury Customs Service Department offers compliance assistance by supporting the various departments involved in the monitoring and detention of food imports (FDA/USDA, 2000). Unlike the
above, some food control systems have their functions integrated under a single authority, not necessarily within a single department of government, but may include a parastatal body that responds to one department of government (FAO/WHO, 2003b). Therefore, a single food control system, food law drafting, inspection, analytical and IECT functions are combined under one body with the same aim and mandate in this type of system. Examples include the Spanish Food Control Agency, a recently developed agency led by the Ministry of Health and Consumer Affairs of Spain (Garcia and Jukes, 2004). This body consolidates past food control operations of a multiple agency food control system consisting of the Ministries of Health and Consumer Affairs, the Ministry of Agriculture, Fisheries and Food and the Ministry of Economic Affairs and Housing, as well as individual control systems of “autonomous communities” (Garcia and Jukes, 2004). Greece has also created the Hellenic Food Safety Authority, which consolidates the functions of five national ministries, namely the Ministry of Agricultural Development and Nutrition, the Ministry of Health and Social Welfare, the Ministry of Economy and Finance, the Ministry of Development and the Ministry of Public Order (Varzkas et al., 2006) and now reports to the Ministry of Development.

The third type of food control system, an integrated agency food control system, is distinguished by the coordination of different system activities by different agencies or departments, such as the independent coordination of food law drafting, inspection, analytical and IECT. The monitoring of the system could also be coordinated by a separate section (FAO/WHO, 2003b). The Korean Food and Drug Administration (KFDA), headquartered in Seoul with regional offices in numerous other cities, is an example of an integrated agency (Kwak et al., 1999). This agency is the head of food safety issues and is responsible for enforcing food laws and performing risk analysis in food (Kwak et al., 1999). Some agencies involved in monitoring and field operations and/or toxicological assessment and analysis are the Food Safety Bureau, the Office of Health Assessment and the National Institute of Toxicological Analysis (Kwak et al., 1999).

It should also be noted that the Codex Alimentarius Commission (CAC), a joint body commissioned by both the FAO and the United Nations (UN) WHO is the most notable of international food standard-setting bodies on an international level, although not a food control system. Developed to provide food safety standards and recommendations, it also plays an enhanced role in foods moving in international trade through the World Trade Organization (WTO) Sanitary and Phyto-Sanitary (SPS) Agreement, which has designated Codex Standards as the international benchmark for food in trade (FAO/WHO, 2005; FAO/WHO, 2003b). While Codex standards do not infer changes in national legislation, many countries, especially developing countries, are using Codex standards and guidelines to establish their own national legislation. Therefore, although this body is not a food control system, it has various features of an international food control system. Most food safety regulations need to be enforced at national level, for example in Nigeria, the Federal Ministry of Health formulates and monitors policies and regulations on food hygiene and safety, the Standards Organization of Nigeria (SON) formulates and enforces standards for the composition of imported and locally produced foods and the National Agency for Food and Drug
Administration and Control (NAFDAC) is responsible for the control of imported and locally processed food at national and state levels (FAO, 2005). Food laws in Nigeria exist, but many are poorly enforced:

- Public Health laws (1917), now known as Public Health Ordinance cap 165 of 1958.
- The Standards Organization of Nigeria Decree No. 56 of 1971.

Among the various institutions concerned with food safety problems, there is a lack of coordination and conflicting or overlapping roles at administrative level. It is important to identify roles in order to avoid discrepancies and to facilitate the smooth running of control activities. There is a very clear need for better coordination of the institutions that have overlapping authority. At national and local levels, the responsibility for administrative, food safety regulation and import certification is shared between different ministries. This condition causes other issues, such as duplication of regulatory operations, increased bureaucracy and fragmentation of operations, as well as lack of coordination between the various bodies, leading to trade disputes in import cases (Nguz, 2007). Food safety systems are generally weak, fragmented and poorly coordinated in most African countries, and are therefore unsuccessful in protecting consumer health adequately (FAO, 2005; FAO/WHO, 2005b, Majdi, 2002; Nguz, 2007). Problems arise as a result of poor handling, processing and storage of food after harvest and also as a result of insufficient facilities and services such as the absence or lack of safe water supply, power, storage facilities like cold stores, transport facilities and networks, etc. (FAO, 2003).
4. FOOD SAFETY LEGISLATION IN NIGERIA

The key determinants of food safety and safety of those producing and processing food are “the procedures, standards and regulations (or lack of) for food production, manufacturing and packaging” (Ericksen, 2008). Therefore, controlling food safety is an important component of urban food system governance. Like many other developed countries, Nigeria is facing the challenges of supplying its affluent population with adequate food supplies. To this end, there is successful promotion of policies and programs aimed at boosting agricultural and food production. The food safety problem, however, presents a more daunting challenge. Like several other nations, Nigeria has to deal with the issue of foodborne diseases with the related social, economic and health costs. The lack of or insufficient use of Good Agricultural Practices (GAP) and the exploitation or misuse by farmers of agrochemicals and during storage in developing countries had serious health effects on the population. Certain unsafe practices include the use of pesticides for farming, improper application of pesticides to stored goods such as beans and grains to avoid infestation by insects, inappropriate use of chemicals to ripen fruits such as bananas or vegetables such as carrots and cabbages for insect infestation control (Omojokun, 2013). Similarly, improper use of food additives such as artificial sweeteners, butylated hydroxyl anisole (BHA), nitrates, nitrites, food colours, etc. may contribute to various conditions ranging from gastrointestinal disorders to cancer and death. Many packaging materials are still used in rural Africa with toxic degradable products that are no longer in use in developed countries. Another issue of concern during food processing is the partial or complete loss or elimination of nutrients. Another cause of health concern is the inadequate digestibility or use of nutrients and the development of new potentially harmful chemicals resulting from poor processing and handling practices (Omojokun, 2013). Therefore, to ensure food safety and quality for domestic consumption and export, necessary and proactive steps must be taken. This is because food was recognized internationally not only as a biological necessity, but also as an economic and political necessity. In cultures and countries, it is always a potential source of socio-political problems. Consequently, an effective national food safety policy would ensure that the food supplied to consumers is sufficient, nutritious, of good quality and balanced (Omotayo and Denloye, 2002). The Federal Government of Nigeria initiated the National Policy on Food Hygiene and Safety in 2000 as an integral part of the Nigerian National Health Policy in recognition of the value of food safety as an important factor in achieving a high level of health for all Nigerians. The overall objective of this policy is to achieve high-level food hygiene and safety practices that promote health, control food borne diseases, reduce and eliminate the risk of illnesses associated with poor food hygiene and safety. The policy aims at stimulating and encouraging food laws in the areas of production, storage, handling, manufacturing, preservation, transportation, transport and marketing. It also seeks to improve the quality of healthcare by ensuring that all food consumed in Nigeria, whether imported or exported, is wholesome, safe, contaminant-free and affordable to consumers. The implementation of the policy is aimed at addressing the unsatisfactory level of food hygiene and safety practices that are largely responsible for the prevalence of foodborne diseases
in Nigeria (Omotayo and Denloye, 2002). The National Food Safety Policy provides for the establishment of a National Committee on Food Safety that draws its membership from the public and private sectors related to the production, storage, processing/preparation, distribution, transportation and sale of food intended for consumption.

I. The Public Sector includes:

   a. Federal Government Ministries
   b. Federal Government Food Control Agencies
   c. State Government Ministries of Health
   d. State Government Ministries of Agriculture
   e. Local Government Departments of Health
   f. Local Government Departments of Agriculture

II. The Private Sector includes:

   a. Industries
   b. Non-Governmental Organizations (NGOs)
   c. International Development Partners
   d. Universities and Research Institutes
   e. Professional Bodies/Associations
   f. Consumer Associations

4.1. **REGULATORY AND LEGISLATIVE FRAMEWORK**

Over the years, numerous laws and regulations have been implemented to ensure the safety and wholesomeness of the food supply in Nigeria. Such legislations include the following:

   b. The Standards Organization of Nigeria Decree No. 56 of 1971.
   f. The National Agency of Food and Drug Administration and Control Decree No. 15 of 1993 (now NAFDAC Act Cap N.1 LFN 2004).
   g. The Food, Drug and Related Products (Registration) Decree No. 19 of 1993 (now Food, Drug and Related Products (Registration) Act Cap F.33 LFN 2004).
i. Various bye-laws enacted by various LGAs in Nigeria.

4.2. KEY ACTORS IN REGULATING AND MONITORING OF FOOD SAFETY STANDARDS AND PRACTICES

The following bodies develop and influence food safety standards in Nigeria:

a. The Federal Ministry of Health (FMH)
b. The National Agency for Food and Drug Administration and Control (NAFDAC)
c. Standards Organization of Nigeria (SON)
d. The Federal Ministry of Agriculture and Rural Development (FMARD)
e. Nigerian Agricultural Quarantine Service (NAQS)
g. The Federal Ministry of Environment
h. Local Government

4.2.1. The Federal Ministry of Health (FMH)

The Federal Ministry of Health is one of the Federal Ministries of Nigeria concerned with the formulation and implementation of policies related to health. It has the responsibility of formulating national policies, guidelines and regulations on food hygiene and safety as well as the monitoring of their implementation. It is also responsible for establishing guidelines for the requirements and assessment of the nutritive value of food and monitoring of environmental sanitation, food environment and handlers, control of food-borne diseases, quality of public water from taps, as well as national and international matters relating to food.

4.2.2. The National Agency for Food and Drug Administration and Control (NAFDAC)

The National Agency for Food and Drug Administration and Control (NAFDAC) is a federal agency under the Federal Ministry of Health that is responsible for regulating and controlling the manufacture, importation, exportation, advertisement, distribution, sale and use of food, drugs, cosmetics, medical devices, chemicals and packaged water at Federal and State levels in Nigeria. Appropriate tests are conducted and compliance with standard specifications for the effective control of the quality of food, bottled water and the raw materials as well as their production processes in factories and other establishments is ensured. The agency undertakes appropriate investigations into production premises and raw materials for food, drugs, cosmetics, medical devices, bottled water and chemicals and establishes relevant quality assurance systems including certification of the production sites and of the regulated products. The role of the agency also includes the inspection of imported foods, drugs, cosmetics, medical devices, bottled water and chemicals and establishes relevant quality assurance systems necessary for certification of the production sites and of the regulated products.
4.2.3. Standards Organization of Nigeria (SON)

The Standards Organization of Nigeria (SON) is the apex standardization body in Nigeria and is responsible for the formulation and enforcement of set standards on the composition of imported and locally manufactured foods. Over 100 standards on food and food products as well as a good number of codes of hygienic practices for food and food products have been established. These standards and codes are reviewed periodically to reflect current trends in technological and industrial development.

4.2.4. The Federal Ministry of Agriculture and Rural Development (FMARD)

The Federal Ministry of Agriculture and Rural Development (FMARD) is a ministry of the Nigerian government that regulates agricultural research, agriculture and natural resources, forestry and veterinary research throughout Nigeria. It is responsible for developing the agricultural sector of the Nigerian economy, with a view to growing the sector, driving income growth, accelerate food and nutrition security, generating employment and transforming Nigeria into a leading global food market, through the commodity value chain concept of the Agricultural Transformation Agenda (ATA). The Ministry promotes agri-business, encourages rural development, supports private sector institutions and broadens stakeholders’ partnership to facilitate raw materials for agro-based industries, diversify agricultural products along commodity value chains and generate foreign exchange earnings for the country.

The Ministry fulfils its responsibilities through its departments and parastatals, and also supervises and provides funding for research institutes such as the National Root Crops Research Institute and colleges of agriculture and forestry.

4.2.5. Nigerian Agricultural Quarantine Service (NAQS)

The Nigerian Agricultural Quarantine Service (NAQS) is a regulatory agency under the Federal Ministry of Agricultural and Rural Development (FMARD). It was created for the harmonization of plants, veterinary and aquatic resources (fisheries) quarantine in Nigeria to promote and regulate sanitary (animal and fisheries health) and phytosanitary (plant health) measures in connection with the import and export of agricultural products with a view to minimizing the risk to agricultural economy, food safety and the environment. The main objective of NAQS is to prevent the introduction, establishment and spread of animal and zoonotic diseases as well as pests of plants and fisheries including their products. NAQS also undertakes emergency protocol to control or manage new pest incursion or disease outbreak in collaboration with key stakeholders. It ensures that agricultural exports meet with international standards in line with International Plant Protection Convention (IPPC) Office, International des Epizootics (OIE) representing the World Organization for Animal Health, WTO/Sanitary and International Trade of Endangered Species (SITES) and SPS conditions of importing countries. Its operations are guided by the enabling legislation enacted by the National Assembly and SPS regulations and schedules.
4.2.6. **Federal Competition and Consumer Protection Commission (FCCPC)**

The Federal Competition and Consumer Protection Commission (FCCPC) is the apex of the Consumer Protection Agency in Nigeria. The overall mandate of the Commission is to protect consumers by taking both preventive and remedial measures. It is committed to nationwide quality assessment of products and services, through inputs into national and international standards, sampling, analysis, investigation, process auditing, developing and issuing of guidelines/standard operating procedures (SOPs) in order to ensure that products, services and processes are of good quality, safe and meet consumers’ expectation, while giving value for money. It is also responsible for market surveillance and enforcement where violations occur, engaging in routine and periodic consumer education to inform consumers of their rights, available enforcement mechanisms and how to use the processes as well as providing information about key market developments such as advisories, warnings, recalls and similar interventions, and conducts numerous specific and general awareness campaigns.

The Commission engages in domestic and global research about products and services, as well as changing or evolving market trends and consumer behaviour.

4.2.7. **The Federal Ministry of Environment**

The Federal Ministry of Environment was established to ensure effective coordination of all environmental matters and to ensure that environmental matters are adequately mainstreamed into all developmental activities. It has focused on involving innovative strategies that emphasize the use of environmental re-engineering as a veritable tool for job creation, poverty eradication, ensuring food security, encouraging sustainable economic development and general improvement in the livelihood of the Nigerian populace. It also has a role to play in the control of environmental food contaminants, persistent organic pollutants, environmental pollution, waste disposal, etc.

4.2.8. **Local Government**

The Local Government is responsible for the control and regulation of out-door advertising, and regulating and monitoring of street food vending, catering establishments, bukaterias, local abattoirs and the traditional markets.

4.3. **NATIONAL FOOD CONTROL SYSTEMS**

Food control includes a number of programs aimed at providing consumer protection and ensuring that all products supplied for human consumption are nutritious, wholesome, comply with safety and quality standards and are labelled honestly and accurately as prescribed by law. To achieve this goal, most countries have some sort of food control system in place. Typically, these programs include various components that may include food policies and legislation, food safety management, testing and analytical laboratories, food inspection, compliance and certification, emergency preparedness and response, food-
borne disease surveillance, and public information, education and information. The efficiency of a national food control system is linked to its ability to effectively, efficiently and sustainably execute adequate functions to provide healthy and quality food for domestic consumption and export. Achieving food safety is a shared responsibility, and various types of stakeholders—including government, food industry, consumers and their organizations, academic and scientific institutions, etc. – are contributing to this capacity. Particularly:

- Government agencies (at central and lower levels) are responsible for establishing and managing an enabling institutional, policy and regulatory framework for food safety, and carrying out food control activities that protect consumers from risks arising from unsafe food and fraudulent practices.
- Food producers, processors, handlers, manufacturers, traders, retailers and caterers (hereafter referred to as the food industry) have the primary responsibility for delivering safe food to consumers. This includes responsibility for developing and managing systems that ensure that the food supplied and/or served is safe and complies with official food safety requirements.
- Consumers and their organizations are responsible for ensuring that food is handled, stored and prepared in accordance with good hygienic practices (GHPs) and for requesting appropriate standards of food safety.

While these stakeholders each have distinct responsibilities and accountabilities, their functions are highly intertwined and interdependent due to the multidimensional complexity of food safety and quality. Therefore, active cooperation between the stakeholders involved in the food chain from farm to table is essential to ensure that the outcomes obtained are successful and sustainable (FAO, 2007).

The principal objectives of national food control systems are:

- Protecting public health by reducing the risk of foodborne illness.
- Protecting consumers from unsanitary, unwholesome, mislabelled or adulterated food.
- Contributing to economic development by maintaining consumer confidence in the food system and providing a sound regulatory foundation for domestic and international trade in food.

Food control systems should cover all food, including imported food, produced, processed and marketed within the country. These systems should have a legal basis and should be mandatory in nature. While a food control system’s components and objectives will vary from country to country, most systems will usually include the following components:

**a. Food laws and Regulations**

An essential component of a modern food control system is establishing applicable and enforceable food laws and regulations. Most countries have weak food laws, which will impact the efficacy of all food safety programs in different countries. Traditionally, food law has consisted of legal definitions of unsafe
food and the provision of compliance methods to exclude unsafe food from trade and prosecute responsible parties after the fact. It has usually not provided a clear policy and authority for food protection authorities to avoid food safety issues. The result was food safety systems that are reactive and enforcement-oriented in their approach to reducing the risk of foodborne disease, rather than comprehensive and holistic. Modern food laws, to the extent possible, not only provide the necessary legal powers and regulations to ensure food safety, but also require the competent food authorities to integrate preventive approaches into the framework. Governments need to amend food standards in addition to regulations. In recent years, horizontal standards have replaced other overly prescriptive requirements that tackle the specific issues involved in achieving food safety goals. Although horizontal standards are a viable approach to achieving food safety goals, they involve a highly controlled food chain with good data on food safety threats and risk management approaches, and as such may not be feasible for many developing countries. Likewise, several food quality guidelines have been scrapped and replaced by criteria for labelling. Countries should take full advantage of the Codex guidelines and lessons learned in other countries in the preparation of food laws and standards. Understanding the experiences in other countries while tailoring knowledge, principles and requirements to the national context is the only sure way to develop a modern regulatory framework that will satisfy both national needs and the requirements of the Sanitary and Phytosanitary (SPS) Agreement and trading partners. Food legislation should cover the following aspects:

- It must provide a high level of health protection.
- It should include clear definitions to increase consistency and legal security.
- It should be based on high quality, transparent and independent scientific advice following risk assessment, risk management and risk communication.
- It should include provision for the use of precaution and the adoption of provisional measures where an acceptable level of risk to health has been identified and full risk assessment could not be performed.
- It should include provisions for the right of consumers to have access to accurate and sufficient information.
- It should include provision for the use of precaution and the adoption of provisional measures where an unacceptable level of risk to health has been identified and where full risk assessment could not be performed.
- It should include provisions for the right to consumers to have access to accurate and sufficient information.
- It should provide for tracing of food products and for their recall in case of problems.
- It should include clear provisions indicating that primary responsibility for food safety and quality rests with producers and processors.
- It should include obligation to ensure that only safe and fairly presented food is placed on the market.
• It should also recognise the country’s international obligations particularly in relation to trade.
• It should ensure transparency in the development of food law and access to information.

a. **Food Control Management**

Effective systems of food control require national policy and organizational coordination. While the specifics of these roles will be decided by national legislation, they would include the creation of a leadership role and administrative frameworks with specific accountability for issues such as the development and implementation of an integrated national food control strategy, the execution of a national food control programme, the procurement of funds and resource allocation. Main tasks include developing regulatory measures, tracking the performance of the program, promoting continuous improvement and providing overall policy guidance.

b. **Inspection Services**

A professional, educated, effective and honest food inspection service is required for the administration and implementation of food laws. The food inspector is the main functionary who has daily contact with the food industry, business, and often with the public. The food control system’s credibility and legitimacy depend to a very large extent on its honesty and capacity. The inspection services’ roles include:

• Inspecting premises and processes for compliance with hygienic and other requirements of standards and regulations.
• Evaluating HACCP plans and their implementation.
• Sampling food during harvest, processing, storage, transport, or sale to establish compliance, to contribute data for risk assessments and to identify offenders.
• Recognizing different forms of food decomposition by organoleptic assessment, identifying food which is unfit for consumption or food which is otherwise deceptively sold to the consumer and taking the necessary remedial action.
• Recognizing, collecting and transmitting evidence when breaches of law occur, and appearing in court to assist prosecution.
• Encouraging voluntary compliance in particular by means of quality assurance procedures.
• Carrying out inspection, sampling and certification of food for import/export inspection purposes when so required.
• In establishments working under safety assurance programmes such as HACCP, conduct risk-based audits.

For an efficient food control system, proper training of food inspectors is a prerequisite. Given the complexity of current food systems, the food inspector must be qualified in food science and technology to understand industrial processes, identify potential safety and quality problems, and have the skills and experience to inspect the premises, collect food samples, and perform an overall assessment. The inspector
must have a good understanding of the applicable food laws and regulations, their competencies under those laws, and the duties placed on the food industry by such laws. They should also be familiar with procedures to gather evidence, write inspection reports, collect samples and send them for review to a laboratory. The inspector should be trained to handle HACCP audit duties with the gradual introduction of HACCP systems in the food industry. Obviously, there is a growing need to train and upgrade existing inspection staff’s skills and have a human resource growth strategy, in particular the recruitment of inspection specialists in specific technical areas. Considering that human resources may be scarce in some food safety agencies in developing countries, environmental health inspectors are also often asked to work as food inspectors. This is not the ideal situation because they may lack the skills and experience to assess and inspect food operations effectively. If it is appropriate to use environmental health inspectors, they should be specifically supervised and provided on-the-job training.

c. Laboratory Services: Food Monitoring and Epidemiological Data

Laboratories are a key component of a food control system. Laboratory establishment requires significant capital investment and is expensive to maintain and run. Careful planning is therefore necessary in order to achieve optimum results. The number and location of the laboratories should be determined in relation to the system's priorities and work duration. If more than one laboratory is needed, consideration should be given to allocating the analytical work to achieve the most effective coverage of the food analyses to be performed and also to having a central research laboratory equipped for sophisticated and reference analyses. All laboratories for food analysis may not be under the authority of one department or government, and a number may be under the jurisdiction of states, regions, and local authorities. Nevertheless, the Food Control Management will set the food control laboratory standards and track their performance. The laboratories should have ample equipment for physical, microbiological and chemical research. In addition to simple routine research, laboratories can be fitted as needed with more sophisticated instruments, equipment and library facilities. It is not just the type of equipment that decides the accuracy and reliability of the analytical tests, but also the analyst's knowledge and skill and the method's reliability. A food safety laboratory’s test finding is often used as evidence in a court of law to determine the country's compliance with legislation or standards. Therefore, it is necessary to take the utmost care to ensure the laboratory's efficient and effective results.

The implementation of scientific quality assurance systems and laboratory accreditation by an acceptable accreditation body inside or outside the country allows the laboratory to enhance its performance and ensure the tests are reliable, accurate and repeatable. Thus, promoting this initiative is the provision of official sampling and analysis methods. An important element of a national food control system is its incorporation into a national food safety system so that it is possible to establish and evaluate connections between food contamination and foodborne diseases. It is important to have access to reliable and current information on the incidence of foodborne disease. The laboratory facilities are generally located outside
the food control agencies for this type of activity. Strong ties between food control agencies and the public health system, including epidemiologists and microbiologists, are important, however. In this way, foodborne disease information can be related to data on food safety and contribute to appropriate food control policies based on risk. Such information includes annual patterns in occurrence, identifying vulnerable population groups, identifying dangerous foods, identifying and monitoring the causes of foodborne diseases, and providing early warning signs for outbreaks and contamination of foods.

d. Information, Education, Communication and Training

The provision of information, education and advice to stakeholders across the farm-to-table spectrum is an increasingly important task for food control systems. Such initiatives include delivering accurate factual information to customers, providing knowledge packages and educational programs for key officials and staff in the food industry, designing train-the-trainer programs and providing reference literature to agricultural and health sector extension employees. The special training needs of their food inspectors and laboratory analysts should be discussed as a high priority by food safety agencies. Such activities provide an effective means to build knowledge and skills in food safety in all stakeholders and thus serve an essential preventive role (FAO, 2003).

4.4. NATIONAL AGENCY FOR FOOD AND DRUG ADMINISTRATION AND CONTROL (NAFDAC)

The National Agency for Food and Drug Administration and Control (NAFDAC) was established by Decree No. 15 of 1993 as amended by Decree No. 19 of 1999 and now the National Agency for Food and Drug Administration and Control Act Cap N1 Laws of the Federal Republic of Nigeria (LFN) 2004 to regulate and control the manufacture, importation, exportation, distribution, advertisement, sale and use of food, drugs, cosmetics, medical devices, packaged water, chemicals and detergents (collectively known as regulated products). The agency was officially established in October 1992 and is the lead agency for food quality and safety. The NAFDAC’s organization consists of the Director General’s Office and fourteen (14) directorates overseeing the functions of the agency and they include:

- Registration and Regulatory Affairs (R & R)
- Food Safety and Applied Nutrition (FSAN)
- Drug Evaluation and Research (DER) Directorate
- Chemical Evaluation and Research (CER) Directorate
- Veterinary Medicine and Allied Products (VMAP)
- Ports Inspection Directorate (PID)
- Laboratory Services Directorate
- Narcotics and Controlled Substances (NCS) Directorate
- Admin and Human Resource Management Directorate
• Pharmacovigilance and Post Market Surveillance (PV/PMS)
• Investigation and Enforcement Directorate
• Planning Research and Statistics Directorate
• Finance and Accounts Directorate
• Legal Services Directorate

4.4.1. FUNCTIONS OF NAFDAC

The functions of NAFDAC as provided in the enabling law that establishes it are to:

• Regulate and control the importation, exportation, manufacture, advertisement, distribution, sale and use of food, drugs, cosmetics, medical devices, bottled water, chemicals and detergents (regulated products).

• Conduct appropriate tests and ensure compliance with standard specifications designated and approved by the Council for effective control of quality of regulated products and their raw materials as well as their production processes in factories and other establishments.

• Undertake appropriate investigation into the production premises and raw materials for regulated products and establish relevant quality assurance systems, including certification of the production sites of the regulated products.

• Undertake inspection of imported regulated products and establish relevant quality assurance systems, including certification of production sites.

• Compile standard specifications, regulations and guidelines for the production, importation, sales, distribution and registration of regulated products.

• Undertake the registration of foods, drugs, cosmetics, medical devices, bottled water, chemicals and detergents.

• Control the exportation and issue quality certification of products intended for export.

• Establish and maintain relevant laboratories or other institutions in strategic areas of Nigeria as may be necessary for the performance of its functions.

• Pronounce on the quality and safety of products after appropriate analysis.

• Take measures to ensure that the use of narcotic drugs and psychotropic substances are limited to only medical and scientific purposes.

• Grant authorization for the import and export of narcotic drugs and psychotropic substances as well as other controlled substances.

• Collaborate with the National Drug Law Enforcement Agency (NDLEA) in the bid to eradicate drug abuse in Nigeria.

• Advice governments, the private sector and other interested bodies regarding the quality, safety and regulatory provisions on regulated products.
• Issue guidelines, grant approvals and monitor the advertisement of food, drugs, cosmetics, medical services, bottled water, chemicals and detergents.

• Compile and publish relevant data resulting from the performance of the functions of the agency or from other sources.

• Sponsor such national and international conferences as may be considered appropriate.

• Liaise with relevant establishments within and outside Nigeria in pursuance of its functions.

• Carry out such activities as are necessary or expedient for the performance of its functions.

4.4.2. REGULATORY STRATEGIES OF NAFDAC

a. Product Registration

The product registration process is one of the regulatory strategies of NAFDAC. The agency uses product registration to establish and monitor the ownership and/or distributorship of the products it regulates, generally known as regulated products (i.e. food, drugs, cosmetics, medical devices, chemicals, bottled water and detergents), their safety, quality, labelling, claims, etc. NAFDAC employs a structured and systematic procedure for product registration at the end of which the product is assigned a NAFDAC Registration Number which is an attestation to the safety, quality and appropriateness of its intended use. The registration process involves the following:

• **Documentation:** Documents are required such as Power of Attorney from the manufacturer authorising an applicant to speak for his principal on all matters relating to the latter’s specialties, Certificate of Manufacture and Free Sale which is an evidence that the product is manufactured and freely sold in the country of origin, Certificate of Incorporation of the representative company in Nigeria, Evidence of Trade Mark registration, Comprehensive Certificate of Analysis of the batch of product to be registered. The permit to import samples for registration purposes is issued if documentation is satisfactory.

• **Labelling:** Labels must be informative, clear and accurate, indicate the name of product, name and address of the manufacturer, packer, distributor, importer, exporter or vendor, make provision for NAFDAC registration number, batch number, manufacturing date and expiry or best before date, net content, ingredients list in metric weight in case of solids, semi solids and aerosols and metric volume in case of liquids.

• **Inspection:** Good Manufacturing Practice (GMP) inspection of production facility is carried out prior to registration of the product.

• **Product Approval Committee Meetings:** A three (3) tier product approval meeting is held to consider the documentation, laboratory reports, GMP inspection reports, product labels, etc. of a product prior to its registration.
Once a product is satisfactory, it is assigned NAFDAC registration numbers and can be freely sold or marketed within the country.

b. Consultative Meetings

NAFDAC encourages sectoral groups, small and medium scale entrepreneurs, etc. to form umbrella associations (e.g. Association of Food, Beverage and Tobacco Employers (AFBE), National Association of Small-Scale Industrialists (NASSI), Association of Table Water Producers (ATWAP), Association of Fast Foods and Confectionaries Operators of Nigeria (AFFCON), All Farmers Association, etc). These associations are encouraged to self-regulate their practices and can easily arrange for consultative meetings with the agency where their views and concerns are addressed and taken into account when making regulatory decisions that concern them. Such an arrangement also enables NAFDAC to organize targeted and focused capacity building training programmes for the various groups. Consultative meetings could also be at the instance of the agency to give information and enlighten the public on NAFDAC requirements, discuss perceived regulatory challenges, inform on international best practices and regulatory trends.

c. Public Enlightenment Campaigns

The agency organizes public enlightenment campaigns on topical and emerging issues using the electronic media, print media and physical presence at campaigns held at grassroot levels where the rural dwellers are invited with the cooperation and involvement of their local chiefs to inform and educate the populace. Programmes such as ‘NAFDAC and Your Health’ are popular television and radio programmes where regulatory officers are invited to speak on issues such as food safety, Codex activities, food supplements, how to check food products for important information on the labels such as date markings, NAFDAC registration number, etc. Some of the programmes are phone-in programmes where the public has the opportunity to ask questions and be enlightened. The agency also uses television advertisements and radio jingles to inform and educate the public.

d. Trainings and Publications

NAFDAC organizes international, national and in-house capacity building training programmes consistently for staff, the industry and the general public. There are also collaborations and exchange programmes with credible regulatory authorities and international bodies such as the United States Food and Drug Administration (USFDA), US Department of Agriculture (USDA), International Atomic Energy Agency (IAEA), World Health Organization (WHO), Directorate General for Health and Consumers (DG SANCO) of the European Commission, African Union/Inter-African Bureau for Animal Resources (AU/IBAR) etc. (Omojokun, 2013).
e. NAFDAC Consumer Safety Club (NCSC)

The NAFDAC Consumer Safety Club (NCSC) is a public enlightenment and sensitization platform of the Agency used in the fight against fake/substandard regulated products, and to promote the ‘quality culture’ in Nigerian youth. The objectives of NCSC are to:

- Reorient the youth and redirect their energy away from social vices and anti-social behaviour towards healthy habits and meaningful development.
- Serve as a platform for the promotion of NAFDAC’s fight against fake drugs and other substandard products.
- Use members as foot soldiers for the reinvigoration of NAFDAC’s anti-drug abuse and misuse campaign.
- Assist with information flow on NAFDAC’s regulatory activities.

To achieve the afore-mentioned objectives, annual NCSC competitions are organized for member schools at the State, Zonal and National levels in both junior secondary and senior secondary categories, and winners are awarded prizes. State level examinations are conducted to identify both state level and zonal level winners. First place winners from the zonal examinations in both categories are invited to the headquarters in Abuja to participate in a grand finale which is in the form of a quiz competition. The grand winners are recognized and honoured at a National Award Ceremony (NAFDAC, 2019).

f. Recalls and Alerts Procedure

**Public Alerts and Dear Healthcare Provider Letters:** The PV/PMS Directorate receives and sources alert notifications on recalls and safety information on regulated products. The information from a notification may be disseminated to the Nigerian public in an Alert Notice and /or Dear Healthcare Provider Letter (DHPL). On review of the safety information received, timely alert notices and safety communication (Dear Healthcare Provider Letter) are provided to the general public and healthcare providers respectively. The alert notices and safety communication contain safety measures to be taken and information that may impact both treatment and diagnostic choices for healthcare providers and patients. Regular visit to the NAFDAC website guarantees access to current alert notices and new safety information on regulated products.

**Rapid Alert System for food and Feeds (RASFF):** RASFF is a rapid alert system for food and feeds. It is a key tool to ensure the cross-border flow of information to swiftly react when risks to public health are detected in the food chain. Border rejections are received from European Commission Authentication Service and notifications are disseminated to the relevant Ministries, Department and Agencies, Nigeria Custom Service, Nigerian Agricultural Quarantine Service (NAQS), Nigeria Export Promotion Council (NEPC), Ministry of Trade and Investment, The Central Bank of Nigeria, and other stakeholders in the food safety supply chain. Nigerian food commodities are being rejected in the
European boarders due to pesticides residues contaminant, spoilage, poor handling, packaging and illegal importation etc. Investors and exporters are encouraged to visit the One Shop Investment Centre (OSIC) domiciled at Nigerian Investment Promotion Commission. OSIC is an initiative of the government to enhance the ease of doing business and facilitate investment and export by bringing the relevant government Agencies and regulators (CAC, CBN, NIPC, FIRS, NIS,NAQS and NAFDAC) to one location where all statutory approvals and document required to set up investment in the Nigeria economy can be processed and obtained. Adequate information is provided by the NAFDAC desk and other competent authorities on permitted level of pesticide residues in food commodities, approved food additives and preservatives proper packaging materials suitable for various food grade, storage conditions, Good manufacturing, Distribution and handling practices and so on. This is to ensure that food export meet the required regulatory standards (NAFDAC, 2019).
5. RESULTS

The following chapter presents the results from the interviews carried out with key food regulatory officers in NAFDAC and also the results from surveys carried out on the wider community in Nigeria.

5.1. Interviews with Regulatory Officers of NAFDAC

Results from the interviews conducted with key regulatory officers at NAFDAC revealed that almost all food commodities are commonly adulterated in Nigeria, with food commodities such as honey, vegetable oil, palm oil, alcoholic and non-alcoholic beverages, flour and sugar being the most commonly adulterated food commodities. Reasons for poor implementation of food laws in Nigeria include inadequate funding and other logistics, gaps as a result of overlapping of functions of the government agencies that regulate food activities, ununified regulation and enforcement, unrealistic policies and lack of compromise by law enforcement agencies. Regarding publications, published articles or a food database where food fraud cases have been documented in Nigeria, the food agency publishes cases of food fraud on its website (i.e. through the recall and alert system) and through annual reports and NAFDAC Consumer Safety publications. It has a functional food database which has registered food products only. One of the regulatory officer stated that food products from supermarkets are registered with a global listing and the agency ensures that any food product that is imported is registered on the global listing. Regarding reasons food commodities are still adulterated in Nigeria, the following factors include poverty and economic gain, ignorance and lack of awareness, porous borders, over regulation and non-seriousness in accepting laid down laws and lack of stiff penalties for offenders. Like one of the regulatory officer quoted “Because people are terrible people; We arrest them, keep them in the cell till Monday, release them on Monday after they have paid the fine and after two weeks, we discover they are still doing the same thing; just wickedness and poverty and because people are only interested in making money”. The processes for recalling adulterated food commodities as explained by the officers are through the following ways:

- Notification of the product and product batch is received from government, individual establishments or stakeholders.
- Authentication of source of consumers’ complaint will be done.
- Investigation and surveillance will take place to authenticate the problem.
- The manufacturer or importer will be notified.
- A public alert notice will be issued.
- A surveillance team will be constituted.
- Product mop-up accompanied by forfeiture form.
- Laboratory analysis.
- Destruction exercise will then take place.
The regulatory processes in NAFDAC are carried out by employed regulators and they include the following:

**For imported products:**

- Collection and vetting of documents.
- Payment of relevant fees.
- Issuance of import permit for samples submission for laboratory analysis.
- Inspecting the facility abroad and collection of on the spot relevant documents.

**For products meant for export and local use:** Inspection of facility where products for export will be manufactured and domiciled. Types of inspection includes:

- Initial (Advisory)
- Production
- Routine
- Investigation
- Surveillance
- Mop-Up
- Renewal
- Good Manufacturing Practice (GMP) Reassessment
- Advocacy
- Enlightenment

When asked about the development of the regulations, they stated that the standard regulations committee under the Registration and Regulatory Directorate is responsible for developing the regulations. The roles of the risk assessors (i.e. the stakeholders) and the risk managers (i.e. the manufacturers) in food safety management as stated by the regulatory officers are (1) To evaluate the risks associated with the products they produce (2) To produce and provide food in the safest manner (3) To analyse the risk using HACCP.

Regarding measures NAFDAC has taken in tackling cases of food fraud in Nigeria, the answers given varied from each of the officers but not limited to the following:

- Routine monitoring of all food establishments.
- Public enlightenment campaign.
- Effective collaboration with related bodies and agencies.
- For frequently committed food fraud, application of stiffer penalties for offenders.
- Sustenance of effective regulation.
- Capacity building and post market surveillance of all retail shops, markets and supermarkets.
- Deregistration of offenders if registered with NAFDAC and stiff sanctioning if not registered.
• Institution of functional food database for all registered food commodities.
• Imported food products are certified before entering into the market. They undergo proper documentation (certificate of analysis of the product from the country of manufacture) and the product is analysed in the laboratory.

The relevance of NAFDAC and other agencies in tackling food fraud as well as promoting food safety in Nigeria and its relevance with the UN Sustainable Development Goals (SDGs) will be covered in subsequent chapters.

5.2. Consumer Survey Questionnaire

The participants’ profiles with regards to gender and age are provided in Table 2. The majority of the participants are aged between 25 and 54 years. According to the results, 38 (55.88%) are male while the remaining 30 (44.12%) are female.

<table>
<thead>
<tr>
<th>Age</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 18</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>18-24</td>
<td>5</td>
<td>7.35</td>
</tr>
<tr>
<td>25-34</td>
<td>34</td>
<td>50.00</td>
</tr>
<tr>
<td>35-44</td>
<td>11</td>
<td>16.18</td>
</tr>
<tr>
<td>45-54</td>
<td>10</td>
<td>14.71</td>
</tr>
<tr>
<td>55-64</td>
<td>8</td>
<td>11.76</td>
</tr>
<tr>
<td>65-74</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Above 75</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>68</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gender</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>38</td>
<td>55.88</td>
</tr>
<tr>
<td>Female</td>
<td>30</td>
<td>44.12</td>
</tr>
<tr>
<td>Total</td>
<td>68</td>
<td>100</td>
</tr>
</tbody>
</table>

Of the food commodities that are commonly adulterated in Nigeria, results showed that fats and oil (n = 36) were the most commonly adulterated, followed by alcoholic and non-alcoholic drinks (n = 17) and honey (n = 4) respectively as shown in Table 3.

<table>
<thead>
<tr>
<th>Food category</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbs and Spices</td>
<td>1</td>
<td>1.47</td>
</tr>
<tr>
<td>Fats and oils</td>
<td>37</td>
<td>54.41</td>
</tr>
<tr>
<td>Dairy products</td>
<td>2</td>
<td>2.94</td>
</tr>
<tr>
<td>Food Commodities</td>
<td>Participants</td>
<td>Percentage</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>--------------</td>
<td>------------</td>
</tr>
<tr>
<td>Cereals</td>
<td>1</td>
<td>1.47%</td>
</tr>
<tr>
<td>Alcoholic and non-alcoholic drinks</td>
<td>17</td>
<td>25.00%</td>
</tr>
<tr>
<td>Baked goods and confectionery</td>
<td>2</td>
<td>2.94%</td>
</tr>
<tr>
<td>Meat and meat products</td>
<td>2</td>
<td>2.94%</td>
</tr>
<tr>
<td>Fish and fish products</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Honey</td>
<td>4</td>
<td>5.88%</td>
</tr>
<tr>
<td>Fruits and vegetables</td>
<td>2</td>
<td>2.94%</td>
</tr>
</tbody>
</table>

A bar graph showing the overall percentage ratio of food commodities commonly adulterated in Nigeria is shown in Figure 5.1.

**Figure 5.1:** Bar graph showing the overall ratio of commonly adulterated food commodities in percentage.

91.18% (n = 62) of participants agree that food laws in Nigeria are poorly implemented while 8.82% (n = 6) do not agree as shown in Figure 5.2.

**Figure 5.2:** Bar graph showing the percentage of participants that agree/disagree on poor implementation of food laws in Nigeria.

However, 70.59% (n = 48) of participants agree that NAFADAC are making efforts in tackling food fraud while 29.41% (n = 20) disagree as shown in Figure 5.3.
Figure 5.3: Pie chart showing the percentage of participants that agree/disagree on the efforts of NAFDAC in tackling food fraud.

Regarding the UN Sustainable Development Goals (SDGs), 64.18% (n = 43) of the participants are fully aware of the 2030 Global Goals while the remaining 35.82% (n = 24) are neither aware or have never heard of the 2030 Global Goals as shown in Figure 5.4.

Figure 5.4: Bar graph showing the percentage of participants that are aware/unaware of the UN Sustainable Goals (SDGs).

Majority of participants with 77.27% (n = 52) agree that food smuggling is a problem in Nigeria while the remaining 22.73% (n = 15) do not agree as shown in Figure 5.5.

Figure 5.5: Bar graph showing percentage of participants that agree/disagree on the problem of food smuggling in Nigeria.

43.94% (n = 29) of participants agree that consumers are partly responsible for food adulteration in Nigeria while the remaining 56.06% (n = 37) disagree as shown in figure 5.6.
Figure 5.6: Bar graph showing the percentage of participants that agree/disagree that consumers are partly responsible for food adulteration in Nigeria.
6. DISCUSSION, RECOMMENDATION AND LIMITATION

Food safety is an essential element of food security. Some types of food fraud decrease food safety and therefore directly threaten food security. Based on their potential health hazard, Everstine et al., (2018) developed a scheme to classify adulterants related to food fraud. The three categories were: (1) potentially hazardous adulterants (2) non-hazardous adulterants and (3) non-hazardous adulterants. When this categorization was applied to over 1000 food fraud incidents reported to the U.S pharmacopeial Convention (USP), nearly half were category one, suggesting many incidents of food fraud pose a risk to human health. The economic costs of both direct and indirect food fraud can be significant. These economic effects can also threaten food and nutrition security, particularly in low-and middle-income countries (LMICs). Detected food fraud in high-income countries (HICs) leads to recalls, resulting in food waste. Companies typically suffer a decline in sales as well as the associated costs. More indirectly, bribery leads to unfair competition with legitimate food businesses around the world, distorting markets and increasing food costs, reducing accessibility to households with income constraints. Since fraud undermines trust in the food system, if customers avoid suspect foods, it can also reduce food and nutrition security. The results from this study probes into the views of the public and regulators on food fraud in the Nigerian context.

Following a series of interviews with key regulators and a survey of public consumers in Nigeria, the results from the research revealed that majority of participants attributed corruption, lack of enforcement, poor implementation, bribery, lack of awareness, poor sensitisation and education as well as poor preservation methods and hygiene as reasons for poor implementation of food laws in Nigeria. They stated also that profit making is one of the major reason for people adulterating food commodities; other reasons included hunger, poverty and greed. Most participants believe that creating awareness and educating the consumers especially in the rural areas on the dangers of food fraud and detecting fake products is one way of promoting food safety in Nigeria. Others attributed other reasons such as effective policies, implementation and enforcement, stiffer penalties to offenders, training and employment of more regulatory officers, frequent monitoring to track offenders as well as strict compliance with the rule of law, public feedback and whistleblowing. Regarding the issues surrounding food smuggling, they revealed that effective measures which the regulatory bodies can adopt includes closing of the land borders, supporting local farmers in producing home-based food commodities, effective border control, partnership with other government agencies to tighten security at borders and monitoring the point of sales in the country as well as total ban of foreign and imported food products into Nigeria. However, some participants disagreed that consumers are partly responsible for adulterating food commodities, stating it is the wholesalers and retailers that are responsible and should be held accountable. Three (3) key themes emerged from the interviews and survey conducted in this research and they include the following:
Poverty: Nigeria has the highest number of people living in poverty across the world, with an estimated 95.02 million Nigerians in extreme poverty (World Poverty Clock, 2019). Poverty in Nigeria is caused by political instability, income elasticity and ethnic conflict. This has led to hunger and malnutrition among women and children, being the most affected, unemployment and corruption.

Corruption: Corruption is a major factor aggravating the level of hunger and poverty in many developing countries. Corruption and poverty in Nigeria are interrelated and encourage each other. Resources that could potentially ameliorate poverty and hunger are often misused (Gelb and Decker, 2012; Shuaib, 2015).

Food safety legislations and control systems: Food safety systems in developing countries are weak, fragmented, and not effective to protect consumers’ health. In Nigeria, this is undermined by lack of Good Agricultural Practices (GAP), inadequate enforcement of available legislations, ignorance and lack of technical expertise.

Food is a fundamental human need and a fundamental right, which plays a key role in a country's economic growth. Yet there is still no daily access to food for a large proportion of the world population. Today, food systems are facing the immense task of feeding a rising increasingly urbanized population and are currently falling short of fulfilling nutritional requirements and ensuring long-term health for nearly half of the world's population (Global Nutrition Report, 2017). As the world's population continues to grow, much more effort and creativity is required to sustainably increase agricultural production, strengthen the global supply chain, reduce food loss and waste, and ensure access to nutritious food for people suffering from hunger and malnutrition (UN, 2019). The 17 Sustainable Development Goals (SDGs) adopted in 2015 by world leaders give a global agenda to 2030. SDG 2 (Zero Hunger) seeks to "end hunger, achieve food security and enhance nutrition, and encourage sustainable farming" (UN, 2015). About 821 million people are undernourished (FAO, 2019), 2 billion people lack essential micronutrients like vitamin A and iron, and 2 billion people are overweight or obese (Development Initiatives, 2017). In addition to the SDG 2 "Zero Hunger," a number of SDGs are related to global hunger issues and include the following:

SDG 1 - No poverty: Millions of people today are struggling to meet their most fundamental needs. Poverty and other socio-economic inequities in low, middle and high-income countries are associated with poor nutrition, including among certain population subgroups in nations. Addressing hunger would boost nutritional outcomes, as it is important to improve nutrition in the fight against poverty (Global Nutrition Report, 2017; Perez-Escamilla et al., 2018).

SDG 2 – Zero Hunger: “End hunger, achieve food security and improved nutrition and promote sustainable agriculture” emphasizes the importance of hunger as a barrier to sustainable development and creates a trap from which people can not escape easily. A world with zero hunger can have a positive impact on our economies, health, education, equality and social development and is a prerequisite for
achieving the other goals of sustainable development such as education, health and gender equality (UN, 2015).

**SDG 3 – Good Health and Well-being:** “Ensure good health and well-being for all at all ages” addresses all major health priorities including communicable diseases (NCDs) (UN, 2015). Overnutrition is one of the major risk factors that drives the rise of NCDs, including heart disease, stroke, cancer and diabetes, and chronic lung disease, collectively responsible for nearly 70% of all deaths worldwide (WHO, 2018c). Not only do NCDs threaten development, they are also a cause and consequence of poverty, and tackling the NCDs needs to addressing social inequity (UN, 2011). Nonetheless, the NCD agenda is at real risk of becoming intangible and not being discussed due to the very large number of targets and measures explicitly in SDG 3 and the SDG in general (Ordunez and Campbell, 2016).

**SDG 4 – Quality Education:** Education is related to better nutritional outcomes. Mothers with high-quality secondary school education are likely to have much better nourished babies. Better nutrition also means improved results in education, jobs and empowerment of women, as well as reduced poverty and inequality (Global Nutrition Report, 2017).

**SDG 5 – Gender Equality:** Ensuring equal access to and control of assets increases agricultural output, increases investment in child education and increases food security for households. The empowerment of women within the food system, from food production to food preparation, is a fundamental prerequisite for social and economic development of communities, but malnutrition hampers efforts in this direction (Oniang'o and Mukudi, 2002).

**SDG 6 – Clean Water and Sanitation:** Billions of people lack access to safe drinking water and adequate hygiene and sanitation services, living at risk of avoidable infections and disease that have a negative effect on nutritional status and health. Addressing water variability, scarcity and competing uses is beneficial for food security and nutrition (Ringler et al., 2018).

**SDG 10 – Reduced Inequalities:** There are important synergies between food security and social protection. Effective social assistance programs may reduce persistent food insecurity, whereas demand-driven or elastic social insurance and safety net systems may tackle intermittent food insecurity induced by seasonality or exposure to shocks in living conditions (HLPE, 2012).

**SDG 12 – Responsible Consumption and Production:** “Ensure sustainable consumption and production patterns” implies that meeting an increasing population's nutritional needs allows consumers to choose and food systems to provide a healthy and healthier diet with a lower environmental footprint. SDG 12 provides specific opportunities to reduce the burden of NCDs and create a global network that is sustainable and balanced.

**SDG 13 – Life on Land:** The diminishing diversity of worldwide agricultural production and food supplies may have significant implications for global diets. Agricultural diversification can contribute
through both subsistence and income-generating pathways to diversified diets and can be an important strategy for improving diets and nutritional outcomes in low- and middle-income countries. More work is also needed to understand the potential impacts on overweight and obesity of agricultural diversification (Jones, 2017).

**SDG 14 – Life Below Water:** Healthy water-related ecosystems provide a series of ecosystem services, many of which in turn support nutrition and health outcomes (Ringler et al., 2018).

**SDG 16 – Peace, Justice and Strong Institutions:** Food security and nutrition can contribute to conflict prevention and mitigation by building and enhancing social cohesion, addressing root causes or drivers of conflicts, and by contributing to the legitimacy of, and trust in governments. Food security can support peace-building efforts and peace-building can reinforce food security (FAO, 2016).

**SDG 17 – Partnerships for the Goals:** The complexity and the relations between all of the SDGs call require a paradigm shift, calling all stakeholders of the food system to engage and share knowledge in supporting communities and countries in achieving the SDGs.

The idea of food security originated in the 1940s and is now widely used in the design, implementation and evaluation of programs and policies for humanitarian emergencies and development. Food security is every government's central concern—in the developed and developing world. In addition, due to the nature of our globalized world, a single country or region’s actions (such as Europe, Africa, South Asia, etc.) affect people's food security in other countries, regions, or the world. Disasters in one area have an impact on food supply and demand elsewhere. Food security is defined as the situation where “all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and preferences for an active healthy life” (FAO, 1996). Food security includes four elements namely: availability, access, utilization and stability of supply. The foundational definition from the 1996 World Food Summit encompasses four dimensions:

- Availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports (including food aid).
- Access by individuals to adequate resources (also called entitlements) for acquiring appropriate foods for a nutritious diet.
- Utilization of food through an adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met.
- Stability in the availability of and access to food, regardless of sudden shocks (e.g. an economic or climatic crisis) or cyclical events (e.g. seasonal food scarcity).

The foods that are commonly involved in food fraud tend to be the most nutritious, aggravating the problem. Several case studies have been documented that involve food fraud and its consequences for food and nutrition security. In 2003 and 2004, over 200 ‘big-headed babies’ in Anhui Province were found
to have suffered from severe malnutrition as a result of consuming substandard baby milk with inadequate levels of protein (Tam and Yang, 2005). In the aftermath, regulators implemented more stringent testing requirements for milk and baby formula. However, the tests used for protein levels were unable to distinguish between milk protein and other nitrogen containing substances. In September 2008, milk deliberately adulterated with melamine to disguise its protein content was detected by the Chinese Department of Health. This led to the death of six babies and more than 290,000 people (most of them infants) poisoned, and the subsequent banning of imported Chinese milk products by the international community (Xiu and Klein, 2010). While the food and nutrition impacts were not fully assessed, these may have been significant. Qiao et al., (2012) found that during the melamine scare, 63% of households with children under the age of 6 reduced consumption of all dairy products; 39% cut milk consumption completely; 18% were reported to cutting consumption by more than half and 43% by at least one-third. This study indicates a significant drop in milk consumption by households with young children.

The time between 6 and 23 months is a vulnerable time for young children as it is a time of rapid growth when children are susceptible to growth stunting. Food fraud results where opportunities are present, there is motivation to cheat and control systems are absent or insufficient to deter (Ruth et al., 2017). Underlying motivations include economic, cultural and psycho social drivers. Several authors have identified profit as the key motivator (Lipp, 2012). For example, fraud is more likely for high value products than for low value products. Also, firms with a strong reputation (and hence more to lose) are less likely to commit fraud than those without. Fraud which can be easily and/or cheaply detected would likewise be expected to be less common. Cultural factors can also influence propensity to commit fraud. In countries with a high level of corruption, firms have been shown to be more likely to use illegal methods. Countries with collectivist cultures have been shown to be more corrupt than countries with individualistic cultures. Poverty and lack of social security support is also associated with high levels of corruption. Individual characteristics and experiences can influence propensity to commit fraud. These include environmental pressures (poverty, lack of alternatives) as well as behavioural risk factors. Illicit trade in food and agricultural products has “many” important and negative consequences throughout the SDGs. Smuggling is usually driven by the price disparity between the place of origin and the destination of the smuggled goods. The key risks associated with smuggled agri-food include tax and tariff losses, as well as “severe” knock-on effects on the economy as a whole, causing unfair competition and limiting local producers. There is also a risk that smuggled products can introduce invasive species, disease-carrying pathogens or pollutants threatening both human health and the agricultural economy (FoodNavigator, 2019). Fraud and smuggling have an effect on many different foods, including beef, dairy products, fish and seafood, fruit juices, oils, honey, spices and wine. Food fraud, commodity smuggling and illegal agrochemicals are undermining sustainable farming, limiting crop yields, and jeopardizing the provision of fair, safe and sustainable food supplies, slowing progress towards zero hunger. Illicit trade in agri-foods undermines the SDGs as follows:
• Reduces competitive and stable agricultural markets that foster economic development and poverty reduction, hitting SDG 1 “no hunger”
• Destabilises food security and undermines sustainable food production and access to food, undermining SDG 2 on “zero hunger”.
• Exposes consumers to harmful ingredients or deprive them of active beneficial ingredients, threatening SDG 3 “good health and wellbeing”.
• Siphons Gross Domestic Product (GDP), jobs and tax revenues from national economies and introduces health risks that can jeopardise corporate brands and economic sustainability, which can be linked to SDG 8 “decent work and economic growth”.
• Deprives consumers of choice and ability to make educated and eco-friendly decisions, dampening SDG 12 “responsible production and consumption”.
• Illegal profits underwrite smugglers, breeds corruption, subsidise wider criminal activity and threaten political and economic stability, undermining SDG 16 on “peace, justice and strong institutions” (FoodNavigator, 2019).

6.1. RECOMMENDATIONS

Increased public awareness and consumer education about the dangers of food fraud are key factors to successful food legislation in Nigeria. There should be better coordination among the bodies charged with responsibilities for food safety; capacity building by training of personnel, producers and regulators is vital towards achieving success in implementation of food safety legislation, and the small and medium-sized enterprises (SMEs) should be urged to form associations for ease of government support through training and awareness creation (Omojokun, 2013). Industry, government and enforcement agencies should always put the needs of consumers above all other considerations; this means giving food safety and crime prevention absolute priority over other objectives. There must be clear leadership and coordination of investigations and prosecutions, and the public interest is recognized in active enforcement and significant penalties for significant food crimes (Brooks et al., 2017). Safe food supply also depends on both sound science and equitable law enforcement. Periodically, new laws and regulations must be enacted to further protect a continuing supply of food products that are safe and wholesome for the health and wellness of people. Once laws are enacted, they must be enforced to ensure compliance by the entire food industry including industries directly or indirectly connected with the food source, labelling, packaging, transportation, distribution down to retail sales. All governmental agencies involved in potential food supply chain must be given resources and authorities to discharge the 3-fold duty of (1) informing citizens of nutrition and components of important food products; (2) enforcing existing laws and regulations on food industry to ensure supply of safe food products and (3) investigating and eliminating potential toxic contaminants and prosecute economic fraud via regular monitoring and surveillance on food supply chain (Fung et al., 2018). To equitably enforce food safety laws, sound science must be the basis of setting the regulations and protocols to inform, enforce and eliminate unsafe foods.
Risk assessment is a scientific process that puts the concern about food contaminations in proper perspective as the purpose of scientific risk calculation is to get the best estimate of the true risk using available and current information (Fung et al., 2018).

6.2. LIMITATIONS

This research thesis has several limitations and they have been identified as follows: Firstly, there were time restraints due to the submission of thesis. Secondly, the sample size of participants, especially from the regulatory agency was insufficient. This was attributed to the fact that getting information from civil servants from government agencies or parastatals in Nigeria is difficult and as a result, majority of them were unwilling to share information during the collection of data. In this case, the regulatory officers who were interviewed and the people who responded to the survey questions may not truly be a random sample.
7. CONCLUSION

Food safety is a shared responsibility of the government, producers, processors, suppliers, retailers, and consumers, with everyone in the food supply chain, as key players with a role to play from the farm to the table to ensure food is safe for human consumption. Based on this study, The Nigerian government and other stakeholders should give utmost priority to the following:

- The fight against corruption.
- Policies that will lift people out of poverty and unemployment.
- Quick resolution of ethnic conflicts and terrorism.
- Agricultural production and nutrition-related interventions to effectively tackle hunger and malnutrition among vulnerable groups, especially children.

The Food Safety and Quality Bill as approved by the Federal Executive Council (FEC), will help to prevent fraudulent or deceptive practices that may affect the health of consumers and also provide a framework for NAFDAC and other regulatory agencies to enforce stricter punishments and persecute offenders caught in food fraud. Policy makers should build and maintain adequate food systems and infrastructures to respond to and manage food safety risks along the entire food chain as well as integrate food safety into broader food policies and programmes such as nutrition and food security, in order to ensure that domestically produced food is safe internationally. Assessing the safety of new and emerging technologies such as nanotechnology, next generation sequencing, omics technologies (genomics, proteomics and metabolomics) and bioinformatics would greatly improve national food safety systems and legal frameworks, and implement adequate infrastuctures to manage food fraud.
8. REFERENCES


FAO (1996). Rome declaration on world food security and world food summit plan of action. World Food Summit, Rome, Italy.


HPLE (2012). Social protection for food security: A report by the high panel of experts on food security and nutrition of the committee on world food security. CFS, Rome.


Proietti, I., Frazzoli, C and Mantovani, A. (2014). Identification and management of toxicological hazards of street foods in developing countries. Food and Chemical Toxicology 63, pp. 143-152.


Food fraud is one of the most urgent and active food research and regulatory areas. It is an evolving problem in Nigeria that has led to the deaths of many people especially the vulnerable groups that includes mostly children, the elderly and immunocompromised persons. Therefore the aim of this study is to investigate the current challenges of food fraud in Nigeria, identify the risks it poses on the health and wellbeing of Nigerians and propose measures to tackle food fraud at local and international levels by regulatory and government agencies. This study explored the relationship between food fraud, food security and the UN Sustainable Development Goals. This study is relatively new as it has never been carried out before so it relied on information from previous research articles, journals and publications. A total of 68 participants from the general public took part in this study and some key officers from the National Agency for Food and Drug Administration and Control (NAFDAC) were interviewed to obtain their opinions on the current state of food fraud in Nigeria. The findings revealed common foods being adulterated in Nigeria are mostly fats and oils, alcoholic and non-alcoholic drinks and honey. Poverty, corruption and poor food safety and control systems were identified throughout this study. The study concluded by reviewing several policy framework and actions taken by the Nigerian government to proffer solutions that can actualise the goals of the Sustainable Development Goals by 2030.

Keywords
Food Fraud; Food Security; Food Safety; Sustainable Development Goals; Nigeria

1.1. Introduction

Fraud can be defined as an intentional misrepresentation of fact by one person alone or acting on behalf of an organization in order to deceive another person to part with something of intrinsic value. Food fraud is a collective term used to include intentional and deliberate substitution, diversion, exploitation or misrepresentation of food, food ingredients or food packaging, or a misleading or false assertion about an economic benefit commodity (Spink and Moyer, 2011a). Food fraud forms include adulteration, bribery, overrun, stealing, diversion, simulation, and falsification (Spink and Moyer, 2011b). Fraud in connection with food is not recent. For economic gain, most early food laws and codes concentrated on adulterants. Philosophers have raised doubts since the 4th century B.C and the penalty of Roman law for food adulteration included servitude or exile (Fortin, 2009). Food fraud's effects are catastrophic. Food
companies and their image are harmed, reports go viral, entire supply chains are painted with the same brush, erodes consumer confidence, failure of markets and management and/or staff are fired, charged and locked up. The overall effects are comparable to other corporate fraud (Kuang and Lee, 2017). Losses for individual businesses may include social losses and sanctions, losses from third parties (e.g. additional tests), losses of confidence, losses of sales and overpayment, as well as losses from recall (Bindt, 2016). There is some popular belief that food theft is primarily an external threat from organized crime groups who aim to permeate the food supply chain. While politically convenient, in fact, actors in the food supply chain who make the most of the criminal opportunities that emerge are more often a problem (Lord et al., 2017). Fraud is the product of the relationship between motivated criminals and the opportunities offered by victims and those responsible for controlling risks according to Levi (2012). While food fraud is not really a new phenomenon, food authentication and the truthfulness of food labels are currently a major concern for many different groups of people, including the food industry, regulators, customers, etc. (Charlebois et al., 2016).

With the increasingly poor food safety and security practices in Nigeria, there is a tendency to suffer severe health consequences and to report massive death rates from pollutants every day. Sadly, there are poor food safety practices and standards in Nigeria which, according to the National Agency for Food and Drug Administration and Control (NAFDAC), has resulted in enormous economic losses, as can be seen in the myriad of rejections of some Nigerian food exports at international borders as a result of contamination, inadequate storage methods and adulteration of food products. A 2015 internal memo issued to Sahara Reporters from the National Agency for Food and Drug Administration and Control (NAFDAC) Nigeria's Food Safety and Applied Nutrition (FSAN) office disclosed that tomato paste imported from China and sold in Nigeria fell well below national food safety standards. This was discovered by the FSAN after conducting a study in which 314 tomato paste packets purchased in Lagos were tested in a laboratory to determine if they had a tomato content of at least 28 percent, the minimum requirement stated by Codex Alimentarius Standards and Nigerian Industrial Standards. The study results showed that 286 samples, or 91.1% of the samples analysed, had tomato content below the minimum of 28%. In the internal FSAN report obtained by Sahara Reporters, the FSAN considered the consequences of the test results to be very alarming and concluded that tomato paste product companies were working with Chinese tomato paste manufacturers to sell to unsuspecting Nigerian consumers because Nigeria consumes approximately 300,000 tons of tomato paste imported from China annually. As a result, the FSAN recommended that retailers refrain from selling imported tomato paste from China until further notice and released a national recall of imported tomato paste brands from China (Sahara Reporters 2016). A dietary study conducted at Lagos and Kano revealed at the point of consumption, an alarming amount of contaminated food. The food was allegedly contaminated with chemicals, metals and traces of pesticides (Premium Times, 2019). In 2018, a warning was issued by the Ghanaian Health Authority against the consumption of puffer fish which resulted in the death of two family members while four others were hospitalized after eating the
fish for dinner. They revealed that the puffer fish contains tetrodotoxin, a neurotoxin that makes the fish lethal and is stated to be 1000 times more toxic than cyanide, and that it does not have an antidote and kills by suffocating the diaphragm (NAFDAC, 2018). There has been a range of different detection methods developed and used in the determination of the authenticity of food. In a review by Reid et al., (2006), many methods of detections were scrutinised including spectroscopy (UV, NIR, MIR, Raman), isotopic analysis, chromatography, electronic nose, polymerase chain reaction, enzyme-linked immunosorbent assay and thermal analysis – all of which are techniques that have been applied to food authentication since 2001.

Historically, the idea of sustainable development (SD) was introduced in a paper called “Our Common Future” by the UN Commission on Environment and Development (Brundtland Commission) report. This definition promotes the need for growth to meet the needs of the present generation without undermining the capacity of the future generation to meet their own needs (Brundtland et al., 1987). Nevertheless, one of the key sustainability issues, according to Govindan et al., (2013) is to operationalize the Brundtland Commission recommendations to guide organizational decisions. Sustainable Development's new principles are becoming more and more relevant than they were two decades ago because it goes beyond purely environmental, economic and social development issues and affects the very life of people (Kumi et al., 2014). There is a need for science to support politics in this sense, as well as coping with demands from the government and various shareholders when they are faced with the task of achieving sustainable development (Aricò, 2014). The idea of creating the SDGs originated at the 2012 Rio+20 United Nations Summit in which Member States decided to adopt a set of guidelines for global development with a view to growing the benchmark for developing countries and disadvantaged communities (Gupta and Vegelin, 2016), as well as building a stronger commitment to human-centred growth, human rights and environmental sustainability. The Sustainable Development Goals were set through a series of measurable goals and required a great deal of global cooperation and commitment at several levels when it came to monitoring, which is sadly seldom even feasible (Giupponi and Gain, 2016). The Rio+20 Conference endorsed a mechanism in its final document, “The Future We Want”, while rejecting several others, in order to negotiate a consensus on the Sustainable Development Goals (UN, 2012). Consequently, the outcome of Rio+20 was structured in many respects to be qualitatively different from the Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs) aimed at being more responsive to a variety of stakeholders at multiple levels of governance (Gellers, 2016). Following “The Future We Want”, the UN document “Transforming Our World: The Sustainable Development Agenda 2030” contains a declaration of the 17 SDGs and 169 targets, as well as monitoring and assessment mechanisms (Gupta and Vegelin, 2016). The Sustainable Development Goals were developed through a comprehensive participatory mechanism and progressed through high-level committees such as “Open Working Groups” (OWG) along with various inquiries until the Heads of State finally approved a negotiated agreement. Five key areas have been identified by the Heads of State or the
Five Ps of the 2030 SDG Agenda, which are people, planet, prosperity, peace, and partnerships (Jayasooria, 2016). As Aitsi-Selmi et al., (2016) reports, 193 countries agreed on the Sustainable Development Goals, predecessors of the Millennium Development Goals, in September 2015 in New York, USA, focusing on an extremely comprehensive set of development goals. The Sustainable Development Goals outlined sensitivities to weaknesses created by gender, age, and disabilities when it comes to losses and disasters. Nevertheless, like the MDGs, the SDGs do not include, in an ecological sense, a particular and consistent goal relevant to world population growth and the new targets for 2030 (Bergaglio, 2016). Subsequently, the SDGs have the ability to mobilize academic groups and social movements around them to seek structural reform and responsibility for those who carry out the objectives. Therefore, they may be reinforced by the commitment to equitable standards of growth towards all stakeholders concerned (Gupta and Vegelin, 2016). To this end, it is the primary responsibility of each government, state or country to mobilize and collect financial resources, which in turn would promote new partnerships between the private sector and civil society (Jayasooria, 2016). According to Stafford-Smith et al., (2016), the SDGs’ objectives established an agenda for the sustainable development of all nations that adhered to economic growth, social inclusion and protection of the environment and includes:

- Goal 1: No poverty
- Goal 2: Zero hunger
- Goal 3: Good health and well being
- Goal 4: Quality education
- Goal 5: Gender equality
- Goal 6: Clean water and sanitation
- Goal 7: Affordable and clean energy
- Goal 8: Decent work and economic growth
- Goal 9: Industry, innovation and infrastructure
- Goal 10: Reduced inequalities
- Goal 11: Sustainable cities and communities
- Goal 12: Responsible consumption and production
- Goal 13: Climate action
- Goal 14: Life below water
- Goal 15: Life on land
- Goal 16: Peace, justice and strong institutions
- Goal 17: Partnerships for the goals
1.2. NIGERIA: AN OVERVIEW

Nigeria, officially the Federal Republic of Nigeria, is a country in West Africa, bordering Niger in the north, Chad in the northeast, Cameroon in the east and Benin in the west. Its coast in the south is located on the Gulf of Guinea in the Atlantic Ocean. It comprises of 36 states and 1 Federal Capital Territory, where the capital Abuja, is located and 774 local government areas. The states are grouped into six distinct geopolitical zones – North Central, North East, North West, South East, South South and South West (Figure 1). Nigeria is often referred to as the ‘Giant of Africa’, owing to its large population and economy. The current population of Nigeria is 202 million based on the latest United Nations data (Worldometers, 2019), ranking Nigeria as the most populous country in Africa and the seventh most populous country in the World. Nigeria has a total area of 923,768 km² (356,669 sq. mi), making it the world’s 32nd largest country. It is comparable in size to Venezuela, and is about twice the size of the US state of California. Its borders span 4,047 kilometres (2,515 mi), and it shares borders with Benin (773 km or 480 mi), Niger (1,497 km or 930 mi), Chad (87 km or 54 mi) and Cameroon (1,690 km or 1,050 mi). Its coastline is least 853 km (530 mi).
Nigeria has been a developing economy with her economic growth being unstable, unpredictable and unsatisfactorily low in recent years especially when compared with some other nations of the world (Machi, 2011). As the largest exporter of oil in Africa and an oil dependent economy, the country has witnessed many oil price shocks and disturbances over the years due to oil price volatility in the international market. The oil price has been fluctuating since the 1980s and the 1990s due to activities of the world powers in the global market. Apart from the incessant drop in the price of oil in the past, the recent notable one was the drastic fall of the oil price from $112 per barrel in 2014 to almost $38 per barrel as at the end of 2015 due to the incessant and massive supply of Shale oil by the United States to the global market (British Petroleum Statistical Review of World Energy, 2017). In 2014, according to International Energy Agency (IEA, 2015), Nigeria earned $77 billion from oil export. However, with the fall in oil price in 2015, Nigeria’s oil revenue fell to $41.33 billion (OPEC Annual Statistical Bulletin, 2016). By implication, the fall in oil price in the global market implies fall in the revenue accruing to the Nigerian economy and difficulties in achieving a sustainable level of growth. The reason being that over 80 percent of the government revenue comes from oil export. In addition, the monolithic nature of the Nigerian economy since the start of oil exploration in the 1970s has been persistently threatened by the fluctuation in oil prices. This has made the government to come to terms with the growing need for economic diversification from oil to non-oil economy. In the 1960s, prior to the discovery of oil, more than 70% of the rural population of Nigeria engaged in one type of agricultural activity or the other and between 1963 and 1964, the non-oil sector contributed as much as 65% to the Nation’s Gross Domestic Product (GDP) (Yesufu, 1996). However, the oil boom of 1973/74 changed the economic environment drastically as the windfall from oil boom around this time had a pervasive effect on the Nigerian economy even till the early 1980s. The shocks nevertheless, slowed-down the economic activity and as a result caused severe fiscal imbalances for Nigeria and oil revenues decreased drastically (Audu, 2012). The over reliance on the exogenous and volatile nature of oil revenue led the Nigeria government to make structural changes in order to look into alternative means of financing the economy by reconsidering the non-oil sector that had been neglected in the past due to oil exploration (Edame and Efefiom, 2013). After decades of neglect, the Federal Government of Nigeria began to reform the agricultural sector in 2011 following strategic direction laid out in the Agricultural Transformation Agenda (ATA) of the Federal Ministry of Agriculture and Rural Development (FMARD) (FMARD, 2016). The ATA’s core purpose was to help Nigeria to refocus federal government policymaker attention to agriculture, and the strategy’s main goal was to rebuild the agricultural sector (FMARD, 2016). The current development strategy of the agricultural sector – denoted the Agriculture Promotion Policy (APP) – builds on and refines the strategic direction of the ATA. The APP was launched in 2016 and applies for the five-year period lasting until 2020. It aims at addressing two key challenges of Nigeria’s agriculture: (1) to meet the food needs of a rapidly growing population with domestically produced food; and (2) to transform the agricultural sector so that Nigeria
becomes a successful exporter of agricultural products complying with international quality standards (FMARD, 2016). Thus, agricultural transformation has been at the centre of Nigeria’s agricultural development policy plan since the beginning of the 2010s. Yet, despite its vast agricultural potential, Nigeria imports food – mostly staple foods – worth billions of dollars annually. Many Nigerians and even a large proportion among the farming population lack adequate food for a healthy diet and suffer from malnutrition. The aims and objectives of this research project is to carry out an investigative study on the challenges of food fraud in Nigeria, identifying the risks and proposing solutions. At the end, this research project will seek to determine the following key areas:

1. To address the level of food fraud and its impact in attaining sustainable economic growth in Nigeria.
2. To identify lack of food policies and national control systems that will enforce regulations in tackling food fraud in Nigeria.
3. To identify how regulatory and government agencies can promote food safety that will enhance good health and wellbeing among consumers in Nigeria.
4. To propose measures that regulatory and government agencies in Nigeria can adopt in preventing food fraud.

2. METHODOLOGY

Data Collection

An internet search was conducted using food fraud and Nigeria as key words. Data sources including online newspapers, ScienceDirect, Google Scholar, Google Books as well as other scholarly articles and journals were used to gather data from scientific studies. However, there was very limited quantity of data available on food fraud cases in Nigeria though cases of food fraud has been reported on various Nigerian online newspapers and from the recall and alert notifications of the National Agency for Food and Drug Administration and Control (NAFDAC) which is the leading agency in food safety and regulation in Nigeria. After an initial comprehensive review of publicly available data, gaps of data were identified. From the identification of the data gaps, non-formal interviews were undertaken with key regulatory officials in an attempt to fill these gaps. Therefore, this project relies on data that is publicly available and interview accounts to provide a detailed overview of food fraud in Nigeria. Given the commercial sensitivity issues surrounding data collection, interviewee identities were kept anonymous throughout this report.

Interview Questions

- What are the food commodities that are commonly adulterated in Nigeria?
- Why are food laws in Nigeria poorly implemented and why are food commodities still adulterated in the Nigerian markets?
• Are there publications, published research articles or a food database where cases of food fraud have been documented in Nigeria for the last 10 years?
• What are the processes for recalling adulterated food commodities and issuing food safety alerts?
• How does the regulatory processes in NAFDAC work and who develops the regulations?
• What are the roles of the risk assessors and risk managers in food safety management?
• What has NAFDAC done in tackling cases of food fraud in Nigeria?
• What is the relevance of NAFDAC and other agencies, both locally and internationally in tackling food fraud?
• What has NAFDAC done in promoting food safety in Nigeria and its relevance with the UN Sustainable Development Goals (SDGs)?

Survey Questionnaire

An online survey questionnaire was designed using SurveyMonkey containing 13 questions, some of which were multiple choice and the remaining being open-ended questions. The survey was distributed via social media such as Facebook, WhatsApp and LinkedIn. Subsequently, a paper-based survey questionnaire alongside an informed consent form and information sheet, was sent to participants via email.

Data Analysis

The results from the survey was analysed on SurveyMonkey by creating custom charts and data tables, filtering and comparing results and exporting results in various formats. The results from the interviews were analysed in order to identify common themes among the responses of the interviewees and consumers.

3. Food Fraud – Current Status in Nigeria

Food Smuggling and Trafficking

Smuggling is the illicit cross-border trade of goods (Joosen and Raw, 2012); the importation of contraband goods (Ferrier, 2009) or the movement of goods into or out of a country or trading area often to avoid tariffs or legal obligations. Smuggling is an ancient practice and is one part of a wider set of informal, illicit or illegal economic activities that are not effectively controlled by government (Hartnett and Dawdy, 2013). Illicit trade is “any statute prohibited action or conduct relating to production, shipping, acquisition, storage, delivery, sale or purchase, including any practice or conduct intended to encourage such activity” (WHO, 2003). Illicit trading is defined by the quality of the goods (Bevan et al., 1988), for example, “black goods” are illegal, whereas “black parallel markets” describe legal goods that are exchanged illegally at the supply chain level rather than individual actors operating in a supply chain that is otherwise legitimate. Terms used to describe illegal goods include black, dark, second, parallel, secret, shadow, underground, unreported, unrecorded, covert or illegal goods (Feige, 1990). Consequently, illicitness is not an intrinsic
property of commodities or of particular economic actors, but rather a temporary quality attribute that is often related to the distribution or circulation mechanisms of a food item (Gregson and Crang, 2016). The Global Food Safety Initiative Position Paper on Food Fraud (GFSI, 2014) states that “food fraud, including economically motivated adulteration subcategory, is of increasing concern. Consumers are misled by the use of food products, ingredients and labelling for economic gain and include substitution, unapproved modifications, misbranding, counterfeiting, stolen or other goods”. The definition does not include trafficking and smuggling of food directly. Spink et al., (2016) however, found smuggling to be a form of food trafficking. Translating concepts of human smuggling and trafficking, food smuggling can be defined as when all parties involved, except regulatory and enforcement agencies, completely agree to illegal behaviour, while food trafficking requires violence against one or more parties, but sometimes the fine line between smuggling and trafficking is ambiguous (Butterly, 2014). Díaz (2015) distinguishes between small, petty smuggling (for personal use) and skilled smuggling or profit trafficking where a large volume of goods is transported via international shipping channels (Ferrier, 2009). Many food products are subject to additional import tariffs to protect national farmers (Lotta and Bogue, 2015). It illustrates the economic driver to participate in such activity for individuals and organizations. Joossens and Raw (2012) distinguished between tax avoidance, legal and legitimate activity, as well as tax evasion, illegal activity, conducted to pay less or no tax. Smuggling to achieve economic advantage is global. The cross-border smuggling of food and other goods is troublesome and has a direct impact on the economic growth of affected countries (Chen-Charpentier et al., 2015). The economic incentive for smuggling is the size of the difference between the price of a food in the country of origin and the price in the country of destination (Ferrier, 2009), citing examples of sugar, wheat and rice (Golub and Mbaye, 2007). Factors that may result in “black” economic activity include high taxes or complex tax structures, low tax morale, low Gross Domestic Product, poor institutions and corruption (Snowdon, 2012). Differences in recorded prevalence rates of smuggling between countries are due to the types of goods affected by any trade prohibitions, the degree of non-transparency of smuggled goods, the ease of putting improperly classified materials on manifest papers, and the targeting of any enforcement resources including purposive sampling (Ferrier, 2009).

Nigerian borders are notoriously porous and several reports have established how numerous goods including rice, find their way into the country through the borders, especially the ones adjoining Benin Republic (Premium Times, 2019). According to a news report by the Comptroller-General of the Nigerian Customs Service, 99 percent of rice smuggled through the land borders are unfit for consumption. He further revealed that rice is mixed with other grain bags or stuffed inside any available crevice and compartments of vehicles, including the engine area to deceive custom service officials. The concealed rice is thereafter re-bagged half cooked and presented in the markets for sale as imported rice. Often times, importers in the borders re-bagged expired rice to prolong their shelf life and as a result, rice being a perishable product, loses valuable shelf life in non-conducive storage conditions (Premium Times, 2016).
In late August 2019, Nigerian President Muhammadu Buhari ordered the partial closure of its boundary with Benin to curb rice smuggling. His administration further banned trading across all land borders to force neighbours Benin and Niger to halt food smuggling into the country (Bloomberg, 2019).

**Street Food Practices**

Safe food supply is a fundamental human right, leading to sound health, prosperity, and a platform for sustainable development and poverty alleviation. Street foods are enjoying increasing patronage due to industrialization, which causes many urban residents to eat their daily meals out of their homes (Alimi et al., 2014). Street food vending is a common feature of most cities and towns in developing countries (Ekanem, 1998). Street food is ready-to-eat food and beverage prepared and sold for immediate consumption by vendors and hawkers, especially in the streets and other public places (WHO, 1996; WHO / FAO, 2015). Street food safety depends on the quality of raw materials, food preparation, handling and storage practices. The sector, however, is full of unhealthy activities that have been reported to raise serious concerns about the safety of practitioners, especially consumer health (Muyanja et al., 2011). Such unhealthy practices spanned the entire street food business chain from agricultural raw materials to the final street food retail and were fingered in the outbreaks of illnesses and diseases (Akinbode et al., 2011).

It has been stated that the prevention, conservation and treatment of diseases from street food borne illnesses has resulted in the heavy drain on individuals and governments’ purses in developing countries due to huge expenditure (Ekanem, 1998). The street food market in Nigeria, as in other developing countries, is facing challenges. Studies have shown that home-made cereal flour and condiments used in street food preparations are contaminated with *Bacillus cereus* (Umoh and Odoba, 1999; Obuekwe and Ogbimi, 1989; Yusuf et al., (1992)) which was allegedly responsible for food-borne disease outbreaks (Gilbert, 1979). The highest frequency of Bacillus cereus recorded by Umoh and Odoba (1999) observed for “kunu”, a fermented cereal product in West Africa was the result of local spices and raw materials used as condiments in their survey of microbial quality of street foods sold in the streets of Zaria, Nigeria.

The mode of transportation plays a significant role in street food contamination. Transportation and display of meat has been reported to play an important role in accelerating their spoilage and zoonotic disease transmission (Okoli et al., 2005). The manner in which animal carcasses are transported from slaughter points to distribution points in crude structures such as wooden carts, open plastic or aluminum trays on heads or “off-road” vehicles has increased the likelihood of cross contamination. Okoli et al., (2005) stated that vehicles not equipped for meat transport such as taxis and buses without cooling facilities and even motorcycles carrying meat products from slaughter points to retail outlets are a common site in Nigeria. Okoli et al., (2005) maintained that it is not unusual to see butchers and retailers turning carcass meat for human consumption into sitting or resting platforms in the vehicles during the cause of transportation. Meats are retailed in open wooden trays in the markets and streets of Africa, which are
typically difficult to wash thoroughly, thereby harboring niches for meat contamination by microorganisms and deposition of airborne pollutants.

**Nigerian Food Fraud Incident/Fraudulent Commodities**

Food fraud is a prevalent problem in Nigeria. On the 28th of November 2019, the management of the National Agency for Food and Drug Administration and Control (NAFDAC) issued an alert on the unscrupulous activities of business men and traders who revalidate expired rice and also repackage local rice as foreign rice. The Ogun State office of the agency received the report from the Department of State Services (DSS) in the state, of ongoing food fraud at Oke-Aje market in Ijebu Ode. On the 14th of November 2019, Officers of the state office in company of officers of the Nigerian Police Force proceeded to the scene of the illegal activity. On arrival, the suspected perpetrators of the food fraud instigated unnamed persons to unleash mayhem on the team of investigators. However, enforcement officers of the agency and its federal task force team stormed the market in company of Department of State Service officials. They sited the perpetrators at the market who took to their heels and discovered expired rice, caked rice, bags of local rice, bags of popular foreign rice and sealing machines at the shops. The NAFDAC enforcement team gained access into the shops and sealed three shops during the operation. The management of the agency noted that expired and caked rice are unwholesome as they contain moulds and microorganisms that cause diseases which are of immense public health concern (NAFDAC, 2019a). Similarly, on the 11th of November 2019, the agency issued an alert to the public on frozen raspberries contaminated with norovirus from China. The contamination of the frozen raspberries with norovirus was detected in Germany with some of the contaminated products being exported to Nigeria from Germany. The agency warned members of the public not to consume the contaminated frozen raspberries as norovirus is a highly infectious virus that causes vomiting and diarrhoea, and implored importers to desist from importing the contaminated product to Nigeria (NAFDAC, 2019b). Major convictions of Nigerian importers and business traders took place between 2017-2019. For example, Mrs Esther Akinsanya, a business woman and her company in a popular market in Lagos, was convicted on the 30th of November, 2018 by the Federal High Court in Lagos for rebagging smuggled, adulterated and misbranded sugar. She was fined the sum of ₦1,300,000.00 ($3,611.00) and ordered by the court to bear the cost of destruction. On the 5th of December, 2018, operatives of the agency in Katsina State arrested three suspects for the sale and distribution of banned and rebagged sugar. The suspects were convicted by the Federal High Court in Katsina and fined the sum of ₦100,050.00 ($277,91.00) each. The court ordered the forfeiture of the products to NAFDAC for destruction and the cost to be borne by the convicts. Okey Joseph Okeke, a business man was arraigned at the Federal High Court, Akwa, Anambra State on 29th April, 2018 for the sale of unwholesome processed foods including vegetable cooking oil, extra virgin cooking oil, alcoholic whisky and vodka. Also, Mrs Nkiru Okoro of Ezedams Enterprises Nigeria Ltd. was investigated for illegal production of counterfeit alcoholic beverages and obstruction of NAFDAC officers in the course
of their operation. She was arraigned at the Federal High Court, Lagos on 27th June, 2019 (NAFDAC, 2019c).

**Food Control Systems**

Most food safety regulations need to be enforced at national level, for example in Nigeria, the Federal Ministry of Health formulates and monitors policies and regulations on food hygiene and safety, the Standards Organization of Nigeria (SON) formulates and enforces standards for the composition of imported and locally produced foods and the National Agency for Food and Drug Administration and Control (NAFDAC) is responsible for the control of imported and locally processed food at national and state levels (FAO, 2005).

Food laws in Nigeria exist, but many are poorly enforced:

- Public Health laws (1917), now known as Public Health Ordinance cap 165 of 1958.
- The Standards Organization of Nigeria Decree No. 56 of 1971.

Among the various institutions concerned with food safety problems, there is a lack of coordination and conflicting or overlapping roles at administrative level. It is important to identify roles in order to avoid discrepancies and to facilitate the smooth running of control activities. There is a very clear need for better coordination of the institutions that have overlapping authority. At national and local levels, the responsibility for administrative, food safety regulation and import certification is shared between different ministries. This condition causes other issues, such as duplication of regulatory operations, increased bureaucracy and fragmentation of operations, as well as lack of coordination between the various bodies, leading to trade disputes in import cases (Nguz, 2007). Food safety systems are generally weak, fragmented and poorly coordinated in most African countries, and are therefore unsuccessful in protecting consumer health adequately (FAO, 2005; FAO/WHO, 2005b; Majdi, 2002; Nguz, 2007). Problems arise as a result of poor handling, processing and storage of food after harvest and also as a result of insufficient facilities and services such as the absence or lack of safe water supply, power, storage facilities like cold stores, transport facilities and networks, etc. (FAO, 2003).

4. **Food Safety Legislation in Nigeria**
Like many other developed countries, Nigeria is facing the challenges of supplying its affluent population with adequate food supplies. To this end, there is successful promotion of policies and programs aimed at boosting agricultural and food production. The food safety problem, however, presents a more daunting challenge. Like several other nations, Nigeria has to deal with the issue of foodborne diseases with the related social, economic and health costs. The lack of or insufficient use of Good Agricultural Practices (GAP) and the exploitation or misuse by farmers of agrochemicals and during storage in developing countries had serious health effects on the population. Certain unsafe practices include the use of pesticides for farming, improper application of pesticides to stored goods such as beans and grains to avoid infestation by insects, inappropriate use of chemicals to ripen fruits such as bananas or vegetables such as carrots and cabbages for insect infestation control (Omojokun, 2013). Similarly, improper use of food additives such as artificial sweeteners, butylated hydroxy anisole (BHA), nitrates, nitrites, food colours, etc. may contribute to various conditions ranging from gastrointestinal disorders to cancer and death. Many packaging materials are still used in rural Africa with toxic degradable products that are no longer in use in developed countries. Another issue of concern during food processing is the partial or complete loss or elimination of nutrients. Another cause of health concern is the inadequate digestibility or use of nutrients and the development of new potentially harmful chemicals resulting from poor processing and handling practices (Omojokun, 2013). Therefore, to ensure food safety and quality for domestic consumption and export, necessary and proactive steps must be taken. This is because food was recognized internationally not only as a biological necessity, but also as an economic and political necessity. In cultures and countries, it is always a potential source of socio-political problems. Consequently, an effective national food safety policy would ensure that the food supplied to consumers is sufficient, nutritious, of good quality and balanced (Omotayo and Denloye, 2002). The Federal Government of Nigeria initiated the National Policy on Food Hygiene and Safety in 2000 as an integral part of the Nigerian National Health Policy in recognition of the value of food safety as an important factor in achieving a high level of health for all Nigerians.

The overall objective of this policy is to achieve high-level food hygiene and safety practices that promote health, control food borne diseases, reduce and eliminate the risk of illnesses associated with poor food hygiene and safety. The policy aims at stimulating and encouraging food laws in the areas of production, storage, handling, manufacturing, preservation, transportation, transport and marketing. It also seeks to improve the quality of healthcare by ensuring that all food consumed in Nigeria, whether imported or exported, is wholesome, safe, contaminant-free and affordable to consumers. The implementation of the policy is aimed at addressing the unsatisfactory level of food hygiene and safety practices that are largely responsible for the prevalence of foodborne diseases in Nigeria (Omotayo and Denloye, 2002). The National Food Safety Policy provides for the establishment of a National Committee on Food Safety that draws its membership from the public and private sectors related to the production, storage, processing/preparation, distribution, transportation and sale of food intended for consumption.
Regulatory and Legislative Framework

Over the years, numerous laws and regulations have been implemented to ensure the safety and wholesomeness of the food supply in Nigeria. Such legislations include the following:

- The Standards Organization of Nigeria Decree No. 56 of 1971.
- The National Agency of Food and Drug Administration and Control Decree No. 15 of 1993 (now NAFDAC Act Cap N.1 LFN 2004).
- The Food, Drug and Related Products (Registration) Decree No. 19 of 1993 (now Food, Drug and Related Products (Registration) Act Cap F.33 LFN 2004).
- Various bye-laws enacted by various LGAs in Nigeria

5. Results

Interview with Regulatory Officers at NAFDAC

Results from the interviews conducted with key regulatory officers at NAFDAC revealed that almost all food commodities are commonly adulterated in Nigeria, with food commodities such as honey, vegetable oil, palm oil, alcoholic and non-alcoholic beverages, flour and sugar being the most commonly adulterated food commodities. Reasons for poor implementation of food laws in Nigeria include inadequate funding and other logistics, gaps as a result of overlapping of functions of the government agencies that regulate food activities, ununified regulation and enforcement, unrealistic policies and lack of compromise by law enforcement agencies. Regarding publications, published articles or a food database where food fraud cases have been documented in Nigeria, the food agency publishes cases of food fraud on its website (i.e. through the recall and alert system) and through annual reports and NAFDAC Consumer Safety publications. It has a functional food database which has registered food products only. One of the regulatory officer stated that food products from supermarkets are registered with a global listing and the agency ensures that any food product that is imported is registered on the global listing. Regarding reasons food commodities are still adulterated in Nigeria, the following factors include poverty and economic gain, ignorance and lack of awareness, porous borders, over regulation and non-seriousness in accepting laid down laws and lack of stiff penalties for offenders. Like one of the regulatory officer quoted “Because
people are terrible people; We arrest them, keep them in the cell till Monday, release them on Monday after they have paid the fine and after two weeks, we discover they are still doing the same thing; just wickedness and poverty and because people are only interested in making money”.

The processes for recalling adulterated food commodities as explained by the officers are through the following ways:

- Notification of the product and product batch is received from government, individual establishments or stakeholders.
- Authentication of source of consumers’ complaint will be done.
- Investigation and surveillance will take place to authenticate the problem.
- The manufacturer or importer will be notified.
- A public alert notice will be issued.
- A surveillance team will be constituted.
- Product mop-up accompanied by forfeiture form.
- Laboratory analysis.
- Destruction exercise will then take place.

The regulatory processes in NAFDAC are carried out by employed regulators and they include the following:

**For imported products:**

- Collection and vetting of documents.
- Payment of relevant fees.
- Issuance of import permit for samples submission for laboratory analysis.
- Inspecting the facility abroad and collection of on the spot relevant documents.

**For products meant for export and local use:** Inspection of facility where products for export will be manufactured and domiciled. Types of inspection includes:

- Initial (Advisory)
- Production
- Routine
- Investigation
- Surveillance
- Mop-Up
- Renewal
- Good Manufacturing Practice (GMP) Reassessment
- Advocacy
• **Enlightenment**

When asked about the development of the regulations, they stated that the standard regulations committee under the Registration and Regulatory Directorate is responsible for developing the regulations. The roles of the risk assessors (i.e. the stakeholders) and the risk managers (i.e. the manufacturers) in food safety management as stated by the regulatory officers are (1) To evaluate the risks associated with the products they produce (2) To produce and provide food in the safest manner (3) To analyse the risk using HACCP. Regarding measures NAFDAC has taken in tackling cases of food fraud in Nigeria, the answers given varied from each of the officers but not limited to the following:

• Routine monitoring of all food establishments.
• Public enlightenment campaign.
• Effective collaboration with related bodies and agencies.
• For frequently committed food fraud, application of stiffer penalties for offenders.
• Sustenance of effective regulation.
• Capacity building and post market surveillance of all retail shops, markets and supermarkets.
• Deregistration of offenders if registered with NAFDAC and stiff sanctioning if not registered.
• Institution of functional food database for all registered food commodities.
• Imported food products are certified before entering into the market. They undergo proper documentation (certificate of analysis of the product from the country of manufacture) and the product is analysed in the laboratory.

The relevance of NAFDAC and other agencies in tackling food fraud as well as promoting food safety in Nigeria and its relevance with the UN Sustainable Development Goals (SDGs) will be covered in the next sections.

**Consumer Survey Questionnaire**

The participants’ profiles with regards to gender and age are provided in Table 2. The majority of the participants are aged between 25 and 54 years. According to the results, 38 (55.88%) are male while the remaining 30 (44.12%) are female.

<table>
<thead>
<tr>
<th>Age</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 18</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>18-24</td>
<td>5</td>
<td>7.35</td>
</tr>
<tr>
<td>25-34</td>
<td>34</td>
<td>50.00</td>
</tr>
<tr>
<td>35-44</td>
<td>11</td>
<td>16.18</td>
</tr>
<tr>
<td>Age Group</td>
<td>Frequency</td>
<td>%</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------</td>
<td>-----</td>
</tr>
<tr>
<td>45-54</td>
<td>10</td>
<td>14.71</td>
</tr>
<tr>
<td>55-64</td>
<td>8</td>
<td>11.76</td>
</tr>
<tr>
<td>65-74</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Above 75</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>68</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gender</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>38</td>
<td>55.88</td>
</tr>
<tr>
<td>Female</td>
<td>30</td>
<td>44.12</td>
</tr>
<tr>
<td>Total</td>
<td>68</td>
<td>100</td>
</tr>
</tbody>
</table>

**Table 2:** Participants’ profile (n = 68)

Of the food commodities that are commonly adulterated in Nigeria, results showed that fats and oil (n = 36) were the most commonly adulterated, followed by alcoholic and non-alcoholic drinks (n = 17) and honey (n = 4) respectively as shown in **Table 3**.

<table>
<thead>
<tr>
<th>Food category</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbs and Spices</td>
<td>1</td>
<td>1.47</td>
</tr>
<tr>
<td>Fats and oils</td>
<td>37</td>
<td>54.41</td>
</tr>
<tr>
<td>Dairy products</td>
<td>2</td>
<td>2.94</td>
</tr>
<tr>
<td>Cereals</td>
<td>1</td>
<td>1.47</td>
</tr>
<tr>
<td>Alcoholic and non-alcoholic drinks</td>
<td>17</td>
<td>25.00</td>
</tr>
<tr>
<td>Baked goods and confectionery</td>
<td>2</td>
<td>2.94</td>
</tr>
<tr>
<td>Meat and meat products</td>
<td>2</td>
<td>2.94</td>
</tr>
<tr>
<td>Fish and fish products</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Honey</td>
<td>4</td>
<td>5.88</td>
</tr>
<tr>
<td>Fruits and vegetables</td>
<td>2</td>
<td>2.94</td>
</tr>
</tbody>
</table>

**Table 3:** Food commodities commonly adulterated in Nigeria.
Figure 3: Bar graph showing the overall ratio of commonly adulterated food commodities in percentage.

91.18% (n = 62) of participants agree that food laws in Nigeria are poorly implemented while 8.82% (n = 6) do not agree as shown below:

Figure 4: Bar graph showing the percentage of participants that agree/disagree on poor implementation of food laws in Nigeria.

However, 70.59% (n = 48) of participants agree that NAFDAC are making efforts in tackling food fraud while 29.41% (n = 20) disagree as shown below:

Figure 5: Pie chart showing the percentage of participants that agree/disagree on the efforts of NAFDAC in tackling food fraud.

Regarding the UN Sustainable Development Goals (SDGs), 64.18% (n = 43) of the participants are fully aware of the 2030 Global Goals while the remaining 35.82% (n = 24) are neither aware or have never heard of the 2030 Global Goals as shown below:
Figure 6: Bar graph showing the percentage of participants that are aware/unaware of the UN Sustainable Goals (SDGs).

Majority of participants with 77.27% (n = 52) agree that food smuggling is a problem in Nigeria while the remaining 22.73% (n = 15) do not agree as shown below:

Figure 7: Bar graph showing percentage of participants that agree/disagree on the problem of food smuggling in Nigeria.

43.94% (n = 29) of participants agree that consumers are partly responsible for food adulteration in Nigeria while the remaining 56.06% (n = 37) disagree as shown below:

Figure 8: Bar graph showing the percentage of participants that agree/disagree that consumers are partly responsible for food adulteration in Nigeria.

6. Discussion, Recommendation and Limitation

The results from this study probes into the views of the public and regulators on food fraud in the Nigerian context. Following a series of interviews with key regulators and a survey of public consumers in Nigeria, the results from the research revealed that majority of participants attributed corruption, lack of enforcement, poor implementation, bribery, lack of awareness, poor sensitisation and education as well as poor preservation methods and hygiene as reasons for poor implementation of food laws in Nigeria. They
stated also that profit making is one of the major reason for people adulterating food commodities; other reasons included hunger, poverty and greed. Most participants believe that creating awareness and educating the consumers especially in the rural areas on the dangers of food fraud and detecting fake products is one way of promoting food safety in Nigeria. Others attributed other reasons such as effective policies, implementation and enforcement, stiffer penalties to offenders, training and employment of more regulatory officers, frequent monitoring to track offenders as well as strict compliance with the rule of law, public feedback and whistleblowing. Regarding the issues surrounding food smuggling, they revealed that effective measures which the regulatory bodies can adopt includes closing of the land borders, supporting local farmers in producing home-based food commodities, effective border control, partnership with other government agencies to tighten security at borders and monitoring the point of sales in the country as well as total ban of foreign and imported food products into Nigeria. However, some participants disagreed that consumers are partly responsible for adulterating food commodities, stating it is the wholesalers and retailers that are responsible and should be held accountable. Three (3) key themes emerged from the interviews and survey conducted in this research and they include the following:

**Poverty:** Nigeria has the highest number of people living in poverty across the world, with an estimated 95.02 million Nigerians in extreme poverty (World Poverty Clock, 2019). Poverty in Nigeria is caused by political instability, income elasticity and ethnic conflict. This has led to hunger and malnutrition among women and children, being the most affected, unemployment and corruption.

**Corruption:** Corruption is a major factor aggravating the level of hunger and poverty in many developing countries. Corruption and poverty in Nigeria are interrelated and encourages each other. Resources that could potentially ameliorate poverty and hunger are often misused (Gelb and Decker, 2012; Shuaib, 2015).

**Food safety legislations and control systems:** Food safety systems in developing countries are weak, fragmented, and not effective to protect consumers’ health. In Nigeria, this is undermined by lack of Good Agricultural Practices (GAP), inadequate enforcement of available legislations, ignorance and lack of technical expertise.

Food is a fundamental human need and a fundamental right, which plays a key role in a country's economic growth. Yet there is still no daily access to food for a large proportion of the world population. Today, food systems are facing the immense task of feeding a rising increasingly urbanized population and are currently falling short of fulfilling nutritional requirements and ensuring long-term health for nearly half of the world's population (Global Nutrition Report, 2017). As the world's population continues to grow, much more effort and creativity is required to sustainably increase agricultural production, strengthen the global supply chain, reduce food loss and waste, and ensure access to nutritious food for people suffering from hunger and malnutrition (UN, 2019). The 17 Sustainable Development Goals (SDGs) adopted in 2015 by world leaders give a global agenda to 2030. SDG 2 (Zero Hunger) seeks to "end hunger, achieve
food security and enhance nutrition, and encourage sustainable farming" (UN, 2015). About 821 million people are undernourished (FAO, 2019), 2 billion people lack essential micronutrients like vitamin A and iron, and 2 billion people are overweight or obese (Development Initiatives, 2017). In addition to the SDG 2 "Zero Hunger," a number of SDGs are related to global hunger issues and include the following:

**SDG 1 - No poverty:** Millions of people today are struggling to meet their most fundamental needs. Poverty and other socio-economic inequities in low, middle and high-income countries are associated with poor nutrition, including among certain population subgroups in nations. Addressing hunger would boost nutritional outcomes, as it is important to improve nutrition in the fight against poverty (Global Nutrition Report, 2017; Perez-Escamilla et al., 2018).

**SDG 2 – Zero Hunger:** “End hunger, achieve food security and improved nutrition and promote sustainable agriculture” emphasizes the importance of hunger as a barrier to sustainable development and creates a trap from which people can not escape easily. A world with zero hunger can have a positive impact on our economies, health, education, equality and social development and is a prerequisite for achieving the other goals of sustainable development such as education, health and gender equality (UN, 2015).

**SDG 3 – Good Health and Well-being:** “Ensure good health and well-being for all at all ages” addresses all major health priorities including communicable diseases (NCDs) (UN, 2015). Overnutrition is one of the major risk factors that drives the rise of NCDs, including heart disease, stroke, cancer and diabetes, and chronic lung disease, collectively responsible for nearly 70% of all deaths worldwide (WHO, 2018c). Not only do NCDs threaten development, they are also a cause and consequence of poverty, and tackling the NCDs needs to addressing social inequity (UN, 2011). Nonetheless, the NCD agenda is at real risk of becoming intangible and not being discussed due to the very large number of targets and measures explicitly in SDG 3 and the SDG in general (Ordunez and Campbell, 2016).

**SDG 4 – Quality Education:** Education is related to better nutritional outcomes. Mothers with high-quality secondary school education are likely to have much better nourished babies. Better nutrition also means improved results in education, jobs and empowerment of women, as well as reduced poverty and inequality (Global Nutrition Report, 2017).

**SDG 5 – Gender Equality:** Ensuring equal access to and control of assets increases agricultural output, increases investment in child education and increases food security for households. The empowerment of women within the food system, from food production to food preparation, is a fundamental prerequisite for social and economic development of communities, but malnutrition hampers efforts in this direction (Oniang’o and Mukudi, 2002).

**SDG 6 – Clean Water and Sanitation:** Billions of people lack access to safe drinking water and adequate hygiene and sanitation services, living at risk of avoidable infections and disease that have a negative effect
on nutritional status and health. Addressing water variability, scarcity and competing uses is beneficial for food security and nutrition (Ringler et al., 2018).

**SDG 10 – Reduced Inequalities:** There are important synergies between food security and social protection. Effective social assistance programs may reduce persistent food insecurity, whereas demand-driven or elastic social insurance and safety net systems may tackle intermittent food insecurity induced by seasonality or exposure to shocks in living conditions (HLPE, 2012).

**SDG 12 – Responsible Consumption and Production:** “Ensure sustainable consumption and production patterns” implies that meeting an increasing population's nutritional needs allows consumers to choose and food systems to provide a healthy and healthier diet with a lower environmental footprint. SDG 12 provides specific opportunities to reduce the burden of NCDs and create a global network that is sustainable and balanced.

**SDG 13 – Life on Land:** The diminishing diversity of worldwide agricultural production and food supplies may have significant implications for global diets. Agricultural diversification can contribute through both subsistence and income-generating pathways to diversified diets and can be an important strategy for improving diets and nutritional outcomes in low-and middle-income countries. More work is also needed to understand the potential impacts on overweight and obesity of agricultural diversification (Jones, 2017).

**SDG 14 – Life Below Water:** Healthy water-related ecosystems provide a series of ecosystem services, many of which in turn support nutrition and health outcomes (Ringler et al., 2018).

**SDG 16 – Peace, Justice and Strong Institutions:** Food security and nutrition can contribute to conflict prevention and mitigation by building and enhancing social cohesion, addressing root causes or drivers of conflicts, and by contributing to the legitimacy of, and trust in governments. Food security can support peace-building efforts and peace-building can reinforce food security (FAO, 2016).

**SDG 17 – Partnerships for the Goals:** The complexity and the relations between all of the SDGs call require a paradigm shift, calling all stakeholders of the food system to engage and share knowledge in supporting communities and countries in achieving the SDGs.

The idea of food security originated in the 1940s and is now widely used in the design, implementation and evaluation of programs and policies for humanitarian emergencies and development. Food security is every government's central concern–in the developed and developing world. In addition, due to the nature of our globalized world, a single country or region's actions (such as Europe, Africa, South Asia, etc.) affect people's food security in other countries, regions, or the world. Disasters in one area have an impact on food supply and demand elsewhere. Food security is defined as the situation where “all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and preferences for an active healthy life” (FAO, 1996). Food security includes four elements namely:
availability, access, utilization and stability of supply. The foundational definition from the 1996 World Food Summit encompasses four dimensions:

- Availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports (including food aid).
- Access by individuals to adequate resources (also called entitlements) for acquiring appropriate foods for a nutritious diet.
- Utilization of food through an adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met.
- Stability in the availability of and access to food, regardless of sudden shocks (e.g. an economic or climatic crisis) or cyclical events (e.g. seasonal food scarcity).

The foods that are commonly involved in food fraud tend to be the most nutritious, aggravating the problem. Several case studies have been documented that involve food fraud and its consequences for food and nutrition security. In 2003 and 2004, over 200 ‘big-headed babies’ in Anhui Province were found to have suffered from severe malnutrition as a result of consuming substandard baby milk with inadequate levels of protein (Tam and Yang, 2005). In the aftermath, regulators implemented more stringent testing requirements for milk and baby formula. However, the tests used for protein levels were unable to distinguish between milk protein and other nitrogen containing substances. In September 2008, milk deliberately adulterated with melamine to disguise its protein content was detected by the Chinese Department of Health. This led to the death of six babies and more than 290,000 people (most of them infants) poisoned, and the subsequent banning of imported chinese milk products by the international community (Xiu and Klein, 2010). While the food and nutrition impacts were not fully accessed, these may have been significant. Qiao et al., (2012) found that during the melanine scare, 63% of households with children under the age of 6 reduced consumption of all diary products; 39% cut milk consumption completely; 18% were reported to cutting consumption by more than half and 43% by at least one-third. This study indicates a significant drop in milk consumption by households with young children.

The time between 6 and 23 months is a vulnerable time for young children as it is a time of rapid growth when children are susceptible to growth stunting. Food fraud results where opportunities are present, there is motivation to cheat and control systems are absent or insufficient to deter (Ruth et al., 2017). Underlying motivations include economic, cultural and psycho social drivers. Several authors have identified profit as the key motivator (Lipp, 2012). For example, fraud is more likely for high value products than for low value products. Also, firms with a strong reputation (and hence more to lose) are less likely to commit fraud than those without. Fraud which can be easily and/or cheaply detected would likewise be expected to be less common. Cultural factors can also influence propensity to commit fraud. In countries with a high level of corruption, firms have been shown to be more likely to use illegal methods. Countries with collectivist cultures have been shown to be more corrupt than countries with individualistic cultures.
Poverty and lack of social security support is also associated with high levels of corruption. Individual characteristics and experiences can influence propensity to commit fraud. These include environmental pressures (poverty, lack of alternatives) as well as behavioural risk factors. Illicit trade in food and agricultural products has “many” important and negative consequences throughout the SDGs. Smuggling is usually driven by the price disparity between the place of origin and the destination of the smuggled goods. The key risks associated with smuggled agri-food include tax and tariff losses, as well as “severe” knock-on effects on the economy as a whole, causing unfair competition and limiting local producers. There is also a risk that smuggled products can introduce invasive species, disease-carrying pathogens or pollutants threatening both human health and the agricultural economy (FoodNavigator, 2019). Fraud and smuggling have an effect on many different foods, including beef, dairy products, fish and seafood, fruit juices, oils, honey, spices and wine. Food fraud, commodity smuggling and illegal agrochemicals are undermining sustainable farming, limiting crop yields, and jeopardizing the provision of fair, safe and sustainable food supplies, slowing progress towards zero hunger. Illicit trade in agri-foods undermines the SDGs as follows:

- Reduces competitive and stable agricultural markets that foster economic development and poverty reduction, hitting SDG 1 “no hunger”
- Destabilises food security and undermines sustainable food production and access to food, undermining SDG 2 on “zero hunger”.
- Exposes consumers to harmful ingredients or deprive them of active beneficial ingredients, threatening SDG 3 “good health and wellbeing”.
- Siphons Gross Domestic Product (GDP), jobs and tax revenues from national economies and introduces health risks that can jeopardise corporate brands and economic sustainability, which can be linked to SDG 8 “decent work and economic growth”.
- Deprives consumers of choice and ability to make educated and eco-friendly decisions, dampening SDG 12 “responsible production and consumption”.
- Illegal profits underwrite smugglers, breeds corruption, subsidise wider criminal activity and threaten political and economic stability, undermining SDG 16 on “peace, justice and strong institutions” (FoodNavigator, 2019).

**Recommendations**

Increased public awareness and consumer education about the dangers of food fraud are key factors to successful food legislation in Nigeria. There should be better coordination among the bodies charged with responsibilities for food safety; capacity building by training of personnel, producers and regulators is vital towards achieving success in implementation of food safety legislation, and the small and medium-sized enterprises (SMEs) should be urged to form associations for ease of government support through training and awareness creation (Omojokun, 2013). Industry, government and enforcement agencies
should always put the needs of consumers above all other considerations; this means giving food safety and crime prevention absolute priority over other objectives. There must be clear leadership and coordination of investigations and prosecutions, and the public interest is recognized in active enforcement and significant penalties for significant food crimes (Brooks et al., 2017). Safe food supply also depends on both sound science and equitable law enforcement. Periodically, new laws and regulations must be enacted to further protect a continuing supply of food products that are safe and wholesome for the health and wellness of people. Once laws are enacted, they must be enforced to ensure compliance by the entire food industry including industries directly or indirectly connected with the food source, labelling, packaging, transportation, distribution down to retail sales. All governmental agencies involved in potential food supply chain must be given resources and authorities to discharge the 3-fold duty of (1) informing citizens of nutrition and components of important food products; (2) enforcing existing laws and regulations on food industry to ensure supply of safe food products and (3) investigating and eliminating potential toxic contaminants and prosecute economic fraud via regular monitoring and surveillance on food supply chain (Fung et al., 2018). To equitably enforce food safety laws, sound science must be the basis of setting the regulations and protocols to inform, enforce and eliminate unsafe foods. Risk assessment is a scientific process that puts the concern about food contaminations in proper perspective as the purpose of scientific risk calculation is to get the best estimate of the true risk using available and current information (Fung et al., 2018).

**Limitations**

This research thesis has several limitations and they have been identified as follows: Firstly, there were time restraints due to the submission of thesis. Secondly, the sample size of participants, especially from the regulatory agency was insufficient. This was attributed to the fact that getting information from civil servants from government agencies or parastatals in Nigeria is difficult and as a result, majority of them were unwilling to share information during the collection of data. In this case, the regulatory officers who were interviewed and the people who responded to the survey questions may not truly be a random sample.

7. **Conclusion**

Food safety is a shared responsibility of the government, producers, processors, suppliers, retailers, and consumers, with everyone in the food supply chain, as key players with a role to play from the farm to the table to ensure food is safe for human consumption. Based on this study, The Nigerian government and other stakeholders should give utmost priority to the following:

- The fight against corruption.
- Policies that will lift people out of poverty and unemployment.
- Quick resolution of ethnic conflicts and terrorism.
• Agricultural production and nutrition-related interventions to effectively tackle hunger and malnutrition among vulnerable groups, especially children.

The Food Safety and Quality Bill as approved by the Federal Executive Council (FEC), will help to prevent fraudulent or deceptive practices that may affect the health of consumers and also provide a framework for NAFDAC and other regulatory agencies to enforce stricter punishments and persecute offenders caught in food fraud. Policy makers should build and maintain adequate food systems and infrastructures to respond to and manage food safety risks along the entire food chain as well as integrate food safety into broader food policies and programmes such as nutrition and food security, in order to ensure that domestically produced food is safe internationally. Assessing the safety of new and emerging technologies such as nanotechnology, next generation sequencing, omics technologies (genomics, proteomics and metabolomics) and bioinformatics would greatly improve national food safety systems and legal frameworks, and implement adequate infrastructures to manage food fraud.

8. References


FAO (1996). Rome declaration on world food security and world food summit plan of action. World Food Summit, Rome, Italy.


HPLE (2012). Social protection for food security: A report by the high panel of experts on food security and nutrition of the committee on world food security. CFS, Rome.


10. **APPENDIX A**

10.1. **Guide for Authors for Food Control Journal**

**INTRODUCTION**

*Food Control* is an international journal that provides essential information for those involved in food safety and process control.

*Food Control* covers:

- Microbial food safety and antimicrobial systems
- Mycotoxins
- Hazard analysis, HACCP and food safety objectives
- Risk assessment, including microbial risk assessment
- Quality assurance and control
- Good manufacturing practices
- Food process systems design and control
- Food Packaging
- Rapid methods of analysis and detection, including sensor technology
- Environmental control and safety
- Codes of practice, legislation and international harmonization
- Consumer issues
- Education, training and research needs.

The scope of *Food Control* is comprehensive and includes original research papers, authoritative reviews, short communications, comment articles that report on new developments in food control, and position papers.

The work described should be innovative either in the approach or in the methods used. The significance of the results either for the science community or for the food industry must also be specified. Contributions that do not fulfil these requirements will not be considered for review and publication.

*Types of paper*

Original high-quality research papers (preferably no more than 7000 words, including tables and illustrations). Major review articles, up to 10,000 words. Short communications of up to 3000 words (not including references), describing work that may be of a preliminary nature but which merits immediate publication. Short reviews on topical subjects, up to 6000 words. Comment articles not exceeding 2000 words. Authoritative position papers from expert groups are also welcome.

*Food Control* also publishes book reviews, Letters to the Editor, conference reports and a calendar of forthcoming events.

The Editor-in-Chief has the right to decline formal review of a manuscript when it is deemed that the manuscript is 1) on a topic outside the scope of the Journal; 2) lacking technical merit; 3) of insufficient novelty for a wide international readership; 4) fragmentary and providing marginally incremental results; or 5) is poorly written.

All contributions deemed suitable for review are read by two or more referees to ensure both accuracy and relevance, and revisions to the script may thus be required. On acceptance, contributions are subject to editorial amendment to suit house style. When a manuscript is returned for revision prior to final acceptance, the revised version must be submitted as soon as possible after the author's receipt of the referees' reports. Revised manuscripts returned after four months will be considered as new submissions subject to full re-review.

*Contact details for submission*
Submission to this journal proceeds totally online. Use the following guidelines to prepare your article. Via the homepage of this journal http://ees.elsevier.com/foodcont you will be guided stepwise through the creation and uploading of the various files.

Submission checklist

You can use this list to carry out a final check of your submission before you send it to the journal for review. Please check the relevant section in this Guide for Authors for more details.

Ensure that the following items are present:

One author has been designated as the corresponding author with contact details:

- E-mail address
- Full postal address

All necessary files have been uploaded:

Manuscript:

- Include keywords
- All figures (include relevant captions)
- All tables (including titles, description, footnotes)
- Ensure all figure and table citations in the text match the files provided
- Indicate clearly if color should be used for any figures in print

Graphical Abstracts / Highlights files (where applicable)

Supplemental files (where applicable)

Further considerations

- Manuscript has been 'spell checked' and 'grammar checked'
- All references mentioned in the Reference List are cited in the text, and vice versa
- Permission has been obtained for use of copyrighted material from other sources (including the Internet)
- A competing interest statement is provided, even if the authors have no competing interests to declare
- Journal policies detailed in this guide have been reviewed
- Referee suggestions and contact details provided, based on journal requirements

For further information, visit our Support Centre.

BEFORE YOU BEGIN

Ethics in publishing

Please see our information pages on Ethics in publishing and Ethical guidelines for journal publication.

Declaration of interest

All authors must disclose any financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work. Examples of potential competing interests include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding. Authors must disclose any interests in two places:

1. A summary declaration of interest statement in the title page file (if double-blind) or the manuscript file
(if single-blind). If there are no interests to declare then please state this: 'Declarations of interest: none'. This summary statement will be ultimately published if the article is accepted.

2. Detailed disclosures as part of a separate Declaration of Interest form, which forms part of the journal's official records. It is important for potential interests to be declared in both places and that the information matches. More information.

Submission declaration and verification
Submission of an article implies that the work described has not been published previously (except in the form of an abstract, a published lecture or academic thesis, see 'Multiple, redundant or concurrent publication' for more information), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. To verify originality, your article may be checked by the originality detection service Crossref Similarity Check.

Preprints
Please note that preprints can be shared anywhere at any time, in line with Elsevier's sharing policy. Sharing your preprints e.g. on a preprint server will not count as prior publication (see 'Multiple, redundant or concurrent publication' for more information).

Use of inclusive language
Inclusive language acknowledges diversity, conveys respect to all people, is sensitive to differences, and promotes equal opportunities. Articles should make no assumptions about the beliefs or commitments of any reader, should contain nothing which might imply that one individual is superior to another on the grounds of race, sex, culture or any other characteristic, and should use inclusive language throughout. Authors should ensure that writing is free from bias, for instance by using 'he or she', 'his/her' instead of 'he' or 'his', and by making use of job titles that are free of stereotyping (e.g. 'chairperson' instead of 'chairman' and 'flight attendant' instead of 'stewardess').

Author contributions
For transparency, we encourage authors to submit an author statement file outlining their individual contributions to the paper using the relevant Credit roles: Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Roles/Writing - original draft; Writing - review & editing. Authorship statements should be formatted with the names of authors first and Credit role(s) following. More details and an example

Changes to authorship
Authors are expected to consider carefully the list and order of authors before submitting their manuscript and provide the definitive list of authors at the time of the original submission. Any addition, deletion or rearrangement of author names in the authorship list should be made only before the
manuscript has been accepted and only if approved by the journal Editor. To request such a change, the Editor must receive the following from the corresponding author: (a) the reason for the change in author list and (b) written confirmation (e-mail, letter) from all authors that they agree with the addition, removal or rearrangement. In the case of addition or removal of authors, this includes confirmation from the author being added or removed.

Only in exceptional circumstances will the Editor consider the addition, deletion or rearrangement of authors after the manuscript has been accepted. While the Editor considers the request, publication of the manuscript will be suspended. If the manuscript has already been published in an online issue, any requests approved by the Editor will result in a corrigendum.

**Copyright**

Upon acceptance of an article, authors will be asked to complete a 'Journal Publishing Agreement' (see more information on this). An e-mail will be sent to the corresponding author confirming receipt of the manuscript together with a 'Journal Publishing Agreement' form or a link to the online version of this agreement.

Subscribers may reproduce tables of contents or prepare lists of articles including abstracts for internal circulation within their institutions. Permission of the Publisher is required for resale or distribution outside the institution and for all other derivative works, including compilations and translations. If excerpts from other copyrighted works are included, the author(s) must obtain written permission from the copyright owners and credit the source(s) in the article. Elsevier has pre-printed forms for use by authors in these cases.

For gold open access articles: Upon acceptance of an article, authors will be asked to complete an 'Exclusive License Agreement' (more information). Permitted third party reuse of gold open access articles is determined by the author's choice of user license.

**Author rights**

As an author you (or your employer or institution) have certain rights to reuse your work. More information.

Elsevier supports responsible sharing

Find out how you can share your research published in Elsevier journals.

**Role of the funding source**

You are requested to identify who provided financial support for the conduct of the research and/or preparation of the article and to briefly describe the role of the sponsor(s), if any, in study design; in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the article for publication. If the funding source(s) had no such involvement then this should be stated.

**Open access**

Please visit our Open Access page from the Journal Homepage for more information.

Elsevier Researcher Academy
Researcher Academy is a free e-learning platform designed to support early and mid-career researchers throughout their research journey. The "Learn" environment at Researcher Academy offers several interactive modules, webinars, downloadable guides and resources to guide you through the process of writing for research and going through peer review. Feel free to use these free resources to improve your submission and navigate the publication process with ease.

Language (usage and editing services)
Please write your text in good English (American or British usage is accepted, but not a mixture of these). Authors who feel their English language manuscript may require editing to eliminate possible grammatical or spelling errors and to conform to correct scientific English may wish to use the English Language Editing service available from Elsevier's Author Services.

Submission
Our online submission system guides you stepwise through the process of entering your article details and uploading your files. The system converts your article files to a single PDF file used in the peer-review process. Editable files (e.g., Word, LaTeX) are required to typeset your article for final publication. All correspondence, including notification of the Editor's decision and requests for revision, is sent by e-mail. Authors must provide and use an email address unique to themselves and not shared with another author registered in EES, or a department.

Referees
Please submit the names and institutional e-mail addresses of several potential referees. For more details, visit our Support site. Note that the editor retains the sole right to decide whether or not the suggested reviewers are used.

PREPARATION

Peer review
This journal operates a single blind review process. All contributions will be initially assessed by the editor for suitability for the journal. Papers deemed suitable are then typically sent to a minimum of two independent expert reviewers to assess the scientific quality of the paper. The Editor is responsible for the final decision regarding acceptance or rejection of articles. The Editor's decision is final. More information on types of peer review.

Use of word processing software
It is important that the file be saved in the native format of the word processor used. The text should be in single-column format. Keep the layout of the text as simple as possible. Most formatting codes will be removed and replaced on processing the article. In particular, do not use the word processor's options to justify text or to hyphenate words. However, do use bold face, italics, subscripts, superscripts etc. When preparing tables, if you are using a table grid, use only one grid for each individual table and not a grid for each row. If no grid is used, use tabs, not spaces, to align columns. The electronic text should be prepared in a way very similar to that of conventional manuscripts (see also the Guide to Publishing with Elsevier).
Note that source files of figures, tables and text graphics will be required whether or not you embed your figures in the text. See also the section on Electronic artwork.

To avoid unnecessary errors, you are strongly advised to use the 'spell-check' and 'grammar-check' functions of your word processor.

**Request you to kindly submit your manuscript with continuous line numbers.**

**Article structure**

**Subdivision - numbered sections**

Divide your article into clearly defined and numbered sections. Subsections should be numbered 1.1 (then 1.1.1, 1.1.2, ...), 1.2, etc. (the abstract is not included in section numbering). Use this numbering also for internal cross-referencing: do not just refer to 'the text'. Any subsection may be given a brief heading. Each heading should appear on its own separate line.

**Introduction**

State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

**Materials and Methods**

Provide sufficient details to allow the work to be reproduced by an independent researcher. Methods that are already published should be summarized, and indicated by a reference. If quoting directly from a previously published method, use quotation marks and also cite the source. Any modifications to existing methods should also be described.

**Key Resources Table**

To enable reproducibility of the research, we encourage authors to submit a Key Resources Table, which helps make the resources clear to readers. The Key Resources Table highlights the genetically modified organisms and strains, cell lines, reagents and other resources essential to reproduce the results presented in a paper. More information is available here [https://www.elsevier.com/authors/author-resources/key-resources-table](https://www.elsevier.com/authors/author-resources/key-resources-table)

**Theory/calculation**

A Theory section should extend, not repeat, the background to the article already dealt with in the Introduction and lay the foundation for further work. In contrast, a Calculation section represents a practical development from a theoretical basis.

**Results**

Results should be clear and concise.

**Discussion**

This should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section is often appropriate. Avoid extensive citations and discussion of published literature.

**Conclusions**

The main conclusions of the study may be presented in a short Conclusions section, which may stand alone or form a subsection of a Discussion or Results and Discussion section.
Appendices

If there is more than one appendix, they should be identified as A, B, etc. Formulae and equations in appendices should be given separate numbering: Eq. (A.1), Eq. (A.2), etc.; in a subsequent appendix, Eq. (B.1) and so on. Similarly, for tables and figures: Table A.1; Fig. A.1, etc.

Essential title page information

- **Title.** Concise and informative. Titles are often used in information-retrieval systems. Avoid abbreviations and formulae where possible.

- **Author names and affiliations.** Please clearly indicate the given name(s) and family name(s) of each author and check that all names are accurately spelled. You can add your name between parentheses in your own script behind the English transliteration. Present the authors' affiliation addresses (where the actual work was done) below the names. Indicate all affiliations with a lowercase superscript letter immediately after the author's name and in front of the appropriate address. Provide the full postal address of each affiliation, including the country name and, if available, the e-mail address of each author.

- **Corresponding author.** Clearly indicate who will handle correspondence at all stages of refereeing and publication, also post-publication. This responsibility includes answering any future queries about Methodology and Materials. **Ensure that the e-mail address is given and that contact details are kept up to date by the corresponding author.**

- **Present/permanent address.** If an author has moved since the work described in the article was done, or was visiting at the time, a 'Present address' (or 'Permanent address') may be indicated as a footnote to that author's name. The address at which the author actually did the work must be retained as the main, affiliation address. Superscript Arabic numerals are used for such footnotes.

Highlights

Highlights are mandatory for this journal as they help increase the discoverability of your article via search engines. They consist of a short collection of bullet points that capture the novel results of your research as well as new methods that were used during the study (if any). Please have a look at the examples here: [example Highlights](#).

Highlights should be submitted in a separate editable file in the online submission system. Please use 'Highlights' in the file name and include 3 to 5 bullet points (maximum 85 characters, including spaces, per bullet point).

Abstract

A concise and factual abstract is required. The abstract should state briefly the purpose of the research, the principal results and major conclusions. An abstract is often presented separately from the article, so it must be able to stand alone. For this reason, References should be avoided, but if essential, then cite the author(s) and year(s). Also, non-standard or uncommon abbreviations should be avoided, but if essential they must be defined at their first mention in the abstract itself.
**Keywords**
Immediately after the abstract, provide a maximum of 6 keywords, using American spelling and avoiding general and plural terms and multiple concepts (avoid, for example, 'and', 'of'). Be sparing with abbreviations: only abbreviations firmly established in the field may be eligible. These keywords will be used for indexing purposes.

**Abbreviations**
Define abbreviations that are not standard in this field in a footnote to be placed on the first page of the article. Such abbreviations that are unavoidable in the abstract must be defined at their first mention there, as well as in the footnote. Ensure consistency of abbreviations throughout the article.

**Acknowledgements**
Collate acknowledgements in a separate section at the end of the article before the references and do not, therefore, include them on the title page, as a footnote to the title or otherwise. List here those individuals who provided help during the research (e.g., providing language help, writing assistance or proof reading the article, etc.).

**Formatting of funding sources**
List funding sources in this standard way to facilitate compliance to funder's requirements:

Funding: This work was supported by the National Institutes of Health [grant numbers xxxx, yyyy]; the Bill & Melinda Gates Foundation, Seattle, WA [grant number zzzz]; and the United States Institutes of Peace [grant number aaaa].

It is not necessary to include detailed descriptions on the program or type of grants and awards. When funding is from a block grant or other resources available to a university, college, or other research institution, submit the name of the institute or organization that provided the funding.

If no funding has been provided for the research, please include the following sentence:

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

**Units**
Follow internationally accepted rules and conventions: use the international system of units (SI). If other units are mentioned, please give their equivalent in SI.

**Math formulae**
Please submit math equations as editable text and not as images. Present simple formulae in line with normal text where possible and use the solidus (/) instead of a horizontal line for small fractional terms, e.g., X/Y. In principle, variables are to be presented in italics. Powers of e are often more conveniently denoted by exp. Number consecutively any equations that have to be displayed separately from the text (if referred to explicitly in the text).

**Mathematical and technical settings**
Use the appropriate number of significant figures to express your data - they should be justifiable and reflect the necessary level of accuracy of the method. A normal maximum should be 3 - e.g., 37.1, 2.53).
Detailed mathematical discussion should be placed in an appendix. Equations and formulae should be typewritten. Equations should be numbered consecutively with Arabic numerals in parentheses on the right-hand side of the page. Special symbols should be identified in the margin, and the meaning of all symbols should be explained in the text where they first occur. If you use several symbols, a list of definitions (not necessarily for publication) will help the editor. Type mathematical equations exactly as they should appear in print. Journal style for letter symbols is as follows: italic (indicated by underlining); constants, roman type; matrices and vectors, bold type (indicated by wavy underlining).

Footnotes

Footnotes should be used sparingly. Number them consecutively throughout the article. Many word processors can build footnotes into the text, and this feature may be used. Otherwise, please indicate the position of footnotes in the text and list the footnotes themselves separately at the end of the article. Do not include footnotes in the Reference list.

Artwork

Electronic artwork

General points

• Make sure you use uniform lettering and sizing of your original artwork.
• Embed the used fonts if the application provides that option.
• Aim to use the following fonts in your illustrations: Arial, Courier, Times New Roman, Symbol, or use fonts that look similar.
• Number the illustrations according to their sequence in the text.
• Use a logical naming convention for your artwork files.
• Provide captions to illustrations separately.
• Size the illustrations close to the desired dimensions of the published version.
• Submit each illustration as a separate file.
• Ensure that color images are accessible to all, including those with impaired color vision.

A detailed guide on electronic artwork is available.

You are urged to visit this site; some excerpts from the detailed information are given here. Formats

If your electronic artwork is created in a Microsoft Office application (Word, PowerPoint, Excel) then please supply 'as is' in the native document format.

Regardless of the application used other than Microsoft Office, when your electronic artwork is finalized, please 'Save as' or convert the images to one of the following formats (note the resolution requirements for line drawings, halftones, and line/halftone combinations given below): EPS (or PDF): Vector drawings, embed all used fonts.

TIFF (or JPEG): Color or grayscale photographs (halftones), keep to a minimum of 300 dpi.

TIFF (or JPEG): Bitmapped (pure black & white pixels) line drawings, keep to a minimum of 1000 dpi.

TIFF (or JPEG): Combinations bitmapped line/half-tone (color or grayscale), keep to a minimum of 500 dpi.
Please do not:
• Supply files that are optimized for screen use (e.g., GIF, BMP, PICT, WPG); these typically have a low number of pixels and limited set of colors;
• Supply files that are too low in resolution;
• Submit graphics that are disproportionately large for the content.

Color artwork
Please make sure that artwork files are in an acceptable format (TIFF (or JPEG), EPS (or PDF), or MS Office files) and with the correct resolution. If, together with your accepted article, you submit usable color figures then Elsevier will ensure, at no additional charge, that these figures will appear in color online (e.g., ScienceDirect and other sites) regardless of whether or not these illustrations are reproduced in color in the printed version. For color reproduction in print, you will receive information regarding the costs from Elsevier after receipt of your accepted article. Please indicate your preference for color: in print or online only. Further information on the preparation of electronic artwork.

Figure captions
Ensure that each illustration has a caption. Supply captions separately, not attached to the figure. A caption should comprise a brief title (not on the figure itself) and a description of the illustration. Keep text in the illustrations themselves to a minimum but explain all symbols and abbreviations used.

Tables
Please submit tables as editable text and not as images. Tables can be placed either next to the relevant text in the article, or on separate page(s) at the end. Number tables consecutively in accordance with their appearance in the text and place any table notes below the table body. Be sparing in the use of tables and ensure that the data presented in them do not duplicate results described elsewhere in the article. Please avoid using vertical rules and shading in table cells.

References
Citation in text
Please ensure that every reference cited in the text is also present in the reference list (and vice versa). Any references cited in the abstract must be given in full. Unpublished results and personal communications are not recommended in the reference list, but may be mentioned in the text. If these references are included in the reference list, they should follow the standard reference style of the journal and should include a substitution of the publication date with either 'Unpublished results' or 'Personal communication'. Citation of a reference as 'in press' implies that the item has been accepted for publication.

Web references
As a minimum, the full URL should be given and the date when the reference was last accessed. Any further information, if known (DOI, author names, dates, reference to a source publication, etc.), should also be given. Web references can be listed separately (e.g., after the reference list) under a different heading if desired, or can be included in the reference list.

Data references
This journal encourages you to cite underlying or relevant datasets in your manuscript by citing them in your text and including a data reference in your Reference List. Data references should include the following elements: author name(s), dataset title, data repository, version (where available), year, and global persistent identifier. Add [dataset] immediately before the reference so we can properly identify it as a data reference. The [dataset] identifier will not appear in your published article.

References in a special issue
Please ensure that the words 'this issue' are added to any references in the list (and any citations in the text) to other articles in the same Special Issue.

Reference management software
Most Elsevier journals have their reference template available in many of the most popular reference management software products. These include all products that support Citation Style Language styles, such as Mendeley. Using citation plug-ins from these products, authors only need to select the appropriate journal template when preparing their article, after which citations and bibliographies will be automatically formatted in the journal's style. If no template is yet available for this journal, please follow the format of the sample references and citations as shown in this Guide. If you use reference management software, please ensure that you remove all field codes before submitting the electronic manuscript. More information on how to remove field codes from different reference management software.

Users of Mendeley Desktop can easily install the reference style for this journal by clicking the following link:
http://open.mendeley.com/use-citation-style/food-control

When preparing your manuscript, you will then be able to select this style using the Mendeley plug-ins for Microsoft Word or LibreOffice.

Reference style

Text: Citations in the text should follow the referencing style used by the American Psychological Association. You are referred to the Publication Manual of the American Psychological Association, Sixth Edition, ISBN 978-1-4338-0561-5, copies of which may be ordered online or APA Order Dept., P.O.B. 2710, Hyattsville, MD 20784, USA or APA, 3 Henrietta Street, London, WC3E 8LU, UK.

List: references should be arranged first alphabetically and then further sorted chronologically if necessary. More than one reference from the same author(s) in the same year must be identified by the letters 'a', 'b', 'c', etc., placed after the year of publication.

Examples:

Reference to a journal publication:

Reference to a journal publication with an article number:
Reference to a book:

Reference to a chapter in an edited book:

Reference to a website:

Reference to a dataset:

Reference to a conference paper or poster presentation:

Journal abbreviations source
Journal names should be abbreviated according to the List of Title Word Abbreviations.

Video
Elsevier accepts video material and animation sequences to support and enhance your scientific research. Authors who have video or animation files that they wish to submit with their article are strongly encouraged to include links to these within the body of the article. This can be done in the same way as a figure or table by referring to the video or animation content and noting in the body text where it should be placed. All submitted files should be properly labelled so that they directly relate to the video file's content. In order to ensure that your video or animation material is directly usable, please provide the file in one of our recommended file formats with a preferred maximum size of 150 MB per file, 1 GB in total. Video and animation files supplied will be published online in the electronic version of your article in Elsevier Web products, including ScienceDirect. Please supply 'stills' with your files: you can choose any frame from the video or animation or make a separate image. These will be used instead of standard icons and will personalize the link to your video data. For more detailed instructions please visit our video instruction pages. Note: since video and animation cannot be embedded in the print version of the journal, please provide text for both the electronic and the print version for the portions of the article that refer to this content.
Data visualization

Include interactive data visualizations in your publication and let your readers interact and engage more closely with your research. Follow the instructions here to find out about available data visualization options and how to include them with your article.

Supplementary material

Supplementary material such as applications, images and sound clips, can be published with your article to enhance it. Submitted supplementary items are published exactly as they are received (Excel or PowerPoint files will appear as such online). Please submit your material together with the article and supply a concise, descriptive caption for each supplementary file. If you wish to make changes to supplementary material during any stage of the process, please make sure to provide an updated file. Do not annotate any corrections on a previous version. Please switch off the 'Track Changes' option in Microsoft Office files as these will appear in the published version.

Research data

This journal encourages and enables you to share data that supports your research publication where appropriate, and enables you to interlink the data with your published articles. Research data refers to the results of observations or experimentation that validate research findings. To facilitate reproducibility and data reuse, this journal also encourages you to share your software, code, models, algorithms, protocols, methods and other useful materials related to the project.

Below are a number of ways in which you can associate data with your article or make a statement about the availability of your data when submitting your manuscript. If you are sharing data in one of these ways, you are encouraged to cite the data in your manuscript and reference list. Please refer to the "References" section for more information about data citation. For more information on depositing, sharing and using research data and other relevant research materials, visit the research data page.

Data linking

If you have made your research data available in a data repository, you can link your article directly to the dataset. Elsevier collaborates with a number of repositories to link articles on ScienceDirect with relevant repositories, giving readers access to underlying data that gives them a better understanding of the research described. There are different ways to link your datasets to your article. When available, you can directly link your dataset to your article by providing the relevant information in the submission system. For more information, visit the database linking page.

For supported data repositories a repository banner will automatically appear next to your published article on ScienceDirect.

In addition, you can link to relevant data or entities through identifiers within the text of your manuscript, using the following format: Database: xxxx (e.g., TAIR: AT1G01020; CCDC: 734053; PDB: 1XFN).
Mendeley Data

This journal supports Mendeley Data, enabling you to deposit any research data (including raw and processed data, video, code, software, algorithms, protocols, and methods) associated with your manuscript in a free-to-use, open access repository. During the submission process, after uploading your manuscript, you will have the opportunity to upload your relevant datasets directly to Mendeley Data. The datasets will be listed and directly accessible to readers next to your published article online. For more information, visit the Mendeley Data for journals page.

Data statement

To foster transparency, we encourage you to state the availability of your data in your submission. This may be a requirement of your funding body or institution. If your data is unavailable to access or unsuitable to post, you will have the opportunity to indicate why during the submission process, for example by stating that the research data is confidential. The statement will appear with your published article on ScienceDirect. For more information, visit the Data Statement page.

AFTER ACCEPTANCE

Online proof correction

Corresponding authors will receive an e-mail with a link to our online proofing system, allowing annotation and correction of proofs online. The environment is similar to MS Word: in addition to editing text, you can also comment on figures/tables and answer questions from the Copy Editor. Web-based proofing provides a faster and less error-prone process by allowing you to directly type your corrections, eliminating the potential introduction of errors.

If preferred, you can still choose to annotate and upload your edits on the PDF version. All instructions for proofing will be given in the e-mail we send to authors, including alternative methods to the online version and PDF.

We will do everything possible to get your article published quickly and accurately. Please use this proof only for checking the typesetting, editing, completeness and correctness of the text, tables and figures. Significant changes to the article as accepted for publication will only be considered at this stage with permission from the Editor. It is important to ensure that all corrections are sent back to us in one communication. Please check carefully before replying, as inclusion of any subsequent corrections cannot be guaranteed. Proofreading is solely your responsibility.

Offprints

The corresponding author will, at no cost, receive a customized Share Link providing 50 days free access to the final published version of the article on ScienceDirect. The Share Link can be used for sharing the article via any communication channel, including email and social media. For an extra charge, paper offprints can be ordered via the offprint order form which is sent once the article is accepted for publication. Both corresponding and co-authors may order offprints at any time via Elsevier’s Author Services. Corresponding authors who have published their article gold open access do not receive a Share
Link as their final published version of the article is available open access on ScienceDirect and can be shared through the article DOI link.

AUTHOR INQUIRIES

Visit the Elsevier Support Centre to find the answers you need. Here you will find everything from Frequently Asked Questions to ways to get in touch.

You can also check the status of your submitted article or find out when your accepted article will be published.
10.2. **APPENDIX B – Survey Questionnaire**

1. What is your gender?
   - [ ] Male
   - [ ] Female

2. What is your age?
   - [ ] Under 18
   - [ ] 18-24 years
   - [ ] 25-34 years
   - [ ] 35-44 years
   - [ ] 45-54 years
   - [ ] 55-64 years
   - [ ] 65-74 years
   - [ ] Above 75 years old

3. What are the food commodities that are commonly adulterated in Nigeria?
   - [ ] Herbs and Spices
   - [ ] Fats and Oils e.g. palm oil, vegetable oil, olive oil, etc.
   - [ ] Diary products e.g. milk, butter, cheese, etc.
   - [ ] Cereals e.g. rice, maize, wheat, etc.
   - [ ] Alcoholic and non-alcoholic drinks
   - [ ] Baked goods and confectioneries e.g. bread, pastries, cakes, chocolates, biscuits, etc.
   - [ ] Meat and meat products
   - [ ] Fish and fish products
   - [ ] Honey
   - [ ] Fruits and vegetables

4. In your opinion, do you feel that food laws in Nigeria are poorly implemented?
   - [ ] Yes
   - [ ] No
5. If yes, state reasons and if no, state reasons.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

6. Do you feel regulatory agencies such as NAFDAC are making efforts to tackle cases of food fraud in Nigeria?
   □ Yes
   □ No

7. In your opinion, state reasons why people adulterate food commodities in Nigeria?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

8. Have you heard of the UN Sustainable Development Goals?
   □ Yes
   □ No

9. How can NAFDAC and other government agencies promote food safety in Nigeria?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

10. In your opinion, do you think food smuggling is a major problem in Nigeria?
    □ Yes
    □ No
11. What measures can be taken to tackle food smuggling in Nigeria?

12. In your opinion, do you feel consumers are partly responsible for food fraud in Nigeria?
   - [ ] Yes
   - [ ] No

13. If yes, state reasons and if no, state reasons.
